

# Mass Gatherings and Infectious Diseases Epidemiology and Surveillance

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**Context:** Every year, millions of people travel around the world to attend a wide range of mass gatherings (MGs) such as sport events and religious festivals. These MGs increase the risk of infectious diseases outbreaks which is facilitated by large number of individuals staying in confined areas, sometimes for a short period of time.

**Evidence Acquisition:** Electronic medical databases including PubMed and EMBASE were searched from 1990 to 2014 on the subject of epidemiology of infectious diseases related to MGs. Keywords including "mass gathering", "crowding", "infectious diseases", "communicable diseases", "outbreak" and "surveillance" were used for retrieving the relevant articles. In this review article, we mainly focused on the epidemiology and surveillance systems related to infectious diseases control and management.

**Results:** The spread of infectious diseases has been a major public health challenge related to MGs. Food-borne diseases and respiratory infections have been the most common outbreaks reported during MG. Preparedness and response plans to manage possible infectious diseases outbreaks requires enhancing infectious diseases surveillance, allocation of appropriate human and financial resources, and coordination among the various divisions of public health. Hajj is an example of good practice which involves millions of pilgrims, in which comprehensive infectious diseases surveillance is in place to monitor health risks and reinforce evidence-based planning for preventive measures.

**Conclusions:** Infectious disease surveillance for MGs should preferably be built via some modification and improvements, made to the existing surveillance and notification system to assist early detection and response to infectious diseases outbreaks.

**Keywords:** Mass Gathering; Infectious Diseases; Outbreaks; Surveillance; Sports

## 1. Context

Mass gatherings (MGs) are typically defined by the World Health Organization as "the influx of a large number of people at a specific location, for a specific purpose, and for a defined period of time"; the size of gathering can generally vary between 1000 to more than 25000 individuals (1). MGs are a common practice in both developing and developed countries. Most of MGs are planned in advance and recurrent, taking place at the same location (e.g. Hajj) or in a different location (e.g. Olympic Games), although some events such as Pope's funeral occur spontaneously. These gatherings comprise a wide range of activities such as sport events (e.g. the FIFA World Cup, the Olympic Games), social events (such as concerts), religious ceremonies and observances (e.g. Hajj), and some other public events including cultural, educational activities and even political rallies. Public health problems associated with changes in population dynamics and behaviors during MGs have drawn the attention of the medical community.

From an epidemiological point of view, MGs are of great importance because of the potential risk for transmission of infectious diseases. Firstly, the participants may themselves play a role as a source of infection among the people (e.g. cases of undiagnosed tuberculosis) or they may be

susceptible to infectious agents which are circulating at the gathering location (for example people not vaccinated against measles traveling to a country with an ongoing disease outbreak). Secondly, the large number of people gathered is highly likely to put a severe strain on the health care system of the host countries and communities. In such a complicated situation, a combination of factors such as high crowding, restricted accessibility, insufficient crowd control, and lack of on-site medical and health care predictions can lead to catastrophic consequences (2). MGs can interfere with public health in not only the hosting country but also the country of origin. Another characteristic of MGs is the dispersion of participants and pilgrims almost immediately following the gathering, which increases the risk of spreading of communicable diseases within their country of origin. With regard to the nature of population movement that takes place in MGs, traditional communicable diseases surveillance systems are not able to efficiently capture all the information needed for disease control and management activities (3). Although population movement poses a great risk of infectious diseases transmission during MGs, in-flight transmission of infections plays only a limited role (4).

## 2. Evidence Acquisition

All international medical databases including PubMed/Medline, EMBASE, Scopus and ISI Web of Knowledge were searched for the published data related to MGs and infectious diseases. The search strategy was limited to English and articles published from January 1990 to July 2014 were considered. Keywords such as "mass gathering", "crowding", "sports" and "Hajj", along with "infectious diseases", "communicable diseases", "outbreak", "disease surveillance", "diseases control" and "diseases management" were used to retrieve the published articles. The titles of all retrieved citations were screened to identify the potentially relevant studies for inclusion. Studies with poor quality of design and/or inadequate reports of results were excluded. The reference lists of the retrieved articles were also searched and included in this review as appropriate.

