

Detection of Respiratory Viruses Among Pilgrims in Saudi Arabia During the Time of a Declared Influenza A(H1N1) Pandemic

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Background. The objectives of this study were to determine whether pilgrim attendance at the Hajj was associated with an increased risk of acquiring influenza, and other respiratory viruses, and to evaluate the compliance of pilgrims with influenza vaccination and other recommended preventive measures.

Methods. A cross-sectional survey was conducted among pilgrims as they arrived at the King Abdulaziz International Airport in Jeddah for the 2009 Hajj and as they departed from the same airport during the week after the Hajj. Nasopharyngeal and throat swabs were tested for 18 respiratory virus types and subtypes using the xTAG Respiratory Viral Panel FAST assay.

Results. A total of 519 arriving pilgrims and 2,699 departing pilgrims were examined. Their mean age was 49 years and 58% were male. In all, 30% of pilgrims stated that they had received pandemic influenza A(H1N1) vaccine before leaving for the Hajj and 35% of arriving pilgrims reported wearing a face mask. Only 50% of arriving pilgrims were aware of preventive measures such as hand hygiene and wearing a mask. The prevalence of any respiratory-virus infection was 14.5% (12.5% among arriving pilgrims and 14.8% among departing pilgrims). The main viruses detected (both groups combined) were rhinovirus-enterovirus ($N = 414$, 12.9%), coronaviruses ($N = 27$, 0.8%), respiratory syncytial virus ($N = 8$, 0.2%), and influenza A virus ($N = 8$, 0.2%) including pandemic influenza A(H1N1) ($N = 3$, 0.1%). The prevalence of pandemic influenza A(H1N1) was 0.2% ($N = 1$) among arriving pilgrims and 0.1% ($N = 2$) among departing pilgrims. The prevalence of any respiratory virus infection was lower among those who said they received H1N1 vaccine compared to those who said they did not receive it (11.8% vs 15.6%, respectively, $p = 0.009$).

Conclusion. We found very low pandemic influenza A(H1N1) prevalence among arriving pilgrims and no evidence that amplification of transmission had occurred among departing pilgrims.

Hajj, the pilgrimage to the holy city of Makkah, is the largest annual gathering of its kind in the world. It brings more than 2 million pilgrims from 160 countries together in a small, geographically confined area.¹ Most of the pilgrims stay in large air-conditioned tents (in Mina and Arafat) during the whole period of Hajj. It is not unusual for 50–100 people to share a tent overnight.² This extreme crowding and continuous close contact greatly increases the risk of spreading infectious diseases, particularly those caused

by respiratory viruses.^{3–5} Acute respiratory infections are very common and are responsible for more than half of admissions to Saudi hospitals during Hajj.⁶ Respiratory viruses, especially influenza virus, are the main cause of acute respiratory infection during the Hajj.^{7,8} Respiratory specimens have been positive for viral pathogens in 10%–20% of pilgrims with upper respiratory tract infections.^{7,8}

Viral pandemics confront Saudi health authorities with extraordinary public health challenges to minimize spread among pilgrims. The emergence of pandemic influenza A(H1N1) a few months before the 2009 Hajj season was the most recent of these pandemics.⁹ The lack of an available, effective, and publicly acceptable vaccine in time was just one of the challenges.¹⁰ Restricting age groups at higher risk of complications

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from attending Hajj activities, as happened for the 2009 Hajj because of the H1N1 influenza threat,¹⁰ or even applying a ban on individuals from certain countries during the maximum incubation period as happened with severe acute respiratory syndrome (SARS),¹¹ was considered at length, though not fully implemented, and may be imperative for a future Hajj or other mass gathering events to combat future epidemics. This study was conducted to better document whether the several recommendations that were put into practice before the launch of 2009 Hajj season¹⁰ were effective in reducing the spread of pandemic influenza A(H1N1) and other viruses among pilgrims. The study's primary objective was to determine whether pilgrim attendance at Hajj venues increased risk of acquiring influenza (or other respiratory viruses). An additional objective was to assess compliance with influenza immunization and other recommended preventive measures.

