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Adherence to Vaccine Requirements among Hajj Pilgrims in Saudi Arabia, 2017-2019

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Abstract: Hajj pilgrims must have certain vaccines for pilgrimage; these requirements aim to reduce the spread of infectious diseases. This study analyzed the trends in vaccine adherence for meningitis, yellow fever, and polio from January 2017-December 2019. These trends can help in guiding future policymaking to prevent outbreaks during Hajj and similar mass gatherings. We analyzed data using descriptive statistics for Hajj pilgrims and Hajj seasonal workers arriving in Saudi Arabia over three years (2017–2019). Health Control Centers (HCCs) collected data at points-of-entry (PoE) and entered it into Saudi Arabia's Health Electronic Surveillance Network (HESN). We reviewed HESN data to collect information on total passengers arriving per country and the number of passengers vaccinated for: meningococcal meningitis, poliomyelitis, and yellow fever. We compared data to identify the difference in vaccination by region. We used chi-square tests to assess differences in compliance rate among these travelers by year and country of origin. The number of participating countries increased from 113 to 132. Meningitis vaccine coverage increased by 5% from 2017–2019. The increase was not statistically significant. Asia had the lowest overall adherence rate (83%). Yellow fever adherence decreased significantly using a difference of mean adherence between 2017 and 2019 (p-value 0.01). Polio vaccination adherence decreased by 5% from 2017 to 2019; this was not significant (p-value = 0.08). The vaccine coverage increased for meningitis and decreased for yellow fever and polio. Less than 100% vaccine adherence among Hajj travelers creates the potential for the spread of infectious diseases. Proof of vaccination should be required in submitted visa applications. Countries of origin and Saudi Arabia must work together to ensure that all Hajjis are adequately vaccinated before departure.

Keywords: Hajj; meningitis; yellow fever; polio; vaccination

INTRODUCTION

In 2005, the World Health Organization (WHO) created the International Health Regulations (IHR). IHR is an agreement between 196 countries, also called State Parties, that aims to prevent global outbreaks and ensure efficient response to public health hazards by implementing and applying various public health activities, including preparation, alert, and response[1]. The Kingdom of Saudi Arabia joined the state parties of IHR on the 15th of June 2007[2].

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Hajj is one of the largest mass gatherings in the world. Hajj season is based on the Islamic calendar and occurs during the 8th–13th of Dhul-Hijah. The number of pilgrims who can perform Hajj is based on a ratio of 1 pilgrim/1000 Muslims in a particular country[3]. Typically, around 2 million pilgrims and 50,000 seasonal workers from more than 183 countries come in close contact during Hajj[4]. Shared living spaces, communal meal preparation, and various Hajj activities, such as barefoot walking, dense crowds often in extreme temperatures (45°C in summer), shared toilet facilities and razors, etc., can increase the risk of infectious disease during Hajj[5]. Common respiratory infections, meningococcal disease, poliomyelitis, hepatitis A, B, and C, gastroenteritis, and other various zoonotic infections pose serious public health threats to Hajj pilgrim[6-8].

Saudi Arabia's Ministry of Health (MOH) annually revisits health requirements for Hajj pilgrims in coordination with international health authorities. This allows them to design and implement policies for preventing the spread of pathogens at Hajj and respond to emerging international outbreaks[9]. The MOH issues an updated list of required and recommended vaccines for pilgrims[10].

Hajj-related meningococcal disease outbreaks have been reported. In 1987, an outbreak was caused by *Neisseria meningitides* serogroup A and Serogroup W135. A 2000 outbreak caused by *N. meningitides* serogroup W135[11,12]. According to Al-Tawfiq and Memish et al., 3.4% of pilgrims arriving for Hajj were carriers of *N. meningitides*. Vaccines against bivalent A and C meningococcal were made mandatory for pilgrims after the 1987 outbreak[13].

All Hajj pilgrims and seasonal workers are required to be vaccinated for meningococcal meningitis[14]. Poliomyelitis and yellow fever vaccine are required for Hajj pilgrims arriving from areas at risk of poliomyelitis and yellow fever transmission. Recommended vaccines include influenza, tetanus, pertussis, diphtheria, measles, and mumps.

