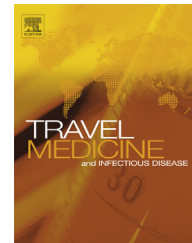




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# Non-pharmaceutical interventions for the prevention of respiratory tract infections during Hajj pilgrimage

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**Summary** Overcrowding during the yearly Hajj mass gatherings is associated with increased risk of spreading infectious diseases, particularly respiratory diseases. Non-pharmaceutical interventions (e.g., hand hygiene, wearing face masks, social distancing) are known to reduce the spread of respiratory viruses from person to person and are therefore recommended to pilgrims by public health agencies. The implementation of effective public health policies and recommendations involves evaluating the adherence to and effectiveness of these measures in the specific context of the Hajj. This review summarizes the evidence related to the effectiveness of non-pharmaceutical interventions in preventing the spread of respiratory infectious diseases during the Hajj. Overall, although hand hygiene compliance is high among pilgrims, face mask use and social distancing remain difficult challenges. Data about the effectiveness of these measures at the Hajj are limited, and results are contradictory, highlighting the need for future large-scale studies.

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## 1. Introduction

Annually, over two million Muslims from more than 180 countries gather in the Kingdom of Saudi Arabia (KSA) to

perform the pilgrimage to Mecca, also known as the “Hajj”. The Hajj is the fifth pillar of Islam and is mandatory for all adult Muslims who are physically and financially capable at least once in their lifetime. The pilgrims usually stay in the KSA for up to 4 weeks. Upon arrival in Mecca, the holiest city in Islam, most Hajj pilgrims begin their visit by performing the “Umrah” (also known as the minor pilgrimage). The rituals of the Umrah can be undertaken at any time of the year and include the circumambulation of the Kaaba (*Tawaf*) in very crowded conditions (Fig. 1) and seven trips

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(*Sa'i*) between two small mountains (*Al-Safa* and *Al-Marwah*) inside the Grand Mosque (*Al-Masjid al Haram*). The Hajj, which retraces the footsteps of the Prophet Mohamed over approximately one week, is performed from the 8th to the 13th of the last month of the lunar Islamic calendar, called "*Dhul Hijja*" (i.e., "the month of Hajj"). As part of the Hajj rituals, pilgrims travel to different sacred places located around the city of Mecca, including Mina, where they camp during the 5-day period of the Hajj in tents (Fig. 2) in close contact with others; the plain of Arafat for the culminating experience of the Hajj; and Muzdalifah. While not required as part of the Hajj, most pilgrims leave Mecca after a final circumambulation of the Kaaba (*Tawaf al-Wada*), traveling to the city of Medina to visit Islam's second holiest site, the Mosque of the Prophet, which contains Muhammad's tomb.

The presence of a large number of pilgrims from many parts of the world in congested and crowded areas, especially when performing the circumambulation of the Kaaba inside the Grand Mosque in Mecca and when using the pedestrian tunnels leading to the *Jamarat* bridge in Mina, where each pilgrim performs the ritual of "*Jamarat*" (stoning the columns symbolizing the Devil), greatly increases the risk of spreading infectious diseases [1], particularly respiratory diseases [2]. It was reported that the prevalence of respiratory symptoms among a cohort of French pilgrims during the 2012 Hajj was 90%, with cough (83%) and sore throat (78%) as the most commonly reported symptoms [3]. Similarly high prevalences of respiratory symptoms were observed in both Iranian and Malaysian cohorts of pilgrims [4,5]. Respiratory diseases are by far the main reason for consultation among pilgrims attending primary health care centers during the Hajj [6]. In addition,

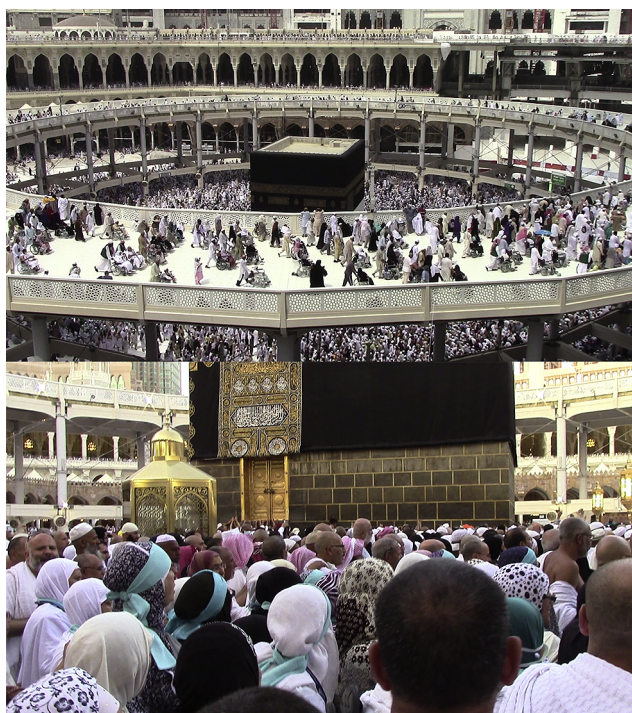


Fig. 1 The circumambulation of the Kaaba (*Tawaf*) in the Grand Mosque in Mecca.



