Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

Journal of Microbiology, Immunology and Infection (2017) 50, 125–132

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.e-jmii.com

REVIEW ARTICLE

Toward a collaborative model of pandemic preparedness and response: Taiwan's changing approach to pandemics

Jonathan Schwartz [a,*], Muh-Yong Yen [b,c,*]

[a] Department of Political Science, State University of New York, New Paltz, NY 12561, USA
[b] Division of Infectious Disease, Taipei City Hospital, Taipei, Taiwan
[c] National Yang-Ming University, School of Medicine, Taipei, Taiwan

Received 15 July 2016; received in revised form 23 August 2016; accepted 25 August 2016
Available online 18 December 2016

KEYWORDS
collaborative governance;
pandemic preparedness;
Taiwan

Abstract *Background:* Over time, as newly emerging infectious diseases have become increasingly common and more easily spread, it has become clear that traditional response mechanisms have proven inadequate to the task of prevention and control.
Purpose: To explore whether enhanced cooperation with local government and community institutions can effectively supplement traditional state-centric public health epidemic responses.
Methods: Drawing on Taiwan as a case study, we assess the role of the whole-of-society approach to epidemic response as arises from the collaborative governance literature. The approach calls for enhanced cooperation, trust building, resource sharing and consensus-oriented decision making among multiple levels of government, business, non-profits, and the public in general.
Results: The Taiwan case illustrates the benefits of the whole-of-society approach. Enhanced cooperation between state, local government and non-state institutions, particularly neighborhood committees, has resulted in a strengthened, holistic epidemic preparedness and response infrastructure.
Conclusion: The Taiwan case provides evidence that by implementing the whole-of-society approach to pandemic preparedness and response governments can enhance their ability to manage future outbreaks. We recommend that governments beyond Taiwan's borders seriously consider adopting this approach.
Copyright © 2016, Taiwan Society of Microbiology. Published by Elsevier Taiwan LLC. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

* Corresponding authors. Department of Political Science, State University of New York, New Paltz, 1 Hawk Drive, New Paltz, New York 12561, USA (J. Schwartz). Division of Infectious Disease, Taipei City Hospital, and National Yang-Ming University, School of Medicine, 100 Kunming Street, Taipei, Taiwan (M.-Y. Yen).
E-mail addresses: schwartj@newpaltz.edu (J. Schwartz), myyen1121@gmail.com (M.-Y. Yen).

http://dx.doi.org/10.1016/j.jmii.2016.08.010
1684-1182/Copyright © 2016, Taiwan Society of Microbiology. Published by Elsevier Taiwan LLC. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Introduction

Despite ongoing improvements in vaccine development, in medical care in general and in public health tools and methods, emerging infectious diseases continue to regularly overwhelm existing plans and government institutions. The potential outcome is significant loss of life, economic and social displacement, as well as undermined political institutions and stability. Although international cooperation remains fundamental to effective pandemic preparedness and response efforts, the inevitable arrival of an outbreak within the borders of a country requires that states prepare domestic plans to manage these outbreaks. At the point the outbreak becomes a domestic affair, the burden of control falls to the pandemic preparedness and response infrastructure and institutions established by the country. As has been repeatedly observed across the globe, no country facing an outbreak has proven itself to possess a fully effective response system.

In this paper, we explore the assertion found in the collaborative governance literature that state—society cooperation contributes to effective implementation through the lens of pandemic preparedness and response in Taiwan. We open with a brief description of the pandemic threat prior to focusing on the collaborative governance arguments for effective response. We then evaluate these arguments through a study of Taiwan's pandemic response efforts. Do Taiwan's pandemic response capabilities offer useful insights into collaborative governance?

The challenge

Disasters constitute a significant disruption to public life. As defined by Fritz,[1] a disaster is "an event concentrated in time and space, in which a society or one of its subdivisions undergoes physical harm and social disruption, such that all or some essential functions of the society or subdivision are impaired." In a disaster situation, physical and social impacts or disruptions occur because the event exceeds existing protections. The 2003 severe acute respiratory syndrome (SARS) outbreak, a disaster by this definition, was a catalyst that focused world's attention on the threat of emerging infectious diseases.

SARS started in China but quickly spread across the globe. Although transmission proved relatively inefficient, its case fatality rate was quite high, and panic spread as the number of fatalities grew. Following SARS came H5N1 (with a 2012 case fatality rate of 62.5%), H1N1 (infecting between 20% and 40% of the global population in 2009); H7N9 (causing 571 laboratory confirmed cases and 212 deaths by February 2015, the vast majority in China); and MERS (1594 laboratory confirmed cases and at least 568 deaths by October 2015), among others.[2—4] In fact, according to a study by Jones et al,[5] between 1940 and 2004 there have been an average of 5.2 emerging infectious diseases every year, with frequency steadily increasing through the 1980s. These and other examples of potential pandemic disasters are made more potent by the easy and rapid international movement of goods, services, people, and vectors (e.g., mosquitoes) characterized by globalization. In short, the threat of a disaster arising from a pandemic outbreak is increasing, and effective responses are very much needed.