Methods

Population

Our study uses data collected from pilgrims participating in the 2009 (1430H) Hajj. The main religious activities of the 2009 Hajj season started on November 25, 2009 and continued for 5–6 days, according to each pilgrim's plan. The 2009 Hajj, similar to the Hajj in other years, included Muslims from all over the world, was one of the world's largest yearly mass gatherings, and was culturally very diverse, including males and females of different ages, races, educational levels, and socioeconomic levels.

Study Design

Two cross-sectional surveys were conducted at the King Abdulaziz International Airport in Jeddah. It is the main airport used by pilgrims and the Hajj terminal is only used by pilgrims. The first survey was conducted during the week before Hajj activities began on November 25, 2009. As the survey was conducted during a declared influenza A(H1N1) pandemic, all pilgrims arriving at the King Khalid international Hajj terminal were screened by thermal cameras and questioned about flu symptoms. This was documented in the incoming survey, and results were included in the final analysis; however, departing pilgrims were not questioned about flu symptoms. The primary sampling units were incoming flights. It proved impractical to select flights by probability sampling; instead, survey teams, after finishing one flight, generally selected the next arriving flight. After deplaning, pilgrims waited in an arrival room (a separate one for each flight) before immigration formalities began, grouped around rows of seats. Interviewers randomly selected a row, a person around the row, and a clockwise or counterclockwise direction, and then interviewed pilgrims successively until the room cleared. In the departure study, primary sampling units were groups of pilgrims arriving together

at the departure area. Survey teams worked with as many arriving groups as possible, interviewing and swabbing as many pilgrims as possible in each group after they passed through immigration.

In each survey, pilgrims were asked for their consent to participate. A nasopharyngeal and throat swab were obtained after the interview.

Data Collection

The questionnaire in the arrival survey included questions about pilgrims' demographics (age, gender, occupation, and nationality), medical history (chronic disease and smoking), vaccination history (including separate questions about vaccination against pandemic influenza A(H1N1) and against seasonal influenza), knowledge about H1N1 influenza (symptoms, transmission, and ways to avoid), and compliance with wearing face masks. The questionnaire used in the departure survey included only questions about age, gender, and pandemic influenza A(H1N1) vaccination history.

Laboratory Methods

Respiratory specimens were placed in viral transport media (VTM) at the point of collection and transported to Jeddah Regional Laboratory where they were stored at -80°C before testing. Specimens selected for analysis were thawed and subjected to total nucleic acid extraction using Corbett X-tractor Gene (Qiagen, Hilden, Germany) and RNA DNA CorProtocol 25101 (Qiagen). Extracts were then tested using the xTAG Respiratory Viral Panel (RVP) FAST assay (Luminex Molecular Diagnostics Inc., Toronto, Canada) per manufacturer's instructions. The xTAG RVP FAST is a qualitative multiplex amplification assay allowing the simultaneous detection of multiple viral nucleic acid targets. In addition to influenza A and B, this test can detect respiratory syncytial virus, parainfluenza virus 1, 2, 3, and 4; rhinovirus, adenovirus, and minor respiratory viruses: coronaviruses, metapneumovirus, and bocavirus.

Amplification of specific matrix target was used to detect influenza A and B. Seasonal influenza H1 and H3 subtypes were detected after amplification with hemagglutinin-specific primers and probes.

Specimens positive for influenza A but negative for seasonal H1 and H3 were subjected to additional PCR amplification to detect pandemic H1 and avian H5 (Qiagen Artus Influenza/H1 RG/LC for H1N1 and TIB MOLBIOL, LightMix kit, Berlin, Germany for H5N1).