Fig. 2 The Mina tents.

respiratory diseases are major causes of hospital admission during the Hajj [7], with pneumonia being a leading cause of hospitalization in intensive care units [8]. In a recent study of Indonesian pilgrims, respiratory diseases were found to be the second most common cause of death, immediately after cardiovascular diseases [9]. Respiratory viruses, especially influenza virus, are the main cause of acute respiratory infection (ARI) during the Hajj [10–13]. High prevalences of rhinovirus [3] and *Streptococcus pneumoniae* [14] were found in pilgrims returning from the Hajj, highlighting the potential of pilgrims to spread these infections to their household contacts upon return to their countries of origin. However, although international outbreaks of *Neisseria meningitidis* serogroup W135 occurred in 2001 and 2002 [15,16], no respiratory epidemics linked to the Hajj have been reported to date.

The transmission routes of the most common respiratory viral pathogens are diverse [17], including direct contact between an infected person and healthy individuals, indirect contact with contaminated surfaces, and droplet and airborne transmission at short range. Current evidence indicates that simple physical interventions would be useful for reducing the spread of respiratory viruses [18]. Consequently, in addition to vaccination, non-pharmaceutical interventions are recommended by various national and international public health agencies, including the Saudi Ministry of Health (MoH), the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC), to prevent the spread of infections during the pilgrimage or in the pilgrims' home countries upon their return [19–21]. These measures include maintaining hand hygiene, particularly hand washing with soap and water and the use of hand sanitizer; using disposable tissues when coughing or sneezing and disposing of these tissues in a

**Table 1** Survey addressing the effectiveness of preventive measures against Hajj-associated respiratory tract infections, 1999–2013.

Hajj season	Study population	Compliance with preventive measures	Evaluation of the preventive effect	Study (year)	Ref.
1999	1707 pilgrims at Mina, Kingdom of Saudi Arabia (KSA)	Use of face mask: 24%	Not evaluated	Al-Shihry et al. (1999)	[22]
2002	1374 pilgrims at Mina, KSA	Frequent hand washing: 67.2% Use of face mask: 33.2%	Not evaluated	Al-Maghderi et al. (2002)	[23]
2002	447 Indonesian pilgrims	Use of face mask: 48.4%	21.8% vs. 73.0% (RR = 3.36; 95% CI: 2.58–4.37; <i>P</i> -value = 0.000) URTI <sup>a</sup> when comparing use vs. non use, respectively, of face mask	Zein (2002)	[32]
2003	1027 pilgrims registered at primary health care centres of Riyadh, KSA	Use of face mask (among all pilgrims):  - Most of time: 33.1% - Sometimes: 20.4%  Use of face mask (among male):  - Most of time: 42.5% - Sometimes: 21.2%  Use of face mask (among female):  - Most of time: 7.6% - Sometimes: 18.4%	15.0% vs. 61.2% (RR = 4.00; 95% CI: 3.14–5.31) ARI <sup>b</sup> when comparing most of time use vs. never use, respectively, of face mask 15.0% vs. 31.4% (RR = 2.10; 95% CI: 1.52–2.89) ARI <sup>b</sup> when comparing most of time use vs. sometimes use, respectively, of face mask 13.5% vs. 76.5% (RR = 5.67; 95% CI: 4.26–7.55) ARI <sup>b</sup> when comparing most of time use vs. never use, respectively, of face mask among male 13.5% vs. 32.7% (RR = 2.43; 95% CI: 1.70–3.47) ARI <sup>b</sup> when comparing most of time use vs. sometimes use, respectively, of face mask among male 38.1% vs. 41.0% (RR = 1.08; 95% CI: 0.61–1.90) ARI <sup>b</sup> when comparing most of time use vs. never use, respectively, of face mask among female 38.1% vs. 27.5% (RR = 0.72; 95% CI: 0.36–1.46) ARI <sup>b</sup> when comparing most of time use vs. sometimes use, respectively, of face mask among female	Al-Mudameigh et al. (2003) Choudhry et al. (2006)	[25] [24]

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Table 1 (continued)

Hajj season	Study population	Compliance with preventive measures	Evaluation of the preventive effect	Study (year)	Ref.
2004	995 domestic pilgrims from Riyadh, KSA: <ul style="list-style-type: none"> <li>– 257 were provided with face mask health education (HE) and free face masks</li> <li>– 292 were provided with face mask HE only</li> <li>– 446 without face mask HE or face masks</li> </ul>	Use of face mask: <ul style="list-style-type: none"> <li>- Among pilgrims with face mask HE and face masks: 81.3%</li> <li>- Among pilgrims with face mask HE only: 51.7%</li> <li>- Among pilgrims without face mask HE or face masks (no intervention): 33.6%</li> </ul>	81.3% vs. 33.6% (OR = 8.59; 95% CI: 5.93–12.44) ARI <sup>b</sup> when comparing face mask HE + face masks vs. no intervention group, respectively 51.7% vs. 33.6% (OR = 2.11; 95% CI: 1.56–2.86) ARI <sup>b</sup> when comparing face mask HE + face masks vs. no intervention group, respectively	Abdin et al. (2005)	[27]
2007	248 pilgrims attending 2 randomly selected hospitals (Mina al Tawarri and Mina El-Jesser) in Mina, KSA	Use of face mask: <ul style="list-style-type: none"> <li>- Among all pilgrims: 12.1%</li> <li>- Among pilgrims who received health education (HE): 24.0%</li> <li>- Among pilgrims who do not received HE: 3.5%</li> </ul> Hand washing (among all pilgrims): <ul style="list-style-type: none"> <li>- Frequently: 31.5%</li> <li>- Infrequent or no: 68.5%</li> </ul> Hand washing (among pilgrims who received HE): <ul style="list-style-type: none"> <li>- Frequently: 58.7%</li> <li>- Infrequent or no: 41.3%</li> </ul> Hand washing (among pilgrims who do not received HE): <ul style="list-style-type: none"> <li>- Frequently: 11.8%</li> <li>- Infrequent or no: 88.2%</li> </ul>	Not evaluated	Khamis et al. (2008)	[28]
2008	528 French residents pilgrims consulting for vaccination at a clinic in Marseille, France	<i>Knowledge and Acceptability, respectively, of precautions against acute respiratory tract infections:</i> <ul style="list-style-type: none"> <li>- Use of face mask: 41.3% and 91.7%</li> <li>- Hand washing: 9.8% and 92.8%</li> </ul>	Not evaluated	Gautret et al. (2009)	[26]

