

Vaccination in Hajj: An Overview of the Recent Findings

Seyed Mansour Razavi, Mina Saeednejad¹, Payman Salamati²

Department of Community Medicine, Research Center for Rational Use of Drugs, Tehran University of Medical Sciences, Tehran, Iran, ¹Faculty of Medicine, Islamic Azad University, Tehran Medical Branch, Tehran, Iran, ²Sina Trauma and Surgery Research Center, Tehran University of Medical Sciences, Tehran, Iran

Correspondence to:

Prof. Payman Salamati, Sina Trauma and Surgery Research Center, Sina Hospital, Hassan Abad Square, Imam Khomeini Avenue, Tehran, Iran.
E-mail: psalamati@tums.ac.ir

How to cite this article: Razavi SM, Saeednejad M, Salamati P. Vaccination in Hajj: An overview of the recent findings. *Int J Prev Med* 2016;7:129.

ABSTRACT

Background: About two million people annually travel to Kingdom of Saudi Arabia to perform Hajj. The pilgrims may be at risk of exposure to communicable diseases in this mass gathering and their vaccination against contagious diseases can prevent many morbidities and mortalities. The aim of our study was to review the papers which evaluated effectiveness and compliance of the vaccines applied in Hajj.

Methods: We used PubMed and Scopus to search international medical databases. The key words were as follows: Hajj, Haj, vaccine, vaccination, and immunization. The time interval of the search was from the beginning of 2010 to May 23, 2016. One hundred and thirty papers were extracted, and their contents were subsequently reviewed after title and abstract screenings. The original articles were included in the study and non-English articles were excluded from the study.

Results: Considering the extracted papers, almost all pilgrims were vaccinated against meningococcal diseases. Using of influenza and pneumococcal vaccine rates were different among the pilgrims. The other vaccines have been taking according to specific conditions.

Conclusions: The findings regarding influenza vaccine effectiveness are contradictory. A few studies confirmed the flu vaccine effectiveness while some others rejected its usefulness. Meningococcal immunization is an effective preventive tool with high compliance for Hajj pilgrims. Further investigations are recommended for the other vaccines.


Keywords: Communicable diseases, preventive medicine, travel medicine, vaccination

INTRODUCTION

About two million people annually travel to Kingdom of Saudi Arabia (KSA) to perform Hajj.^[1,2] The pilgrims are exposed to various infectious agents in this mass gathering. Considering previous research, the prevalent infectious disorders among the pilgrims are respiratory, gastrointestinal, and liver diseases.

Common infectious respiratory diseases are the common cold, influenza, exudative pharyngitis, bronchitis, sinobronchitis, sinusitis, pneumonia (viral, classic, and atypical bacteria and mycobacterial), and superimposed infections on asthma.^[3,4] The common infectious gastrointestinal and liver diseases are gastroenteritis, food poisoning, and hepatitis.^[4]

Furthermore, the responsible infectious pathogens are reported as follows:

Access this article online	
Quick Response Code: 	Website: www.ijpvmjournal.net/www.ijpm.ir
	DOI: 10.4103/2008-7802.195826

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

Respiratory pathogens

Rhinoviruses,^[3-5] coronaviruses (E229 – SARS – MERS),^[6] adenoviruses, both seasonal and pandemic influenza^[7] including, influenza A (H3N2) and B,^[3] influenza H1N1, parainfluenza viruses, respiratory syncytial viruses, herpes simplex virus,^[5,8,9] meningococcal diseases^[10] and meningococcal carrier state,^[11] emerging hypervirulent strains, i.e., *Streptococcus* spp.,^[10] *Haemophilus influenzae*,^[3] *Bordetella pertussis*,^[12] *Chlamydomphila pneumoniae*, *Legionella pneumophila*, *Mycoplasma pneumoniae*,^[3] and respiratory tuberculosis.^[13]

Gastrointestinal and liver pathogens

Food poisoning agents,^[14] *Vibrio cholerae*,^[15] Hepatitis A, E, B, and C.^[16]

The other pathogens

Brucella,^[17] arboviruses,^[6] phlebovirus (the cause of rift valley fever),^[18] hemorrhagic viruses (Ebola),^[19] and *Enterobacillus*^[3] [Table 1].

Based on the above findings, the greatest risk of infections is related to respiratory and gastrointestinal systems, and some effective vaccines against infections of these two systems are available now.

There are different ideas among Hajj researchers about which vaccines should administer to Hajj pilgrims before their departure to KSA. Hence, the aim of our study was

to review the papers which evaluated effectiveness and compliance of the vaccines applied in the Hajj published through the recent years.