Models: collaborative governance and whole-of-society

The international community is not insensate to this threat having initiated numerous efforts to develop protocols and guidelines aimed at facilitating communication and cooperation across countries. For example, in the wake of SARS, the international community responded to obvious weaknesses in existing health regulations with the 2005 updated International Health Regulations that include new guidelines on information sharing, numerous global meetings, and greater institutionalization of international pandemic response mechanisms.[6] Although such developments are encouraging, as has become increasingly clear, international cooperation cannot alone effectively block the spread of emerging infectious diseases. Recognizing the near-inevitability of domestic penetration by outbreaks, countries have sought to supplement global cooperation with comprehensive domestic response systems.

Comprehensive state public health plans may be necessary for effective pandemic response, but alone they are insufficient to achieve the goal of pandemic control. Success cannot rely solely on high-technology medical tools, physician care, and vaccination/immunization, but must incorporate widespread implementation of sometimes straightforward yet unpopular (and potentially disruptive) protocols such as social distancing, constraints on population movements, mask distribution, and hand washing. Constructing and implementing an effective domestic pandemic response system thus requires far more than simply investing heavily in traditional public health approaches. As is often noted, even where technically sound solutions exist, they are not always used because of political constraints.[7,8] Indeed, the political nature of pandemic response requires that government officials responsible for pandemic response develop a model that incorporates both advanced public health tools, and local government officials and nonstate actors.

Such an approach is not simple. And yet, the World Health Organization (WHO) and other organizations are increasingly calling for such collaboration.[9,10] In what is described as a whole-of-society pandemic readiness approach, the WHO argues that states should draw on nonstate actors to play a variety of roles, including distributing resources such as bed nets, condoms, and sanitary toilets; obtaining and disseminating information to educate and mobilize the public to achieve healthcare priorities; representing community interests while promoting equitable access; and providing some financing and monitoring of care. As the WHO argues, "there is great potential for improving public health through systematic collaboration between governments and civil society…."[11,12]

The Collaborative Governance literature speaks directly to the "whole-of-society" approach. According to Ansell and Gash,[13] collaborative governance describes an arrangement between one or more public agencies that collaborate with nonstate actors in a collective decision-

making process aimed at implementing public policy or managing public programs or assets. Actors engage in consensus-oriented decision making, fostering mutual trust, resource sharing, and responsibility. Collaboration may be formal or informal, and may include multiple levels of government, businesses, nonprofit and philanthropic organizations, communities, and the public as a whole.

The government hierarchy plays important policy and legal functions. However, as it often lacks the resources and/or the will to enforce policies, the result may be poor outcomes, frustration, and in the case of pandemic preparedness and response, potentially widespread outbreaks and ensuing human and economic losses.

Collaborative governance assumes that no single actor has sufficient knowledge or capacity to manage complex problems in an increasingly complex, dynamic, and diverse sociopolitical environment.[14–17] Collaboration enables better understanding of local conditions, vulnerabilities, and capacities, and better allocation of resources. In short, collaboration enhances the ability of participating actors to resolve problems that cannot be solved, or solved easily, by a single actor.

Within the collaborative governance literature, Kapucu[16] notes that effective response requires resilience. Resilience refers to the ability to cope with, and rebound from, unexpected extreme events such as pandemics. Resilience incorporates four properties: robustness—the ability to resist an event without a significant loss of capacity; resourcefulness—the ability to apply material, informational, and human resources to the event; redundancy—the extent of systems and institutions available to satisfy needs even if loss or disruption occurs; and rapidity—the ability to contain losses and restore prior conditions in a timely manner. By expanding collaboration to include a wide variety of organizations beyond the state, resilience is nurtured, and response effectiveness is increased.

In addition to resilience, effective collaboration requires building trust and accountability, and sharing information.[18] Trust is influenced by the success of past interactions, organizational reputation, a sense of mutual understanding and legitimacy, and the expectation that partners will follow through on their commitments. Accountability contributes to trust by ensuring that partners are bound to each other and will not renege on commitments. Finally, trust building contributes to the willingness to share information, a key to arriving at better informed decisions.

To assess the impact of collaboration on achieving effective pandemic preparedness and response, we turn to a study of Taiwan.

