

Reducing the risk of public health emergencies for the world's largest mass gathering

2010 World Exposition, Shanghai, China

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Mass Gatherings and Public Health

Mass gatherings are highly visible events with the potential for serious health and political consequences if not managed carefully and effectively.^{1–4} Mass gatherings have been reported to have significant impact upon public health systems throughout the world.^{5–10} International mass gathering events, such as those associated with the Olympic Games, often carry high political significance and have a historical risk for terrorist attacks.² Mass gatherings ranging from the subnational level to the international level have also been associated with outbreaks and subsequent spread of communicable diseases. These events have included outbreaks of foodborne shigellosis occurring at an outdoor music festival in the United States.^{5–6} The annual Hajj pilgrimage in Saudi Arabia has been plagued by public health threats such as fires, stampedes and an outbreak of meningitis.^{7,9} Influenza outbreaks were also reported during the 2008 World Youth Day mass gathering in Australia.¹⁰ Local, provincial and national public health and medical agencies are frequently involved before, during and after a major event. Therefore, disaster risk reduction is a key element for the effective management of mass gatherings.

Disaster Risk Reduction

Throughout the world, the overall approach to emergencies and disasters has recently shifted from post-impact activities (i.e., ad hoc relief and reconstruction) to a more systematic and comprehensive process of risk management.¹¹ Disaster risk management includes pre-impact disaster risk reduction (i.e., prevention, preparedness, and mitigation) as well as post-impact response and recovery.¹² While planners may not always have the ability to prevent health hazards from occurring at mass gathering events, the health sector can play an important role in preventing the public health impact of such hazards. This manuscript describes a comprehensive approach for disaster risk reduction as implemented by those entities responsible for health security associated with the 2010 Shanghai World Exposition (Shanghai Expo).

Introduction

The Shanghai Expo was the largest mass gathering in world history. Over 240 nations and international organizations took part in the exhibition. The Expo was held in Shanghai, China from May 1st to Oct 31st and lasted 6 mo (182 d). The event attracted 70 million visitors to a city of 20 million people. The site of the exposition (Expo Park) was 5.3 km² (530 hectares) or two square miles (1280 acres) and accommodated an average of 400,000 visitors per day, with 700,000 on most peak days and 1,003,000 persons as a record high for daily attendance. An estimated 3–5% of these visitors were expected to travel from abroad and 50% were expected to arrive from provinces other than Shanghai.

The long duration and the large number of visitors, together with a history of relatively high incidences of endemic seasonal intestinal and respiratory infections during summer and autumn months in Shanghai, contributed to concerns that the event

could impose great challenges on the public health security of Shanghai. Anticipated medical problems included heat illness, injuries, communicable disease, food borne illness and mass casualty events.

During the Shanghai Expo, the Shanghai Municipal Center for Disease Control and Prevention (SCDC) established a special unit to coordinate public health and medical services within and outside the Park. These services included the following ten key areas:

- Risk assessment
- Medical assistance
- Disease surveillance
- Vector surveillance
- Laboratory testing
- Immunizations
- Risk communication
- Health education and interventions

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Table 1. SCDC public health workgroups established for the Expo response

Working group	Function
Comprehensive Coordination Group	Coordinate all the other public health working groups within and outside Expo Park.
Expo Park Working group	Assist the physicians in the five medical service centers to perform health surveillance in Expo Park
	Respond to any public health emergency occurring inside Expo Park
Surveillance and Analysis Group	Perform vector surveillance and control within Expo Park
	Integrate comprehensive public health monitoring
Laboratory Group	Provide regular monitoring reports to the Shanghai Municipal Health Bureau
Logistical Support Group	Perform diagnostic and confirmatory testing
	Coordinate material support of public health efforts

- Food safety
- Water safety

In this paper we review the SCDC medical and public health response for the Shanghai Expo.

Methods

Organizational structure. The SCDC began preparing for the Shanghai Expo two years in advance of the opening day. SCDC's subsequent public health response had three main goals as follows: (1) maintain public health security with efficiency; (2) ensure the clarity and accuracy of information submitted to the Shanghai Municipal Health Bureau; (3) respond to infectious diseases and other public health related events in a timely manner. To accomplish these goals, SCDC established an Office of Public Health Security for the Shanghai Expo as the core of the public health organization system related to Expo issues. This central office was in charge of routine work, and was supported by 5 working groups: the Comprehensive Coordination Group, the Expo Park Working Group, the Surveillance and Analysis Group, the Laboratory Group and the Logistical Support Group. The role of each group is listed in Table 1.

