New Microbes and New Infections 60–61 (2024) 101442

Contents lists available at ScienceDirect

New Microbes and New Infections

journal homepage: www.journals.elsevier.com/new-microbes-and-new-infections

Evidence for transmission of SARS-CoV-2 at religious mass gatherings: A systematic review

Ndiaw Goumballa [a,b,c,1], Van Thuan Hoang [d,1], Jaffar A. Al-Tawfiq [e,f,g], Cheikh Sokhna [a,b,c], Philippe Gautret [a,b,*]

[a] IHU-Méditerranée Infection, Marseille, France
[b] Aix Marseille Univ, AP-HM, SSA, RITMES, Marseille, France
[c] MINES, Campus International IRD-UCAD de L'IRD, Dakar, Senegal
[d] Thai Binh University of Medicine and Pharmacy, Thai Binh, Viet Nam
[e] Specialty Internal Medicine and Quality Patient Safety Department, Johns Hopkins Aramco Healthcare, Dhahran, Saudi Arabia
[f] Infectious Diseases Division, Department of Medicine, Indiana University School of Medicine, Indianapolis, IN, USA
[g] Infectious Diseases Division, Department of Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, USA

A B S T R A C T

Background: Transmission of SARS-CoV-2 at major mass gatherings (MGs) has been observed during the COVID-19 pandemic.
Methods: In this systematic review done according to the PRISMA guidelines, PubMed and Scopus databases were searched for relevant studies to describe the epidemiology of SARS-CoV-2 in relation to major religious MGs including the Grand Magal of Touba (GMT), Hajj, Umrah, Kumbh Mela, Arbaeen and Lourdes pilgrimage during the COVID-19 pandemic.
Results: Ten articles met the inclusion criteria and were included.
No cases of SARS-CoV-2 were detected at 2020 and 2021 GMT or at the 2020 Hajj. In a small study, 7 % of tested individuals were positive after the 2022 GMT. SARS-CoV-2 prevalence during the 2021–2022 Hajj and Umrah seasons varied from 0 to 15 % in different studies. At the 2021 Kumbh Mela, 0.4 million COVID-19 cases were diagnosed among returning pilgrims across India and 1 % tested positive during a one-day survey conducted on participants. During the 2021 Arbaeen pilgrimage, 3 % pilgrims were tested positive. No relevant data were found in relation to SARS-CoV-2 transmission at the 2021 Arbaeen and Lourdes pilgrimages.
Conclusion: The transmission of the SARS-CoV-2 virus during religious MG events depends on many factors such as: the number and density of pilgrims, the intensity of circulation of the virus in the hosting country and in countries sending international participants at the time of the event, the transmissibility of virus variants at the time of the event, the various preventive measures adopted, and the immune status of the pilgrims.

1. Introduction

Religious mass gatherings (MGs) represent a high risk for the transmission of communicable diseases and require an effective mitigation system to protect the participants' health [1]. Respiratory infections are very common in religious gatherings such as the Hajj in Saudi Arabia, the Grand Magal of Touba (GMT) in Senegal and the Kumbh Mela in India [1–3]. In early 2020, several religious MGs were associated with COVID-19 outbreaks. The Sri Petaling MG, a Muslim missionary event with 19,000 participants in Kuala Lumpur, Malaysia accounted for more than 35 % of cases in the country at that time and triggered regional spikes of COVID-19 cases across Southeast Asia through international participants [4]. The Shincheonnji Christian religious group's MG with about 200,000 participants in Daegu, South Korea accounted for nearly 3000 cases of COVID-19 out of 5621 cases in the country at that time [5]. About 600 cases of COVID-19 were reported among 8000 Pakistani pilgrims returning from a Shia Muslim pilgrimage that took place in Qom, Iran, accounting for 60 % of cases in Pakistan in that period [6]. Another example is the "Porte Ouverte Chrétienne" religious MG in Mulhouse, France with about 2000 participants. Of the 1516 individuals with COVID-19-like symptoms, 15.6 % reported being part of a household in which at least one member participated in the gathering [7]. These early reports suggested the potential for larger well-known MGs to trigger SARS-CoV-2 outbreaks.

