



## Review

# Meningococcal disease burden and transmission in crowded settings and mass gatherings other than Hajj/Umrah: A systematic review



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## ABSTRACT

**Background:** Mass gatherings (MGs) such as the Hajj and Umrah pilgrimages are known to amplify the risk of invasive meningococcal disease (IMD) due to enhanced transmission of the organism between attendees. The burden of IMD at MGs other than Hajj and Umrah has not previously been quantified through a systematic review.

**Methods:** A systematic search for relevant articles in PubMed and Embase was conducted using MeSH terms; this was buttressed by hand searching. Following data abstraction, a narrative synthesis was conducted to quantify the burden of IMD at MGs and identify potential risk factors and mitigation measures. **Results:** Thirteen studies reporting occurrence of IMD at MGs or similar crowded settings were identified. Eight studies reported cases or outbreaks in MGs of  $\geq 1000$  people; five others reported IMD in other crowded settings; all occurred between 1991 and 2015. All age groups were involved in the identified studies; however the majority of cases (~80%) were young people aged 15–24 years. The number of affected people ranged from one to 321 cases and the overall crude estimate of incidence was calculated as 66 per 100,000 individuals. Serogroups A, C, B and W were identified, with serogroups A and C being most common. Of 450 cases of IMD reported in non-Hajj/Umrah MGs, 67 (14.9%) had fatal outcomes.

**Conclusion:** IMD outbreaks at non-Hajj/Umrah MGs are generally much smaller than Hajj-related outbreaks and affect mainly young people. Health education and vaccination should be considered for attendees of high risk non-Hajj/Umrah MGs, especially those involving adolescents and young adults.

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## 1. Introduction

*Neisseria meningitidis* is an important cause of sepsis and meningitis worldwide [1], and is associated with a considerable case fatality rate (CFR) in spite of treatment [2,3]. It is the only pathogen linked to epidemics of bacterial meningitis and each year approximately 1.2 million cases of invasive meningococcal disease (IMD) are reported globally, of which around 135,000 succumb to the illness [4,5]. IMD remains a major global public health issue, with most cases being caused by serogroups A, B, C, W, Y and X [1]. Elevated rates of IMD among military servicemen in the United States of America (USA) during the 1960s inspired the development of meningococcal polysaccharide vaccines [6]. Subsequently, more immunogenic polysaccharide-conjugate vaccines were developed against most serogroups that cause disease; however global uptake has been slow and limited and sporadic cases and outbreaks continue to occur, particularly in crowded settings and mass gatherings (MGs) [7–9].

MGs are characterised by a large congregation of people in a specific geographic area, over a defined duration, for a specific purpose [10]. The number of participants attending, as well as the location, frequency and duration of the event may vary according to the type of MG. Generally, the minimum number of attendees required for an event to qualify as a MG is 1000 people [10]. The event may be a one-time occurrence (e.g., a state funeral), an annual gathering (e.g., Hajj) or one that occurs less often (e.g., the Olympic Games). The congregations may last for weeks (e.g., Kumbh Mela) or just a few hours (e.g., a sporting fixture). Furthermore, the degree of organisation and monitoring, and thus the ability to protect the health and safety of attendees, also varies, from very detailed management of the event (e.g., the Olympic Games) to more informal oversight (e.g., music festivals). Despite the heterogeneity of these events, close contact between a large number of individuals from diverse backgrounds is the hallmark of all MGs, and the risk of transmission of communicable diseases [11] including IMD [12] amplifies during such events.

Additionally, shared accommodation, compromised hygiene and other high risk behaviours (e.g. smoking, intimate kissing) increase the risk of outbreaks of IMD at MGs [13,14]. For example, two large intercontinental outbreaks of IMD have occurred in the past due to Hajj, an annual assembly of more than two million Muslims in Makkah. The first, in 1987, affected around two thousand pilgrims [15]; and in 2000–2001 a second outbreak affected over 2400 individuals across the world [16]. These have been well-reported elsewhere and the subject of several excellent reviews [17–19]. Meningococcal outbreaks have occurred in other MGs or crowded settings, but have not previously been systematically reviewed. To this end, this review aims to synthesise the currently available data on IMD (including outbreaks) in non-Hajj/Umrah MGs to assess the burden of disease and to enhance understanding of risk factors and potential prevention and control strategies.

## 2. Methods

### 2.1. Search strategy

A search was undertaken through Medline and Embase using the following search terms: ‘meningococcal’, ‘meningitis’ and ‘*Neisseria meningitidis*’ with a combination of keywords and terms associated with MGs including ‘mass gathering’, ‘gathering’, ‘crowd’, ‘camp’, ‘championship’, ‘sport’, ‘Olympics’, ‘FIFA’, ‘EURO’, ‘concert’, ‘festival’, ‘pilgrimage’, ‘nursing home’, and ‘travel’. Publications in all potential languages from database inception to 31 August 2016 were retrieved. A manual search was also performed to identify additional relevant papers from reference lists of identified studies.

### 2.2. Study selection

Two reviewers (AB, HR) independently selected studies for inclusion while other authors (RB, AK) arbitrated when a discrepancy occurred. Mendeley® was used to identify and delete duplicate records [20]. Any original manuscript published in English that described the occurrence of IMD in any MG or crowded setting was included. Articles related to IMD occurring at Hajj or Umrah or those related to asymptomatic carriage or to non-meningococcal meningitis were excluded. For the purpose of this review we included any publications describing meningococcal outbreaks in an event attended by 1000 or more people. Publications reporting IMD outbreaks in crowded settings of  $\geq 1000$  individuals (such as university residential halls, military barracks, cruise ships and large dance parties) were also included to help better understand the transmission and epidemiology of IMD during MGs. The ‘preferred reporting items for systematic reviews and meta-analyses (PRISMA)’ statement was used to guide and report the search methodology.

### 2.3. Data extraction

The following data (if available) were extracted from each article: setting of outbreak, place, year, duration, number of attendees/affected population, number of cases, age group, fatalities, serogroups responsible and control measures undertaken.

### 2.4. Quality assessment

To evaluate data quality, the Newcastle-Ottawa Scale (NOS) for cross-sectional and cohort studies ([http://www.ohri.ca/programs/clinical\\_epidemiology/oxford.asp](http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp)) was used. Two authors (AB, HR) independently evaluated the quality of included studies; any disagreement was resolved through consensus.

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