Coordination and communication. Public health security for the Shanghai Expo relied upon coordination among different organizations and sectors. During the Expo, SCDC held regular public health security meetings once a week among all working groups. During the week leading up to the opening of the Expo, (April 30th -May 4th), the frequency of the meeting was increased to once daily. In addition, SCDC purchased a telephone conference system to ensure that on-duty working staff and those working in the five medical service centers in the Park could also participate in the meetings and communicate with other working groups. Moreover, during the course of the Expo SCDC held a total of 18 video conferences with the Zhejiang Municipal, the Jiangsu Municipal and the Chinese Center for Disease Control and Prevention in order to share information regarding any infectious disease or public health emergency situations during the Expo.

Risk assessment. In order to develop updated plans for emergency preparedness and response activities related to the Shanghai Expo, SCDC performed four dynamic risk assessments from April 2009 to September 2010. These assessments considered risks related to infectious disease, injury, lab bio-safety

and natural disasters or other emergencies. For each of the four rounds, the risk assessment was performed by an expert group using a standard risk assessment methodology based on the AS/NZ 4360:2004 Standard for Risk Assessment,¹³ and modified according to advice provided by the US Centers for Disease Control and Prevention (CDC). Assessments were performed one year prior to the start of the Expo; one month prior to the start; at the mid-term; and then again one month prior to the ending. These risk assessments identified and prioritized the primary threats to public health during the Expo.

The first three assessments used the same methodology and resulted in no significant change in any of the assessment scores. Compared with the previous three rounds, the fourth and final risk assessment focused specifically on the increased number of visitors that were expected at Expo Park during the final two months of the event. In September 2010, SCDC performed the fourth round risk assessment and identified the following risks:

- Extreme (high) temperature
- Typhoon
- Stampede
- Infectious disease
- Food poisoning
- Shortage of medical resources within Expo Park
- Occupational risks for working staff

After the fourth risk assessment, SCDC provided updated recommendations to the Organizing Committee of the World Exposition 2010 Shanghai China for public health security activities that would better accommodate the expected increase in event census. These recommendations included the following measures:

- Enhancing medical and rescue personnel within Expo Park.
- Strengthening sanitation inspection of food and drinking water within Expo Park.
- Continuing with health education and issuing health advisories in a timely manner.

Medical assistance at Expo Park. Five medical service centers located inside Expo Park provided medical care and first aid services for visitors, working staff (including volunteers) and the exhibitors (See Fig. 1). These medical stations were staffed by a total of ten physicians and ten nurses as well as 15 Red Cross staff and 15 emergency medical technicians. There was a physician, a surgeon, two nurses, a Red Cross staff and several emergency medical technicians placed in every medical station. Each

medical station was affiliated with two local Shanghai hospitals. In the case of a serious illness requiring hospitalization, ambulances assigned to each of the medical stations transported patients to one of the two hospitals affiliated with that particular station.

The Shanghai Municipal Health Bureau also added 11 temporary medical stations (one for every entrance to Expo Park) to supplement the five main centers. Because there were visitors coming from abroad, and many from other provinces, all the physicians in the medical service centers of Expo Park received specialized training related to imported and emerging infectious diseases. SCDC also provided reference manuals related to rare, imported or emerging infectious diseases for each of the medical service centers.

Public health surveillance. It has been well described that public health surveillance should be implemented in mass gatherings to facilitate rapid detection of outbreaks and other health-related events, and to enable the groups responsible for public health security to respond with control measures in a timely manner. Ten public health surveillance systems were set up to detect emerging outbreaks of infectious disease. Surveillance activities ranged from passive systems for detecting specific infectious disease to the development of a syndromic surveillance system for rapidly identifying unusual clusters of suspicious symptoms. Disease surveillance was established and maintained for areas both inside Expo Park, as well as for the Shanghai metropolitan area in general.

SCDC established the real-time surveillance system for abnormalities among clinic visits within Expo Park in conjunction with Shanghai Municipal Health Bureau so as to detect outbreaks which may require a rapid public health response. Monitoring points included the five medical service centers in Expo Park, and the eight special hospitals located in the districts where Expo Park was located. The physicians working in the five medical service centers of Expo Park directly inputted their patient data through an online surveillance system on a daily basis. The following day, SCDC reported the monitoring data to the Shanghai Municipal Health Bureau. All presentations to the medical stations were monitored for the incidence of key illnesses and syndromes that may require a rapid public health intervention (See Fig. 1).