METHODS

We used PubMed and Scopus to search international medical databases. The keywords were as follows: Hajj, Haj, vaccine, vaccination, and immunization. The time interval of the search was from the beginning of 2010 to May 23, 2016. The main reason for choosing this period was reviewing only new findings. After removing duplicated records, one hundred and thirty papers were selected, and their contents were subsequently reviewed through title and abstract screenings. The flow diagram of our search steps was presented in Figure 1. All original articles which had evaluated effectiveness or compliance of the vaccines administered in the Hajj were included in the study and non-English articles were excluded from the study. Considering our objectives to discuss the common vaccines which administered to pilgrims and since there is other under review vaccines which most Hajj researchers do not agree with their usages, we excluded the papers of the vaccines which were evaluated only in one paper. Two review authors extracted data independently from each study regarding authors, type of vaccine, published year, journal, type of study, location of study, pilgrims'

Table 1: Hajj common infectious pathogens reported by the researchers

Category	Pathogen/s	Author/s	Number of reference
Respiratory system	Rhinoviruses	Alborzi	[5]
	Coronaviruses (E229 – SARS – MERS)	Al-Tawfiq	[6]
	Influenza A (H3N2)	Razavi	[3]
	Influenza B		
	Influenza H1N1	Alborzi,	[5,8,9]
	Parainfluenza viruses	Balkhy,	
	Respiratory syncytial viruses	Ashshi	
	Herpes simplex virus		
	Meningococcal carrier state	Karsany	[11]
	<i>Streptococcus</i> spp.	Razavi	[3]
	<i>Haemophilus influenzae</i>		
	<i>Bordetella pertussis</i>	Wilder-Smith	[12]
	<i>Chlamydomphila pneumoniae</i>	Razavi	[3]
	<i>Legionella pneumophila</i>		
<i>Mycoplasma pneumoniae</i>			
Respiratory tuberculosis	Wilder-Smith	[13]	
Gastrointestinal and liver pathogens	Food poisoning agents	Al-Mazrou	[14]
	<i>Vibrio cholerae</i>	Gautret	[15]
	Hepatitis A, E, B, C	Rafiq	[16]
	<i>Enterobacillus</i>	Razavi	[3]
	<i>Brucella</i>	Memish	[17]
The other pathogens	Arboviruses	Al-Tawfiq	[6]
	Phlebovirus (the cause of Rift Valley fever)	Fagbo	[18]
	Hemorrhagic viruses (Ebola)	Al-Tawfiq	[19]

nationality, and a number of participants [Tables 2 and 3]. In the next step, the highlighted points were synthesized according to the objectives of our research. No further assessment was performed regarding the quality of the reviewed manuscripts, and the credit of journals was considered sufficient.

RESULTS

Eleven articles on pneumococcal, meningococcal, and influenza vaccines met our criteria. The studies

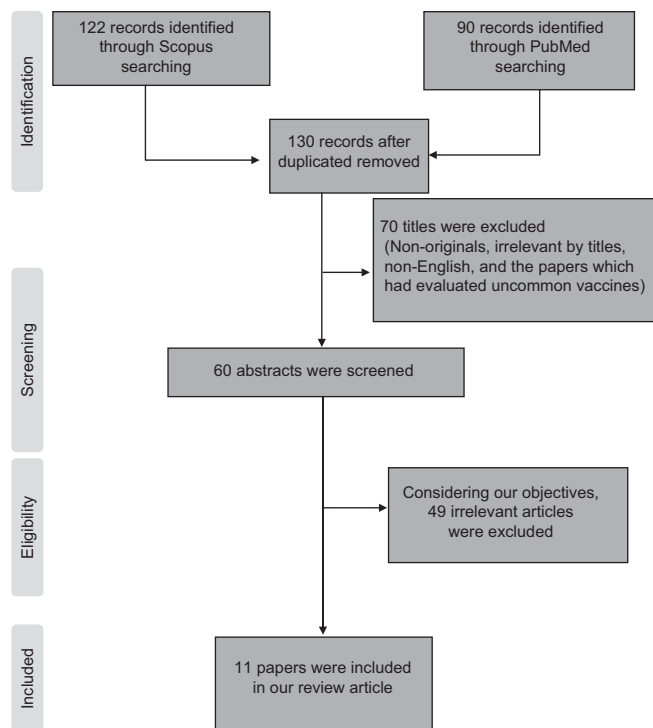


Figure 1: The flow diagram of our search steps

investigated the effectiveness or compliance of different vaccines in the Hajj. Two papers explained both topics.