Data Analysis

Demographics, medical history, vaccination history, knowledge of H1N1 influenza, and compliance with infection control practices among arriving pilgrims were analyzed as frequency distributions. Differences in the prevalence of respiratory viruses between the arriving and departing pilgrims were examined using chi-square test or Fisher exact, as appropriate. Differences in the prevalence of respiratory viruses between potential

Table 1 Demographic characteristics and history of pandemic H1N1 vaccination among pilgrims arriving for the 2009 Hajj and departing from 2009 Hajj, King Abdulaziz International Airport, Jeddah

	Arrival survey	Departure survey	Total	<i>p</i> Value
Age (mean ± SD)	44.7 ± 13.9	50.0 ± 13.4	49.4 ± 13.5	<0.001
Age group				
13–40	142 (41.3%)	720 (26.5%)	862 (28.2%)	<0.001
41–60	163 (47.4%)	1333 (49.1%)	1496 (48.9%)	
61–94	39 (11.3%)	661 (24.4%)	700 (22.9%)	
Total	344 (100.0%)	2714 (100.0%)	3058 (100.0%)	
Gender				
Male	282 (75.4%)	1414 (55.9%)	1696 (58.4%)	<0.001
Female	92 (24.6%)	1114 (44.1%)	1206 (41.6%)	
Total	374 (100.0%)	2528 (100.0%)	2902 (100.0%)	
H1N1 vaccination				
No	230 (61.2%)	1959 (71.1%)	2189 (69.9%)	<0.001
Yes	146 (38.8%)	798 (28.9%)	944 (30.1%)	
Total	376 (100.0%)	2757 (100.0%)	3133 (100.0%)	

SD = standard deviation.

confounding groups such as age groups and getting pandemic influenza A(H1N1) vaccine were examined using chi-square test or Fisher exact, as appropriate. All *p* values were two-tailed. *p* Value <0.05 was considered as significant. SPSS (release 17.0, SPSS Inc., Chicago, IL, USA) software was used for all statistical analyses.

Results

A total of 782 arriving pilgrims were examined before the 2009 Hajj season with 432 questionnaires filled and 519 nasal and throat swabs examined. A total of 2,768 pilgrims were examined after the 2009 Hajj season with 2,730 questionnaires filled and 2,699 nasal and throat swabs examined. Table 1 shows the demographic and clinical characteristics of arriving and departing pilgrims in the survey samples. The mean age of the two groups combined was 49.4 years (SD ± 13.5 y). The mean age of pilgrims in the arrival survey (44.7 y) was significantly less than among pilgrims in the departure survey. Those aged >60 years represented 24% of the samples of arriving pilgrims and 11% of the sample of departing pilgrims. The majority of pilgrims were male (58%); this proportion was higher among arriving pilgrims (75%) than among departing pilgrims (56%). Arriving pilgrims were mainly (63%) Middle Eastern (including 10% Saudi); 37% were Asian or African.

Table 2 shows that the majority of arriving pilgrims described their health as excellent (49%) or at least very good (33%). Only 13% stated they had a chronic disease, namely hypertension, diabetes, heart disease, or asthma. None of the pre-Hajj population was a current smoker and the majority (85%) stated they had never smoked.

Table 2 also shows the vaccination status of arriving pilgrims. The majority (84%) stated that they had received at least one vaccine before the Hajj. Coverage for meningococcal and seasonal influenza vaccine in both groups combined was relatively high (73% and

53%, respectively), but coverage for pandemic influenza A(H1N1) vaccine was considerably lower (30%). The reasons reported for not getting the seasonal influenza vaccine in the past year were lack of knowledge about the vaccine (41%), did not know it was required (20%), did not know where to get it (15%), felt healthy and was not worried about influenza (14%), and did not think influenza is a serious illness (9%). In all, 35% of arriving pilgrims reported wearing a face mask. Although meningococcal vaccination is a Hajj requirement for all pilgrims arriving into the Kingdom of Saudi Arabia (KSA), unfortunately compliance with this requirement is not 100%. The government of KSA does not send back pilgrims who are found not to be vaccinated; instead they are administered prophylactic antibiotics and allowed to complete the Hajj ritual.

