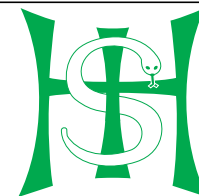




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Review

# From SARS in 2003 to H1N1 in 2009: lessons learned from Taiwan in preparation for the next pandemic

M.-Y. Yen<sup>a,\*</sup>, A.W.-H. Chiu<sup>b</sup>, J. Schwartz<sup>c</sup>, C.-C. King<sup>d</sup>, Y.E. Lin<sup>e</sup>, S.-C. Chang<sup>f</sup>,  
D. Armstrong<sup>g</sup>, P.-R. Hsueh<sup>f,h,\*\*</sup>

<sup>a</sup> Section of Infectious Diseases, Taipei City Hospital, Department of Medicine, National Yang-Ming University School of Medicine, Taipei, Taiwan

<sup>b</sup> Department of Surgery, Taipei City Hospital, Department of Health, Taipei City Government and National Yang-Ming University School of Medicine, Taipei, Taiwan

<sup>c</sup> Department of Political Science, State University of New York, New Paltz, NY, USA

<sup>d</sup> Institute of Epidemiology and Preventive Medicine, College of Public Health, National Taiwan University, Taipei, Taiwan

<sup>e</sup> Center for Environmental Laboratory Services, National Kaohsiung Normal University, Kaohsiung, Taiwan

<sup>f</sup> Department of Internal Medicine, National Taiwan University Hospital, National Taiwan University College of Medicine, Taipei, Taiwan

<sup>g</sup> Memorial Sloan Kettering Cancer Center, New York, NY, USA

<sup>h</sup> Department of Laboratory Medicine, National Taiwan University Hospital, National Taiwan University College of Medicine, Taipei, Taiwan

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## SUMMARY

In anticipation of a future pandemic potentially arising from H5N1, H7N9 avian influenza or Middle East Respiratory Syndrome, and in large part in response to severe acute respiratory syndrome (SARS) in 2003, the city of Taipei, Taiwan, has developed extensive new strategies to manage pandemics. These strategies were tested during the 2009 H1N1 outbreak. This article assesses pandemic preparedness in Taipei in the wake of recent pandemic experiences in order to draw lessons relevant to the broader international public health community. Drawing on Taiwan and Taipei Centers for Disease Control data on pandemic response and control, we evaluated the effectiveness of the changes in pandemic response policies developed by these governments over time, emphasizing hospital and medical interventions with particular attention paid to Traffic Control Bundling. SARS and H1N1 2009 catalysed the Taiwan and Taipei CDCs to continuously improve and adjust their strategies for a future pandemic. These new strategies for pandemic response and control have been largely effective at providing interim pandemic containment and control, while development and implementation of an effective vaccination programme is underway. As Taipei's experiences with these cases illustrate, in mitigating moderate or severe pandemic influenza, a graduated process including Traffic

\* Corresponding author. Taipei City Hospital, Department of Medicine, National Yang-Ming University School of Medicine, Taipei 11221, Taiwan, No. 100, KunMing Street, Taipei City, 10844 Taiwan. Tel.: +886 921699678; fax: +886 2 23703747.

\*\* Corresponding author. Department of Laboratory Medicine, National Taiwan University Hospital, National Taiwan University College of Medicine, No. 7 Chung-Shan South Road, Taipei 100, Taiwan. Tel.: +886 2 23123456x65355; fax: +886 2 23224263.

E-mail addresses: [myyen1121@gmail.com](mailto:myyen1121@gmail.com) (M.-Y. Yen), [hsporen@ntu.edu.tw](mailto:hsporen@ntu.edu.tw) (P.-R. Hsueh).

Control Bundles accompanied by hospital and medical interventions, as well as school- and community-focused interventions, provides an effective interim response while awaiting vaccine development. Once a vaccine is developed, to maximize pandemic control effectiveness, it should be allocated with priority given to vulnerable groups, healthcare workers and school children.

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## Introduction

Despite previous outbreaks such as the 1918 Spanish, the 1957 Asian, and 1968 Hong Kong influenza pandemics, attention to the possibility of a significant public health threat due to a pandemic outbreak was largely provoked only in 1997 with the outbreak of human cases of H5N1 avian influenza in Hong Kong.<sup>1,2</sup> Following this outbreak, the Taiwan Centre for Disease Control (TCDC) began coordinating an influenza surveillance network, which, since 1998, has regularly monitored avian influenza focusing on potential emergence among wild birds, on poultry farms, and in poultry markets together with human epidemiological and virological patterns of influenza endemics.<sup>3–5</sup> Despite enhanced surveillance efforts, severe acute respiratory syndrome (SARS) arrived unexpectedly in 2003.