The Taiwan case study

Why study Taiwan? Taiwan provides a number of clear benefits as a case study of collaborative, whole-of-society pandemic preparedness and response. First, Taiwan has suffered a number of pandemic outbreaks in recent years, from SARS through H7N9, H1N1, and dengue. As a result, the government has drawn lessons from its experiences, adopting and adapting many WHO recommendations, and thereby implementing "best practices" in many aspects of pandemic preparedness and response. Second, Taiwan has a public health system that provides high quality care to all its citizens. As a result, traditional public health initiatives can be relatively easily implemented. Third, Taiwan is a medium-sized, contained, wealthy island democracy with an advanced economy. This ensures that Taiwan possesses the resources necessary for pandemic response while also being attentive to and constrained by public interests and concerns. Fourth, Taiwan has an increasingly well-developed nonstate sector with the potential to work with government to achieve shared goals.

Finally, while better prepared than it was prior to SARS (2003), Taiwan's government-led response system has repeatedly proven inadequate to alone handle major epidemics.[19] This assessment is supported by Taiwan Centers for Disease Control (CDC) officials, academics, and by the former Minister of Health and current vice president. In short, Taiwan's pandemic response capabilities have improved since SARS, yet they remain inadequate. Taiwan was unable to cope with and rebound quickly from an unexpected event, reflecting a lack of adequate resilience. Well aware of the likelihood of future pandemics, the government continues to experiment with new approaches to preparedness and response that include incorporating different levels of state and nonstate actors in collaborative efforts.

In the following section, we examine a sampling of collaborative efforts among state, and with nonstate, actors. Not intended to be exhaustive, our examination provides an indication of the types of collaboration currently being advanced.

Actors in collaborative governance: the state

As described in the collaborative governance literature, the state plays an essential role in, among other things, developing the laws and regulations that guide action. In its *Influenza Pandemic Preparedness Plan in Taiwan* 2005—2010, the Taiwan CDC predicts the possibility of more than 3 million people (in a population of 23 million) requiring some level of medical assistance and a large number of deaths should an outbreak of avian influenza occur.[20] The Taiwan government has responded to the potential threat by investing in building a comprehensive state-driven epidemic preparedness and response network intended to quickly identify an outbreak and mobilize resources. The essentials appear in the 2009, amended *Communicable Disease Control Act*.[21]

As the Central Competent Authority, the Ministry of Health and Welfare (MoH) is responsible for formulating policy responses to outbreaks while also acting on national level challenges (such as port quarantines, epidemiological surveillance) (Art. 1, subsection 1). Municipal and county authorities have similar responsibilities at the local level, and may turn to the Center for assistance as needed (Art. 1, subsection 2). Should an outbreak occur, the central government may mobilize the Central Epidemic Command Center (CECC) in order to centralize epidemic response efforts and facilitate cooperation. Under the leadership of

the MoH, participating government units may include environment, agriculture, education, interior, police, transportation, and foreign affairs. The CECC holds regular meetings to cooperate on developing implementation plans and to coordinate control of the outbreak. Command centers similar to the CECC may also be established by local governments, which have their own disease prevention resources.

As needed, the central government may supplement the *Communicable Disease Control Act*. Recent supplements include laws on controlling communicable diseases and regulations governing quarantine. In response to specific outbreaks, new regulations may also be introduced. For example, with the spread of dengue (2014), the government released the *Guidelines for Dengue Control*, which were later updated and rereleased as the *Guidelines for Dengue, Chikungunya and Zika Control* (February 2016).[22]

Although Taiwan's MoH is the lead agency dealing with epidemic preparedness and response, since 1999 it has been supported by the Taiwan CDC (TCDC). According to the TCDC 2015 Annual Report, TCDC responsibilities include formulating policy recommendations on addressing epidemic outbreaks, collaborating with international actors, controlling international ports of entry, and providing guidance to local authorities on epidemic control.[23]

The TCDC maintains a surveillance network that relies on regular reports from schools; populous institutions such as elder care facilities, prisons, and international entry points. During WHO-declared pandemic phase 4 (increased evidence of human-to-human transmission), physicians in Taiwan have 24 hours to update the TCDC via the Internet regarding any notifiable diseases they encounter among patients. The TCDC utilizes these data to publish weekly online reports that are distributed to participating schools, institutions, and physicians.

Taiwan also draws on the state's ability to gather information on outbreaks through the national health system.[24] All patient records are electronic and are immediately available to the MoH. The national health system draws on its power to facilitate hospital accreditation and reimburse medical facilities for services provided to ensure these facilities closely adhere to government pandemic-related guidelines.