Influenza vaccine

Effectiveness

Hasan *et al.* compared the influenza vaccine effectiveness between two groups of vaccinated and nonvaccinated Malaysian Hajj pilgrims. They scored the number of symptoms from 1 to 5. The average score was 0.95 (standard deviation [SD] = 0.9) in the intervention group and 0.88 (SD = 0.69) in the control group ($P = 0.781$).^[20] In another study, Emamian *et al.* assessed the effects of influenza vaccination on respiratory tract infections excluding the common cold. Twenty-four patients (75%) in the case group and 48 participants (76.2%) in the control group were vaccinated ($P = 0.898$).^[21] Moreover, Deris *et al.* assessed the effectiveness of the influenza vaccine on acute respiratory symptoms of Malaysian pilgrims but found no effect of the vaccine on respiratory symptoms.^[22] Furthermore, Memish *et al.* studied pilgrims from different countries based on their history of pandemic influenza A vaccination and respiratory infections. The frequency of respiratory infections was higher among people who did not vaccinate compared to those who vaccinated ($P = 0.009$) [Table 2].^[23]

Compliance

Barasheed *et al.* estimated the influenza vaccination rate among Australian pilgrims in 2 consecutive years. In 2011, of 431 Australians participated in the survey, 65% mentioned receiving the influenza vaccine. In 2012, of 535 Australians, 89% declared receiving the vaccine.^[28]

In another Malaysian study, Deris *et al.* calculated the influenza vaccine uptake among Malaysian pilgrims. They found that 72.8% of the pilgrims received influenza

Table 2: The characteristics of the papers which evaluated the vaccine effectiveness in Hajj

First author	Reference number	Type of vaccine	Published year	Journal	Type of study	Location of study	Pilgrims nationality	Number of participants
Hasan	[20]	Influenza	2014	J Immigrant Minority Health	Cohort	Malaysia	Malaysian	65 in the vaccinated group and 41 in the control group
Emamian	[21]	Influenza	2012	Int J Prev Med	Nested case-control	KSA	Iranian	338
Deris	[22]	Influenza	2010	Journal of Travel Medicine	Cross-sectional	Malaysia	Malaysian	387
Memish	[23]	Influenza A	2012	Journal of Travel Medicine	Cross-sectional	KSA	Various, 63% Middle Eastern and 37% Asian or African	A total of 519 arriving pilgrims and 2699 departing pilgrims were examined
Memish	[24]	Meningococcal	2013	Euro Surveillance	Case series	KSA	Saudi citizens, residents, foreign pilgrims, and illegal immigrants	265 in preepidemic and 184 in postepidemic periods
Ceyhan	[25]	Meningococcal	2013	Clinical and Vaccine Immunology	Cohort	Turkey	Turkish	472 before the Hajj and 296 after the Hajj

Table 3: The characteristics of the papers which evaluated the vaccine compliance in Hajj

First author	Reference number	Type of vaccine	Published year	Journal	Type of study	Location of study	Pilgrims nationality	Number of participants
Memish	[26]	Influenza, meningococcal, and pneumococcal	2014	The Journal of Infectious Diseases	Cohort	KSA	Various India: 17.1% Indonesia: 12.9% Pakistan: 11.9% Turkey: 10.7% and others	3210 pre-Hajj and 2025 post-Hajj pilgrims
Memish	[27]	Meningococcal	2014	International Journal of Infectious Diseases	Case series	KSA	Various Indonesia: 18.62% Pakistan: 14.17% India: 13.36% and Turkey: 12.01%	861
Barasheed	[28]	Influenza	2014	Journal of Travel Medicine	Cross-sectional	Australia	Australian	431 in 2011 and 535 in 2012
Deris	[22]	Influenza	2010	Journal of Travel Medicine	Cross-sectional	Malaysia	Malaysian	387
Memish	[23]	Influenza A	2012	Journal of Travel Medicine	Cross-sectional	KSA	Various 63% Middle Eastern and 37% Asian or African	519 arriving pilgrims and 2699 departing pilgrims
Alqahtani	[29]	Influenza	2016	Int J Infect Dis	Cross-sectional	Australia	Australian	365
Tashani	[30]	Pneumococcal	2014	Infectious Disorders – Drug Targets	Cross-sectional	Australia	Australian	158, 513 and 219 in the years of 2011, 2012 and 2013 respectively

KSA=Kingdom of Saudi Arabia

vaccine before traveling.^[22] As well as, Alqahtani *et al.* in one study carried out on 356 Australian Hajj pilgrims have shown that vaccination rate against influenza before traveling was 80%.^[29]