2007	387 Malaysian pilgrims at transit center in Jeddah and Medina, KSA	<ul style="list-style-type: none"> <li>- Use of hand disinfectant: 2.8% and 98.1%</li> <li>- Use of disposable handkerchief: Not reported and 96.8%</li> <li>- Social distancing: 48.7% and 62.5%</li> <li>- Contact avoidance: 47% and 62.1%</li> </ul> Use of face mask: 72.9%	78.1% vs. 69.4% (OR = 1.57; 95% CI: 0.98–2.52; <i>P</i> -value = 0.060) ILI <sup>c</sup> when comparing use vs. non use, respectively, of face mask	Deris et al. (2010)	[5]
2009	274 French residents pilgrims consulting for vaccination at a clinic in Marseille, France	Use of face mask: 79.6% <ul style="list-style-type: none"> <li>- Frequently: 40.9%</li> <li>- Occasionally: 38.7%</li> </ul> Hand washing (more frequently than usual): 69.7% <ul style="list-style-type: none"> <li>- Use of hand disinfectant: 77.4%</li> <li>- Use of disposable handkerchief: 89.8%</li> </ul> Use of face mask: 56.5% <ul style="list-style-type: none"> <li>- Most of the time: 14.3%</li> <li>- Sometimes: 24.4%</li> <li>- Occasionally: 17.7%</li> </ul> Hand washing: <ul style="list-style-type: none"> <li>- &gt;5 times per day: 90.3%</li> <li>- &lt;5 times per day: 9.7%</li> </ul> Use of hand sanitizer: 45.5%           Use of face mask: 48.9%           Hand hygiene: 67.2%	None of the preventive measures significantly affected the occurrence of respiratory symptoms <sup>d</sup>	Gautret et al. (2011)	[29]
2010	1507 pilgrims consulting for vaccination at Primary Health Care Centers of Riyadh, KSA	Use of face mask: 56.5% <ul style="list-style-type: none"> <li>- Most of the time: 14.3%</li> <li>- Sometimes: 24.4%</li> <li>- Occasionally: 17.7%</li> </ul> Hand washing: <ul style="list-style-type: none"> <li>- &gt;5 times per day: 90.3%</li> <li>- &lt;5 times per day: 9.7%</li> </ul> Use of hand sanitizer: 45.5%           Use of face mask: 48.9%           Hand hygiene: 67.2%	53.7% vs. 55.0% (RR = 1.17; 95% CI: 1.00–1.38; <i>P</i> -value = 0.045) URTI <sup>e</sup> when comparing sometimes use vs. never use, respectively, of face mask 45.4% vs. 55.0% (RR = 1.21; 95% CI: 1.03–1.43; <i>P</i> -value = 0.014) URTI <sup>e</sup> when comparing most of the time use vs. never use, respectively, of face mask	Al-Jasser et al. (2012)	[31]
2009	186 US residents pilgrims from Minnesota (recruited at a weekly clinic for Hajj travelers) and Michigan (recruited at multiple settings), USA	Use of face mask: 48.9%           Hand hygiene: 67.2%	41.6% vs. 33.3% (OR = 1.42; 95% CI: 0.70–2.88; <i>P</i> -value = 0.21) respiratory illness <sup>f</sup> when comparing practicing vs. non practicing, respectively, face mask 35.0% vs. 60.0% (OR = 0.36; 95% CI: 0.14–0.94; <i>P</i> -value = 0.03) respiratory illness <sup>f</sup> when comparing	Balaban et al. (2012)	[33]

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Table 1 (continued)