## 3. Results

### 3.1. Mass Gathering and the Risk of Infectious Diseases Outbreaks

The spread of Infectious diseases is an important problem pertinent to MGs and outbreaks such as food-borne diseases (e.g. shigellosis, cholera (5)), respiratory infectious diseases (e.g. influenza and measles) and other infectious diseases associated with environmental conditions (legionellosis, leptospirosis, etc.) have been well documented across the globe (6). Sexually transmitted infections may also occur, but they are usually underestimated and underreported.

In a literature review of articles related to the outbreaks of infectious diseases in competitive athletes from 1966 through 2005, Herpes simplex virus infections found to be common among wrestlers and rugby players and methicillin-resistant *Staphylococcus aureus* was a causative agent for numerous outbreaks of soft tissue and skin infections. The most common mode of transmission was direct person-to-person contact (7). In this review, only two episodes of blood-borne exposure associated with outbreaks of hepatitis were identified and airborne and vector transmissions were rarely reported.

In spite of advances in food and water hygiene, food-borne diseases outbreaks are still a public health concern in MGs. For instance, in July 1987, poor camp site sanitation resulted in a large outbreak of multidrug-resistant shigellosis among attendees of the annual Rainbow Family Gathering in Nantahala National Forest, North Carolina. The attack rate was greater than 50% among an estimated 12700 attendees (8). Similarly, in August 1988, another outbreak of shigellosis linked to an uncooked tofu salad affected approximately 3175 women who attended a five-day outdoor music festival in Michigan (9). In a preparation for Brazil 2014 FIFA World Cup, 1586 travelers who had visited Brazil from July 1997 through May

2013 were examined for contracting infectious diseases linked to their travel. Dermatological conditions (40%), diarrheal syndromes (25%), and febrile systemic illnesses (19%) were the three common infections detected. Most of the febrile illnesses were caused by dengue and malaria (mainly *Plasmodium vivax*) and they were also the most common reasons for hospitalization after travel (10). Similarly, a seven-fold increase in febrile disorders during a MG for Ashura in 2010 in Karbala city, Iraq, was identified as compared with the pre-event phase (11). During an annual MG in Pakistan, the prevalence of diarrhea increased significantly, from 6.0 per 100000 to 82.0 per 100000 persons. However, no appreciable changes were observed in malaria prevalence (12).

Respiratory infectious diseases are extremely contagious communicable diseases with a relatively high risk of spread during MGs. In July 2008, for instance, an influenza outbreak was identified during the World Youth Day 2008 in Sydney, Australia, caused by several strains of the influenza virus (13). Another influenza outbreak occurred during the Winter Olympics in Salt Lake City in 2002, in which Influenza A/B was diagnosed in 36 patients, including 13 athletes (14). However, quick response to the outbreak limited the spread of the infectious agents. A surveillance system was established to capture health-related problems during the anniversary of the death (urs) of Baba Farid, an annual MG in Pakpattan, Pakistan. As compared with the week before the event, the prevalence of acute respiratory illness showed a sharp increase from 6.7 per 100000 to 167.0 per 100000 individuals during the event (12). During the 2009 H1N1 influenza pandemic, the results from computer simulation models that were used to explore the influence of MGs and holiday traveling on the course of pandemic, showed that MGs that occur within 10 days before the epidemic peak were associated with a 10% relative increase in the peak prevalence and the total attack rate (15).