The goal of this paper is to evaluate the various initiatives developed by the Taipei City government in response to pandemic outbreaks. As part of the evaluation, the paper includes a discussion of Taiwan (ROC) preparedness and response efforts because they directly impact all Taipei City government efforts. Under Taiwan law, the TCDC is responsible for developing and recommending disease control policies. Lower levels of government, including Taipei City and Taipei CDC can adapt TCDC policies to local conditions but may not weaken them.<sup>6</sup>

## SARS background

Encountering SARS in 2003 had a major impact on Taiwan's strategies to prevent and control communicable diseases. In late April 2003, the first outbreak of SARS occurred in one municipal hospital in Taipei. Soon, Taipei became the centre of a SARS outbreak that spread over the entirety of Taiwan in the span of six weeks.<sup>7</sup> By late June, SARS had caused 73 fatalities in Taiwan, affecting physicians and nurses as well.<sup>8</sup> SARS was a highly contagious, emerging infectious disease (EID) that, just like influenza, was spread through droplet aerosols and contact transmission. When countermeasures were taken to control the epidemic, the initial efforts suffered weaknesses including lack of adequate inter-organizational coordination, an unclear chain of command, inefficient resource allocation, poor risk communications, and disrupted information flows. The consequence was a total of 347 casualties, of whom 70% were from healthcare-associated infections and 30% were of healthcare workers (HCWs).<sup>7,9,10</sup>

## Lessons from the post-SARS evaluation of pandemic response

The highly contagious character of SARS induced the TCDC to reform its hospital infection control strategy. Reforms included revising the surveillance system, and improving

educational and support systems. Annual inspection and on-site audits were also initiated, and in compliance with the 2007 World Health Organization (WHO) hand hygiene campaign, alcohol dispensers coupled with hand disinfection checkpoints first implemented during SARS were incorporated into Taiwan's hospital disease control strategy.<sup>11,12</sup>

To increase HCW protection from nosocomial infections and EIDs, an additional step by the government included funding annual seasonal influenza vaccinations for all HCWs and emphasizing hand hygiene strategies. Although not mandatory, vaccination programmes were included in the accreditation and inspection process by the TCDC as of 2003. The average annual rate of vaccination against seasonal influenza by HCWs is currently around 90%. The emphasis on hand hygiene strategies has had a direct impact on reduced MRSA nosocomial infections in Taiwan.<sup>13</sup>

The TCDC also developed a systematic and integrated approach for countermeasures against highly contagious EIDs based on the Incident Management System (IMS) and Six Sigma. The IMS describes a chain of command and control system that consists of four components: action, planning, financing, and logistical support. It can be applied to any scale of disaster and enables the TCDC to coordinate responses across institutional spheres.<sup>14</sup> 'Six Sigma' is a principle of process management that originated from industrial engineering and management systems. This tool simplifies complex processes into smaller, more manageable steps that can be more easily analysed to set control points in approaching a final product, achieving a failure rate of less than three per million.<sup>15,16</sup> The TCDC deploys the principles of IMS and Six Sigma to enhance its efforts in the key spheres of Traffic Control Bundling, Communicable Disease Control Networks, and Crisis Management.

## Traffic Control Bundling

During the SARS outbreak it became clear that HCWs were vulnerable to infection in the period between patients' arrival for care and when they were classified as 'probable SARS cases'.<sup>10</sup> Sources of vulnerability included casual contact with fomites through contaminated environments, and the unwarranted assumption among HCWs caring for SARS patients that existing barrier precautions and personal protective equipment, such as gloves and gowns, provided sufficient protection and obviated the need for handwashing. Such incorrect assumptions led to some HCWs' exposure to, and acquisition of, SARS.<sup>9,17–20</sup>

At the peak of the SARS epidemic, and in coordination with the TCDC, the Taipei CDC developed a new mechanism for integrated infectious disease control, namely Traffic Control Bundling. Traffic Control Bundling includes the following procedures: triaging and dispatching patients before they enter

the hospital; confining confirmed patients in a contamination zone; confining HCWs in a clean zone before entering the contamination zone; and installing dispensers with 75% alcohol for gloves-on hand sanitation at checkpoints so as to increase the pervasiveness of handwashing between zones of risk. Heightened handwashing and clearly delineated zones of risk improve hand hygiene compliance from an average of 30% to 100%.<sup>21</sup>

The Traffic Control Bundling protocols were tested in a pilot hospital with promising results (Figure 1).<sup>22</sup> During the three-week study period, only two HCWs in the pilot hospital acquired SARS, which was significantly lower than the 93 cases in the control hospitals (0.03 vs 0.13 cases per isolation bed, respectively,  $P = 0.03$ ). Given this significant difference and the fact that the pilot hospital had the highest proportion of SARS patients in Taiwan without the benefit of a single negative pressure isolation room, the TCDC mandated that the newly developed Traffic Control Bundling protocols be immediately implemented across all of Taiwan's hospitals.