Health Control Centers (HCCs) at 31 Points of entry (PoE) work under IHR to prevent disease importation[15]. Hajj pilgrims must meet specific health requirements to obtain a Hajj visa. To the best of our knowledge, no recent reports have been published to estimate the trend in vaccine coverage for meningitis, yellow fever, or polio vaccine. A detailed review of the vaccine adherence data among the pilgrims arriving for Hajj from around the globe can help identify vaccination trends. It can guide future policymaking to ensure the prevention of any outbreaks. This study aims to describe the adherence rate and other variables associated with compliance to vaccination requirements for meningococcal meningitis, yellow fever, and polio during the Hajj season for 2017–2019.

MATERIALS AND METHODS

We analyzed data using descriptive statistics for pilgrims and seasonal workers (Hajj travelers to represent the combined population) arriving in Saudi Arabia for Hajj from January 2017–December 2019. Data were collected by HCCs at PoE and entered into Saudi Arabia's Health Electronic Surveillance Network (HESN). Included subjects were Hajj travelers from targeted countries. We reviewed data on vaccines against meningococcal meningitis, poliomyelitis, or yellow fever in Hajj pilgrims. Umrah pilgrims (those performing rites outside of Hajj season) were excluded, with the Hajj season lasting for ten days each year.

The Institutional Review Board at the Saudi Center for Disease Control and Prevention reviewed and approved the study protocol. Data were collected

retrospectively from HESN. No personally identifiable information was collected to protect participant's privacy. Data were stored on a password-protected computer.

We reviewed HESN data to collect information on total passengers arriving per country and the number of passengers vaccinated for meningococcal meningitis, poliomyelitis, and yellow fever. We performed a descriptive analysis of vaccination adherence rates. We conducted Chi-square tests to assess differences in compliance rate among pilgrims by year and country of origin.

RESULTS AND DISCUSSION

The number of pilgrimage-participating countries was 113 countries in 2017, 128 in 2018, and 132 in 2019. Figure 1 shows countries where Hajj pilgrims were received in KSA with yellow fever and polio risk in 2019. The gender distribution of Hajj pilgrims was almost the same for the three years.

Figure 1. Risk-based Color Coded GeoMap of Countries from where Hajj Pilgrims were Received in 2019.

Table 1. The total Hajjis and Adherence Rates for Meningitis, Yellow fever, and Polio Vaccination, 2017-2019.

Year	**Total Hajjis Received**	**Meningitis vaccine Adherence Rate**
2017	1,723,192	86%
2018	1,692,407	89%
2019	1,691,699	91%
All years	5,107,298	89%
Year	**Total Hajjis Received**	**Yellow fever vaccine Adherence Rate**
2017	184,424	94%
2018	172,606	88%
2019	181,965	84%
All years	539,995	89%
Year	**Total Hajjis Received**	**Polio vaccine Adherence Rate**
2017	769,918	67%
2018	362,762	80%
2019	393,103	52%
All years	1,525,783	66%

Table 1 shows the total number of Hajjis and the percentage that met vaccine requirements (vaccination adherence). Overall mean adherence to meningitis vaccination requirements was 90%, overall mean adherence to yellow fever vaccination requirements was 81%, and overall mean adherence to polio vaccination requirements was 66%. Meningitis vaccine coverage increased by 5% over the observed time frame. The increase was not statistically significant when comparing the difference of mean adherence over time (p=0.1). Yellow fever vaccination adherence decreased significantly (p<0.01) by 10% from 2017–2019. Polio vaccination adherence decreased by 5% between 2017–2019 (p=0.08).

Table 2. Adherence to Meningitis, Yellow fever and Polio Vaccination by Continent, 2017-2019.

