

# Prevention of pneumococcal infections during mass gathering

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The interest in mass gathering and its implications has been increasing due to globalization and international travel. The potential occurrence of infectious disease outbreaks during mass gathering is most feared. In this context, respiratory tract infections are of great concern due to crowding in a limited space which facilitates and magnifies the potential of disease spread among attendees. Pneumococcal disease is best described among pilgrims to Makkah and vaccination is one of the methods for the prevention of this disease. Pneumonia was described in a mass gathering with a prevalence of 4.8/100,000 pilgrims and contributes to 15–39% of hospitalizations. Various studies showed that 7–37% of pilgrims are 65 y of age or older. The uptake of pneumococcal vaccine among pilgrims is low at 5%. There is no available data to make strong recommendations for *S. pneumoniae* vaccination of all pilgrims, it is important that a high risk population receive the indicated vaccination. We reviewed the available literature on the burden of pneumococcal infections during mass gathering and evaluate the available literature on pneumococcal vaccinations for attendees of mass gathering.

## Introduction

Globalization and increased international travel brought in an increased interest in mass gathering medicine. In a mass gathering, a large number of people gather in a defined area to the extent to strain the planning and response capacities of a given community or country.<sup>1</sup> The annual Pilgrimage (Hajj) is one of the largest mass gatherings that occur each year.<sup>2–13</sup> Annually, the number of pilgrims has increased from 1.5 to 2 million in 2006 and 2010, respectively.<sup>14</sup> One of the most feared events during a mass gathering is the occurrence of infectious diseases with epidemic or pandemic potential. The incidence of infectious diseases during mass gathering is variable (depending on size, location and origin of attendees of the event) and has been reported as low as 1% of health care visits at the Olympic Games in Atlanta in

1996 and in Sydney in 2000.<sup>14</sup> Of potential infectious diseases occurring during a mass gathering, respiratory tract infections are of great importance due to intense crowding, and limited space which facilitates and magnifies disease spread among attendees.<sup>14</sup> During mass gatherings, influenza outbreaks were reported.<sup>15–17</sup> Early and intense preparation for prevention of respiratory illnesses during mass gatherings, and working with countries sending pilgrims and global public health agencies, can lead to significantly reduced influenza spread.<sup>18</sup> Only a limited number of cases of H1N1 were reported during the initial phase of the influenza outbreak.<sup>19</sup> Pneumococcus infection is one of the vaccine preventable infections that may occur during mass gatherings. In this review, we present the available literature on prevalence of pneumococcal infections during MG events and data on attempted strategies on prevention of pneumococcal infections during a mass gathering. We first review the epidemiology of pneumococcal infection then we discuss the burden of pneumonia and pneumococcal infection during Hajj, and microbiology of pneumonia and circulating *S. pneumoniae* serotypes in mass gathering. Then, we transition to underlying chronic diseases among attendees of mass gathering to build the case for any vaccination recommendation. The available data on this subject is limited and do not allow a systematic review. The current narrative review is a step toward our understanding of the impact and implication of pneumococcal disease during mass gatherings.

## Search Strategy

We searched PubMed and reviewed retrieved articles for relevant studies. We used the following key words: pneumococcal, mass gathering, *Streptococcus pneumoniae*, pneumonia, Hajj, Pilgrim, pilgrimage, respiratory tract infections, and mass gathering.

## Epidemiology of pneumococcal infection

*Streptococcus pneumoniae* is considered one of the top vaccine preventable diseases in children and the elderly.<sup>20</sup> *S. pneumoniae* causes a variety of invasive diseases including meningitis, bacteremia, pneumonia and upper respiratory tract infections.<sup>21</sup> Pneumococcal polysaccharide conjugate vaccine [PCV13, adsorbed])

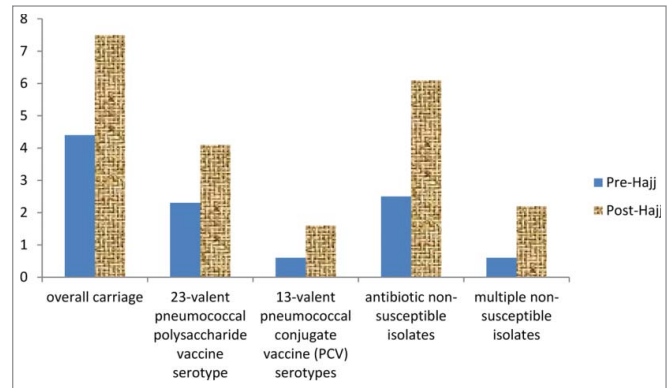
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can prevent a first episode of vaccine-type pneumococcal community-acquired pneumonia (CAP), including non-bacteremic/non-invasive CAP, and vaccine-type invasive pneumococcal disease (IPD) in adults > 65 y.<sup>22</sup>