In this study, we summarize the evidence related to the transmission of SARS-CoV-2 in relation to the major religious MGs that were held during the COVID-19 pandemic. We limited our search to major religious MGs including the GMT, the Hajj, the Kumbh Mela, the Lourdes

* Corresponding author. Institut Hospitalo-Universitaire Méditerranée Infection, 19-21 Boulevard Jean Moulin 13385 Marseille Cedex 05, France.
E-mail address: philippe.gautret@ap-hm.fr (P. Gautret).
[1] Equal work.

https://doi.org/10.1016/j.nmni.2024.101442
Received 22 January 2024; Received in revised form 4 June 2024; Accepted 8 June 2024
Available online 12 June 2024

pilgrimage and the Arbaeen.

2. Materials and methods

2.1. Search strategy and selection criteria

This review was conducted according to the Preferred Reporting Items for Systematic Reviews and MetaAnalyses (PRISMA) guidelines (http://www.prisma-statement.org). The following databases were searched with the aim of identifying relevant studies published on PubMed (http://www.ncbi.nlm.nih.gov/pubmed) and Scopus (https://www.scopus.com/). The most recent search was conducted on December 31, 2023. The topic search terms used for searching through the databases were the following:

#1: "Hajj" OR "Magal of Touba" OR "Kumbh Mela" OR "Lourdes" OR "Arbaeen" OR "Arba'een" OR "Ashura" OR "Karbala".

#2: "COVID-19″ OR "SARS-CoV-2".

#3: #1 AND #2.

Only articles published in English and French were included. For inclusion, articles had to fulfill two criteria: (1) be related to religious MGs and (2) describe the occurrence of SARS-CoV-2 infection or carriage among religious MG attendees or in the general population of areas where these MGs were held. Reference lists of selected articles were screened to identify studies that might have been missed during the search.

After manually removing duplicates, three researchers (NG, HVT and GP) independently performed the screening of the abstracts, applying the inclusion and exclusion criteria. In addition, articles without an abstract were included for full-text screening and assessed at this stage. Any discordant results were discussed in a consensus meeting. After screening the abstracts, the full texts of the articles were assessed for eligibility by the same researchers and were selected or rejected for inclusion in the systematic review.

2.2. Data collection process

The following data (if available) were extracted from each article: country where the MG was held, time period of the study, number of attendees, number of participants screened for SARS-CoV-2, diagnostic method(s), and number and proportion of positive cases.

2.3. Data synthesis and analysis

The nature of the selected studies and the heterogeneity of the patient populations did not allow a formal meta-analysis. Therefore, the results were summarized to describe the epidemiology of SARS-CoV-2 in relation to major religious MGs. When possible and when the data were not provided in the reviewed articles, percentages were calculated from the available data.

2.4. Risk of bias and quality of study assessment

The quality of studies was accessed using the National Institutes of Health Study quality assessment tools for observational cohort and cross-Sectional studies [8], consisting of 14 items with a maximum score of 14. The score of the study classifies the quality as good (11–14), fair (5–10), and poor (0–4) [8,9].

3. Results

3.1. Study selection and types of studies

The study selection is presented in the PRISMA flow diagram (Fig. 1, Supplementary Table 1). The search algorithm produced 7636 articles from the PubMed and Scopus databases. After removing duplicates, 7434 articles were scanned based on their titles and abstracts. A total of 29 articles were processed for full-text screening. Ten articles met the