Additional resources exist at the local level. Local governments have independent epidemic response budgets and may request supplemental support from the central CDC. Local governments may also choose to mobilize active and retired healthcare workers and volunteers in the case of a pandemic.[25]

Exemplifying how these various state institutions cooperate to manage a pandemic is Taiwan's response to 2009 H1N1. As H1N1 spread globally, the WHO raised the pandemic alert level to phase 4.[26] In response, the Taiwan government mobilized the CECC under the leadership of the vice premier and the MoH director. The CECC enacted enhanced border controls; public education via the mass media; a massive face mask release to the public to relieve fears of shortages; while also developing clear regulations for school closures and initiating a vaccination program that eventually reached 24.5% of the population (including 75% of students and healthcare workers).

Taiwan's H1N1 response differed from its SARS response in many ways, and the outcomes were notably better. And although this is encouraging, even with H1N1 there were many shortcomings. In one particularly troubling example, having provided 10 million doses of an indigenously developed vaccine, the public reacted negatively when the media, despite a lack of evidence, tied the death of the son of a physician to the vaccine. The government was unable to overcome this story and as a result, trust in the government, its statements, and recommendations declined, and in many cases individuals refused vaccination.[27]

Furthermore, while following SARS the central government increased the CDC's budget and human resources significantly, but in later years the budget steadily declined, with investment in epidemic control particularly undermined.[28] Further undermining pandemic preparedness and response, the government restricted global budget growth for the national health system, even as demand for health services steadily increased. Hospitals have responded by seeking savings, including cutting in areas they perceive to be relatively noncritical including emerging disease control and surge capacity.[29]

As becomes clear from Taiwan's H1N1 experience, even after adjusting government policies, guidelines, and protocols in the wake of SARS, funding for state institutional response remained inadequate, undermining effective response while at the same time the public was swayed by rumors to distrust government actions. The result was an insufficient response. Inadequate resources and declining public trust are both recognized in the collaborative governance and whole-of-society literatures as challenges to effective pandemic response. Faced with a vulnerable public that distrusts, yet expects insufficiently resourced state institutions to protect them, responsible state actors must develop alternatives to the traditional, state-led approaches.

Taiwan has taken some steps in this direction by moving toward incorporating various levels of participation. Taiwan is now divided into six communicable disease control networks, each supervised by a regional Taiwan CDC center (six regional and a seventh that oversees cross-border affairs). The network facilitates communication and integrates response efforts (including sharing training and surge capacity) among the national and local level governments while also incorporating input from hospitals, infection control units and local health departments. This intrastate collaboration across levels of government includes work with government hospitals.

State—hospital cooperation

An important lesson drawn from the SARS outbreak was that nosocomial infections could be a major challenge to pandemic control and that protocols were needed to address this weakness in pandemic preparedness and response. The TCDC, in collaboration with the Taipei CDC, therefore developed, tested, and piloted a response model based on Incident Management Systems and Six Sigma. Incident Management Systems describes a chain of command and control with four components that enhance response coordination across institutional spheres. These

components include planning, financing, logistical support, and action. Six Sigma is a process management tool that simplifies complex processes by breaking them down into smaller, more manageable steps. Both tools influenced Traffic Control Bundling (TCB)—a model developed to arrest nosocomial infection of healthcare workers and patients in hospitals. TCB involves triaging and dispatching patients prior to hospitalization (often outside the hospital itself); maintaining zones of contamination where confirmed cases are housed; distinguishing zones of contamination from clean zones; disinfection stations established between zones with all zones clearly delineated. Studies of hospital infection rates during SARS found that, when implemented, TCB proved highly effective. As a result, TCB has been expanded across Taiwan's hospital system and has been deployed in outbreaks that have occurred since then.[30]

In addition to the microapplication of TCB to hospitals, TCB has also been applied nationally, drawing on the six regional communicable disease control centers. The network facilitates communication and integrates response efforts (including sharing training and surge capacity) among the national and local level governments while also incorporating input from hospitals, infection control units and local health departments.

State—private sector cooperation

As emerging infectious diseases are largely imported from abroad, the state must collaborate with institutions in the private sector that have extensive international interactions. The Taipei CDC has developed a collaborative relationship with the city's hotels, designating them as checkpoints for foreigners entering the country during the containment phase of an outbreak. The Taipei CDC requires hotels to coordinate a preparedness and training plan for hotel staff that focuses on disinfection, increased cleaning frequency, and basic syndromic screening. Hotel personnel are expected to report fever, flulike illness, diarrhea, rash, and other symptoms among hotel guests to the public health authorities. In addition, hotel administrators are required to distribute notices to guests explaining epidemic risks and the various measures to be taken to avoid infection.[30]

This same approach has been adopted in other cities across Taiwan. Kaohsiung city government implemented similar collaboration with its hotels when, while hosting the 2009 World Games, the city was struck by the 2009 H1N1 outbreak. Hualien city, on Taiwan's east coast, adopted the approach during the 2013 H7N9 outbreak.