Table 3 shows the knowledge of H1N1 among arriving pilgrims. The majority of pilgrims believed that H1N1 is a serious disease (76%). However, they were roughly split in expressing their worry about catching pandemic influenza A(H1N1) during Hajj, with 47% worried and 53% not worried. More than half (56%) of pilgrims were aware of fever as a main symptom of H1N1 influenza. However, not more than a quarter were aware that sore throat (26%), cough (24%), and headache (22%) were also main symptoms of H1N1 influenza. Only a few pilgrims (12%–15%) were aware that symptoms such as troubled breathing, muscle or joint pain, and gastrointestinal symptoms could be symptoms of H1N1 influenza. The main sources or vehicles of H1N1 transmission recognized by pilgrims were people with H1N1 (43%), air (39%), contaminated patient objects (25%), and poor hygiene (16%). Very few pilgrims (1%–3%) answered that animals, water, or food could be potential sources or vehicles of H1N1 transmission. The main ways to avoid H1N1 infection, as described by pilgrims, were hand hygiene (48%), wearing a mask (45%), using a hand sanitizer (29%), staying away from sick people (28%), covering the

Table 2 Health and vaccination status and reasons for not having received seasonal influenza vaccine, pilgrims arriving for the Hajj at the King Abdulaziz International Airport, Jeddah, 2009

Variables	N (%)
Own description of general health	
Excellent	168 (49.1)
Very good	111 (32.5)
Good	52 (15.2)
Fair	9 (2.6)
Poor	2 (0.6)
Getting sick during travel or Hajj	
Yes	11 (3.8)
No	282 (96.2)
Total	293 (100.0)
Chronic diseases	
Yes	57 (13.2)
No	375 (86.8)
Total	432 (100.0)
Smoking status	
Current	0 (0.0)
Previous	65 (15.0)
Never	367 (85.0)
Getting any vaccines before Hajj	
Meningococcal	253 (75.3)
Seasonal flu	179 (53.3)
H1N1	146 (38.8)
Tetanus toxoid	11 (3.3)
Any shots	315 (83.8)
Wearing a mask	106 (35.1)
Getting seasonal influenza vaccine in the past year	201 (61.3)
Reasons for not getting seasonal influenza vaccine in the past year?	
I don't know	52 (40.9)
I didn't know if I needed a flu shot	25 (19.7)
I don't know where to get a flu shot	19 (15.0)
I am healthy/not worried about flu	18 (14.2)
Influenza/flu is not a serious illness	11 (8.7)
I was afraid I would get sick/have side effects	7 (5.5)
I don't believe in vaccination	7 (5.5)
I hate needles/getting shots	5 (3.9)
Not much you can do to keep from getting flu	2 (1.6)
Flu shot won't keep me from getting the flu	2 (1.6)
I don't have health insurance	1 (0.8)
Flu shot is too expensive	1 (0.8)

mouth when coughing or sneezing (21%), and avoiding crowds or public gatherings (18%). Only 6% of pilgrims thought that H1N1 vaccine could keep them from getting H1N1 infection.

A total of 3,218 swabs obtained from pilgrims just before and after the Hajj were tested for influenza A and B; respiratory syncytial virus; parainfluenza virus 1, 2, 3, and 4; rhino-enterovirus; adenovirus; and three additional respiratory agents: corona, metapneumo, and bocavirus (Table 4).

The overall prevalence of any respiratory virus was 14.5% (465/3,218). The main viruses detected were rhino-enteroviruses ($N = 414$, 12.9%), coronaviruses ($N = 27$, 0.8%), respiratory syncytial virus ($N = 8$, 0.2%), and influenza A virus ($N = 8$, 0.2%) including

Table 3 Knowledge about pandemic H1N1 among pilgrims arriving for the Hajj at the King Abdulaziz International Airport, Jeddah, 2009