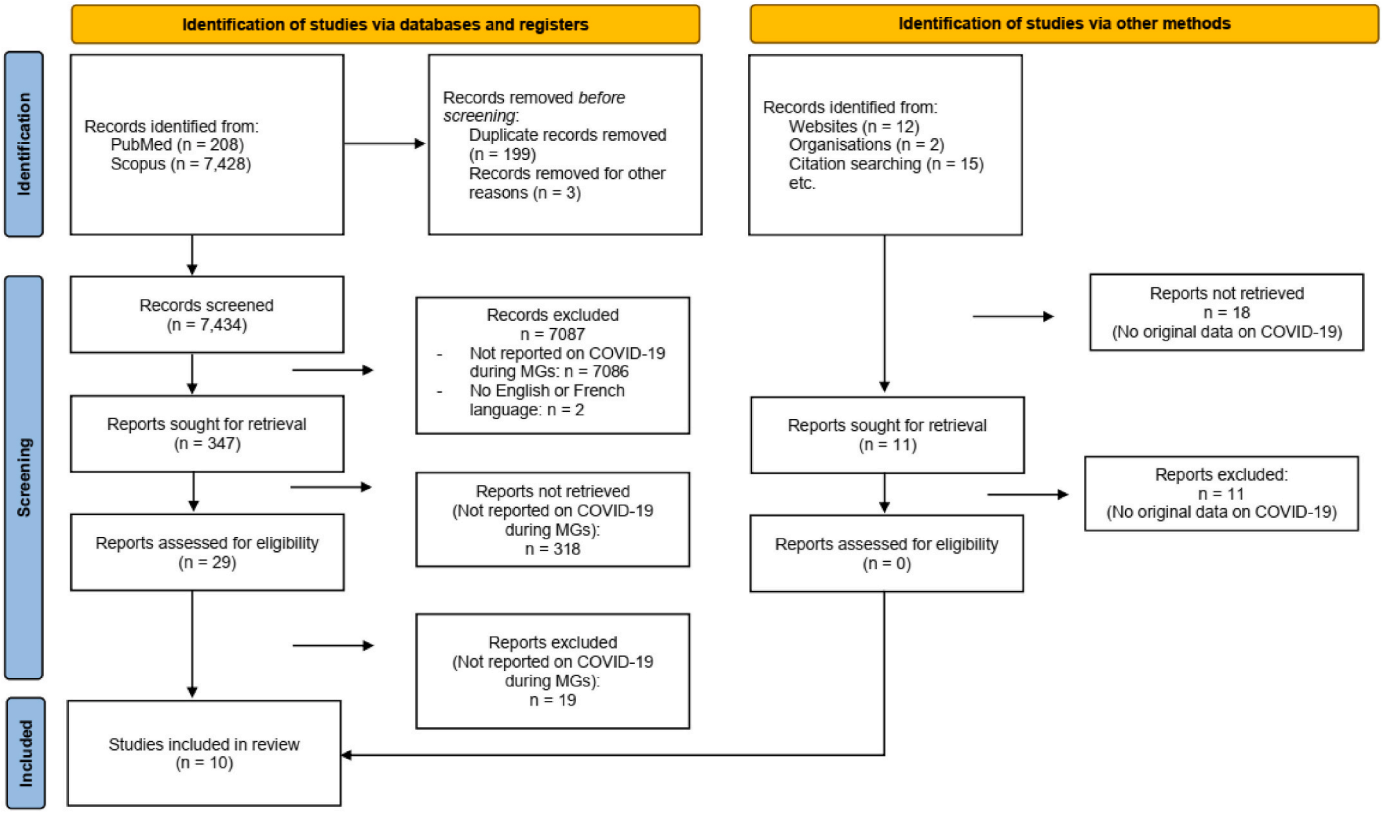

Fig. 1. PRISMA flow chart of selected studies.

inclusion criteria and were included in the qualitative synthesis of the systematic review [10–19].

According to the NIH criteria, one study was scored as good quality and nine studies as fair quality (Supplementary Table 2).

3.2. SARS-CoV-2 circulation at religious mass gatherings

Four articles reported on COVID-19 during the GMT from 2020 to 2022 [10–13] with 549 pilgrims investigated either when ill and consulting at a health care center during the event or as part of systematic sampling in prospective study cohorts (Table 1). Overall, 76 % pilgrims were symptomatic and no case of SARS-CoV-2 infection was identified in 2020 and 2021 GMT [10,11]. In 2022, 6 % were positive for SARS-CoV-2 [13].