Daily and cumulative summaries were delivered to the Shanghai Municipal Health Bureau. The syndromic surveillance system collected, arranged, analyzed and integrated the information of clinic visits from the medical service stations in order to



Figure 1. SCDC staff member reviewing online surveillance data.

monitor, identify and evaluate out-of-the-ordinary information. The surveillance system provided a much-needed capability for early warning and rapid response in order to control the spread of infectious diseases in a timely, scientific and effective manner.

Monitoring content. Public health surveillance data contained two main elements as follows:

- Key illness: acute gastrointestinal, fever, injury, heat stroke, upper respiratory tract infection, urgent onset of chronic disease, etc.
- Syndromes: flu-like syndrome, gastrointestinal syndrome, fever with rash syndrome, fever with hemorrhage syndrome, central nervous system syndrome and jaundice-like syndrome.

Table 2 describes the case definitions used for various categories of syndromic illnesses.

In addition to syndromic surveillance, additional epidemiological information was also collected for key illnesses such as: enteric disease, upper respiratory tract infection, fever of unknown origin, food poisoning, chemical poisoning and injury (See Table 3).

Prevention and control measures. *Enteric disease.* During the Shanghai Expo, 22 patients experiencing diarrhea were detected using syndromic surveillance. Among the 22 cases, 15 occurred among one group of visitors. Although they went to the different medical service centers for treatment, they were traceable through the epidemiological information. Once detected, the cluster was then reported to the Shanghai Food and Drug Administration (SFDA). At the same time, the Expo Park working group

Table 2. Case definitions used for various syndromic illnesses

Syndrome category	Definition
gastrointestinal	Diarrhea (3 times or more/day), accompanied with blood in the stool, abdominal pain or vomiting.
flu-like	Fever (oral temperature $\geq 38^{\circ}\text{C}$) with cough or angina.
fever and rash	Fever (oral temperature $\geq 38^{\circ}\text{C}$) with papule, macule or maculopapule.
fever with hemorrhage	Fever (oral temperature $\geq 38.5^{\circ}\text{C}$) with headache, muscular soreness, bleeding tendency or purpuric rash.
central nervous system	Fever (oral temperature $\geq 38.5^{\circ}\text{C}$) with projectile vomiting or disturbance of domestic peace and security.
jaundice-like	Icteric sclera or xanthochromia with anorexia or malaise.

Table 3. Epidemiology information collected for various diseases

Disease Category	Main content information for tracing to source	Remark
Enteric disease	General information (address, telephone), past medical history of chronic diarrhea, dietary history in Expo Park, drinking water information	The tourist groups need to fill in the contact information of the escort
Upper respiratory tract infection, fever of unknown origin	General information(address, telephone, etc)	None
Food poisoning	General information (address, telephone), past medical history of chronic diarrhea, dietary history in Expo Park, drinking water information	The tourist groups need to fill in the contact information of the escort
Chemical poisoning	General information (address, telephone), history of exposure to chemicals	Asked whether other patients have similar symptoms
Injury	Injury location, nature, cause, injury intention	none

immediately deployed staff to carry out epidemiological investigations and emergency response.

Injury. On any given day, there were 300,000–500,000 visitors present in Expo Park. With so many people attending the Expo at the same time, injuries were quite likely to occur. Therefore, in order to reduce the incidence of injuries SCDC performed an assessment of injury risk factors from May 11 to June 14. The assessment evaluated 16 separate environments/facilities within Expo Park according to 14 risk factors. It also evaluated the results of 40 injury cases. Based on the assessment and evaluation of injuries SCDC recommended that steps be taken to reduce environmental risk factors, particularly those associated with the risk of falls, and to strengthen the health education on site.

Heat illness. Shanghai's hot and humid summer weather combined with overcrowding in Expo Park, made prevention of heat-related illness a major challenge during the Shanghai Expo. Expo Park was already designed and fitted with multiple water air-misting stations, shaded rest areas and easy access to drinking water to help visitors keep cool. In order to further decrease the number of heat-illness cases, the SCDC provided fans free of charge to visitors at the Expo and recommended that the Organizing Committee of the World Exposition increase the area



Figure 2. SCDC staff member performing vector surveillance in Expo Park.

of shade awnings provided at pavilion entrances where visitors were standing in long queues.