Variables	N (%)
Do you think H1N1 influenza is a serious disease?	
Serious	206 (75.5)
Not serious	67 (24.5)
How worried are you about catching H1N1 influenza during Hajj?	
Worried	146 (46.9)
Not worried	165 (53.1)
Symptoms of H1N1 influenza	
Fever	242 (56.0)
Sore throat	114 (26.4)
Cough	103 (23.8)
Headache	95 (22.0)
Trouble breathing	66 (15.3)
Tiredness	57 (13.2)
Diarrhea	57 (13.2)
Muscle/joint pain	55 (12.7)
Nausea/vomiting	52 (12.0)
Congestion/stuffy nose	49 (11.3)
Chills	36 (8.3)
Pneumonia	29 (6.7)
Vehicles/sources of H1N1 infection	
People with H1N1	185 (42.8)
Air	170 (39.4)
Contaminated patient objects	107 (24.8)
Dirty/poor hygiene	70 (16.2)
Animals	13 (3.0)
Water	11 (2.5)
Food	8 (1.9)
Soil	7 (1.6)
Ways to avoid H1N1 infection	
Frequent washing of hands	208 (48.1)
Wearing a mask	193 (44.7)
Using hand sanitizer	123 (28.5)
Staying away from sick people	121 (28.0)
Covering own cough/sneeze	89 (20.6)
Avoiding crowds/public gatherings	79 (18.3)
Using antibiotics/medicine	43 (10.0)
Checking with a doctor/nurse	41 (9.5)
Don't know/not sure	25 (5.8)
Staying home from work/school	24 (5.6)
Taking H1N1 vaccine	24 (5.6)
Taking vitamins/herbs/natural remedies	23 (5.3)
Nothing can be preventive	3 (0.7)

pandemic influenza A(H1N1) ($N = 3$, 0.1%). Although coronaviruses (1.0% vs 0.2%) and respiratory syncytial virus (0.3% vs 0.0%) were slightly more prevalent among departing pilgrims than among arriving pilgrims, none of these viruses or other detected viruses was significantly more prevalent in one group than the other.

Figure 1 shows the prevalence rate of any respiratory virus infection by age group, gender, and H1N1-vaccination status. The prevalence of respiratory viruses was slightly but not significantly higher among those >60 years old and ≤40 years old compared to those 41–60 years old (who made up half of the survey

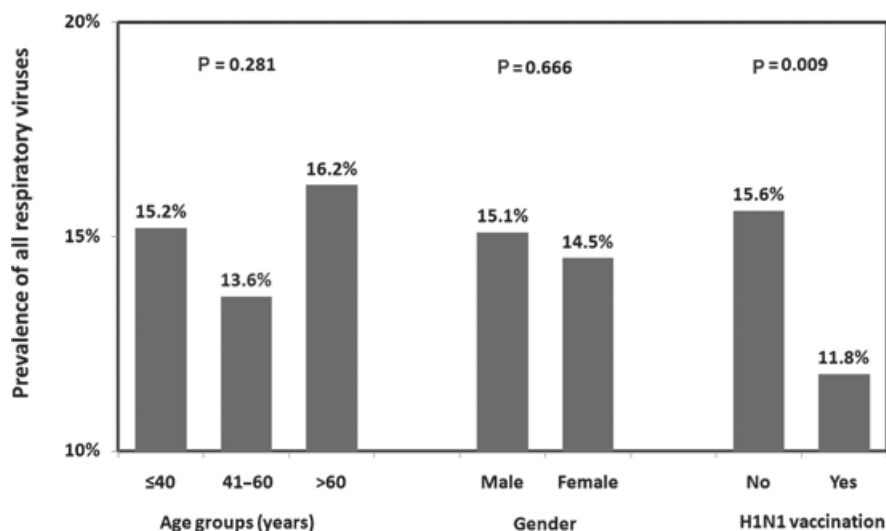


Figure 1 Prevalence of any respiratory virus infection by age group, sex, and vaccination history, arriving and departing pilgrims combined, King Abdulaziz International Airport, Jeddah, 2009.

samples). The prevalence of respiratory viruses was similar in both males and females (15.1% vs 14.5%, respectively) but lower among those who stated they got H1N1 vaccine compared to those who stated they did not (11.8% vs 15.6%, respectively, $p = 0.009$).

Discussion

At least one respiratory virus was detected in 14.5% of respiratory specimens from more than 3,200 pilgrims

(Table 4). The overall detection of respiratory viruses is comparable to or lower than that found in previous studies performed among pilgrims with upper respiratory symptoms.^{7,8,12,13} Using different laboratory methods, 10%–32% of the pilgrims in these studies were found to be infected with a respiratory virus.