State—society collaboration

As discussed, the collaborative governance model identifies state—society collaboration as a key to effective pandemic preparedness and response. The whole-of-society literature specifically argues that no single organization has the knowledge or capacity to alone manage complex problems in a complex environment. Only through collaboration with local actors can a clearer picture of local conditions be reached. Furthermore, it is through cooperation with local actors that the best results can be achieved. Taiwan's Li Zhang (in the cities, and Cun Zhang in the countryside) provide an opportunity for such state—society collaboration. Through the Li Zhang, the state can engage local communities, individuals, and social organizations in cooperation to manage pandemics.

Below the lowest level of government in the Taiwan political bureaucracy lies the Li, or neighborhood. The Li is headed by the Li Zhang (neighborhood warden). The warden is separate from the state, receiving no salary (though they receive a monthly "subsidy"), and is free from a requirement to implement government initiatives.[31] The warden is elected by his/her community and is generally a long-time community resident. The average warden represents 5800 people. Wardens select approximately 20 block leaders (Lin Zhang) to assist with fulfilling responsibilities. Each block leader is responsible for between 100 and 300 people.[32] Warden familiarity with community members, history, and geography, coupled with the support of block leaders ensures that the wardens are strongly positioned to effectively engage the community members, deploying resources and supporting residents.

Although warden responsibilities are not well delineated, they generally include:

1. Helping implement local government policies while advocating on behalf of the public
2. Organizing public recreation and cultural activities in cooperation with local community groups
3. Making recommendations to local government on how to improve neighborhood conditions
4. Assisting residents applying for government services
5. Assisting government officials with environmental protection, vector control, local security, disaster investigations, and reporting
6. Supporting postdisaster counseling and helping residents with compensation and legal claims relating to the disaster
7. Organizing elections
8. Additional miscellaneous tasks (such as gathering residents for vaccination)[33]

These roles, coupled with the many undefined tasks wardens take on, offer an opportunity to link the state and local residents. The warden fosters community trust through daily engagement often via organized local activities. Daily engagement also provides the opportunity to convey important messages, educate local residents, and engage them in initiatives.

Historically, pandemic-related activities have not been a major warden responsibility. However, given that the Li system includes all Taiwanese, the wardens are well positioned to provide the kind of cooperation and support called for in the whole-of-society and collaborative governance models. The wardens, working in tandem with block captains, are ubiquitous, and sit in an intermediary position between the state and the community, engaging both and enjoying reach far greater than any nongovernment organization.

A 2012—2013 field study of the role played by wardens during SARS illustrates that tremendous potential they have to make a difference during pandemic outbreaks. Interview

data illustrate that in some cases, Wardens took minimal action on SARS, limiting themselves to distributing flyers and accompanying public and environmental health and safety officials on visits. In these cases, wardens often argued that they had neither the time nor the training to accept more onerous responsibilities, and considered such work outside their capacity.

By contrast, other wardens accepted extensive responsibilities. In some cases, wardens kept track of the comings and goings of Li residents, noting those who might be contagious and either reaching out to them directly or through public health nurses. They also assisted with disinfection efforts, equipment distribution (cleaning materials, face masks, etc.), education, and in some cases, quarantine of suspected carriers in the neighborhood.

Since the SARS outbreak, a number of steps have been taken by state institutions to encourage expanded warden participation in pandemic preparedness and response.[22,25] Such initiatives outline responsibilities for different agencies and organizations in terms of coordination, mobilization, and information provision to the public. Roles that are suggested for wardens include notifying public health officials about ill or potentially ill residents, educating the public about disease outbreaks, and participation in vector control (among other activities). Importantly, reflecting their nonstate status, wardens cannot be required to take action; however, they are encouraged to do so. Here, we discuss two examples of state—society collaboration: one in Taipei that is still in the planning stage, and one that has been implemented and expanded in the cities of Kaohsiung and Tainan.