Respiratory infections. Starting in April 2011, Shanghai government departments released health education information to the public that included precautions that could be taken against respiratory illness. The information was distributed in various ways, such as newspapers, internet, mobile media, etc. Visitors to the Expo had easy access to health education information about key illnesses such as influenza, measles and scarlatina.

Vector surveillance and control. During the Shanghai Expo, especially from June to August, environmental conditions remained favorable for vector breeding. Also the large influx of international visitors into Shanghai increased the potential for intercontinental transmission of emerging and imported infectious diseases. For these reasons, it was important to guard against the outbreak of vector-borne infectious disease. SCDC strengthened vector surveillance from May 1st to Oct 31, 2010, including mosquitoes, flies, mice and cockroaches in Expo Park (see Fig. 2).

By the end of the Shanghai Expo, SCDC had achieved the goal of eliminating vector-borne disease in Expo Park and the city as a whole, thus minimizing the risk of outbreaks and spread of disease.

Vector control. SCDC also implemented the following key elements of prevention and control measures to reduce the number of various vectors in Expo Park:

- Ensured adequate sewage treatment by strengthened health supervision and inspection.
- Reduced the mosquito breeding sites.
- Set fly traps in public green land, road surrounding areas, etc.
- Implemented ultra-low volume spraying to reduce the mosquito density on public green lands, lakes, etc.
- Exterminated rodents within the pavilions and other public areas.
- Set rat traps and poisonous bait stations in the non-open areas.
- Strengthened the supervision and examination of pest control measures.

Surveillance of disinfection (or infection control) effect within Expo Park. On an average day approximately 400 patients presented to the medical centers in Expo Park making infection



Figure 3. Screenshots from Chinese and English versions of the SCDC Expo column for World Expo tourists.

control in these centers critical for preventing the spread of infectious disease, maintaining health care quality, ensuring the safety of patients and medical personnel, and in providing for the public health security during the Expo. The bacterial count of the air in the transfusion rooms and therapeutic rooms in the medical centers was monitored regularly in order to maintain a high level of quality control.

In addition to the disinfection quality surveillance, SCDC also provided fit-tested respiratory protection masks for the doctors and other medical personnel who worked in Expo Park in order to limit potentially infectious exposures among the health-care staff during patient care. Moreover, according to the relevant requirements established by the Shanghai Counter-terrorism office, SCDC purchased a stockpile of additional personal protective equipment, including masks, protective clothing, gloves and shoes to be used if circumstances warranted.

Laboratory confirmation. To compensate for some specific limitations of in-house laboratory testing capacity, SCDC engaged the support of the World Health Organization (WHO) and the Chinese Center for Disease Control and Prevention. In the event that Shanghai CDC did not have diagnostic capability, arrangements were made in advance for transport of samples to China CDC or to WHO for laboratory analysis. At the same time, SCDC established a laboratory referral network including 18 district CDCs, the Institute of Forensic Science Ministry of Justice P.R. China, the Institute of Forensic Science, Shanghai Municipal Public Security Bureau, the Institute Pasteur of Shanghai Chinese Academy of Sciences, the Shanghai Public Health Clinical Center and the Shanghai Institute for Food and Drug Control.

Vaccination campaign. With assistance from the Bureau of Shanghai World Expo Coordination, SCDC launched a vaccination campaign targeting the working Expo staff in order to further reduce the risk from key infectious diseases within Expo Park.

A total of 843 doses of Hepatitis A vaccine, 2322 doses of Measles vaccine, 318 doses of seasonal influenza vaccine, 132 doses of novel H1N1 influenza vaccine and 2883 doses of cholera vaccine were given to staff working within Expo sites, including medical workers, food handlers and volunteers. In addition, SCDC also purchased 100 doses of the Japanese Encephalitis vaccine to hold as an emergency reserve to be used in the event of a terrorist release.

Risk communication. In order to ensure timely and effective communication of public health information to the public during the World Expo, SCDC established the following risk communication system components:

- A media working group
- A system of spokespersons
- A work plan for information transfer
- A system for measuring public feedback

On April 30th, 2010, (one day before the start of the Expo), the director of SCDC provided several media interviews. During these interviews the director discussed the extensive level of SCDC public health preparedness. The director noted that although disease outbreak was highly unlikely, it would be necessary to prepare for it. In addition, the SCDC also offered additional opportunities for tourists to obtain health information by way of a World Expo column on the SCDC webpage. The column included Expo news, travel health tips, health education and health resources. The Chinese and English interfaces of World Expo column were both updated on April 30th and June 25th, and then ran without interruption during World Expo. As of October 31st, the World Expo column had 27,000 visits (see Fig. 3).