As the SARS epidemic subsided, the TCDC conducted an analysis of the protective efficacy of the Traffic Control Bundling protocols in preventing infection among HCWs.<sup>23</sup> A total of 51 hospitals that cared for SARS patients during the SARS epidemic were studied. Among them, 18 hospitals had HCWs infected by SARS; the remaining 33 hospitals had no cases of HCW-acquired nosocomial SARS infections. A univariate analysis demonstrated significant protective effects arising from reliance on Traffic Control. HCWs benefited from establishing fever screening stations, triaging fever patients, cohorting SARS patients, separating the entrances and traffic routes (Figure 1) for patients and HCWs, and increasing facilities for handwashing ( $P < 0.001$ ). A multiple logistic regression found that triage with fever-screening stations outside the

emergency department (ED) and setting up alcohol dispensers for handwashing between zones of risk were significant factors in protecting HCWs.

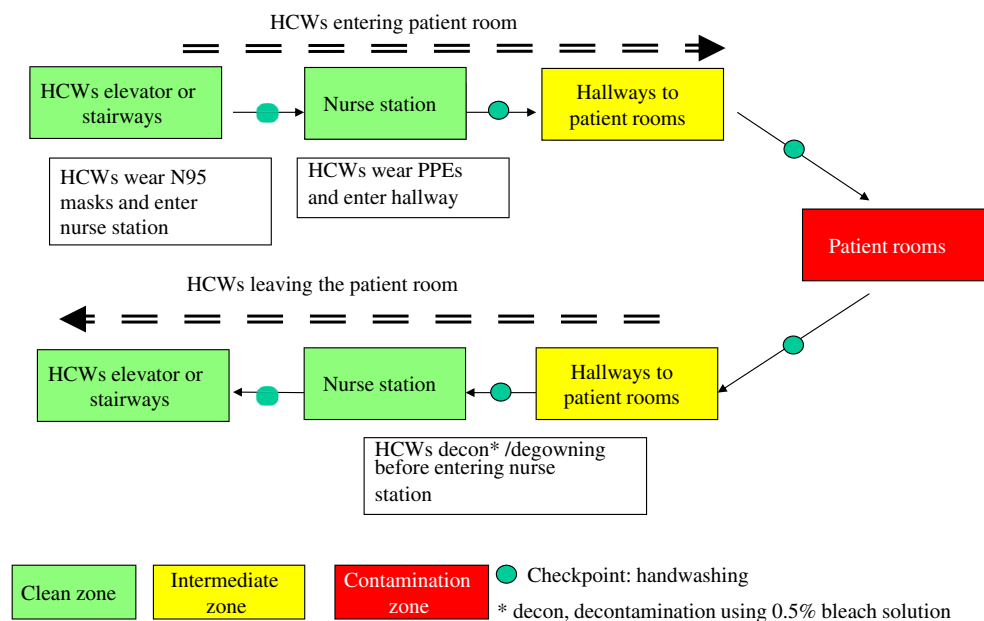
Hospital patients also clearly benefited from implementation of the Traffic Control procedures. The same study found that only two patients developed SARS in the 18 hospitals designated to implement Traffic Control Bundling protocols, as compared to 203 cases in the 33 control hospitals.

From its peak, the SARS epidemic was halted within two weeks – a far better outcome than the normal pattern for communicable diseases control.<sup>7,22,24</sup> This result suggests that the Traffic Control Bundling protocols played an important role in controlling SARS.

In our post-SARS review, we concluded that the Traffic Control Bundling model corresponds closely to Six Sigma. In the pandemic control case, strategically installing alcohol dispensers and enforcing hand disinfection between zones of risk played the role of control points, which led to total adherence with routine handwashing protocols that ultimately minimized SARS transmission. Importantly, by observing the basic principle of process management in Six Sigma it is possible to adapt Traffic Control Bundling to different types of future EIDs with additional non-pharmaceutical interventions.

### Communicable disease control networks

Drawing on lessons from the SARS outbreak and principle of IMS, the TCDC integrated medical and public health systems by establishing six Communicable Disease Control Networks (CDCNs) across Taiwan. Experts from hospitals, public health and infection control units, local health departments and the TCDC were recruited to work under the coordination of a medical director who plays the role of commander in the IMS



**Figure 1.** Conceptual scheme of traffic control bundle included triaging patients before admission to the hospitals, included cohorting the patients, separating the space and routes from the emergency department entrance through the hallways and the elevators to the negative pressure isolation rooms for patients and healthcare workers (HCWs). Patients were thus confined in the contamination zone. HCWs and patients were separated by zones of risk, with decontamination and handwashing with 75% alcohol disinfectant at checkpoints positioned in between zones of risk. PPE, personal protective equipment. (Adapted with permission from Yen *et al.*<sup>23</sup>)

system. This model enables streamlined command and information flows through communications such as regular face-to-face meetings, video conferences and telephone conferences during emergency events.

To facilitate medical planning and action in pandemic preparedness, the CDCNs share human resources, logistical support and surveillance information as well as surge capacity and special isolation hospitals. CDCNs also conduct exercises to test the effectiveness of inter-organizational coordination.<sup>11,25</sup> In this way a chain of command and control has been established that reaches from the local level through the CDCNs to the central level TCDC.