Memish *et al.* also investigated the H1N1 vaccine compliance among 519 arriving and 2699 departing pilgrims. Thirty percent of the pilgrims reported that they had vaccinated against pandemic influenza A before departure to the KSA [Table 3].^[23]

Meningococcal vaccine

Effectiveness

Memish *et al.* conducted another study to analyze invasive meningococcal disease (IMD) surveillance data in KSA from 1995 to 2011. They compared the related data before and after the new policy about using polysaccharide quadrivalent ACWY vaccine for pilgrims. They evaluated the changes between the preepidemic and postepidemic periods. The results showed that the mean annual IMD rate decreased from 0.20 (SD) = 0.1–0.06 (SD = 0.06) cases/100,000 ($P = 0.02$). Moreover, the mean number of Hajj-related diseases changed from 13 (SD = 9.3) to 2 (SD = 2.3) cases/year ($P = 0.02$).^[24]

Ceyhan *et al.* performed a study on Turkish Hajjis to assess acquisition of meningococcal carriage in pilgrims who had received polysaccharide quadrivalent ACWY vaccine before their departure to the KSA. They showed that 13% of the 472 participants were meningococcal

carriers before Hajj and 27% were meningococcal carriers after Hajj. All of the pilgrims were infected by serogroup W135 [Table 2].^[25]

Compliance

Memish *et al.* evaluated the pilgrim's immunological profile at the time of their entrance to the KSA. Serum samples of 796 out of 861 pilgrims were collected. A total of 98.2% of the pilgrims were vaccinated by the meningococcal quadrivalent in the last 3 years [Table 3].^[26]

Pneumococcal vaccine

Compliance

Tashani *et al.* assessed a group of Australian pilgrims over 3 consecutive years with the aim of the evaluation of the pneumococcal vaccine uptake. The frequencies were as follows: 28.5% (2011), 28.7% (2012), and 14.2% (2013), respectively.^[30]

In addition, Memish *et al.* evaluated nasopharyngeal samples of 5235 pilgrims from different countries. Only 4.2% of the pilgrims were vaccinated against pneumococcal diseases [Table 3].^[27]

DISCUSSION

An important question is whether vaccination against influenza prevents respiratory infections. The findings in various studies are confirmed,^[31] and the efficacy of this

vaccine in the prevention of respiratory diseases in the Hajj is not confirmed in some other studies.^[32]

Alqahtani *et al.* reported that the uptake of seasonal influenza vaccine in different studies ranged from 0.7% to 100% with the highest coverage rate in the elderly pilgrims and those with preexisting comorbidities.^[29] In a study by Razavi *et al.* on 32,370 Iranian pilgrims, a total of 3465 pilgrims (10.7%) were vaccinated against influenza before departure. The incidence of ILI was about 56% among vaccinated pilgrims against influenza and 72% among those not vaccinated ($P < 0.001$), with odds ratio = 0.50; thus, the efficacy of the influenza vaccine in this study was 50%.^[31]

Alfelali *et al.* in one study carried out on 33,213 pilgrims have shown that overall combined data from studies suggest that over the last decade with increasing of influenza vaccination, the influenza-like illness frequency decreased among Hajj pilgrims (RR = 0.2, $P < 0.01$).^[33]

Ziyaeyan *et al.*^[34] in one study conducted on 305 Iranian pilgrims have shown some cases of H1N1 pdm09 among the pilgrims after returning to their original country. Most of the cases had the history of vaccination against seasonal influenza.

The effectiveness of the meningococcal vaccine is satisfactory now. Hence, the Ministry of Health of the KSA has considered it as one of the components of the mandatory immunization programs for all pilgrims entering the KSA for the Hajj. The pilgrims' compliance is high for meningococcal vaccination.^[27] Surveillance of meningococcal carriage state in Hajj is recommended.^[10]

In another study, Madani *et al.* conducted a study on 392 health-care workers in the Hajj services and assessed their compliance with the meningococcal, influenza, and hepatitis B vaccination. They showed that the vaccination coverage level against meningococcal, influenza, and hepatitis B was suboptimal, very low, and suboptimal, respectively.^[35] This study confirms our previous idea regarding the compliance of influenza and meningococcal vaccines among Hajj pilgrims.