Health education and interventions. Health education and health intervention was an important part of public health security for the event. To improve the knowledge and skills of local healthcare providers, SCDC performed training on eight health



Figure 4. Expo Park visitor using a direct drinking water point.

education and intervention topics in the five medical service centers within Expo Park. The five topics were: respiratory infectious diseases; intestinal infectious diseases; vector borne infectious diseases; the disinfection and infection control of Expo pavilions; food borne diseases; acute exacerbation of chronic diseases; injuries and heat-stroke.

From May 1st to Oct 31st, 2010 more than 121,500 health education and health intervention materials (including hygiene and infection control tips while visiting Expo pavilions and an intestinal infection prevention and control manual) were printed out and delivered to the visitors in the Expo site. In addition, travel health tips for Expo 2010 Shanghai China were also provided in many of the hotels around Shanghai.

Food safety. The enormous influx of visitors made food safety critically important. There were 244 restaurants serving food in Expo Park, including the public catering units, dining hall and staff canteen.

In order to ensure food safety, the public health and medical groups of Shanghai World Expo established the Department of Food Security, which included the Shanghai Food and Drug Administration (SFDA), the Shanghai Agriculture Committee, the Shanghai Entry-Exit Inspection and Quarantine Bureau and others.

The Department of Food Security established four monitoring systems to ensure food safety. These systems including the following:

1. On-site electronic monitoring system of food safety to collect the real-time temperature data. The system implemented real-time monitoring of temperatures in the refrigerated warehouse and the food that required temperature control. If the monitoring temperature was higher than the set value, the system would send a warning message.

2. A food safety rapid detection system to carry out the fast detection and analysis of the food safety. A supervising officer used rapid testing equipment to test tableware, disinfectant,

meat, dairy products, vegetables, fruit, aquatic products and edible oil for quick intervention, as necessary.

3. Food security information systems which uses an electronic label to track storage, production and circulation of the food item, thus allowing for traceability.

4. System for monitoring sampling data analysis results for bacterial food poisoning and providing early warning if indicated.

Drinking water safety. During the 2010 Shanghai World Expo, there were on average about 400,000 people drinking water in Expo Park on a daily basis. According to the Shanghai Health Inspection and Supervision Bureau, there were no outbreaks of waterborne disease at the Shanghai World Expo Park. In order to ensure the drinking water safety, Shanghai World Expo Coordination Board prohibited carrying drinking water into Expo Park. Inside Expo Park, all beverages provided by the vendors were pre-designated by the Coordination Board, and direct drinking water was provided free of charge at “Direct-Drinking Water Points” (see Fig. 4).

The Shanghai World Expo Coordination Board provided about 117 Direct-drinking Water Points in Expo Park. In order to ensure the drinking water safety of Expo Park, Shanghai Health Inspection and Supervision Bureau implemented the two following important measures:

- Establishment of 30 real-time surveillance points to monitor the direct-drinking water all day during the Expo. Results were transmitted to the Command Center for Health Inspection and Supervision within 3 to 5 min after testing.

- Twenty Health Inspection and Supervision security staff performed the water quality testing for all the Direct-drinking Water Points and the complete water distribution system during all hours of operation at Expo Park, (8:00 a.m. to 12:00 a.m. daily).

Emergency preparedness and response. Taking the results of the risk assessment and other public health security needs into consideration, SCDC worked to improve and integrate 30 separate hazard-specific emergency plans, and then to validate the plans through a series of emergency exercises from August to December, 2009. A supplementary document, an all-hazard, capability-based plan for public health emergencies inside the Expo site, was also developed. In the event of a public health emergency occurring in the Expo site, this more generic plan could be implemented immediately. SCDC also developed three emergency response teams stationed at SCDC. If a public health emergency occurring within Expo Park exceeded the capabilities of the Expo Park Working Group, these 12-member rapid response teams were to be mobilized to facilitate a rapid emergency response. These teams were able to perform activities concerning investigation of infectious diseases, vector control, disinfection, acute chemical poisoning and radiation accident disposal. Finally, 18 district-level CDCs in the greater Shanghai metropolitan area also built several emergency response teams as a component of the overall public health response system for the Shanghai Expo. Each of these district level CDCs coordinate directly with the SCDC.