Only three (0.1%) pilgrims were positive for pandemic influenza A(H1N1). This very low prevalence during the H1N1 2009 pandemic year was unexpected, especially in light of the expected high number of H1N1

Table 4 Prevalence of 18 respiratory viruses among pilgrims arriving for the Hajj and departing after the Hajj at the King Abdulaziz International Airport, Jeddah, 2009

	Arriving pilgrims, N (%)	Departing pilgrims N (%)	Total (%)	p Value
Influenza A	1 (0.2)	7 (0.3)	8 (0.2)	>0.90
H1N1	1 (0.2)	2 (0.1)	3 (0.1)	0.410
Influenza B	0 (0.0)	2 (0.1)	2 (0.1)	>0.90
Respiratory syncytial virus	0 (0.0)	8 (0.3)	8 (0.2)	0.369
Coronavirus 229E	0 (0.0)	6 (0.2)	6 (0.2)	0.598
Coronavirus HKU1	0 (0.0)	2 (0.1)	2 (0.1)	>0.90
Coronavirus NL63	1 (0.2)	2 (0.1)	3 (0.1)	0.410
Coronavirus OC43	0 (0.0)	16 (0.6)	16 (0.5)	0.092
All coronaviruses	1 (0.2)	26 (1.0)	27 (0.8)	0.110
Parainfluenza 1	0 (0.0)	0 (0.0)	0 (0.0)	—
Parainfluenza 2	0 (0.0)	0 (0.0)	0 (0.0)	—
Parainfluenza 3	0 (0.0)	1 (0.0)	1 (0.0)	>0.90
Parainfluenza 4	0 (0.0)	0 (0.0)	0 (0.0)	—
All parainfluenza viruses	0 (0.0)	1 (0.0)	1 (0.0)	>0.90
Enterovirus	63 (12.1)	351 (13.0)	414 (12.9)	0.589*
Metapneumovirus	0 (0.0)	3 (0.1)	3 (0.1)	>0.90
Adenovirus	0 (0.0)	1 (0.0)	1 (0.0)	>0.90
Human bocavirus	0 (0.0)	1 (0.0)	1 (0.0)	>0.90
All types of viruses				
One virus	65 (12.5)	394 (14.6)	459 (14.3)	0.344*
Two viruses	0 (0.0)	3 (0.1)	3 (0.1)	0.194
Any virus	65 (12.5)	400 (14.8)	465 (14.5)	0.780*

*Chi-square.

cases among elderly pilgrims attending the 2009 Hajj season.¹⁴ Nevertheless, and in support of the current finding, the Saudi Ministry of Health reported <100 pandemic influenza A(H1N1) cases and five pandemic influenza A(H1N1) deaths among more than 2 million pilgrims during the 2009 Hajj season.¹⁵ It has been suggested that the low burden of reported pandemic A(H1N1) disease but relatively high case fatality rate among 2009 pilgrims may be explained by the tendency of symptomatic H1N1 pilgrims to defer contact with the health care system until worsening of the symptoms to avoid disrupting their Hajj commitment.^{15,16} Another possible explanation for the very low incidence of H1N1 could be the origin of the majority of pilgrims where at the time of the Hajj, H1N1 had not yet become a problem. Rhinovirus-enterovirus was the most prevalent virus detected (13%) among pilgrims of this study. Similarly, it was the main virus detected among UK pilgrims (13%)¹² and was one of the main viruses detected among Iranian pilgrims (6%) in previous years.¹³ Rhinovirus-enterovirus is observed worldwide and is the primary cause of common colds.^{17,18}