Five articles reported on COVID 19 during the Hajj from 2020 to 2022 and the Umrah in 2022 (Table 1). A total of 31,044 pilgrims were tested for SARS-CoV-2, either systematically when participating to the events or during cross sectional studies conducted in pilgrims returning to Egypt. In addition, one study was conducted in Saudi citizens and pilgrims suffering severe respiratory tract infections in 2022. The 2020 Hajj was carried out under strict restrictions, open only to Saudi nationals and local residents of various nationalities who were under 65 years of age without underlying chronic diseases, and was limited to 1000 pilgrims who tested negative by PCR screening prior to participation [20]. None of the 1000 pilgrims tested positive for SARS-CoV-2 after participating in this event [14]. In 2021, SARS-CoV-2 PCR testing was conducted on 25,000 pilgrims, resulting in 41 positive cases (0.2 %) [15]. A survey conducted among 3862 Egyptian pilgrims returning from the 2022 Hajj 4 % of whom reported respiratory symptoms showed that 10 % of all pilgrims were infected with SARS-CoV-2 [16]. Another study conducted in 2022 at an Egyptian airport among 1003 Egyptian pilgrims returning from the Umrah pilgrimage during Ramadan, 4 % of whom reported respiratory symptoms showed that the proportion of SARS-CoV-2 infection was 7 % [17]. During the 2022 Hajj pilgrimage, only 38 cases of COVID-19 out of nearly 900,000 participants were reported in Saudi Arabia [21]. Among 179 cases with severe acute respiratory symptoms consulted at Hajj hospitals during the two months peri-Hajj in 2022, 27 patients were positive for SARS-CoV-2 [18].

Despite the 2021 Kumbh Mela was a major envent with an estimated 10–20 Million participant, we found no formal study aiming at documenting SARS-CoV-2 infection among participants. About 0.4 million COVID-19 cases were diagnosed among returning pilgrims from Kumbh Mela, in India as of May 8, 2021 suggesting that the MG participate to the spread of SARS-CoV-2 across the country [22]. One newspaper release reported a prevalence of SARS-CoV-2 infections among 18,169 pilgrims tested during the event of 102 (0.6 %) [23].

Despite this significant attendance, there were no published articles or papers related to the Lourdes pilgrimage and COVID-19 cases associated with the event (Table 1). COVID-19 monitoring is a priority in France and it is unlikely that any outbreak linked to the pilgrimage would have been missed.

We found only one article mentioning COVID-19 cases related to the Arbaeen pilgrimage among 139 Omani pilgrims with a 3 % proportion of SARS-CoV-2 infection [19] (Table 1).

Table 1
Major religious mass gatherings since the COVID-19 pandemic started and available information about SARS-CoV-2 infection in participants.

Mass gathering (date)	Country	Number of attendees	Individual tested (method)	Testing methods	Number of positive cases (%)	References
Grand Magal de Touba (October 2020)	Senegal	4-5 million (estimated)	109 Senegalese patients with RTI symptoms, consulting at a health care center near Touba, October 4–8, 2020 (PCR on nasal swabs) 106 Senegalese pilgrims returning home to their villages after the event, 57 % with RTI symptoms	PCR on nasal swabs	0 0	[10] [11]
Grand Magal de Touba (September 2021)	Senegal	4-5 million (estimated)	53 Senegalese patients with RTI symptoms consulting at a health care center near Touba September 24–28, 2021 125 Senegalese pilgrims returning home to their villages after the event, 55 % with RTI symptoms	PCR on nasal swabs	0 0	[12] [11]
Grand Magal de Touba (September 2022)	Senegal	4-5 million (estimated)	57 Senegalese patients with RTI symptoms consulting at a health care center near Touba September 24–28, 2022 99 Senegalese pilgrims returning home to their villages after the event, 45 % with RTI symptoms	PCR on nasal swabs	1 (1 %) 7 (7 %)	[13]
Hajj (July–August 2020)	Saudi Arabia	1000	All 1000 Saudi participants were tested following participation in the pilgrimage	PCR	0	[14]
Hajj (July 2021)	Saudi Arabia	58,428	25,000 Saudi pilgrims were tested following participation in the pilgrimage	PCR	41 (0.2 %)	[15]
Umrah (May 2022)	Saudi Arabia	2.75 million	1003 Egyptian pilgrims returning home following participation in the pilgrimage, 6 % with RTI symptoms	PCR on nasopharyngeal and oropharyngeal swabs	67 (6.7 %)	[15] [16]
Hajj (July 2022)	Saudi Arabia	899,353	3862 Egyptian pilgrims returning home following participation in the pilgrimage, 4 % with RTI symptoms	PCR on nasopharyngeal and oropharyngeal swabs	384 (9.9 %)	[16]
Hajj (July 2022)	Saudi Arabia	899,353	179 Saudi citizens and residents of the two holy cities and Hajj pilgrims with severe acute respiratory illness were tested during the 2022 peri-Hajj period	PCR on nasopharyngeal swabs	28 (15.0 %)	[18]
Lourdes Pilgrimage (2020 and 2021)	France	800,000 and 1.6 million	No data	No data	No data	–
Arbaeen (October 2020 and September 2021)	Iraq	Unknown in 2020, 40,000 in 2021	No data	No data	No data	–
Arbaeen (August 2021)	Iraq	40,000	139 Omani pilgrims tested following participation in the pilgrimage, no data on clinical symptoms	PCR	4 (2.9 %)	[19]