Results

Medical assistance inside of Expo Park. During the Shanghai World Expo, 97,708 visitors sought on-site medical care and 97,059 were diagnosed by physicians. Among these patient encounters, 213 required hospitalization and 3530 required EMS transport.

The most common indication for physician examination was upper respiratory tract infection (17.8%); enteric disease was diagnosed in 16.6%. Injuries (including lacerations and abrasions) were also relatively common during the surveillance period, accounting for 12.8% of patient encounters. Other reasons for seeking medical care included 6.8% visits for heat-related illness, 6.6% for headache, 4.5% for fever, 5.0% for abdominal pain and 3.1% for acute exacerbation of chronic disease (e.g., high blood pressure or chest pain). The onset ages ranged from 0 to 101 y old, and 51% of the cases were between the ages of 15 to 39 y old. The gender ratio of males to females was 0.92. There were no deaths during the event (see Fig. 5).

Disease surveillance. During the Shanghai Expo, there were no indications of any serious infectious disease outbreaks or epidemics either inside or outside of Expo Park. There were no events reported inside Expo Park that involved chemical poisonings or severe injuries.

Shanghai Major Metropolitan Area (outside of Expo Park). Disease surveillance. The incidence rate of notifiable infectious diseases has shown a low level of fluctuations in Shanghai from 1950–2008. The major diseases are syphilis, gonorrhea, viral hepatitis, tuberculosis and dysentery. Sexually transmitted disease is the major category of infectious diseases, and tuberculosis is the leading cause of death due to infectious disease in Shanghai. According to the surveillance results, the incidence rate of diseases of a relatively high priority in China remained at a low level in Shanghai during the Expo. As compared with the same period last year, the incidence rate of these diseases decreased 14.4%. Compared with the same period last year, cases of a similar prioritized disease (hand-foot-and-mouth disease) increased, but these incidence trends were consistent with trends in the rest of the nation.

Laboratory surveillance. During the duration of the Shanghai Expo, a total of 1,020,251 laboratory samples were tested by SCDC and the 18 district CDCs, including emergency samples and monitoring samples. Twenty-one batches of samples were sent to the Chinese Center for Disease Control and Prevention for viral testing (including specimens for polio, measles, influenza and Creutzfeldt-Jakob).

Area within Expo Park. Disease surveillance. As depicted in Figure 6, the incidence rate of injuries decreased every week after the start of the Expo and reached the lowest level during the final (26th) week. The incidence rate for upper respiratory tract infections decreased from the first week and reached a peak between weeks 10–20.

The incidence of enteric disease and heat-illness begin to rise from the 10th week, and decreased gradually from

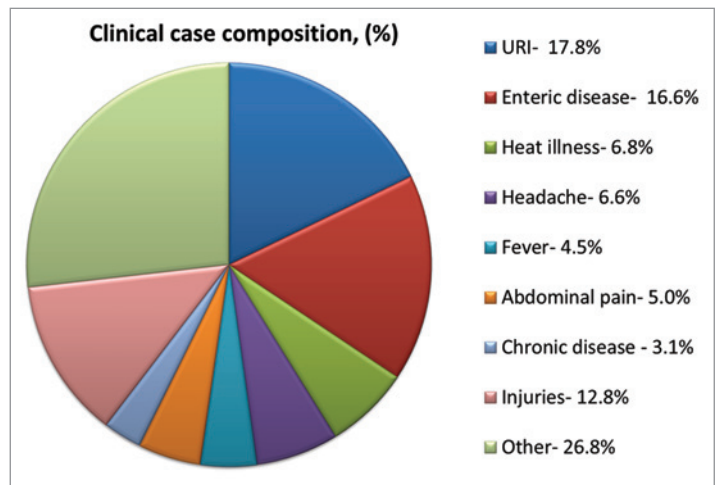


Figure 5. Clinical case composition among visitors presenting to medical clinics at the 2010 Expo Park, May 1 – October 31, 2010.

the 19th week. Despite high seasonal ambient temperatures at Expo Park, cases of heat illness were less frequent than anticipated. In comparison, the peak incidence rate for the entire 2010 World Expo was 3 cases per week (among a weekly average of 250,000 attendees) and 6.8% of all cases seen onsite for the entire event, while the peak incidence for the 1996 Olympics was reported as 24 cases in one day, (among 100,000 attendees), comprising 10% of all cases seen onsite for the entire event.¹ There were no major food safety incidents or major outbreaks of food borne disease. The vector surveillance system detected no vector-borne infectious disease among the vector populations in or near Expo Park. Vector density remained similar to that of previous years for that same location.