### *Crisis management*

In terms of crisis management, Taiwan has developed a warning phase system that closely parallels that of the WHO. Taiwan's local pandemic risk notification system is divided into four alert phases. The phases include 0, A, B, and C.<sup>26</sup> Taiwan's level 0 and A correspond to the WHO's 'inter-pandemic' and 'alert' phase, respectively. Taiwan phases B and C are equivalent to the WHO's 'global pandemic alert' phase and are directly relevant to hospital mobilization. As such, we focus on phases B and C here.

Phase B is declared when a limited number of cases of human-to-human transmission in Taiwan have been identified. The response strategy during this phase is to increase all epidemiological efforts, such as mobilizing public health resources, and expanding available resources to contain the disease by quarantining contacts and isolating the sick within hospitals with special isolation units designed for communicable diseases. Additional containment tactics include increasing social distancing by drawing on such strategies as suspending public mass transit.

Phase C is declared when efficient and sustained human-to-human transmission within the community has been identified. During this phase there will be an inevitable upsurge of people seeking medical assistance that may overwhelm existing medical facilities. The TCDC strategy during this phase is to transition to disaster response mode in order to mitigate impacts, maintain social order and support the healthcare system.

Finally, post pandemic (WHO 'transitional phase'), the TCDC focuses on crisis recovery and drawing lessons to improve pandemic response in preparation for future outbreaks. Throughout the pandemic, the TCDC draws on IMS guidelines for crisis Prediction, Preparedness, Response and Recovery (2P2R).

In addition to the adaptations to already existing TCDC-driven programmes, the Taipei CDC developed two important, complementary initiatives intended to strengthen the city's response to pandemics. These initiatives focus on surveillance and surge capacity.

### *Surveillance*

Among the various surveillance systems for infection control, respiratory syndromic surveillance has been a valuable tool to identify and raise the alarm about novel EIDs. However, a major lesson learned from SARS was that the long-established, existing respiratory syndromic surveillance system is insufficiently effective. The main reason for this is that frontline doctors – key to successful implementation – proved unable to comply efficiently with the requirements of the

system.<sup>27</sup> This inability largely derived from the fact that the passive reporting respiratory syndromic surveillance system detected unknown aetiologies of pulmonary syndrome too late to prevent highly contagious EIDs. During SARS this shortcoming resulted in catastrophic consequences in terms of containing the spread of disease.

To address this shortcoming in contagion detection and control, the Taipei CDC developed an automated hospital ED-based syndromic surveillance protocol that functions in real-time and is based on the prodromal chief complaint or ICD-9 codes.<sup>28</sup>

The Taipei CDC team responsible for this new approach selected five branches of the Taipei City Hospital system that are evenly distributed throughout the Taipei metropolitan area. The team designed the surveillance system according to the following principles: (1) an integrated syndromic surveillance system that can automatically collect data from hospital EDs in a timely and flexible fashion; (2) algorithms that enable early detection of outbreaks by analysing data from the above-mentioned chief complaints collection or ICD-9 codes; and (3) user-friendly web-based interfaces that enable triage nurses to input standardized data simply by clicking through menus to upload information automatically for epidemiological analysis.<sup>29</sup>

In addition to the new surveillance and reporting protocols, physician and public awareness of surveillance has been emphasized by highlighting the importance of taking a patient's history regarding travel (T), occupation (O), contact (C) and clustering cases (C), or 'TOCC'.

### *Surge capacity*

During the WHO-defined pandemic phase, an upsurge of patients seeking medical attention may overwhelm existing medical facilities. This drives home the critical importance of surge capacity in crisis management preparedness. The Taipei CDC has stockpiled antiviral medications and other necessary materials for surge capacity in the event of a pandemic. It has also designated special isolation hospitals to control communicable diseases.<sup>25,26,30</sup> However, the number of influenza patients may exceed the capacity of the designated hospitals and then overflow into general hospitals, jeopardizing the ability of the medical system to respond to routine patient needs.

Recognizing this challenge, the TCDC has long sought to develop alternative care sites to expand surge capacity.<sup>31</sup> The Taipei CDC identified schools to provide surge capacity because they offer the benefits of accessibility, availability, expandability, and safety. Due to their layouts, schools are relatively easily transformed into epidemic response care sites. Already existing separations among buildings, floors, and classrooms facilitate traffic control and establishment of designated zones of risk. In addition, large open spaces in gymnasiums and athletic fields provide excellent sites for community screening stations. Classrooms with natural window ventilation can take the place of negative-pressure isolation rooms.<sup>32</sup> Overall, identifying schools as pre-designated alternative care sites ensures that required surge capacity is available.