### Burden of Pneumonia and Pneumococcal Infection during Hajj and other mass gathering

There are few studies addressing the burden of pneumonia among attendees of mass gatherings. These studies are related to large surveys conducted during the annual Hajj pilgrimage from 1985 to 2014. Overall pneumonia is the leading cause of hospital admission during Hajj (20–39%).<sup>23</sup> In one study conducted during 2004 Hajj season pneumonia was the leading cause of severe sepsis and septic shock during Hajj (55%) and *Streptococcus pneumoniae* was found to be the leading Gram positive organism isolated (50%).<sup>24</sup> In another study conducted during 1986 hajj season, pneumonia was the second cause of hospitalization with an incidence of 4.8 per 100,000 pilgrims.<sup>25</sup> Another study of hospital admissions in Makkah and Mina reported that 39% of hospitalizations were for pneumonia in 2002,<sup>26</sup> 20% of admissions in Mina hospitals were for pneumonia in 2003,<sup>27</sup> while in 2005, 15% of admissions to a tertiary hospital in Makkah were due to pneumonia.<sup>28</sup> In 2 studies of pneumonia among Iranian pilgrims, pneumonia incidence was 24 and 34 per 10,000 in 2004 and 2005, respectively (Table 1).<sup>25,29</sup> Of the etiology of pneumonia among pilgrims, bacterial pathogens were detected in 84.6% (22/26) and *S. pneumoniae* was in 53.8% of positive samples.<sup>30</sup>

In a small study of 196 French pilgrims, *Streptococcus pneumoniae* was detected in 12 (7.3%) participants before departing to Kingdom of Saudi Arabia (KSA), in 5 (7.1%) of 70 symptomatic pilgrims during Hajj, and in 30 (19.5%) pilgrims during 3 d before departing KSA (Fig. 1).<sup>31</sup> In another small study of 129 French pilgrims, 50.0% and 62.0% of pre-Hajj and post-Hajj pilgrims were positive for *S. pneumoniae* and 36.3% of the pilgrims acquired the infection during the Hajj.<sup>33</sup> In a recent study of the acquisition of pneumococcal pre-hajj and post-hajj showed an increase in the percentage of acquisition from 4.4% to 7.5% in the beginning and end of Hajj, respectively (Fig. 1).<sup>32</sup> The prevalence of the 23-valent pneumococcal polysaccharide vaccine serotypes was 2.3% and 4.1%, 13-valent pneumococcal conjugate vaccine (PCV) serotypes were 1.1% and 3.6%, and the 10-valent PCV serotypes were 0.6% and 1.6% the beginning and



**Figure 1.** Rate of *Streptococcus pneumoniae* carriage and serotype coverage by pneumococcal vaccine among pilgrims (adopted from Benkouiten S et al.<sup>32</sup>)

end of Hajj, respectively.<sup>32</sup> There was also an increase in the acquisition of antibiotic non-susceptible and multiple non-susceptible isolates.<sup>32</sup> Another recent study during the 2013 Hajj showed an acquisition rate of *S. pneumoniae* of 12%.<sup>34</sup> The prevalence of *S. pneumoniae* in a paired cohort was 5.6% and 12.7% on arrival and departure, respectively.<sup>34</sup> This rate was similar to that in a non-paired cohort of 4.7% and 13.6% on arrival and departure, respectively.<sup>34</sup>

### Microbiology of Pneumonia and Circulating *S. pneumoniae* Serotypes during Mass Gathering

Limited data exist regarding the microbiology and circulating serotypes among attendees of mass gatherings. In two studies of Hajj pilgrims, *S. pneumoniae* was isolated from 4.8–12.3% of 395 sputa, and from 9.4% of 64 sputa in 1991–1992 and 1994, respectively.<sup>35,36</sup> In a cohort of French pilgrims, *S. pneumoniae* was isolated from 12 (7.3%) of 165 participants before departing for the KSA, 5 (7.1%) of 70 symptomatic pilgrims during Hajj, and in 30 (19.5%) of 154 pilgrims during the last 3 d of the Hajj.<sup>31</sup> The most common serotype circulating among pilgrims in KSA were serotypes 3 (17%), 19F (5%) and 34 (5%).<sup>33</sup>

### Underlying chronic diseases among Attendees of Mass gathering

The age distribution and the presence of chronic diseases among attendees of mass gathering depend on the gathering's purpose. Religious mass gatherings may be predominated by older adults. It is estimated that about 33% of Hajj pilgrims are at risk of pneumococcal disease due to age or presence of underlying comorbidities.<sup>37</sup> In a study of French pilgrims to the annual Hajj showed that: 20 % had diabetes mellitus, 23% had hypertension, 10% had hypercholesterolaemia, and 5% had chronic respiratory disease.<sup>38-40</sup> A summary of studies indicating comorbidities among pilgrims is shown in

**Table 1.** Prevalence of Pneumonia among Pilgrims according to the study population and the year of the study

Year	Population	Rate of Pneumonia	City	Reference
1986	Hospitalized	4.8/100,000		25
2002	Hospitalized	39%	Makkah	26
2003	Hospitalized	20%	Mina	27
2005	Hospitalized	15%	Makkah	28
2004	Hospitalized	24/10,000	Makkah and Medina	29
2005	Hospitalized	48/10,000	Makkah and Medina	29