*The proportion was calculated on the total of participants.

4. Discussion

4.1. The grand Magal of Touba

The GMT takes place each year on 18th Safar, the second month of the Muslim calendar, in Touba, Senegal. The GMT celebrates the departure into exile of Cheikh Ahmadou Bamba Mbacké, the founder of Mouridism (a Suffi Muslim order) and of the holy city of Touba. The event's main activity consists of visiting the Grand Mosque and the mausoleum of the Cheikh. An estimated four to five million pilgrims from across Senegal and the surrounding countries, as well as from countries outside Africa, participate in the celebration [2]. The GMT took place in 2020 and 2021 without major restrictions in terms of participant numbers but with hand washing at strategic points, mandatory wearing of face masks in enclosed spaces, and a decreased flow of pilgrims in public places of pilgrimage (mosques, mausoleums, etc.). The World Health Organization (WHO) trained 80 religious leaders on the mode of transmission of SASR-CoV-2 and provided posters explaining correct hand hygiene in Arabic and Wolof, the language of the Senegalese people, to use during the pilgrimage [24]. The Ministry of Health of Senegal collaborated with the religious authorities to deploy a team to communicate with the population on the health risks during the 2020 and 2021 GMT [25,26]. During the 2021 GMT, the WHO deployed specialists to boost epidemiological surveillance and awareness of health risks [27]. It should be noted that the dates of the event coincided with periods of low circulation of the SARS-CoV-2 in Senegal from 2020 to 2022 (Fig. 2) [10–12]. There were no case reported in the 2020 and 2021 GMT, but we observed some cases in 2022 [8–11]. It could be explained by a lower adherence to preventive measures by pilgrims during the 2022 GMT.

4.2. The Hajj and umrah

The Hajj is a religious gathering that takes place every year in Mecca, Saudi Arabia between the 8th and the 13th of Dhul Hijjah, the 12th and last month of the Islamic calendar [28]. It is one of the five pillars of Islam and is mandatory once in a lifetime for any Muslim who is able to perform the Hajj rituals. The Hajj usually brings together 2 to 3 million pilgrims from 180 countries each year [29]. Several rituals retracing the steps of the prophet Muhammad are performed by the pilgrims in Mecca and other sacred sites in the surrounding area for five days. The Umrah, unlike the Hajj, is a smaller pilgrimage that can be made during any month but especially during the month of Ramadan, with an estimated 10 million participants each year in the pre-COVID period. It takes place in the Mecca Gran Mosque only. Like other respiratory infections, SARS-CoV-2 poses a public health challenge in the host countries of mass gatherings.