State and society collaboration: Taipei city's layered containment strategy

A major government goal is to minimize pandemic impacts in the period between an outbreak and vaccine availability (usually approximately 6 months). To that end, the Taipei CDC has developed *layered containment strategy* as an initial response.[25] The city is divided into 12 administrative districts, each led by a district head (Qu Zhang) appointed by the mayor. The 12 districts are further subdivided into 68 subdistricts. Each subdistrict houses between five and seven adjacent Li. Based on TCB and Six Sigma principles, and depending on the geographic extent and seriousness of the outbreak, the Taipei CDC designates each of the 68 subdistricts as a "hot zone" (outbreak cluster appears), an "intermediate zone" (surrounding and buffering the hot zones), or a "cold zone" (no outbreak). To limit outbreak spread, interzonal traffic is restricted by checkpoints that are established between subdistricts, and public transportation is blocked among the subdistricts. Isolated cases of illness in cold zones are identified and transferred to a designated isolation hospital for treatment.

In hot zones, the district head activates the District Command Center. All government employees, including public health nurses, CDC officials, and staff from the Department of Environmental Protection, the police and fire departments (as required) coordinate and implement responses. The lead organization under the District Command Center is the district public health center.

One warden per subdistrict is designated subdistrict leader responsible for organizing and leading community response in that subdistrict. Wardens are responsible to ensure that pandemic-related information reaches their residents and that the residents are aware of the boundaries of their subdistricts. Wardens mobilize volunteers to participate in environmental cleanups (e.g., removing standing water where mosquitoes breed) and to patrol the Li to ensure that ill residents do not cross subdistrict boundaries and that they receive adequate medical support.

Collaborative TCDC—Tainan and Kaohsiung cities dengue fever response initiative

On May 21, Tainan city confirmed its first dengue case of 2015. By the end of the year, Tainan had identified 22,752 cases, more than half of the 43,280 diagnosed cases across Taiwan. The 2015 dengue outbreak was the worst in Taiwan's history, coming on the heels of a record outbreak the previous year. Major contributors to the record setting outbreak included rising temperatures caused by El Niño and global warming in general, as well as increased imported cases. Tainan's mayor identified city-specific contributors as well, including locally heavy rains and the public's response to a past drought by storing water near or in their homes. Because dengue is a mosquito-borne disease and standing water provides ideal breeding conditions, the mosquito population exploded.[34,35]

In the previous year, 2014, Kaohsiung city also suffered a record-setting dengue outbreak, diagnosing more than 15,000 cases—96% of those reported in Taiwan. As in Tainan, Kaohsiung's outbreak was attributed to unusually warm weather coupled with heavy rain and widespread, standing water.[36]

Having learned from the Kaohsiung experience, the Taiwan MoH responded to the Tainan outbreak by collaborating with the city government, designating four dengue isolation hospitals with wards allocated to managing any surge in dengue-infected patients. As there is no dengue vaccine currently available, TCDC focused primarily on eliminating vectors. The strategy can be summarized as educating local government officials and the general public about dengue fever sources and engaging in community training and mobilization to identify and eliminate mosquito breeding grounds. This was supplemented with improved surveillance and reporting systems to facilitate information sharing and updates by both public health officials and the public in general.[37]

Such policies rely heavily on public participation. In anticipation of dengue's return in 2016, the TCDC director initiated a further experiment in collaborative pandemic preparedness and response. First, the TCDC identified the 309 Li from among the 1670 Li in Tainan and Kaohsiung that had suffered 90% of all confirmed 2015 dengue cases in those two cities. The TCDC then focused on providing those 309 wardens with training and additional resources to enhance their capacity to work with health officials to educate and mobilize residents and to track and eliminate dengue vectors. Since wardens cannot be required to participate in this initiative, the TCDC encourages

participation by offering rewards to those wardens whose Li's enjoy the greatest improvement in dengue infection rates compared to the previous year. As the TCDC director argues, working through wardens may be the most effective way to engage the public at the ground level in awareness building and dengue prevention and control.

Discussion

The traditional expectation has been that pandemic preparedness and response is a state responsibility. However, working alone the state has proven only partially effective, a situation exacerbated by the natural tendency within the public to ignore as improbable or irrelevant to themselves the potential for future pandemics. Governments respond to the public's tendency by focusing their limited resources on immediate, visible projects (road construction, bridge repair, park expansions, etc.), often shortchanging preparations for future outbreaks.

However, when a pandemic strikes, the public nonetheless expects the state to effectively manage it. Lacking adequate capacity to do so effectively, the state may draw a public reaction characterized by increasing distrust and disappointment. As occurred in Taiwan during the SARS outbreak, these attitudes may catalyze a cycle in which the public questions and challenges government initiatives, sometimes refusing to cooperate or even actively concealing information from the state. As was recently illustrated by events during the 2014 Ebola outbreak in western Africa, this phenomenon is not limited to Taiwan.

The whole-of-society and collaborative governance models highlight the benefit of mobilizing and engaging both state and nonstate actors in a collaborative effort. How to do so remains the challenge.