Likewise, Read *et al.* showed that the quadrivalent glycoconjugate meningococcal vaccination decreased the pharyngeal meningococcal carrier state among university students in the UK. Therefore, they suggested that it might affect the transmission when widely used.^[36]

Dbaiibo *et al.*, in one study, examined a single-dose vaccine of MenACWY-TT (a kind of meningococcal vaccine conjugated to tetanus toxoid) in 400 healthy adult travelers without the history of tetanus and meningococcal appropriate vaccination. After using a single dose of MenACWY-TT in adults 56 years of age and older, they concluded that this combined vaccine was immunogenic. The vaccine response rate was $\geq 76\%$.^[37]

There are studies that show that the use of pneumococcal vaccine to prevent pneumococcal diseases, especially in high-risk patients is efficient.^[38,39] Dabiran *et al.* suggested that the high-risk groups in Hajj including patients with chronic obstructive pulmonary disease, asthma, chronic bronchitis, emphysema, cardiac diseases, cancers, and those who have been splenectomy should receive pneumovax-23 vaccine.^[38]

Al-Tawfiq *et al.* have also stated that the pneumococcal vaccine uptake is 5% in Hajj.^[40] According to a report by Ridda, 90% of pneumococcal serotypes will be covered by the 23-valent pneumococcal polysaccharide vaccine. Therefore, we can use the pneumococcal vaccine in the Hajj, at least for high-risk groups.^[41] On the basis of Alqahtani *et al.* study, the rate of pneumococcal vaccines uptake was low.^[42]

This author, in another study, has stated that the rate of pneumococcal vaccination among Australian Hajj Pilgrims was 30%.^[29] The Saudi Thoracic Society recommended that all children smaller than 5 years old, people elder than 50 years old, and adults who have specific risk factors and are elder than 6 years old should be vaccinated against pneumococcal infections.^[39]

We presented a summary table of the vaccines which are currently mandatory or recommended by the Saudi authorities in Table 4.

Other vaccines

Tetanus, diphtheria, and pertussis vaccine

Gautret *et al.*, in a cross-sectional survey study which was conducted on 580 pilgrims, reported that the total vaccination rates for tetanus, diphtheria, and poliomyelitis (TdP) were 18.9%, 14.7%, and 15.0%, respectively, which is not an appropriate status.^[43]

Furthermore, in another study, Gautret and Wilder-Smith recommended using a booster dose of tetanus and diphtheria vaccine for travelers.^[44] On the basis of Alqahtani *et al.* study, the rate of diphtheria vaccines uptake was low.^[42] This author, in another study, has stated that the rate of pertussis vaccine use among Australian Hajj Pilgrims was 30%.^[29]

In addition, Wilder-Smith *et al.* performed a prospective seroepidemiological study on 358 adult pilgrims and reported that 1.4% of the pilgrims acquired pertussis. Moreover, they recommended that acellular pertussis vaccine should be administered for the pilgrims before the Hajj.^[12]

Poliomyelitis vaccine

As poliomyelitis currently occurs in a few countries, the travelers of such countries should be vaccinated against it.^[44]

Tetanus, diphtheria, and poliomyelitis vaccine

Gautret *et al.*, in one cross-sectional study conducted on 580 pilgrims, evaluated social determinants of the

Table 4: The vaccines which are currently mandatory or recommended based on the countries (released by the Ministry of Health of Kingdom of Saudi Arabia)

Vaccine	Mandatory	Recommended
Yellow fever	Angola, Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Congo, Cote d'Ivoire, Democratic Republic of the Congo, Equatorial Guinea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Mali, Mauritania, Niger, Rwanda, Senegal, Sierra Leone, The Republic of South Sudan, Sudan, Togo, Uganda, Argentina, Bolivarian Republic of Venezuela, Brazil, Colombia, Ecuador, French Guiana, Guyana, Panama, Paraguay, Peru, Plurinational State of Bolivia, Suriname, and Trinidad and Tobago. All means of transportations come from these countries, all ships	Other countries
Meningococcal vaccine	All countries All citizens and residents of Medina and Mecca Haj workers and any individual working in contact with pilgrims in the KSA	-
Poliomyelitis	Afghanistan, Nigeria, Pakistan, Cameroon, Chad, Ethiopia, Kenya, Niger, Somalia, Syria Equatorial Guinea, Yemen, and Iraq	Others particularly India and Indonesia
Seasonal influenza	-	International pilgrims, pregnant women, children over 5, elderly, preexisting health condition such as asthma, chronic heart and lung disease, HIV/AIDS infection, internal pilgrims, all health-care workers
Diphtheria	-	All
Tetanus	-	All
Pertussis	-	All
Polio	-	All
Measles	-	All
Mumps	-	All

Tdp vaccination coverage. They concluded that pilgrims with lower socioeconomic status and linguistic, cultural, and religious characteristics had a low level vaccination against TdP. Inequities of national preventive services were pointed by the authors.^[43]