**Table 2.** A summary of reported risk factors (percentage) among pilgrims in reference to pneumococcal infection

Country [reference]	% smoker	% Pulmonary	Diabetes Mellitus	Age > 65
Multiple countries [10]			6.8	15.3
Saudi Arabia [12]		2.1	10.3	
Multiple countries [16]	93.4			
USA [17]				10.8
Saudi Arabia [18]	11.6			
Iranian [29]			2.4–2.9	
UK [31]	15.3			8.9
UK and Saudi Arabia [32]		4	10.7	8
UK and Saudi Arabia [32]		3.6	3.6	
UK [33]		3.5	7.8	7.1
France [39]				32.6
France [39]				34.7
France [40]		5.5	23.7	26.3
Singapore [41]			8.8	
The Netherlands [42]			19.5	
Iran [43]		1.6	2.4	
Australia [44]		9-Feb	6.4–11.5	
UK [45]		5.1		

**Table 2.**<sup>10,12,16-18,29,39-44</sup> Of chronic medical conditions, the presence of specific diseases among pilgrims were diabetes mellitus (20–40%), obesity (30%), bronchial asthma (10%), chronic obstructive pulmonary disease (10%), and tobacco smoking (10%).<sup>10,15,18,29,45-52</sup> Diabetes mellitus was 5 times higher in French pilgrims compared to the overall French population.<sup>53</sup>

### Individual preventive measures against ARI

The knowledge and acceptance of the use of preventive measures — during mass a gathering — is variable. In one study, knowledge about preventive measures was 41% for face mask use, 10% for hand washing, and 3% for hand disinfectant use.<sup>54</sup> The acceptability of preventive measures were: 92% for face mask use, 93% for hand washing, 98% for hand disinfectant, and 97% for disposable handkerchief use.<sup>54</sup>

### Vaccination

Currently, there are 4 types of pneumococcal vaccines: 7-, 10- and 13-valent pneumococcal conjugate vaccines (PCV7, PCV10, PCV13) and 23-valent pneumococcal polysaccharide vaccine (PPSV23).<sup>55</sup> The PPSV23 vaccine is found to be effective against severe invasive pneumococcal disease.<sup>56</sup> In the United States, about 25% of invasive pneumococcal disease and 10% of community-acquired pneumonia in those aged  $\geq 65$  years are caused by PCV13 serotypes.<sup>57</sup> According to the Advisory Committee on Immunization Practices (ACIP), PCV13 and PPSV23 should be administered routinely to all adults aged  $\geq 65$  years.<sup>57</sup>

**Table 3.** Summary of the Pneumococcal vaccination Rates among attendees of the Hajj

Reference	Year of study	Country	n/N (%) Received Pneumococcal vaccine	Comments
10	2013	22 countries	230/5235 (4.4)	overall rate
29	2004	Iran	750/30037 (2.5)	overall rate
29	2005	Iran	6735/75676 (8.9)	overall rate
31	2012	France	22/46 (47.8)	* at risk
40	2009	France	86/274 (31.4)	overall rate
44	2011	Australia	49/158 (30.6)	* at risk
44	2012	Australia	95/513 (45.3)	* at risk
44	2013	Australia	31/219 (29)	* at risk
54	2011	France	(5)	overall rate
60	2010	France	(5)	* at risk
61	2005	United Kingdom	(15)	overall rate

At risk: age  $\geq 65$  years, smoker, comorbid medical conditions (chronic lung, heart, liver, kidney, neuromuscular, metabolic)

Pneumococcal vaccine has not been mandated among attendees of mass gatherings. It is recommended for those older than 65 y of age.<sup>13,58</sup> Among those with risk factors, the pneumococcal vaccination rate was low (5%) (Table 3).<sup>10,31,40,44,54,60,61</sup> In another study, only 50% of pilgrims who have an indication for pneumococcal vaccine received such vaccinations.<sup>31</sup> In a large study of 5235 adult pilgrims from 22 countries, only 4.4% had pneumococcal vaccinations.<sup>10</sup> There is limited data on the acquisition of *S. pneumoniae* during the Hajj or other mass gathering events. The current pneumococcal 13-valent and 10-valent PCVs are thought to cover 37% and 18% of identified serotypes during the Hajj.<sup>33</sup> In a study, the compliance with pneumococcal vaccine was 4.4% (237/5235) overall, 1.5% (12/800) > 65 y of age, and 27.3% (3/11) among diabetics.<sup>10</sup> The presence of a large population of pilgrims older than 65 y put those pilgrims at higher risk of pneumococcal infections. Although there is no available data to verify the strong recommendations for vaccination of all pilgrims against *S. pneumoniae* it is important that high risk populations receive the indicated vaccination.

In conclusion, there is evidence of globalization of respiratory pathogens during mass gatherings.<sup>34,9-12</sup> The risk of acquisition of *S. pneumoniae* is shown in a few studies.<sup>30</sup> Since, the risk of complication of *S. pneumoniae* infection is highest in those with pre-existing comorbidities, and those 65 y of age and older, it is important that the current ACIP recommendations get followed. There is not enough evidence to support large scale recommendations to have all pilgrims vaccinated against *S. pneumoniae*. Further studies are needed to further elucidate the risk of transmission of this organism, based on age group and the presence of comorbidities.

### Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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