In addition to designating surge capacity sites, sufficient medical personnel to staff them must also be identified. During a future pandemic outbreak, a shortage of medical personnel due to spiking demand but also due to high absenteeism rates should be anticipated. Studies find that during crises,

absenteeism among healthcare professionals may reach as high as 30%.<sup>33</sup>

The Taipei CDC response has been to implement an ongoing programme to recruit and train medical personnel, including general practitioners, retired medical professionals and school nurses.<sup>34</sup> The programme also recruits and trains non-medical personnel such as taxi drivers who volunteer to provide transportation for patients with mild illness. These teams can be mobilized as needed to support emergency medical teams when existing public health mobilization resources have been stretched thin.

According to a study of preparedness across 28 countries conducted by Coker, these initiatives have resulted in Taiwan's overall pandemic preparedness being highly rated.<sup>35</sup> The study finds that Taiwan achieves a 70% readiness rating, falling short only in terms of vaccine preparedness, where Taiwan is below the median.

These adjustments to Taiwan's pandemic response protocols faced their first significant test during the 2009, H1N1 pandemic. It is to this case that we now turn.

## The H1N1 2009 pandemic and lessons learned

In late April 2009, novel H1N1 influenza virus began in Mexico before spreading worldwide within six weeks. On May 20, the first imported case of pandemic influenza H1N1 virus (pdm H1N1/09) in Taiwan was isolated and identified in Taipei City.<sup>36</sup>

### The containment stage

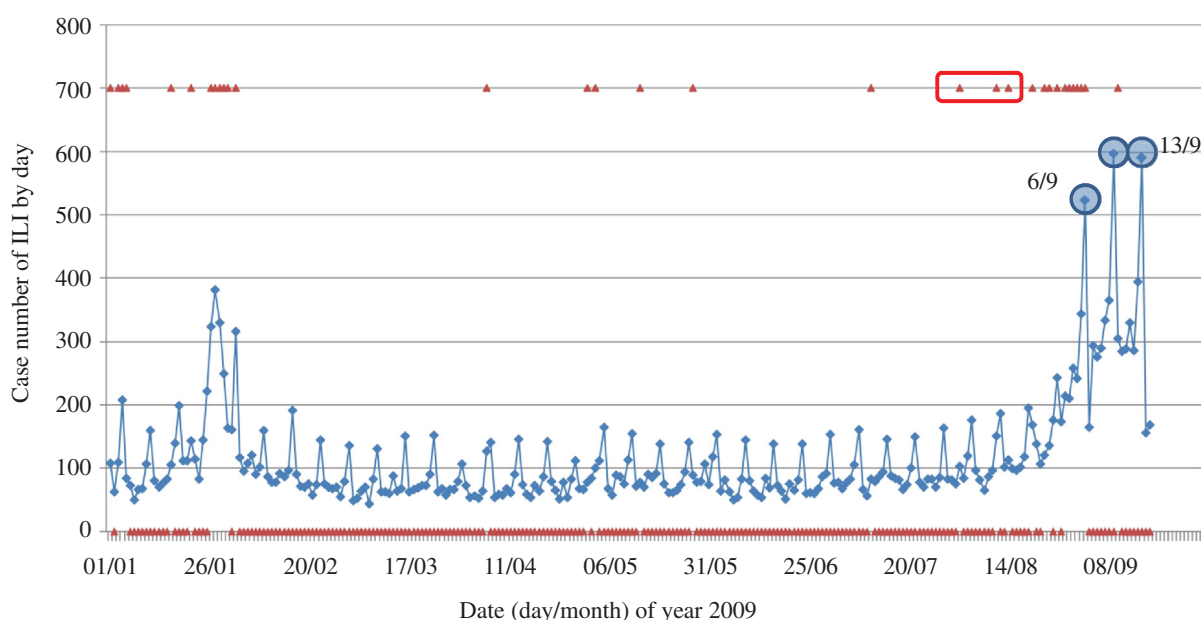
In response to the first and later imported cases, the Taipei CDC activated its designated special isolation hospital to isolate and treat those who had fallen ill with H1N1. Taipei's

initial public health response was containment, which focused on finding cases through active epidemiological investigations and contact tracing, followed by home quarantine for contacts.

The protocols and policies developed post SARS produced a relatively successful outcome during the containment stage of the H1N1 response as measured by total number of cases during that stage. Of the 1363 cases investigated in Taiwan between April 27 and June 19, only 59 imported and two intra-family transmission cases of H1N1 were identified.<sup>36</sup> In short, during the containment stage, the spread of H1N1 2009 throughout the community as a whole was avoided.<sup>36</sup>

On 20 June 2009, following the WHO announcement of a global H1N1 pandemic, and recognizing the inevitable spread of the pandemic into the local community, Taiwan's strategy shifted from containment to mitigation.<sup>25</sup> In fact, as of 1 July, sporadic cases and clusters (with a minimum of three cases per cluster) were reported, and by 18 August, Taipei had identified 36 clusters, with most appearing in 19 schools (52%). Other clusters were reported in school workshops (14%), military facilities (14%), long-term care facilities (6%), one workplace, and one imported case (3% each). As of mid-August, three hospitals reported nosocomial clusters (8%).