Yellow fever, typhoid, cholera, and rabies vaccines

In a prospective study, Pavli *et al.* assessed pretravel vaccination in a total of 2494 travelers in Greece. In this study, 615 (24.7%), 28 (1.1%), 12 (0.5%), 1629 (65.3%), and 666 (26.7%) travelers were vaccinated for typhoid fever, cholera, rabies, yellow fever, and meningococcal infections, respectively. The study showed the necessity of revising the recommendations for people who travel to developing countries.^[45]

Gautret *et al.*, in a cohort study conducted on 461 Hajj pilgrims to Mecca, reported that the rate of vaccination was low and 87% of travelers did not have an appropriate vaccination for pertussis and hepatitis A, 75% for diphtheria and poliomyelitis, 70% for tetanus, and 67% for influenza.^[46]

Currently, polio has been eradicated in most countries except Pakistan, Afghanistan, and Nigeria.^[47] Therefore,

to participate in the Hajj rituals, polio vaccination against poliomyelitis is also recommended.^[48]

Shaving the hair by the male pilgrims, Estehlagh, is one of the rituals in the Hajj. In this situation, the pilgrims will shave their hair. This practice is a mental training for forsaking the interests that may drive a man away from spirituality.

During shaving the hair with contaminated blades, the pilgrims may be exposed to some diseases such as hepatitis. Therefore, shaving hygiene and vaccination against diseases such as hepatitis should also be considered.

In an endemic area for rabies where the people are attacked by suspicious animals, they must be vaccinated against the disease on days 0, 3, 7, 14, and 28.^[49]

In this situation, vaccination should be continued during the journey. Therefore, health managers should be prepared to manage these cases, and the principles should not be forgotten.

Moreover, Al-Tawfiq *et al.* strongly recommended vaccination against yellow fever and poliomyelitis for the pilgrims of high-risk countries and against meningococcal infections for all pilgrims.^[19]

CONCLUSIONS

Meningococcal immunization is an effective preventive tool with high compliance among pilgrims. The findings regarding influenza vaccine effectiveness are contradictory. Hence, further investigations are recommended through original research particularly large cohorts in different populations.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Received: 03 Mar 16 Accepted: 16 Nov 16