Discussion

Disaster risk reduction as applied to mass gathering events. Mass gatherings have become high-visibility, international events with the potential to impact the health of literally millions of people as well as national security of the host nation. For this reason,

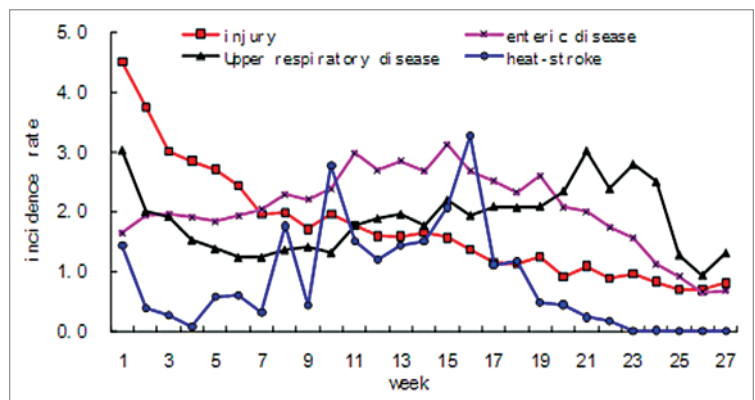


Figure 6. Incidence of key illnesses reported inside the World Expo Park, according to week of event.

a comprehensive and well integrated approach to disaster risk management is much more preferable than a system inordinately focused on preparedness for post-impact crisis management.

Disaster reduction has emerged as a core element of sustainable development.¹⁴ The 2002 World Summit on Sustainable Development concluded that “An integrated multi-hazard, inclusive approach to address vulnerability, risk assessment and disaster management, including prevention, mitigation, preparedness, response and recovery, is an essential part of a safer world in the twenty-first century.”¹⁵

Disaster risk reduction shares some tenets with preventive medicine.¹⁶ As in preventive medicine, risk reduction calls for a basic attitude shift in the minds of many who traditionally get sick first and seek treatment later. The challenge for disaster risk reduction as applied to health is to broaden the focus of disaster risk management from that of tertiary prevention, (response and recovery) to also emphasize primary and secondary prevention, (prevention, preparedness and mitigation).¹⁷ In the case of mass gatherings, disaster risk reduction offers a more comprehensive approach to avoiding public health emergencies that could adversely impact not only health but also impart serious commercial and socio-political repercussions.

Risk reduction activities seek first to prevent public health disaster from ever occurring and then seek to prepare for and mitigate the disaster’s health effects. Public health may not have the capability to influence the probability of a hazard occurrence (i.e., preventing the heat wave itself), but within public health lies a unique ability and opportunity to lessen human vulnerability to the hazard. Given that an environmental hazard is likely to occur, the risk of a public health disaster is lessened by (1) reducing human *exposures* to the hazard by a reduction of human vulnerability, (2) lessening human *susceptibility* to the hazard and (3) building *resilience* to the impact of the hazard.¹⁸

Risk assessment for the expo. SCDC performed a series of extensive and dynamic risk assessments, beginning one year prior to the start of the Expo and extending throughout the entire duration of the event. These assessments served to not only identify potential hazards, but to also recognize key vulnerabilities that involved both the public health institution, as well as the population served. As a result of the risk assessment, SCDC was able to identify internal and external gaps in capacity and capability that could be addressed far in advance of the event. SCDC also used the ongoing risk assessments to identify physical hazards associated with the various exhibitions, as well as environmental hazards such as sun exposure for people waiting in line. In both of these examples interventions that would prevent significant adverse health impact were in place within a very short period of time after being identified. The dynamic nature of the risk assessment helped to raise awareness and diligence for recognition of potential disaster risk.

Risk reduction for the expo. Hazard avoidance. The optimum strategy for disaster risk reduction is to avoid the presence of hazards altogether. One advantage of the Expo site was that it was specifically designed and newly constructed to promote crowd safety. The venue was located outside of the major metropolitan area that offered good ventilation and adequate drainage. The layout of the

site offered mostly open areas thus minimizing any such bottlenecks that could contribute to overcrowding or stampedes. Trip and fall hazards were kept to a minimum. Vehicle traffic was very limited within the site, and public transportation routes within the venue were kept separate from areas of pedestrian traffic.