Hajj season	Study population	Compliance with preventive measures	Evaluation of the preventive effect	Study (year)	Ref.
2009	432 pilgrims arriving at the King Abdulaziz International Airport in Jeddah, KSA	<p>Cough etiquette: 46.2%</p> <p>Social distancing: 34.4%</p> <p>Contact avoidance: 24.2%</p> <p>Use of face mask: 35.1%</p> <p><i>Knowledge of ways to avoid H1N1 infection:</i></p> <ul style="list-style-type: none"> <li>- Use of face mask: 44.7%</li> <li>- Frequent hand washing: 48.1%</li> <li>- Use of hand sanitizer: 28.5%</li> <li>- Covering own cough or sneeze: 20.6%</li> <li>- Avoiding crowds/public gatherings: 18.3%</li> <li>- Staying away from sick people: 28%</li> </ul>	<p>practicing vs. non practicing, respectively, hand hygiene 37.6% vs. 39.7% (OR = 0.92; 95% CI: 0.46–1.82; <i>P</i>-value = 0.47) respiratory illness<sup>f</sup> when comparing practicing vs. non practicing, respectively, cough etiquette 28.1% vs. 46.8% (OR = 0.44; 95% CI: 0.22–0.90; <i>P</i>-value = 0.02) respiratory illness<sup>f</sup> when comparing practicing vs. non practicing, respectively, social distancing 27.9% vs. 43.0% (OR = 0.51; 95% CI: 0.24–1.11; <i>P</i>-value = 0.06) respiratory illness<sup>f</sup> when comparing practicing vs. non practicing, respectively, contact avoidance</p> <p>Not evaluated</p>	Memish et al. (2012)	[30]
2012	137 French residents pilgrims consulting for vaccination at a clinic in Marseille, France	<p>Use of face mask:</p> <ul style="list-style-type: none"> <li>- Frequently: 9.6%</li> <li>- Intermittently: 45.6%</li> </ul> <p>Hand washing (more frequently than usual): 40.3%</p>	<p>No significant effect of face mask use on overall prevalence of respiratory viruses<sup>g</sup></p> <p>53.6% vs. 23.3% (OR = 3.79; 95% CI: 1.23–11.69; <i>P</i>-value = 0.018) prevalence of any respiratory viruses<sup>g</sup> when comparing increased vs. usual, respectively, hand washing 53.7% vs. 32.5% (OR = 2.41; 95% CI:</p>	Benkouiten et al. (2013)	[3]

2009	186 US residents pilgrims (who had taken both the pre- (information) and post-travel surveys) from Minnesota (recruited at a weekly clinic for Hajj travelers) and Michigan (recruited at multiple settings), USA + 34 US residents pilgrims (who took only the post-travel survey) from Michigan (contacted after their return from the Hajj)	Use of hand sanitizer: 46.3%  Use of disposable handkerchief: 87.6%  <i>Among pilgrims who had taken both the pre- (information) and post-travel surveys:</i> - Use of face mask: 61.8% - Hand hygiene: 86.3% - Cough etiquette: 59.5% - Social distancing: 45.5% - Contact avoidance: 31.3% <i>Among pilgrims who took only the post-travel survey:</i> - Use of face mask: 65.5% - Hand hygiene: 86.2% - Cough etiquette: 65.5% - Social distancing: 17.2% - Contact avoidance: 31.0%	1.18–4.90; <i>P</i> -value = 0.014) ILL <sup>c</sup> when comparing increased vs. usual, respectively, hand washing 16.4% vs. 5.6% (OR = 3.28; 95% CI: 0.97–11.07; <i>P</i> -value = 0.045) prevalence of any respiratory viruses <sup>s</sup> when comparing use vs. non use, respectively, of hand sanitizer No significant effect of handkerchief use on overall prevalence of respiratory viruses <sup>s</sup> Not evaluated	Balaban et al. (2013)	[36]
2010	338 Iranian pilgrims from 2 caravans, one of which was the first to enter Mecca, and the other the first to enter Medina  - Case group: 32 symptomatic pilgrims - Control group: 63 asymptomatic pilgrims	Use of face mask: - In case group: 65.6% - In control group: 57.1% Room contact: - In case group: 28.1% - In control group: 17.5%	The impact of face mask use on prevalence of respiratory tract infections <sup>h</sup> (OR = 0.64; 95% CI: 0.23–1.78; <i>P</i> -value = 0.39) The impact of room contact on prevalence of respiratory tract infections <sup>h</sup> (OR = 2.14; 95% CI: 0.68–6.70; <i>P</i> -value = 0.19)	Emamian et al. (2013)	[35]
2009, 2013	Photo frames of pilgrims during the 5-day period of Hajj, KSA:  - In 2009: 131 photo frames of 1607 pilgrims - In 2013: 171 photo frames of 1724 pilgrims	Use of face mask: - In 2009: 8.4% - In 2013: 0.02%	Not evaluated	Elachola et al. (2013)	[34]

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Table 1 (continued)

Hajj season	Study population	Compliance with preventive measures	Evaluation of the preventive effect	Study (year)	Ref.
2013	360 French residents pilgrims (179 pilgrims at-risk) consulting for vaccination at a clinic in Marseille, France	Postponement of Hajj: 0%	Not evaluated	Gautret et al. (2013)	[41]

<sup>a</sup> Acute upper respiratory tract infections (URTIs), diagnosed by clinical symptoms (such as cough, fever, sore throat, hoarseness, and cold) and by physical examination.

<sup>b</sup> Acute respiratory infections (ARIs), defined as at least one of the constitutional symptoms (fever, headache, myalgia) along with one of the local symptoms (running nose, sneezing, throat pain, cough with/without sputum, difficulty breathing).

<sup>c</sup> Influenza-like illness (ILI), defined as the triad of cough, subjective fever, and sore throat.

<sup>d</sup> One or more of the following symptoms: cough, sore throat, rhinorrhea, voice failure, or shortness of breath.

<sup>e</sup> Acute upper respiratory tract infections (URTIs), defined as at least one of the constitutional symptoms (fever, headache, myalgia) along with one of the local symptoms (running nose, sneezing, throat pain, cough with/without sputum).

<sup>f</sup> Respiratory illness was defined as an illness with the presence of one or more of the following localizing signs or symptoms: cough, congestion, sore throat, sneezing, or breathing problems.