Published: 15 Dec 16

REFERENCES

- Benkouiten S, Charrel R, Belhouchat K, Drali T, Nougairède A, Salez N, et al. Respiratory viruses and bacteria among pilgrims during the 2013 Hajj. *Emerg Infect Dis* 2014;20:1821-7.
- Benkouiten S, Charrel R, Belhouchat K, Drali T, Salez N, Nougairède A, et al. Circulation of respiratory viruses among pilgrims during the 2012 Hajj pilgrimage. *Clin Infect Dis* 2013;57:992-1000.
- Razavi SM, Mohazzab Torabi S, Salamati P. Treatment and prevention of acute respiratory infections among Iranian hajj pilgrims: A 5-year follow up study and review of the literature. *Med J Islam Repub Iran* 2014;28:31.
- Razavi SM, Sabouri-Kashani A, Ziaee-Ardakani H, Tabatabaei A, Karbakhsh M, Sadeghipour H, et al. Trend of diseases among Iranian pilgrims during five consecutive years based on a syndromic surveillance system in Hajj. *Med J Islam Repub Iran* 2013;27:179-85.
- Alborzi A, Azhar E, Johargy A, Jamalidoust M, Moeini M, Pourabbas B, et al. Viral etiology of acute respiratory infections among Iranian Hajj pilgrims, 2006. *J Travel Med* 2009;16:239-42.
- Al-Tawfiq JA, Zumla A, Memish ZA. Travel implications of emerging coronaviruses: SARS and MERS-CoV. *Travel Med Infect Dis* 2014;12:422-8.
- Moattari A, Emami A, Moghadami M, Honarvar B. Influenza viral infections among the Iranian Hajj pilgrims returning to Shiraz, Fars Province, Iran. *Influenza Other Respir Viruses* 2012;6:e77-9.
- 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;11:82-6.
- Ashshi A, Azhar E, Johargy A, Asghar A, Momenah A, Turkestani A, et al. Demographic distribution and transmission potential of influenza A and 2009 pandemic influenza A H1N1 in pilgrims. *J Infect Dev Ctries* 2014;8:1169-75.
- Yezli S, Assiri AM, Alhakeem RF, Turkistani AM, Alotaibi B. Meningococcal disease during the Hajj and Umrah mass gatherings. *Int J Infect Dis* 2016;47:60-4.
- Karsany MS, Elshayeb AA, Saeed ES, Elaigib R, Ibrahim SA, Elsamani E, et al. Patterns of meningococcal infection in Sudan with emergence of *Neisseria meningitidis* serogroup W135. *East Mediterr Health J* 2013;19:843-6.
- Wilder-Smith A, Earnest A, Ravindran S, Paton NI. High incidence of pertussis among Hajj pilgrims. *Clin Infect Dis* 2003;37:1270-2.
- Wilder-Smith A, Foo W, Earnest A, Paton NI. High risk of *Mycobacterium tuberculosis* infection during the Hajj pilgrimage. *Trop Med Int Health* 2005;10:336-9.
- Al-Mazrou YY. Food poisoning in Saudi Arabia. Potential for prevention? *Saudi Med J* 2004;25:11-4.
- Gautret P, Benkouiten S, Sridhar S, Al-Tawfiq JA, Memish ZA. Diarrhea at the Hajj and Umrah. *Travel Med Infect Dis* 2015;13:159-66.
- Rafiq SM, Rashid H, Haworth E, Booy R. Hazards of hepatitis at the Hajj. *Travel Med Infect Dis* 2009;7:239-46.
- Memish Z. Brucellosis control in Saudi Arabia: Prospects and challenges. *J Chemother* 2001;13 Suppl 1:11-7.
- Fagbo SF. The evolving transmission pattern of Rift Valley fever in the Arabian Peninsula. *Ann NY Acad Sci* 2002;969:201-4.
- Al-Tawfiq JA, Memish ZA. The Hajj: Updated health hazards and current recommendations for 2012. *Euro Surveill* 2012;17:20295.
- Hasan H, Deris ZZ, Sulaiman SA, Abdul Wahab MS, Naing NN, Ab Rahman Z, et al. Effect of influenza vaccination on acute respiratory symptoms in Malaysian Hajj pilgrims. *J Immigr Minor Health* 2015;17:1114-9.
- Emamian MH, Hassani AM, Fateh M. Respiratory tract infections and its preventive measures among Hajj pilgrims, 2010: A nested case control study. *Int J Prev Med* 2013;4:1030-5.
- Deris ZZ, Hasan H, Sulaiman SA, Wahab MS, Naing NN, Othman NH. The prevalence of acute respiratory symptoms and role of protective measures among Malaysian Hajj pilgrims. *J Travel Med* 2010;17:82-8.
- Memish ZA, Assiri AM, Hussain R, Alomar I, Stephens G. Detection of respiratory viruses among pilgrims in Saudi Arabia during the time of a declared influenza A (H1N1) pandemic. *J Travel Med* 2012;19:15-21.
- Memish Z, Al Hakeem R, Al Neel O, Danis K, Jasir A, Eibach D. Laboratory-confirmed invasive meningococcal disease: Effect of the Hajj vaccination policy, Saudi Arabia, 1995 to 2011. *Euro Surveill* 2013;18:pii:20581.
- Ceyhan M, Celik M, Demir ET, Gurbuz V, Aycan AE, Unal S. Acquisition of meningococcal serogroup W-135 carriage in Turkish Hajj pilgrims who had received the quadrivalent meningococcal polysaccharide vaccine. *Clin Vaccine Immunol* 2013;20:66-8.
- Memish ZA, Yezli S, Almasri M, Assiri A, Turkestani A, Findlow H, et al. Meningococcal serogroup A, C, W, and Y serum bactericidal antibody profiles in Hajj pilgrims. *Int J Infect Dis* 2014;28:171-5.
- Memish ZA, Assiri A, Almasri M, Alhakeem RF, Turkestani A, Al Rabeeh AA, et al. Prevalence of MERS-CoV nasal carriage and compliance with the Saudi health recommendations among pilgrims attending the 2013 Hajj. *J Infect Dis* 2014;210:1067-72.
- Barasheed O, Rashid H, Heron L, Ridda I, Haworth E, Nguyen-Van-Tam J, et al. Influenza vaccination among Australian Hajj pilgrims: Uptake, attitudes, and barriers. *J Travel Med* 2014;21:384-90.
- Alqahtani AS, Wiley KE, Tashani M, Willaby HW, Heywood AE, BinDhim NF, et al. Exploring barriers to and facilitators of preventive measures against infectious diseases among Australian Hajj pilgrims: Cross-sectional studies before and after Hajj. *Int J Infect Dis* 2016;47:53-9.
- Tashani M, Barasheed O, Azeem M, Alfalali M, Badahdah AM, Bokhary H, et al. Pneumococcal vaccine uptake among Australian Hajj pilgrims in 2011-2013. *Infect Disord Drug Targets* 2014;14:117-24.
- Razavi SM, Sadegi-Hasanabadi M, Salamati P. The comparison of influenza vaccine efficacy on respiratory disease among Iranian pilgrims. *Acta Med Iran* 2005;43:279-81.
- Razavi SM, Dabiran S, Ardekani HZ. The incidence of influenza like illness and determination of the efficacy of flu vaccine in Iranian pilgrims during Hajj pilgrimage. *Acta Med Iran* 2004;42:397-401.
- Alfalali M, Barasheed O, Tashani M, Azeem MI, El Bashir H, Memish ZA, et al. Changes in the prevalence of influenza-like illness and influenza vaccine uptake among Hajj pilgrims: A 10-year retrospective analysis of data. *Vaccine* 2015;33:2562-9.
- Ziyaeyan M, Alborzi A, Jamalidoust M, Moeini M, Pouladfar GR, Pourabbas B, et al. Pandemic 2009 influenza A (H1N1) infection among 2009 Hajj pilgrims from Southern Iran: A real-time RT-PCR-based study. *Influenza Other Respir Viruses* 2012;6:e80-4.
- Madani TA, Ghabrah TM. Meningococcal, influenza virus, and hepatitis B virus vaccination coverage level among health care workers in Hajj. *BMC Infect Dis* 2007;7:80.
- Read RC, Baxter D, Chadwick DR, Faust SN, Finn A, Gordon SB, et al. Effect of a quadrivalent meningococcal ACWY glycoconjugate or a serogroup B meningococcal vaccine on meningococcal carriage: An observer-blind, phase 3 randomised clinical trial. *Lancet* 2014;384:2123-31.
- Dbaibo G, El-Ayoubi N, Ghanem S, Hajar F, Bianco V, Miller JM, et al. Immunogenicity and safety of a quadrivalent meningococcal serogroups A, C, W-135 and Y tetanus toxoid conjugate vaccine (MenACWY-TT) administered to adults aged 56 years and older: Results of an open-label, randomized, controlled trial. *Drugs Aging* 2013;30:309-19.
- Dabiran S, Razavi SM, Sabouri-Kashani A, Karbakhsh M, Naser-Hodjati H, Peyafarin F. Effects of flu vaccine, solely or accompanied by pneumovax-23