### 3.2. Hajj and Infectious Diseases Control Lessons

Hajj is an annual religious event which attracts a large number of pilgrims (over two million Muslims from all over the world) to Saudi Arabia. This is a unique MG in terms of cultural and geographical diversity of the pilgrims. In spite of all the challenges, Hajj organizers in the course of decades of managing millions of pilgrims have acquired the necessary skills and experiences for providing health care at MGs. An ongoing infectious diseases surveillance and data analysis is in place to monitor health risks and reinforce evidence-based planning of preventive measures. To address all aspects of Hajj rituals, the health care programs are updated on an annual basis (16). The programs include extensive public health planning, surveillance systems to monitor public health risks, and health services needed to provide to pilgrims (17). According to the surveillance data collected during the Hajj ritual, some preventive measures have been tak-

en to reduce the risk of infectious diseases. For instance, following the outbreaks of meningococcal meningitis in 2000 and 2001, meningococcal ACWY (meningococcal polysaccharide groups A, C, W135 and Y) vaccination has become obligatory for Saudi Arabia (18). In addition, as a result of inevitable overcrowding that takes place during the Hajj season, respiratory infections have been the most frequently reported complaint and influenza vaccination has been recommended. Another example of good practice is the 2009 pandemic influenza A H1N1 and upcoming Hajj (19). The Hajj organizers with the help of global public health agencies reviewed the country preparedness plans with an emphasis on prevention and control of pandemic influenza, which resulted in several practical guidelines. A severe and potentially fatal respiratory syndrome caused by a novel coronavirus called Middle East respiratory syndrome coronavirus (MERS-CoV) has emerged in Saudi Arabia (20). Rigorous efforts in terms of preventive measures has been undertaken to mitigate the new infections and minimize the risk of the global spread of MERS-CoV during the Hajj rituals.

### 3.3. Mass Gathering Outbreaks Preparedness and Response

When an MG is planned or expected, the public health system of the hosting country should take all necessary actions to rapidly detect and respond to unusual disease events during the gathering. This requires extensive planning, allocation of appropriate human and financial resources, timely notification, and coordination among the various divisions of public health (21). As a part of the preparedness and planning process, an initial risk assessment should be undertaken along with the evaluation of the available capacities and shortcomings in terms of workforce, resources, training, and coordination relevant to public health services. This assessment should also take into account all aspects of the gathering, including health care service availability, type and duration of event, gathering size and density, potential risk of communicable diseases, sanitation, etc. Learning from past experiences with MGs along with a focused literature review might be useful to identify the potential risks related to the event (22).

A plan of action should be developed based on health risk assessment which incorporates factors such as epidemiological surveillance, capacity building activities, laboratory strengthening, improved organization of control and prevention activities, health care services and management of communicable disease cases and communication mechanisms. Infectious disease surveillance for MGs should be preferably built via some modification and improvements, made to the existing surveillance and notification systems (23). For the sake of rapid communication and efficient notification, the planned surveillance system needs to be proactive and if possible based on an electronic platform. Identification of the

limitations of current infectious diseases surveillance systems have to be part of the planning for upcoming MGs (24). A combination of infectious diseases surveillance across geographic boundaries and scientific modeling that uses a wide range of specialties could produce an efficient real-time risk assessment tool which is likely to improve our understanding of potential global risks of infectious disease, before, during, and immediately after MGs (25).

All communicable diseases surveillance systems should go through a full testing prior to the beginning of the gathering (26). However, not all MGs require planning an enhanced infectious diseases surveillance system. Additional responses should be planned according to geographical spread, number of international visitors, event duration, and political and religious considerations (27).

## 4. Conclusions

MG, regardless of its size, duration and place, pose a high risk of infectious diseases spread. As a part of the preparedness and response plan, public health authorities in collaboration with event organizers need to enhance their communicable diseases surveillance systems, according to the nature of the event, to enable early detection of potential public health threats. Dissemination of information and increasing the awareness of participants and other stakeholders is of great importance.

## Authors' Contributions

Seyyed Mahdi Tabatabaie and Maliheh Metanat carried out the literature review and drafted the manuscript. Maliheh Metanat critically revised the manuscript.

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