<sup>g</sup> One or more of the following 11 respiratory virus types and subtypes: Influenza A, influenza B, influenza C, and A/2009/H1N1 viruses; human respiratory syncytial virus A and B; human metapneumovirus; human rhinovirus; MS2 bacteriophage; human adenovirus; and human enterovirus.

<sup>h</sup> All types of respiratory tract infections other than the common cold including tonsillitis, pharyngitis, laryngitis, sinusitis, otitis media, bronchitis, pneumonia and Influenza.

waste basket; attempting as much as possible to avoid hand contact with the eyes, nose and mouth; avoiding direct contact with ill individuals; wearing masks, especially when in crowded places; and maintaining good personal hygiene, with the aim of interrupting or reducing the spread of infections from person to person.

The objective of this review is to summarize the evidence related to the effectiveness of non-pharmaceutical interventions in preventing the spread of respiratory infectious diseases during the Hajj.

## 2. Search strategy

On 1 January 2014, we searched the MEDLINE database ([www.ncbi.nlm.nih.gov/pubmed](http://www.ncbi.nlm.nih.gov/pubmed)) for articles published in English using the following search strategy:

- #1: "hadj" OR "hajj" OR "mass gathering" OR "pilgrimage";  
 #2: "respiratory" OR "infection" OR "infections" OR "infectious diseases";  
 #3: #1 AND #2.

The search results were surveyed for methodological articles, and their titles and abstracts were then scanned. In addition, reference lists of relevant articles were hand searched for further references that could be considered for inclusion in this review. To be included, studies had to provide information on the actual use of non-pharmaceutical preventive measures by pilgrims during the Hajj or present data about the evaluation of the protective effect of these non-pharmaceutical preventive measures. Relevant review articles were included for useful background information.

## 3. Included studies

A total of 135 papers were found from the search, of which 122 were retrieved for full-text review and 13 met inclusion criteria. Four additional references were found through hand searches. Table 1 summarizes the relevant 17 papers included in this review.

## 4. Use of face masks

Major studies addressing the knowledge and practice of pilgrims concerning Hajj-related health problems have been conducted in the past by the Saudi Arabia Field Epidemiology Training program [22,23]. Large multinational samples of pilgrims were recruited while staying in Mina and interviewed using a self-administered questionnaire. As part of these studies, face mask use was reported by only 17.8% of the respondents during the 1998 Hajj season [22] compared to 24% and 33.2% in 1999 and 2002, respectively [22,23]. In a large cohort study of pilgrims recruited during the pre-travel consultation, 53.6% of those who were followed up by telephone after the 2003 Hajj reported using face masks during the pilgrimage [24,25]. A survey of knowledge, attitude and practice was conducted in the city of Marseille among French pilgrims intending to

perform the 2008 Hajj who attended a pre-Hajj meningococcal vaccination campaign [26]. Of the respondents in this study, prior to travel, only 41.3% were aware that face masks could protect them from ARI, and 24.6% were aware that face masks could be used for community protection [26]. However, the willingness of pilgrims to wear face masks during the Hajj was high (91.7%) after the importance of their use was explained [26]. The effect of a health promotion intervention and the distribution of free face masks were evaluated in a study in 2004, showing a significant increase in face mask use among pilgrims who received both health promotion and free face masks (81.3%) compared to controls who did not receive health education or face masks (33.6%) [27]. In another study of patients attending Mina hospitals in 2007, pilgrims who received health education were also significantly more likely to wear face masks during the Hajj than those who did not [28]. However, the overall compliance with face mask use of pilgrims in this study was low (12.1%) [28]. These interventions have improved pilgrim compliance with face mask use during the Hajj; however, it was not stated in these studies whether pilgrims used their masks frequently or intermittently. The compliance with face mask use of French pilgrims who were recruited during their pre-travel consultation was investigated by telephone questionnaire as the pilgrims returned to France after the 2009 Hajj [29]. In this study, the percentage of pilgrims who self-reported using face masks during the pilgrimage was 79.6% [29]. In a large cross-sectional survey conducted before the 2009 Hajj, 35.1% of pilgrims arriving at the King Abdulaziz international airport in Jeddah reported wearing a face mask, and only 44.7% were aware of this measure as a way to prevent H1N1 infection [30]. A cohort study was conducted among pilgrims traveling from Riyadh with the intention to perform the Hajj in 2010. Pilgrims were recruited as they sought their required pre-Hajj meningococcal vaccination and followed up by telephone upon their return from the Hajj. In this study, 56.5% of pilgrims reported using face masks during the pilgrimage [31]. This result is comparable to that reported in another study conducted among French pilgrims during the 2012 Hajj by a medical doctor traveling with the pilgrims, in which 55.1% of pilgrims actually used face masks during the pilgrimage [3]. Other studies conducted among pilgrims from various countries [5,32,33] have shown variable results (Table 1). However, study designs and populations were highly variable from one study to another and did not allow for relevant comparisons. In an interesting recent study about face mask usage among pilgrims during the 5-day Hajj periods of 2009 and 2013, photos of the moving crowd taken from elevated areas revealed that significantly more pilgrims used face masks during the 2009 influenza A (H1N1) outbreak than during the 2013 MERS-CoV outbreak; however, compliance was low in both years [34]. It must be noted that in this study, face masks were provided as part of a welcome kit to each arriving pilgrim at the international airport in Jeddah.