Similar to the whole study sample, pandemic influenza A(H1N1) prevalence among departing pilgrims was very low (0.1%). Given the 1–4-day incubation period of influenza viruses and the 5-day duration of Hajj activities, this finding may indicate a low transmission of H1N1 influenza during the 2009 Hajj season. This could be because of any number of reasons including the liberal use of specific influenza antiviral without testing and the aggressive campaign by the Saudi Ministry of Health to use protective measures including wearing face masks, avoiding crowds when possible, and using respiratory etiquette.¹⁰ The voluntary cancellation of Hajj plans by individuals with extreme age, chronic disease, or immunosuppression and by pregnant women, as recommended by the Saudi authorities,¹⁹ may have limited the spread of H1N1 influenza virus by breaking the chain of infection at its weakest point. Additionally, it was suggested that the traditionally large proportion of older pilgrims (>50 y old, representing half the pilgrims in our surveys), who are relatively at lower risk of catching pandemic influenza A(H1N1) compared to younger persons, may have contributed to the low number of H1N1 cases recorded during the 2009 Hajj season.²⁰

Despite the strong recommendation of getting pandemic influenza A(H1N1) vaccines,¹⁹ only 30% of the pilgrims in this study were able to get the vaccine before Hajj. This could be explained by the fact that pandemic influenza A(H1N1) vaccine was not available in many Islamic countries or at most available only a short time before the departure of pilgrims from their home countries. About 10% of pilgrims come from the world's most resource-limited countries where access to H1N1 vaccine is extremely limited.²¹ Additionally, the reported suboptimal acceptance of H1N1 influenza vaccine may have contributed to such lower vaccination coverage.²² Actually, very few pilgrims in this study thought of

pandemic influenza A(H1N1) vaccine as a protective measure to avoid H1N1 infection compared with hand hygiene and wearing a mask. The observed association of H1N1 influenza vaccine with a lower prevalence rate of infection with any respiratory virus may simply be a marker for pilgrims who are more health conscious and perhaps use other preventive measures more frequently rather than due to the effect of H1N1 influenza vaccine on the acquisition of rhinovirus-enterovirus or coronaviruses.

Although the majority of pilgrims in this study believed that H1N1 is a serious disease, only one fourth were aware of symptoms such as sore throat or cough and less than half were aware of preventive measures such as hand hygiene and wearing a mask. The proportion of pilgrims using a face mask in this study was comparable to that of previous studies recruiting pilgrims from different nationalities^{23,24} but lower than among French and Malaysian pilgrims.^{20,25} It is interesting that some Muslims wrongly believe that covering the face (with a mask) during the Hajj is religiously prohibited. The low level of knowledge about H1N1 symptoms and preventive measures as well as the underutilization of face masks may point to suboptimal education of pilgrims before the Hajj.

Our study has many strengths, such as the large number of respiratory viruses we tested for, and the large sample size, among typically healthy pilgrims with or without upper respiratory symptoms (to encompass pilgrims who are incubating or just recovering from a viral upper respiratory infection), in the midst of a declared pandemic influenza A(H1N1) in a very crowded setting. Nevertheless, we acknowledge the inability to recruit the same pilgrims before and after the Hajj, and sound recruitment strategies were not feasible under the circumstances, which limited our ability to further study viral acquisition during the Hajj. In addition, it needs to be highlighted that this study was not intended to be a vaccine efficacy study, so any conclusions about protective effects of the H1N1 vaccine need to be taken with caution.

In conclusion, we found low pandemic influenza A(H1N1) influenza infection prevalence among a group of fairly healthy pilgrims in the midst of the H1N1 pandemic. Overrepresentation of influenza low-risk groups rather than H1N1 vaccination may have contributed to the observed low H1N1 prevalence.

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Declaration of Interests

The authors state that they have no conflicts of interest to declare.