In Taiwan, the state has drawn on its past experience to develop a variety of tools that encompass both intragovernmental and state—nonstate actor cooperation. The CECC draws together ministries and departments from across the national-level bureaucracy to cooperate on pandemic response. The central government also collaborates with lower levels of government such as is the case with Taipei, Tainan, and Kaohsiung, and with state hospitals. Collaboration with city hotels exemplifies local government collaboration with private sector actors. Finally, the ongoing and expanding cooperation of central and local state actors with neighborhood wardens exemplifies outreach and collaboration that engages community actors.

These initiatives exemplify the type of collaboration identified as critical to effective action found in the collaborative governance and whole-of-society literature. Taiwan's collaborative approach facilitates trust building and understanding of local conditions and vulnerabilities while enhancing capacities and more effectively allocating resources for pandemic prevention and control. Given Taiwan's ongoing vulnerability to pandemics, the state should continue to supplement government initiatives with those that draw heavily on this approach.

Finally, it might be argued that the collaborative approach adopted by Taiwan, particularly as regards the neighborhood warden, is interesting yet irrelevant beyond Taiwan's borders. However, equivalents to the neighborhood warden system exist in many other parts of East and Southeast Asia. The Taiwan case offers an opportunity for countries in these regions to learn from the Taiwan experience.

Conflicts of interests

There are no conflicts of interest.

Funding

The research was partially supported by funding from the Taiwan Ministry of Foreign Affairs in the form of a Taiwan Fellowship for one of the authors.

References

1. Fritz CE. Disaster. In: Merton RK, Nisbet RA, editors. *Contemporary social problems*. New York: Harcourt; 1961. p. 651—94.
2. World Health Organization. *Disease outbreak news. Middle East respiratory syndrome coronavirus (MERS-CoV) — Jordan*. Available from: http://www.who.int/csr/don/12-october-2015-mers-jordan/en/; Oct. 12 2015 [accessed 06.15.16].
3. World Health Organization. *Risk assessment of human infections with Avian Influenza A(H7N9) virus*. Available from: http://www.who.int/influenza/human_animal_interface/influenza_h7n9/RiskAssessment_H7N9_23Feb20115.pdf; Feb. 23 2015 [accessed 06.15.16].
4. Yuen KY. From SARS to MERS and Ebola. *J Microbiol Immunol Infect* 2015;**48**:S3. http://dx.doi.org/10.1016/j.jmii.2015.02.002.
5. Jones KE, Patel NK, Levy MA, Storygard DB, Gittleman JL, Daszak P. Global trends in emerging infectious diseases. *Nature* 2008;**451**:990—3.
6. World Health Organization. *International health regulations*. Available from: http://www.who.int/ihr/9789241596664/en/index.html; 2005 [accessed 06.15.16].
7. Brinkerhoff DW, Crosby BL. *Making policy reform: concepts and tools for decision makers in developing and transitioning countries*. Bloomfield, CT: Kumarian Press; 2002.
8. Thomas S, Gilson L. Actors management in the development of health finance reform: health insurance in South Africa, 1994—1999. *Health Policy Plan* 2004;**19**:279—91.
9. World Health Organization, Civil Society Initiative. *WHO and civil society: linking for better health*. Available from: http://www.who.int/civilsociety/documents/en/CSICaseStudyE.pdf; 2002 [accessed 06.15.16].
10. Youde J. *Global health governance*. Malden: Polity; 2012.
11. World Health Organization. *Whole-of-society pandemic readiness. Geneva*. Available from: http://www.who.int/influenza/preparedness/pandemic/2009-0808_wos_pandemic_readiness_final.pdf; 2009 [accessed 06.15.16].
12. World Health Organization. *Strategic Alliances: the roles of civil society in health, discussion paper No. 1. Geneva*. Available from: http://www.who.int/civilsociety/documents/en/alliances_en.pdf; 2001 [accessed 06.15.16].
13. Ansell C, Gash A. Collaborative governance in theory and practice. *J Public Admin Res Theory* 2008;**18**:543—71.
14. Agranoff R. Inside collaborative networks: ten lessons for public managers. *Public Admin Rev* 2006;**66**:56—65.
15. Kuo MF, Wang CY, Chang YY, Li TS. Collaborative disaster management: lessons from Taiwan's local governments. In: Jing YJ, editor. *The road to collaborative governance in China*. US: Palgrave; 2015. p. 147—70.