The effectiveness of face mask use in preventing respiratory illness during the Hajj has been evaluated in various studies (Table 1). However, the results of these studies were contradictory. One study conducted among Indonesian pilgrims reported that pilgrims who did not use

a face mask (that were provided to pilgrims by the Indonesian Hajj committee free of charge) during the Hajj had a threefold greater risk of acquiring an acute upper respiratory tract infection compared to those using face masks [32]. A significant reduction in respiratory symptoms was also observed in a Saudi [31] study, whereas several other studies reported no significant effect [5,29,33,35]. A second Saudi study showed a significant reduction in respiratory symptoms with face mask use, but only in the male or total sample and not in the female group [24,25]. Two other studies have addressed the impact of face mask use during the Hajj on the prevalence of both respiratory symptoms and viral pathogens using PCR assays from pilgrim nasal samples, and no significant effect was observed [30,3].

## 5. Hand hygiene

Compliance with hand hygiene practices was assessed during the 1999 Hajj season in a cross-sectional survey on a large multinational sample of pilgrims staying in Mina using a self-administered questionnaire [22]. Overall, 67.2% of respondents reported washing their hands frequently during the pilgrimage [22]. In a large prospective study of domestic pilgrims from Central Saudi Arabia, 90.3% and 45.5% reported, on their return from the 2010 Hajj, washing their hands more than 5 times per day and using hand sanitizer during the pilgrimage, respectively [31]. In another study of pilgrims attending two randomly selected Mina hospitals during the 2007 Hajj season, only 31.5% reported washing their hands frequently [28]. However, in this study, the pilgrims who received health education washed their hands significantly more frequently during the Hajj than those who did not [28]. A study assessing the compliance with protective measures among US pilgrims prior to and following travel to the 2009 Hajj reported that 67.2% of the respondents practiced hand hygiene during the pilgrimage [33]. However, in a second study conducted among the same cohort of US pilgrims with the aim of evaluating the possible effects of knowledge acquired from taking the pre-travel survey, the impact of the pre-travel survey as an effective means of health communication or education for pilgrims remained unclear [36]. A large cross-sectional survey conducted in 2009 among pilgrims arriving at the King Abdulaziz international airport in Jeddah showed that 48.1% and 28.5% of pilgrims were aware that frequent hand washing and use of hand sanitizer, respectively, could prevent H1N1 infection [30]. The proportions were even lower among French pilgrims intending to perform the 2008 Hajj, with less than 10% and 3% of participants being aware prior to travel of frequent hand washing and use of hand disinfectant, respectively, as precautions against respiratory infections [26]. However, this study revealed high levels of acceptance of these measures among participants (>90%) after their importance was explained [26]. Upon return from the 2009 Hajj, 69.7% and 77.4% of French pilgrims have self-reported increased hand washing and increased use of hand disinfectant, respectively, during the pilgrimage [29]. More recently, the compliance with hand hygiene among French pilgrims during the 2012 Hajj was also assessed by a medical doctor

traveling with them, and 40.3% and 46.3% of pilgrims actually washed their hands more than usual and used hand sanitizer, respectively, during the pilgrimage [3].

The effectiveness of hand hygiene practices in preventing respiratory illness during the Hajj has been evaluated in only a few studies (Table 1). A study conducted among US Hajj pilgrims during the 2009 Hajj confirmed that hand hygiene was associated with a reduced risk of respiratory illness [33]. By contrast, no positive effect of frequent hand washing or using hand sanitizer was observed among French pilgrims on the occurrence of respiratory symptoms during the 2009 Hajj [29] or on the prevalence of respiratory viruses as investigated by PCR assays on nasal swabs during the 2012 Hajj [3]. On the contrary, hand washing was significantly associated with symptoms of influenza-like illness and with a higher prevalence of respiratory viruses during the 2012 Hajj [3].

## 6. Cough etiquette and disposable handkerchief

In a large cross-sectional study from the KSA, pilgrims arriving at the King Abdulaziz International Airport in Jeddah for the 2009 Hajj were found to have low knowledge of cough etiquette as a way to prevent H1N1 infection (20.6%) [30]. In 2009, a study among US pilgrims showed that their compliance with cough etiquette was 46.2%, with, however, no significant beneficial effect on the prevalence of respiratory symptoms [33]. A second study, conducted among the same cohort of US pilgrims, found no impact of taking the pre-travel survey on compliance with cough etiquette during the Hajj [36]. In another study conducted among French pilgrims intending to perform the 2008 Hajj who attended a pre-Hajj meningococcal vaccination campaign, the knowledge prior to travel about disposable handkerchief use as a preventive measure against respiratory tract infections among the community was also very low (1.1%), but the willingness of pilgrims to use disposable handkerchiefs during the Hajj was excellent after the importance of their use was explained [26]. The use of disposable handkerchiefs among French pilgrims was 89.8% during the 2009 Hajj as self-reported by the pilgrims [29] and 87.6% during the 2012 Hajj as assessed by a medical doctor traveling with them [3]. However, the use of disposable handkerchiefs had no significant beneficial effect on the prevalence of either respiratory symptoms among pilgrims during the Hajj [29] or viral pathogens from their nasal samples, as recently reported [3].