References

1. Memish ZA, Venkatesh S, Ahmed QA. Travel epidemiology: the Saudi perspective. *Int J Antimicrob Agents* 2003; 21:96–101.
2. Gatrads AR, Shafi S, Memish ZA, Sheikh A. Hajj and the risk of influenza. *BMJ* 2006; 333:1182–1183.
3. Ahmed QA, Arabi YM, Memish ZA. Health risks at the Hajj. *Lancet* 2006; 367:1008–1015.
4. Memish ZA, Ahmed QAA. Mecca bound: the challenges ahead. *J Travel Med* 2002; 9:202–210.
5. Alzeer AH. Respiratory tract infection during Hajj. *Ann Thorac Med* 2009; 4:50–53.
6. Al-Ghamdi SM, Akbar HO, Qari YA, et al. Pattern of admission to hospitals during Muslim pilgrimage (Hajj). *Saudi Med J* 2003; 24:1073–1076.
7. El-Sheikh SM, El-Assouli SM, Mohammed KA, Albar M. Bacteria and viruses that cause respiratory tract infections during the pilgrimage (Haj) season in Makkah, Saudi Arabia. *Trop Med Int Health* 1998; 3:205–209.
8. Balkhy HH, Memish ZA, Bafaqeer S, Almuneef MA. Influenza a common viral infection among Hajj pilgrims: time for routine surveillance and vaccination. *J Travel Med* 2004; 11:82–86.
9. Dawood FS, Jain S, Finelli L, et al. Emergence of a novel swine-origin influenza A (H1N1) virus in humans. *N Engl J Med* 2009; 360:2605–2615.
10. Memish ZA, McNabb SJN, Mahoney F, et al. Establishment of public health security in Saudi Arabia for the 2009 Hajj in response to pandemic influenza A(H1N1). *Lancet* 2009; 374:1786–1791.
11. Madani TA. Preventive strategies to keep Saudi Arabia SARS-free. *Am J Infect Control* 2004; 32:120–121.
12. Rashid H, Shafi S, Haworth E, et al. Viral respiratory infections at the Hajj: comparison between UK and Saudi pilgrims. *Clin Microbiol Infect* 2008; 14:569–574.
13. Alborzi A, Aelami MH, Ziyaeyan M, et al. Viral etiology of acute respiratory infections among Iranian Hajj pilgrims, 2006. *J Travel Med* 2009; 16:239–242.
14. World Health Organization. The Regional Office of Eastern Mediterranean. Pandemic (H1N1) 2009. Available at: http://www.emro.who.int/csr/h1n1/h1n1_update.htm. (Accessed 2011 Apr 5)
15. Haworth E, Rashid H, Booy R. Prevention of pandemic influenza after mass gatherings—learning from Hajj. *J R Soc Med* 2010; 103:79–80.
16. Memish ZA, Ebrahim SH, Ahmed QA, et al. Pandemic H1N1 influenza at the 2009 Hajj: understanding the unexpectedly low H1N1 burden. *J R Soc Med* 2010; 103:386.
17. Mackay IM. Human rhinoviruses: the cold wars resume. *J Clin Virol* 2008; 42:297–320.
18. Hong CY, Lin RT, Tan ES, et al. Acute respiratory symptoms in adults in general practice. *Fam Pract* 2004; 21:317–323.
19. Health conditions for travellers to Saudi Arabia for the pilgrimage to Mecca (Hajj). *Wkly Epidemiol Rec* 2009; 84:477–480.
20. Gautret P, Vu Hai V, Sani S, et al. Protective measures against acute respiratory symptoms in French pilgrims participating in the Hajj of 2009. *J Travel Med* 2010; 18:53–55.
21. Khan K, Memish ZA, Chhabra A, et al. Global public health implications of a mass gathering in Mecca, Saudi Arabia during the midst of an influenza pandemic. *J Travel Med* 2010; 17:75–81.
22. Ahmed GY, Balkhy HH, Bafaqeer S, et al. Acceptance and adverse effects of H1N1 vaccinations among a cohort of national guard health care workers during the 2009 Hajj season. *BMC Res Notes* 2011; 4:61.
23. Choudhry AJ, Al-Mudaimigh KS, Turkistani AM, Al-Hamdan NA. Hajj-associated acute respiratory infection among Hajjis from Riyadh. *East Mediterr Health J* 2006; 12:300–309.
24. Khamis NK. Epidemiological pattern of diseases and risk behaviors of pilgrims attending Mina hospitals, Hajj 1427 h (2007 g). *J Egypt Public Health Assoc* 2008; 83:15–33.
25. Deris ZZ, Hasan H, Sulaiman SA, et al. The prevalence of acute respiratory symptoms and role of protective measures among Malaysian Hajj pilgrims. *J Travel Med* 2010; 17:82–88.