	Continent	Countries	Adherence (%)	Countries	Adherence (%)	Countries	Adherence (%)	Total (%)
Meningitis	Africa	44	89	48	94	49	92	92
	Asia	39	81	42	82	38	86	83
	Europe	21	88	25	88	31	91	90
	America	5	88	9	100	11	100	98
	Australia	4	100	4	100	3	100	100
	Total	113	89	128	93	132	94	93
	Africa's Meningitis Belt	15	98	15	89	16	94	94
	Others	98	85	113	89	116	90	88
	Total	113	-	128	-	132	-	-
Yel	Africa	21	94	12	88	22	85*	89
	The Americas	0	-	0	-	3	72	72
Po	Africa	14	72	6	31	8	33*	52
	Asia	5	65	3	65	3	60*	63

Table 2 shows Meningitis vaccination adherence by continent. The overall mean adherence to meningitis vaccination was 89% in 2017, 93% in 2018, and 94% in 2019. The number of countries where <100% of all pilgrims were vaccinated for meningitis decreased in 2018 to 8 and 7 in 2019, with Asia having the lowest overall adherence rate (83%). Nine countries had less than 80% meningitis vaccination adherence rate in 2017: Qatar (0%), Yemen (2.1%), Nepal (5%), Afghanistan (46%), Kazakhstan (53%), Syria (62%), and Palestine (72%), Pakistan (73%), and Myanmar (80%). In 2018, 12 countries had less than 80% meningitis vaccination adherence. Yemen, Pakistan, Afghanistan had less than 40%, Nepal, Ukraine, and Myanmar countries had between 40–65%, and Iraq, Bangladesh, Cambodia, Jordan, and Palestine had between 65–80% of pilgrims vaccinated for meningitis. In 2019, only six countries had less than 80% adherence, with Yemen and Afghanistan at an adherence rate of less than 45%, Turkmenistan, Jordan, and Palestine between 60–70%, and Pakistan at 79.6%.

We compared Africa's meningitis belt countries to other countries for meningitis vaccine adherence (Table 3). Africa's meningitis belt includes Sudan, South Sudan, Mali, Burkina Faso, Guinea, Guinea-Bissau, Nigeria, Ethiopia, Cote d'Ivoire, Niger, Benin, Cameroon, Chad, Eritrea, Gambia, Senegal, Republic of Central Africa. The

difference in adherence between meningitis belt countries and the others was significant for 2017 ($p < 0.01$), with the mean value of the Meningitis belt at 98% and others at 85%.

Table 2 shows the yellow fever vaccine adherence in African and American Yellow Fever endemic countries. The overall trend in adherence has decreased significantly ($p <0.01$). In 2018, only 27% of the entire countries had 100% adherence rates. South Sudan and Burundi had less than 10% adherence to Yellow Fever vaccination requirements, and the rest of Africa had more than 85% adherence. In 2019, 6 out of 25 (24%) countries had more than 80% of pilgrims vaccinated for Yellow Fever. Gabon, Panama, Chad, and Ghana had adherence between 25–65%. Between 65–80% of pilgrims from Chad, Kenya, Niger, Mauritania, and Mali were vaccinated for Yellow Fever.

Adherence to polio vaccine requirements decreased over time in Asian and African countries (Table 2). In 2017, Mali and Congo had an adherence rate of less than 70%. In 2018, Mali, Niger, South Sudan, and Sudan had 0% adherence, whereas Nigeria and Somalia had more than 90%. In 2019, Congo, Guinea, and Mali had a 0% adherence rate. Niger and Somalia had 30–60%, and the remaining six countries had more than 80%. Yemen had a <1% adherence rate; Syria, Pakistan, and Iraq had 70–90%. Afghanistan had a 93% adherence rate. In 2018, Yemen had less than 2% adherence while Pakistan and Afghanistan had more than 95%. In 2019 again, Yemen had 1% adherence, Afghanistan 85%, and Pakistan 94%. Overall, polio vaccine adherence in polio-endemic countries and polio-high-risk countries was found to be 66%. The overall Polio vaccination adherence rate dropped from 67% to 52% from 2017–2019 for all Hajjis.

Table 3 provides the total number of pilgrims from counties from various belts: African belt, south Asian belt, Eat Asian Belt, Arab Belt, Turkish Belt, and US/Europe belt. It also presents the proportion of pilgrims from each country within each belt. Although the number of countries varied, the overall adherence to vaccination requirements did not vary significantly over three years.

As the number of participating countries and Hajj travelers continues to increase, so does the risk for outbreaks. Vaccination is a critical tool to preventing many outbreaks, and we found vaccine adherence rates much less than 100% and that vaccination rates varied significantly across regions. Analysis of these differences and the trends in adherence rates can guide stakeholders in policymaking to increase coverage and minimize the risk of outbreaks.