## 7. Social distancing and contact avoidance

Only 28% and 18.3% of pilgrims arriving at the King Abdulaziz International Airport in Jeddah for the 2009 Hajj were aware of the usefulness of staying away from sick people and avoiding crowds/public gatherings, respectively, in preventing H1N1 infection [30]. In a study conducted among US pilgrims during the 2009 Hajj, the observance rates of social distancing and contact avoidance were 34.4% and 24.2%, respectively, with a significant beneficial effect on

the occurrence of respiratory symptoms during the Hajj [33]. A second study, conducted among the same cohort of US pilgrims, found that pilgrims who took both pre- and post-travel surveys were more likely to report practicing social distancing during the Hajj (45.5%) than those who took only the post-travel survey (17.2%) [36]. However, the pre-travel survey had no impact on the observance of contact avoidance by pilgrims during the Hajj in this study (approximately 31% in both groups) [36]. French pilgrims intending to perform the 2008 Hajj showed more knowledge about social distancing and contact avoidance as preventive measures for self-protection against respiratory tract infections (about 50%) [26]; and the acceptability of these measures was approximately 62% after the importance of their observance was explained [26]. However, in a recent nested case–control study among Iranian pilgrims during the 2010 Hajj, the mean daily presence in holy places and direct contact with ill pilgrims in the same room appeared to have no effect on the incidence of respiratory tract infections [35].

## 8. Postponement of Hajj for at-risk populations

The 2009 Hajj took place during the influenza A/H1N1 pandemic. This coincidence led the Saudi Arabian Ministry of Health to organize, in 2009, a health experts' meeting in Jeddah [37], with the participation of consultants from global public health agencies. This consultation resulted in several practical recommendations for reducing the pandemic's effects during the Hajj [37,38]. Among several recommendations, one of the most challenging was to ask the population groups considered to be at high risk of complications from influenza (pregnant women, people with underlying comorbidities, people older than 65 years and children younger than 12 years) to voluntarily refrain from participating in the 2009 Hajj. An assessment of compliance with these recommendations among French pilgrims actually participating in the 2009 Hajj showed that at least one risk factor for complications from H1N1 virus infection was present in 49.5% of them [39]. In 2013, because of concerns over the Middle East respiratory syndrome coronavirus (MERS-CoV) with the KSA identified as the epicenter of the outbreak, the WHO published the 2013 Hajj requirement [19] in which the Saudi Ministry of Health recommended that elderly people (older than 65 years); those with chronic diseases (such as heart disease, kidney disease, respiratory disease, and diabetes); and pilgrims with immune deficiency (congenital and acquired), malignant disease, and terminal illnesses, as well as pregnant women and children (younger than 12 years), not perform the Hajj and Umrah that year [19,20]. In a recent study, at least one of these risk factors was found in one out of two French pilgrims undertaking the 2013 Hajj season [40,41]. In another study of French pilgrims recruited during their pre-travel consultation before the 2013 Hajj season, it appears that two-thirds of the participants were aware of the MERS-CoV situation in Saudi Arabia, and one-third were aware of the Saudi recommendation for all individuals in these high-risk groups to postpone their participation in the 2013 Hajj; however, none of them decided to cancel their participation, even after this advice was given [41].



## 9. Discussion

Many non-pharmaceutical interventions are worth implementing on their own merit, even if the evidence for their effectiveness for preventing respiratory infectious diseases during the Hajj is sometimes weak and has rarely been studied in large populations. It is often difficult to assess the effect of one intervention independently from other interventions or other factors in infection control, such as environmental hygiene, crowding and education. Moreover, most studies used different clinical criteria for evaluating the prevalence of respiratory symptoms in pilgrims during the Hajj and were conducted in different settings, including hospitals and airports, with possible bias in the inclusion process. Additionally, some of these studies were performed among small numbers of pilgrims and cannot be extrapolated. Because compliance with these preventive measures appears to be highly variable from one study to another, studying heterogeneous populations of pilgrims in different settings as well as the use of different methods may limit the ability to identify effective measures. Future large-scale prospective intervention studies should be designed to accurately estimate the effectiveness of and adherence to each measure in preventing respiratory tract infections during the Hajj.

At this time, the improvement of face mask use among pilgrims is a major challenge. In fact, there appears to be a discrepancy between willingness, perceived compliance and actual compliance of pilgrims with respect to face mask use. While several studies showed that face mask use is highly accepted by pilgrims providing that educational intervention is implemented, such intervention is impractical in the context of the Hajj. Various reasons may partially explain the low compliance of face mask usage. First, the stifling heat (in Mecca during October, the average temperature is  $>38^{\circ}\text{C}$  during the day and  $>25^{\circ}\text{C}$  at night) makes conditions worse and the continuous wearing of masks more difficult to achieve, especially for elderly pilgrims. In addition, pilgrims must carry out the ritual washing (which involves washing the face with water) before each of the five obligatory prayers, forcing them to remove their masks several times per day. Finally, due to the overcrowded conditions in the tent camps where pilgrims spend most of their time during the 5-day period of the Hajj, they are encouraged to take minimum personal belongings with them in a small bag, making it much more difficult for them to transport a large number of disposable face masks. However, in addition to compliance, an important issue is whether masks are being worn correctly by the pilgrims. The effectiveness of face masks in preventing the transmission of influenza and ARIs is dependent on various factors, including setting and compliance. Thus, the role of face mask use has been advocated in a number of studies conducted in multiple settings, including health care facilities, household contacts of index case patients, and university residents. Although most studies have found that the use of masks was associated with a reduced risk of severe acute respiratory syndrome, none of the studies established a conclusive relationship between mask use and protection against influenza infection [42,43]. Moreover, metadata from these studies indicated that wearing

surgical masks did not change the frequency of laboratory-confirmed influenza [44]. As the effectiveness of face masks is likely linked to early, consistent and correct usage, we continue to recommend their use, although available studies do not provide strong evidence for their effectiveness in the prevention of the viral respiratory infection known as "Hajj cough". Some actions that may be taken to improve compliance with face mask use are the launch of recall campaigns during the Hajj to inform pilgrims of the importance of face mask and how to use it properly, and free mask distribution to pilgrims, particularly during their stay in Mina.