- vaccine on clinical consequences of the respiratory diseases among Iranian pilgrims in Hajj. *Health* 2014;6:1-5.
39. Alharbi NS, Al-Barrak AM, Al-Moamary MS, Zeitouni MO, Idrees MM, Al-Ghobain MO, et al. The Saudi Thoracic Society pneumococcal vaccination guidelines-2016. *Ann Thorac Med* 2016;11:93-102.
 40. Al-Tawfiq JA, Memish ZA. Prevention of pneumococcal infections during mass gathering. *Hum Vaccin Immunother* 2016;12:326-30.
 41. Ridda I, King C, Rashid H. Pneumococcal infections at Hajj: Current knowledge gaps. *Infect Disord Drug Targets* 2014;14:177-84.
 42. Alqahtani AS, Rashid H, Heywood AE. Vaccinations against respiratory tract infections at Hajj. *Clin Microbiol Infect* 2015;21:115-27.
 43. Gautret P, Yong W, Soula G, Parola P, Brouqui P, DelVecchio Good MJ. Determinants of tetanus, diphtheria and poliomyelitis vaccinations among Hajj pilgrims, Marseille, France. *Eur J Public Health* 2010;20:438-42.
 44. Gautret P, Wilder-Smith A. Vaccination against tetanus, diphtheria, pertussis and poliomyelitis in adult travellers. *Travel Med Infect Dis* 2010;8:155-60.
 45. Pavli A, Spilioti A, Lymperi I, Katerelos P, Maltezou HC. Vaccinations for international travellers travelling from Greece. *Travel Med Infect Dis* 2013;11:225-30.
 46. Gautret P, Gaillard C, Soula G, Delmont J, Brouqui P, Parola P. Pilgrims from Marseille, France, to Mecca: Demographics and vaccination status. *J Travel Med* 2007;14:132-3.
 47. Ahmed QA, Nishtar S, Memish ZA. Poliomyelitis in Pakistan: Time for the Muslim world to step in. *Lancet* 2013;381:1521-3.
 48. Wilder-Smith A, Leong WY, Lopez LF, Amaku M, Quam M, Khan K, et al. Potential for international spread of wild poliovirus via travelers. *BMC Med* 2015;13:133.
 49. Rupprecht CE. Viral zoonoses – Rabies. In: Wallace RB, Kohatsu N, editors. *Maxey-Rosenau-Last Public Health and Preventive Medicine*. 15th ed. New York: McGraw-Hill; 2008. p. 419-23.