Mass immunization campaigns have led to a significant reduction in transmission of infections among pilgrims since 2001[16-19]. High adherence rates among pilgrims from North America and Australia in our study are supported by the gradual decline in the incidence of bacterial meningitis in Western countries by 3–4% per year to 0.7–0.9 per 100,000 per year in the past 10–20 years[20], likely due to mass immunization campaigns in the regions. The number of pilgrims not vaccinated for meningitis was high for Asia and Europe. Meningitis incidence rates are still higher among African countries (Burkina Faso and Malawi) (Table 2)[20]. Vaccine adherence for Africa's meningitis belt was higher than other African countries, as shown in Table 2. Meningitis vaccination adherence peaked in 2017, then dropped significantly in 2018, and by 2019 had still not recovered (Table 1). According to WHO, routine meningitis immunization has been introduced in the African meningitis belt since 2016. As of April 2021, 26 countries in the African meningitis belt have conducted mass preventive campaigns[16]. The uptick in adherence to meningitis vaccination may be due to these collaborative efforts between WHO and endemic countries.

Yellow fever virus is endemic to the subtropical and tropical areas of Africa and South America. Yellow fever vaccine adherence decreased significantly during the study period. The adherence rates were higher among the American countries as compared to African countries (Table 2).

Table 3, Overall Vaccine Adherence Rate by Country and Year, 2017-2019

		% Vaccinated	
African Belt	**2017**	**2018**	**2019**
Ethiopia	8	8	9
Eritrea	0	0	0
Sudan	20	21	20
Cameroon	1	2	-
Niger	7	7	7
Benin	1	0	1
Burkina Faso	4	5	4
Chad	2	3	4
The Gambia	1	1	1
Central Africa	0	0	0
Guinea	3	4	4
Guinea-Bissau	0	0	0
Côte d'Ivoire	3	4	4
Mali	6	7	7
Nigeria	45	32	33
Senegal	-	7	6
South Sudan	-	0	0
Belt Total			
Arab Belt	**2017**	**2018**	**2019**
UAE	3	1	1
Bahrain	1	1	1
Algeria	11	12	11
Libya	3	3	4
Syria	4	5	5
Somalia	2	3	3
Iraq	13	13	17
Kuwait	3	2	1
Morocco	11	11	12
Yemen	7	8	8
Oman	4	4	4
Palestine	3	3	3
Qatar	0	0	0
Lebanon	5	4	3
Egypt	3	29	29
Mauritania	1	1	1
Belt Total			
South African Belt	**2017**	**2018**	**2019**
Uganda	9	7	4
Togo	22	20	15
Tanzania	11	9	18
South Africa	37	46	34
Djibouti	21	18	29

Belt Total			
South Asian Belt	**2017**	**2018**	**2019**
India	35	35	41
Pakistan	39	38	38
Bangladesh	25	25	20
Sri Lanka	2	1	1
Nepal	0	0	0
Belt Total			
East Asian Belt	**2017**	**2018**	**2019**
China	4	4	5
Philippines	2	3	3
Indonesia	76	79	80
Burunai	0	0	-
Thailand	3	3	3
Korea	0	0	0
Singapore	0	1	1
Maldives	0	0	0
Malaysia	14	10	8
Burundi	-	0	-
Belt Total			
Turkish Belt	**2017**	**2018**	**2019**
Afghanistan	12	13	13
Uzbekistan	3	3	3
Iran	32	34	36
Azerbaijan	1	0	1
Turkmenistan	0	1	1
Turkey	49	46	44
Dagestan	0	0	0
Tajikistan	2	3	2
Kazakhstan	1	1	1
Belt Total			
Europe, United States of America	**2017**	**2018**	**2019**
Australia	3	4	5
Bosnia	4	2	4
Sweden	0	0	0
UK	20	21	15
Norway	0	0	1
USA	14	16	16
Greece	1	0	0
Italy	3	3	2
Spain	1	1	2
Albania	0	0	0
Germany	3	3	2
Russia	37	36	37
Switzerland	1	0	1
France	10	11	12
Canada	4	3	3
Serbia	-	-	1
Belt Total			