16. Kapucu N. Interorganizational coordination in dynamic context: networks in emergency response management. *Connections* 2005;**26**:33—48.
17. Simon G, Bies AL. The role of non-profits in disaster response: an expanded model of cross-sector collaboration. *Public Admin Rev* 2007;**67**:126—42.
18. Provan KG, Kenis P. Modes of network governance: structure, management and effectiveness. *J Public Admin Res Theory* 2008;**18**:229—52.
19. Schwartz J. Compensating for the authoritarian advantage in crisis response: a comparative case study of SARS pandemic responses in China and Taiwan. *J Chin Polit Sci* 2012;**17**:313—32.
20. Inglesby T, Cicero A, Nuzzo J, Adalja A, Tonic E, Rambhia K, et al. *Report on Taiwan's Public Health Emergency Preparedness Programs 10 Years after SARS. Center for Biosecurity of UPMC*. Available from: http://www.upmchealthsecurity.org/our-work/publications/Taiwans-public-health-emergency-preparedness-programs-10-years-after-SARS; December 28, 2012 [accessed 08.04.16].
21. Taiwan Communicable Disease Control Act (2015). Available from: http://law.moj.gov.tw/LawClass/LawAll.aspx?PCode=L0050001 [accessed 08.04.16].
22. Taiwan Centers for Disease Control. *Guidelines for Dengue Control*. 6th ed. 2013.
23. Centers for Disease Control, Ministry of Health and Welfare, R.O.C. (Taiwan). *2015 Centers for Disease Control Annual Report*. Centers for Disease Control, Ministry of Health and Welfare, R.O.C. (Taiwan); Aug. 2015. Available from: http://61.57.41.133/uploads/files/201509/0cc797c3-5252-477f-bd33-91b68c62238d.pdf [accessed 08.04.16].
24. Boslaugh SE. *Health care systems around the world: a comparative guide*. SAGE Publications, Inc; 2013. p. 451—2.
25. Department of Health, Taipei City Government. *Taipei city Influenza Pandemic Preparedness and Response Plan*. 10th ed. 2015.
26. World Health Organization. *Current WHO phase of pandemic alert for Pandemic (H1N1)*. Available from: http://www.who.int/csr/disease/swineflu/phase/en/; 2009 [accessed 08.02.16].
27. Huang WT, Hsu CC, Lee PI, Chuang JH. Mass psychogenic illness in nationwide in-school vaccination for pandemic influenza A (H1N1) 2009, Taiwan, November 2009—January 2010. *Euro Surveill* 2010;**15**:19575.
28. Centers for Disease Control, Department of Health, R.O.C (Taiwan). *Centers for Disease Control Annual Report 2011*. Centers for Disease Control, Department of Health, R.O.C (Taiwan); July 2011. Available from: http://www.cdc.gov.tw/uploads/files/201205/4b6a6c9c-41c3-40a1-9b60-d3f63ab705ec.pdf [accessed 08.04.16].
29. Chang HS, See LC, Chou MJ, Shen YM, Lin SR. Work perception and job stress among clinical nurses while implantation of global budget payment system in Taiwan. *Chin J Occup Med* 2012;**19**:15—27.
30. Yen MY, Chiu WH, Schwartz J, King CC, Lin YE, Chang SC, et al. From SARS in 2003 to H1N1 in 2009: lessons learned from Taipei, Taiwan in preparation for the next pandemic. *J Hosp Infect* 2014;**87**:185—93.
31. Yeh KY, Shieh JJ. Taipei city public funds welfare budget table for the Li Zhang. Liberty Times Net. Available from: http://news.ltn.com.tw/news/local/paper/807844 [accessed 02.25.16].
32. Wang HP. The Role of the Li Zhang. National Policy Foundation commentary. Available from: http://www.npf.org.tw/post/1/8272 [accessed 02.25.16].
33. *Essential Services provided by Taipei City Li and Lin Zhang. Statutory provisions Taipei*. Available from: http://www.laws.taipei.gov.tw/lawsystem/wfLaw_ArticleContent.aspx?LawID=P02B2016-20120823; 2013 [accessed 02.25.16].
34. Taiwan Centers for Disease Control press release (Nov. 20, 2015). Available from: http://www.cdc.gov.tw [accessed 02.26.16].
35. Yang SR, Hsu E. *Tainan proposes dengue fever control strategies. Focus Taiwan*. Available from: http://focustaiwan.tw/news/asoc/201601040020.aspx; 2016 [accessed 02.26.16].
36. Wang SF, Chang K, Lu RW, Wang WH, Chen YH, Chen M, et al. Large dengue virus type 1 outbreak in Taiwan. *Emerg Microbes Infect* 2015;4:e46.
37. Taiwan Centers for Disease Control. Communicable diseases and prevention, dengue fever (Nov 24, 2015). Available from: http://www.cdc.gov.tw [accessed 02.26.16].