Concurrently, a series of early warning signals of community transmission were detected by the chief-complaint-based ED syndromic surveillance system (Figure 2). In Taipei, imported H1N1 cases first spread to family members, then to school-aged children and from there into the schools (which are efficient virus transmission amplifiers). From the schools, the outbreak quickly spread to the larger community.<sup>34,37</sup> The community incubation period was relatively long (six to eight weeks) because of the summer vacation. Had school been in session, it is likely that the community incubation period would have been shorter.



**Figure 2.** Epicurve of automated chief-complaint-based syndromic surveillance system for influenza-like illness (ILI) from emergency departments of five general hospitals of Taipei City in 2009. The epidemic signal (red triangles) at the beginning of 2009 were caused by seasonal influenza A H1N1. Red-encircled signals of 30 July, 8 August, 11 August, and 17 August, which were concordant with the first hospital cluster on 13 August, indicate the early warning signal of a community outbreak starting on 6 September.

This is the pattern that developed in Taipei, where a family–school–community transmission cascade occurred. Although pandemic H1N1 2009 was largely a disease with mild clinical manifestations, as the total number of sick patients increased, the number of patients who were sick enough to seek medical attention also increased, and intra-hospital transmission occurred.

### *The mitigation stage*

After the initial H1N1 outbreak in mid-August, a surge in community outbreaks, aggravated by the start of the school year, occurred in Taipei. Since schools and hospitals normally play key roles in catalysing a cascade of community outbreaks, the Taipei City mitigation strategy focused on mitigation in schools while also diverting potential ILI patients from hospitals to community influenza centres (CICs).

#### *Class suspensions*

Throughout Taiwan, non-pharmaceutical interventions began with class suspensions in mid-September 2009. For students under 18 years of age, classes were suspended for five days if more than two students in the class developed H1N1 2009 over a three-day period.<sup>6</sup> The logic underlying class suspensions rather than school closures is that in Taiwan, students remain in a home-room with a 'core teacher', whereas all other teachers move among the classes. The fact that students do not move around the school decreases the opportunity for disease spread, making it less likely that school closure will be necessary.<sup>6</sup> Suspending classes in an effort to slow the time to reach the epidemic peak appears to have been an effective social-distancing measure during 2009 H1N1, while also enabling schools to remain in session, thereby limiting disruption in the communities.

#### *Community Influenza Centres (CICs)*

Outdoor fever screening stations successfully triaged fever patients and controlled the SARS epidemic in 2003.<sup>23</sup> However, as the severity of pandemic influenza 2009 H1N1 was only mild, activating fever screening stations outside of hospitals was not indicated. Instead, Taipei established 212 CICs citywide, each equipped with alcohol dispensers, rapid antigen test kits, and government-funded oseltamivir for those who screened positive or who fit the criteria for illness with 2009 pandemic H1N1.<sup>38</sup> Based on the principles of Traffic Control Bundling, CICs provided surge capacity as triaging checkpoints, handling the massive inflow of potential patients that would have otherwise overwhelmed hospitals. This measure not only prevented patients with ILI directly visiting hospitals, it reduced the risk of cross-transmission within hospitals.

Once activated, CICs contributed to a rapid decline in the 2009 pandemic H1N1 influenza infection rate among HCWs.<sup>38</sup> Clearly, however, neither class suspensions nor CICs are sufficient to eradicate an epidemic. At best, they can delay the peak, buying time while pandemic vaccines are developed.<sup>39</sup>

### *The vaccination campaign stage*

The Taiwan government obtained H1N1 vaccines from two sources. The first, Adimmune Corp., is a partially Taiwan government-funded corporation. Adimmune provided 11

million vaccine doses between June and late December 2009.<sup>40,41</sup> The government purchased an additional 500,000 doses from abroad. When deciding how to dispense the available vaccine doses, the government prioritized HCWs and refugees from typhoon Morakot in communal shelters. The government also targeted school-aged children between seven and 18 years to be vaccinated, resulting in a 74% vaccine coverage rate.<sup>6</sup>

Another important contributor to the successful H1N1 outbreak response was the post-SARS TCDC practice of auditing hospitals for annual seasonal influenza vaccination among HCWs. As a result of the increased attention to HCW influenza vaccination, more than 70% of HCWs in Taiwan received the H1N1 2009 vaccine.<sup>38</sup> This vaccination rate exceeds that of most other countries.<sup>42,43</sup> And yet despite these efforts, Taipei's overall 21% vaccination rate remains insufficient to achieve herd immunity.