Despite their poor knowledge of the usefulness of hand hygiene in preventing respiratory infections, hand washing compliance of pilgrims during the Hajj is usually quite good. This finding is not surprising because in several cultures and religions, hand hygiene is not only an action aimed at body care. In Islam, the ritual purification takes the form of ablution (*Wudu*), which is, in most cases, repeated before the five daily obligatory prayers. Ablution consists of the methodical washing of the hands, mouth, nose, face, forearm, head, ears, and feet three times each with running water. The effectiveness of hand hygiene interventions varies depending on setting, context and compliance [45]. Several reviews of published work have been conducted to evaluate the effect of hand hygiene in preventing respiratory tract infections, especially in the health care setting [46–48]. Available evidence suggests that hand hygiene might help reduce the transmission of a range of important nosocomial pathogens [47] and acute respiratory tract infections [45]. However, hygienic hand disinfection has better efficacy than hand washing [47,49]. During their stay in Mina, pilgrims live in crowded tent camps where the water and sanitation that are available outside the tents are to be used collectively. Frequent hand washing outside the ritual context of ablution may be difficult in these conditions. Additionally, during a few days of the Hajj, when pilgrims are in the state of "Ihram" (a sacred state that pilgrims must enter to perform the pilgrimage), they are not allowed to use scented soap, and although unscented soap may be available, pilgrims most commonly wash their hands only with water. Alcohol-based hand rubs may be better than traditional hand washing, as they require less time, act more rapidly, and contribute to sustained improvement in compliance associated with decreased infection rates [47,49]. Therefore, as alcohol is permitted as a medicinal agent within Islam [50,51], the implementation of effective hand hygiene practices focusing on the regular use of alcohol-based hand rubs is recommended. Promotion of hand hygiene among pilgrims attending the Hajj should continue as a preventive measure against both respiratory and diarrheal diseases [52].

Both social distancing and contact avoidance may reduce the transmission of respiratory tract infections; however, these recommendations cannot be assiduously implemented in the context of the Hajj given the extremely high density to which pilgrims are exposed when performing the Hajj rituals. In particular, there is a very dense crowd when performing the *Tawaf* in the Grand Mosque, with up to eight pilgrims per square meter near the Kaaba [53,54]. Moreover, pilgrims are accommodated in tents during the 5-day Hajj, living in close contact with others (some with up

to 50–100 people per tent) in the pilgrims' camp in Mina outside the holy city of Mecca.

The recommendation for pilgrims in high-risk groups to postpone their plans to perform the Hajj and Umrah should be maintained, as postponement is an effective measure to protect these individuals from the risk of respiratory tract infections during the stay; however, we do not believe that this recommendation will be followed by pilgrims with the intention to perform the Hajj. In fact, the Hajj is the religious high point of a Muslim's life and is usually performed once in a lifetime. Due to financial constraints, it is often planned years in advance. Therefore, particularly considering the advanced age of most pilgrims, it must be a very difficult decision for them to voluntarily cancel or postpone their plans to perform the Hajj.

Pending further rigorous scientific evidence on effectiveness, it is important for local, national and international health agencies and those providing health care services and advice to pilgrims to work with communities using effective communication strategies, before and during the pilgrimage, to increase awareness of the health hazards during the Hajj. In the context of the Hajj, health risk perception is very likely influenced by cultural and religious beliefs. To be successful in this role, health agencies must work in partnership with community leaders, travel agents and imams by spreading awareness, especially through educational campaigns, among pilgrims about these measures and discouraging those at high risk from attending Hajj.

Respiratory diseases continue to be a major concern during the Hajj. It is expected that public health research projects developed through international collaboration will provide key information about the dynamics of infectious diseases spread during the Hajj and the implications for their global spread. Some large cohort studies on the risk of acquiring pathogens during the Hajj are ongoing among multinational samples of pilgrims. The roles of host (e.g., age, underlying chronic diseases, vaccination status) and environmental factors in pathogen transmission will also be addressed. Interventional studies assessing the effectiveness of non-pharmaceutical individual measures in preventing the spread of respiratory infectious diseases will be conducted. In particular, large randomized controlled trials on face mask use will be conducted among cohorts of pilgrims from several countries [44]. It is expected that the results of these studies will lead to the implementation of evidence-based recommendations on preventive measures such as face mask use, hand hygiene and other individual measures for pilgrims participating in the Hajj in the next years. Investigations exploring the link between communication and behavior will also be conducted to provide the evidence base for the adoption of effective approaches to improving communication with pilgrims and to better meet the needs of diverse communities.

The recently established Global Centre for Mass Gathering Medicine, in partnership and collaboration with other WHO collaborating centers and between states, international organizations and scientific centers, with the aim of sharing experience and knowledge through global health diplomacy will therefore play a central role in achieving these goals [55].

Thus, it is hoped that this review will help relevant authorities in providing recommendations for prevention of respiratory infectious diseases during the Hajj, particularly for prevention of MERS-CoV transmission [56].

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## Conflict of interest

The authors have no conflicts of interest to declare.

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