Our findings also suggest weaknesses in The Eliminate Yellow fever Epidemics (EYE) Strategy launched in 2017, as indicated by a reduction in the percentage of vaccinated individuals arriving from Yemen from 2017–2019 (Table 2)[21]. The partnership supports 40 at-risk countries in the Americas and Africa to prevent, detect, and respond to yellow fever suspected cases and outbreaks[21]. The global shortage of yellow fever vaccines in recent years, the difficulties of properly storing and transporting yellow fever vaccines, and the serious adverse effects associated with vaccines could increase the number of at-risk unvaccinated travelers, including Hajj pilgrims[22]. IHR requires travelers to provide certificates for yellow fever vaccination; this requirement is inadequately monitored and enforced[21]. Vector control can prevent transmission, and the Saudi government must ensure appropriate vector control efforts to reduce exposure to pilgrims.

Poliomyelitis is a highly infectious disease that mainly affects children under the age of 5 years. In 1988, WHO adopted a resolution for polio eradication and launched the Global Polio Eradication Initiative[23]; wild poliovirus cases have decreased by over 99% since then. Wild poliovirus types 2 and 3 have been completely eradicated[23]. Wild poliovirus type 1 cases are still reported in Pakistan and Afghanistan[23]. Polio vaccine adherence decreased over the study period among pilgrims from Africa and Asia (Table 2). The decrease was observed for both pilgrims from countries with wild polio and vaccine-derived polio cases. Closer analysis showed that the proportion of countries with full adherence decreased to zero in 2019 (Table 2).

Similarly, the countries with >90% coverage also reduced during the study period. Adherence rates were not satisfactory for polio vaccination among the endemic countries from Asia and Africa (Table 3). Afghanistan's ongoing conflict makes vaccination efforts difficult, and travelers from Afghanistan can bring polio to Pakistan. In Pakistan, the mass immunization campaigns are organized routinely by the joint efforts of the government, WHO, and UNICEF, trying to improve relations with marginalized ethnic and religious groups to enhance vaccine uptake. The reduced proportion of unvaccinated individuals from these countries indicates the success of these efforts among Hajj pilgrims.

Pilgrims' interaction starts long before they arrive in Saudi Arabia, and any vaccination provided upon arrival would not immediately provide immunity. The Saudi government provides one dose of oral polio vaccine (OPV) to all pilgrims who have not been vaccinated. While a single dose cannot provide complete immunity, the booster dose can increase immunity among adults who have been immunized during childhood[24]. OPV also has the potential to infect others and cause symptomatic disease.

We conducted a retrospective study and collected data from an existing surveillance program. No individual data were collected to identify any factors that may impact vaccine compliance rates. Furthermore, our study focused on only three diseases. The respiratory viruses have been responsible for pandemics, and we are still facing one. These viruses spread more quickly and cause serious life-threatening illnesses. Respiratory diseases such as influenza and recently emerged severe acute respiratory syndrome-associated coronavirus 2 (SARS-CoV 2) must also be accounted for. The adherence rates for the vaccination against respiratory viruses must also be analyzed in the future to further decrease the risk of any outbreaks.

CONCLUSION

During Hajj, the risk of meningitis, yellow fever, and poliomyelitis is mainly preventable through maximizing vaccine coverage. While the adherence trend for the

meningitis vaccine showed an increase, the reverse was observed for yellow fever and polio among Hajj pilgrims during 2017–2019. The government of the respective country must ensure compliance with vaccine requirements, and the government of KSA must only grant visas to those providing vaccine certificates. Future investigations should focus on respiratory diseases such as influenza and severe acute respiratory syndrome-associated coronavirus 2 (SARS-CoV 2). While vaccines are not as widely available, these viruses, on the other hand, spread globally and rapidly, causing severe life-threatening illnesses. Adherence rates for the vaccination against respiratory viruses must also be analyzed to further decrease the risk of any outbreaks. Currently, the vaccine against SARS-COV 2 is included in the list of required vaccines, and the influenza vaccine is only recommended for Hajj.

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CONFLICT OF INTERESTS

There are no competing interests among study authors or funding sources.

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