Nonetheless, pandemic 2009 H1N1 declined sharply and quickly came under control. This success may largely be attributed to the focus on establishing vaccination checkpoints in schools, but also, arguably, in hospitals.<sup>6</sup>

## **Post-2009 pandemic H1N1 influenza lessons and actions**

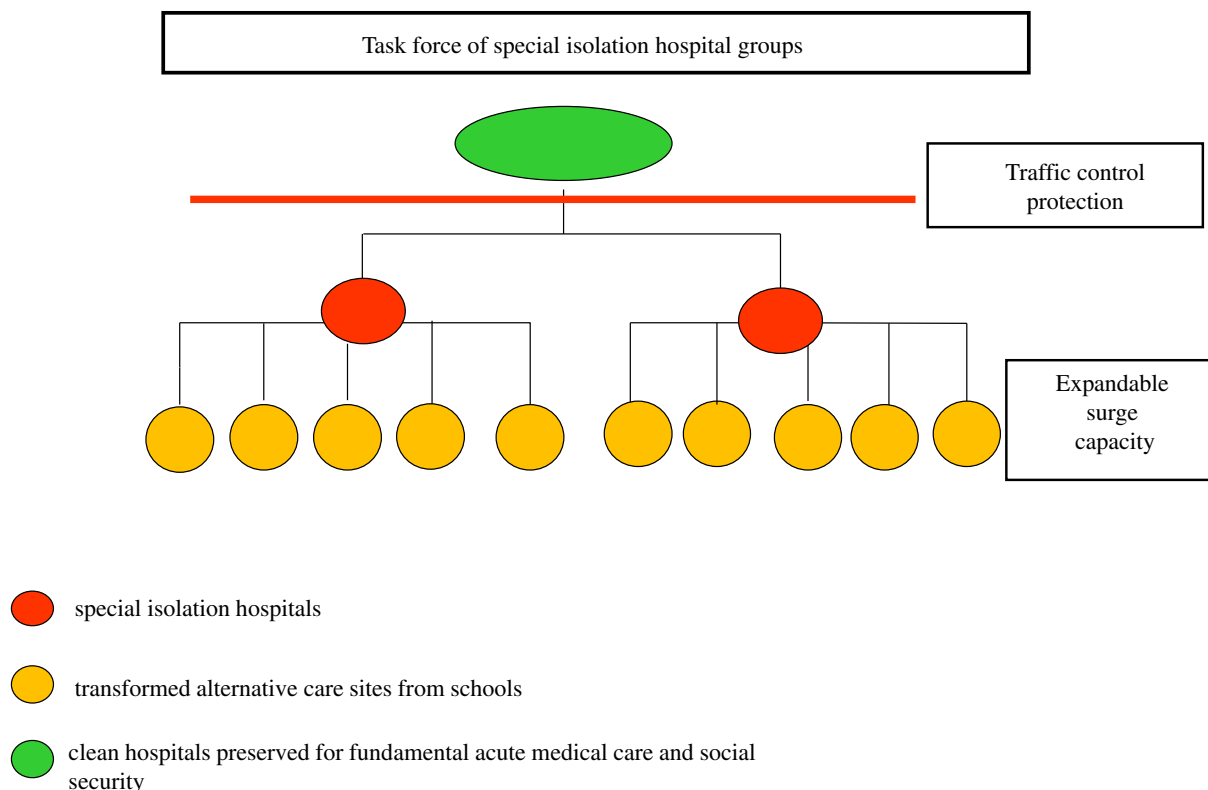
Although the 2009 pandemic was generally considered a mild one and the H1N1 virus did not prove as virulent as other pandemics, it still provided an opportunity to evaluate Taiwan's full-scale, post-SARS reconfiguration of emergency management, and to test Taipei's disaster response plans for pandemic influenza.<sup>44</sup>

Lessons learned from the mitigation strategies include the value of suspending classes without closing schools and of installing citywide CICs. For example, Taiwan's approach in the face of H1N1 compares favourably with that of Japan. Whereas in Japan the transmission of pdm H1N1/09 into households may have been minimized by the Japanese government decision to cancel classes, transmission nonetheless continued outside the schools and increased due to the lack of CICs.<sup>45,46</sup>

Interestingly, during the post-pandemic 2010–2011 influenza season, pdm H1N1/09 resurged and accounted for 72.6% of total isolates in Taiwan. Hospitalizations increased, as did deaths.<sup>47</sup> These outcomes clearly indicate that, as noted, checkpoint controls in schools and hospitals offer only short-term protection in response to an outbreak, and should only be expected to buy time while vaccines are developed.

## **Strategies to prepare for the next emerging infectious disease**

Among the new challenges identified as arising during H1N1 is the impact of international air travel on pandemic preparedness and response. Increasing numbers of people travelling to more destinations, more frequently, has accelerated the spread of novel pandemics and decreased the time available for crisis response.<sup>48</sup> Epidemiological and economic modelling studies have shown that travel restrictions are not as cost-effective and efficient in containing pandemics as is in-country application of intervention measures to interrupt transmission.<sup>49</sup>



**Figure 3.** Conceptual scheme of expandable task forces of special isolation hospital groups for surge capacity in mitigating novel pandemics. Each working group comprised one designated communicable disease isolation hospital (red ovals) with five alternative care sites (yellow circles) transformed from recruited schools. Other general hospitals (green ovals) should prioritize strict infection control to remain free from nosocomial outbreaks of novel pandemic and maintain the integrity of the healthcare system.