Exposure reduction. Public health disasters are prevented when populations are protected from exposure to the hazard if in fact it does occur. As mentioned above, dynamic and ongoing risk assessments allow for identification of previously unrealized hazards and lead to rapid interventions to avoid or mitigate population exposures (such as trip hazards, sun exposure, etc.) at the Expo.

Extensive efforts were made to prevent and control the occurrence of infectious disease and injury. In addition to careful surveillance of vectors and food service, clinical and laboratory surveillance were used to inform subsequent public health interventions. These interventions included recommendations regarding physical safety of venue facilities to prevent falls, precautions against heat illness, measures to ensure food and water safety as well as vector control. These measures proved successful in preventing the outbreak of disease as well as lessening the incidence of injuries over time. Clinical care at the venue was also closely coordinated with local hospital facilities and linked to the public health coordinating groups.

In order to obtain timely and relevant public health information during the World Expo and cope with the challenges posed by the event, the SCDC constructed ten de novo integrated monitoring systems to ensure the public health security of the Expo. This comprehensive approach linked the expo venue itself to a citywide monitoring network for infectious disease and public health risk factors. This monitoring offered public health officials an effective system for early warning that could then guide rapid interventions.

Susceptibility reduction. Within the context of disaster risk reduction, susceptibility is defined as the likelihood of suffering an adverse health effect when exposed to a given health hazard. The transient nature of the population attending the Expo, limited the ability to reduce susceptibility to illness or injury among the majority of participants. However, extensive efforts were undertaken that would reduce susceptibility of Expo workers and staff to potential disaster hazards. Most notably, key Expo staff members (medical workers food handlers and volunteers) were immunized, so as to reduce their susceptibility to communicable diseases. The staff pool was also intentionally selected and hired, thus the cohort was also at healthy baseline, thereby minimizing any other vulnerabilities noted in previous disaster studies, (such as extremes of age, presence of comorbidities such as chronic disease, etc).

Resilience building. Resilience is defined as the capacity of a system, community or society to resist or to change in order that it may obtain an acceptable level in functioning and structure. This largely involves activities focused around preparedness, response and recovery.

SCDC began building an effective framework for resilience by establishing an organizational structure that would be flexible, as well as scalable. Each of the various work groups was assigned a separate functional area and all of them organized according to

the need for rapid interaction between technical subject matter experts and decision-makers. SCDC also relied on an extensive system for coordination among different institutions and sectors. These connections were well-established and tested far in advance of the Expo event itself.

Medical assistance inside the Expo Park was also well developed to absorb and respond to casualties. These included contingencies for not only routine care, but also one-to-one direct linkages between each of the five medical service centers and five corresponding major hospitals. This would allow for significant surge capacity to occur in the event of an emergency medical response involving mass illness or casualties. This medical system was also adjusted during the event to accommodate some degree of variation in the population distribution within the Expo site.

Public health surveillance also contributed significantly to the capacity for resilience. Systems existing both inside and outside the park were developed and maintained in order to prepare for a rapid detection and effective response. Small incidents involving injury patterns as well as heat illness and gastrointestinal illness were identified early allowing for rapid response that prevented what could have resulted in a larger adverse health event.

An extensive system for timely and effective risk communication and public health information was also developed. The system would contribute to a resilient and proactive public health outreach for domestic Chinese as well as international visitors. The system would also assist in preparing for any potential disaster event that would require extensive public communication.

Extensive capacity for emergency preparedness and response was also developed both within SCDC as well as among its key partners. All hazard, capability-based plans were established, and validated by drills and exercises. Public health staff was educated regarding the principles of disaster preparedness and response.

Conclusion

The 2010 Shanghai World Exposition posed significant challenges for ensuring the medical and public health security of local and visiting populations. This event was unique among mass gatherings in both scale and duration. The success of the Shanghai Expo depended upon a comprehensive approach for disaster risk management that included prevention, mitigation, preparedness, response and recovery. Public health played a key role in ensuring the safety and security of Expo attendees and of Shanghai citizens, in general. Organizers of future such events should consider early and extensive integration of public health with a focus on disaster risk reduction for management of the event.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Disclaimer

The findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of the US Centers for Disease Control and Prevention.

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