In terms of in-country application of intervention measures, the Taipei CDC has expanded beyond the general strategy established at the national level to contain and mitigate disease spread, designing and testing an initial response model to future pandemics based on Traffic Control Bundling and Six Sigma.

In accordance with the 'zones of risk' concept, hospital task forces establish working groups assigned to specific contamination zones. Each working group has one designated communicable disease response hospital. The hospital works with five alternative care sites established in schools recruited for this purpose. In total, each zone has a capacity of 1000–1500 beds.<sup>32</sup> The disaster-response pandemic influenza surge capacity system in Taipei consists of eight such zones.<sup>27,50</sup> Hospitals not included in this system are expected to function as 'clean hospitals', providing ongoing routine medical care and maintaining the integrity of the general healthcare system (Figure 3). Those hospitals and medical facilities not directly engaged in pandemic treatment are required to prioritize infection control in an effort to remain free from nosocomial outbreaks.

During Taiwan pandemic phases B and C, Traffic Control Bundling is implemented in the general hospitals, including outdoor screening stations and CICs to triage patients before they enter the hospitals. When patients are admitted to a hospital for medical treatment for a routine medical condition, they remain in detention wards – zones of risk – for secondary screening until they are past the incubation period of the pandemic disease.

Healthcare workers should wear masks for respiratory protection. In order to increase vigilance with regard to hand hygiene, checkpoints to wash hands with alcohol dispensers should be installed in the wards and in public locations throughout hospitals. There should be mandatory daily monitoring of every HCW, who should report any flu symptoms, such as fever and diarrhoea. Any documented or suspected case should be investigated by the hospital with strict contact tracing and containment to control infection spread.<sup>27,50</sup>

## Discussion

Sixteen years have passed since the appearance of the first potential major 'next pandemic' – 1997 Hong Kong H5N1 avian influenza. Despite the many lessons learned and changes made in the wake of SARS, H1N1, H5N1, MERS and H7N9, these potentially devastating pandemics continue to constitute a serious threat.<sup>51,52</sup> However, it remains difficult to predict precisely how severe the consequences of the next pandemic might be and when or where it might occur. Though H1N1 turned out to be mild, healthcare resources were nevertheless strained.<sup>38</sup> Should an influenza pandemic such as Spanish Flu appear again, or should currently circulating influenzas such as H5N1, H7N9 or MERS become efficient at human to human transmission, we must anticipate unprecedented demands on the healthcare system.

Drawing on Taiwan's responses to SARS and H1N1, the international healthcare and policy communities can draw



lessons on how to effectively and continuously adjust and improve local strategies for novel pandemic preparedness and response. While it is the case that H1N1's mild nature somewhat limits the lessons we can derive, by combining our experiences with the different pandemics in terms of mechanisms of transmission and disease severity, we have an excellent opportunity to develop improved preparedness and disaster response protocols.

Lessons from 2009 H1N1 demonstrated that deploying class suspensions and CICs as social distancing measures can delay the pandemic peak while vaccines remain in development. Lessons from both 2003 SARS and 2009 H1N1 illustrate that Traffic Control Bundling can effectively protect HCWs during a pandemic, and that schools and hospitals are critical control points for pandemic response when the response requires non-pharmaceutical intervention or when it requires vaccination campaigns to engage and mitigate the pandemic.

In addition, the appearance of one or more hospital clusters may be viewed as an early signal of approaching community saturation. The Taipei experience points to the clear benefit of activating either screening stations outside hospitals or CICs. Activating Traffic Control Bundles, at the hospital level and/or at the community level, based on zones of risk, is an additional key step in minimizing the pandemic impact in the interim period between outbreak and vaccine availability, and may be especially useful as a pre-emptive tool in countries with limited public health resources.

A final important lesson is that high vaccination rates among school children and HCWs result in a combined effect that may end the vicious cycle of school–community–hospital transmission. Therefore, to allocate scarce vaccines effectively in the early pandemic stage or during a moderate-to-severe pandemic when vaccine supplies are limited, we recommend that priority be given to achieving herd immunity among school children and HCWs, along with high-risk vulnerable groups.<sup>53</sup>

In conclusion, a well-planned, effectively communicated and coordinated emergency response that draws on medical mobilization is the key to a successful strategy for pandemic preparedness and response, and will minimize the health threat of future pandemic influenzas. Whereas this paper focuses on the tools developed to respond effectively to pandemic outbreaks in Taiwan, we argue that these tools may and should be adopted and adapted for use by healthcare officials in other countries too. After all, healthcare officials around the world are faced with similar challenges as they prepare for, and respond to, pandemic occurrences in their own countries. Taiwan provides a rare example of a 'battle-tested' approach to effective pandemic response.

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