Several preventive measures such as hand hygiene, face mask wearing, and use of disposable handkerchiefs were recommended by the Kingdom of Saudi Arabia (KSA) Ministry of Health from the beginning of the COVID-19 pandemic [30]. In addition, several measures have been implemented in the country, including in the holy cities of Mecca and Madina [31]. Suspension of entry for Umrah was on February 27, 2020 and suspension of Umrah was on March 7, 2020. The government also suspended prayers in mosques on March 17 with full curfew in Mecca and Madina on April 2, 2020 [32]. The Umrah was suspended in early March 2020. In addition, pilgrims were assigned to groups (safety bubbles) of 20 pilgrims. Each group was separated from the others during transportation, housing and rituals [14]. For the 2021 Hajj, the authorities expanded the number of pilgrims to 60,000 pilgrims aged 18–60 years old who had no comorbidities such as obesity and were fully vaccinated against COVID-19. International pilgrims had to have a negative SARS-CoV-2 PCR test 72 h prior to arrival in the holy cities. In addition, face mask use, hand hygiene practice and physical distancing were implemented among pilgrims and the safety bubble strategy was increased to 100 pilgrims [15,28,33]. Of note, the Hajj seasons in 2020 and 2021 took place during periods of active transmission of SARS-CoV-2 in Saudi Arabia (Fig. 2). Umrah was reopened in October 2020 to fully vaccinated pilgrims with health checks at various points, mandatory face mask wearing and use of hand sanitizer, and strict social distancing [33]. In August 2021, Umrah permits were issued to international pilgrims and all restrictions were lifted in April 2022. No significant changes in COVID-19 epidemiology in KSA resulted from reopening the Umrah [28].

Three studies conducted among pilgrims during the 2022 Hajj season were included [16,18,21] and we observed SARS-CoV-2 infection rates varying from 0.004 % to 15.0 %. This may be explained by differences in study populations. According to KSA Ministry of Health report, only 38 cases (0.004 %) were recorded. However, in this report, the number of people tested was not mentioned [21]. In the study by Kandeel et al. the authors systematically investigated SARS-CoV-2 infection in 3826, 4 % of whom had respiratory symptoms and 10 % were infected [16]. The study by Assiri et al. [18] was performed on 179 Saudi citizens and residents of the two holy cities and Hajj pilgrims with severe acute respiratory illness, therefore, the proportion of SARS-CoV-2 infection was highest (15.0 %).

4.3. The Kumbh Mela

The Purna Kumbh Mela is a large Hindu religious gathering that takes place in India on the banks of the Ganges, Shipra and Godavari rivers once every 12 years at four holy cities, usually starting in January and lasting about three months. However, the Maha Kumb Mela occurs once every 144 years. In 2013, an estimated 120 million pilgrims participated in the Maha Kumb Mela during the 55 days of celebration [34]. The last Purna Kumbh Mela was postponed to April 2021 and shortened to 30 days because India was experiencing a COVID-19 wave (Fig. 2). The single COVID-19 vaccination dose rate of the overall Indian population at the time of the event did not exceed 20 % [35]. The event took place in the city of Haridwar (Uttarakhand state) and was attended by an estimated 10–20 million people [36]. Daily new cases of COVID-19 in India were below the 100,000-mark before the event but reached the 400,000-mark at the end of the 30-day Kumbh Mela, suggesting that the mass gathering acted as a superspreading event for COVID-19 in the country [36]. The increase in cases during the event was 276 % in Haridwar and 236 % in Uttarakhand state, compared to 92 % in India overall [36]. The only available data on SARS-CoV-2 testing in pilgrims showed a low positivity rate during the 2021 Kumbh Mela but the event seems to be a superspreading event, however, pilgrims were tested before the main days of the event. Indeed, there were three main days during the Kumbh Mela (April 12, 14, and 27, 2021) while pilgrims were tested on April 11, 2021 [23].

4.4. The lourdes pilgrimage

Numerous pilgrimages are organized in Lourdes on different dates each year, including domestic and international Christian pilgrimages. They celebrate the vision of the Virgin Mary and the discovery of a sacred source of water by Bernadette Soubirou in 1858. Pilgrims visit the source located in a crypt and the various basilica and chapels of the sanctuary. The annual attendance at the sanctuary was estimated at 3.5 million people in 2019, including 7000 participants on Assumption Day [37]. Most of these pilgrimages were cancelled or restricted in 2020 and 2021, with crypt access closure, limited participant numbers, mandatory face mask use, and social distancing [38,39]. Nevertheless, in those two years about 800,000 and 1.6 million pilgrims visited the sanctuary [40] including during periods of active transmission of COVID-19 (Fig. 2).

4.5. The Arbaeen

The Arbaeen (fortieth in Arabic) is a Shiite Muslim event that commemorates the death of Imam Hussein Ben Ali. The Arbaeen is

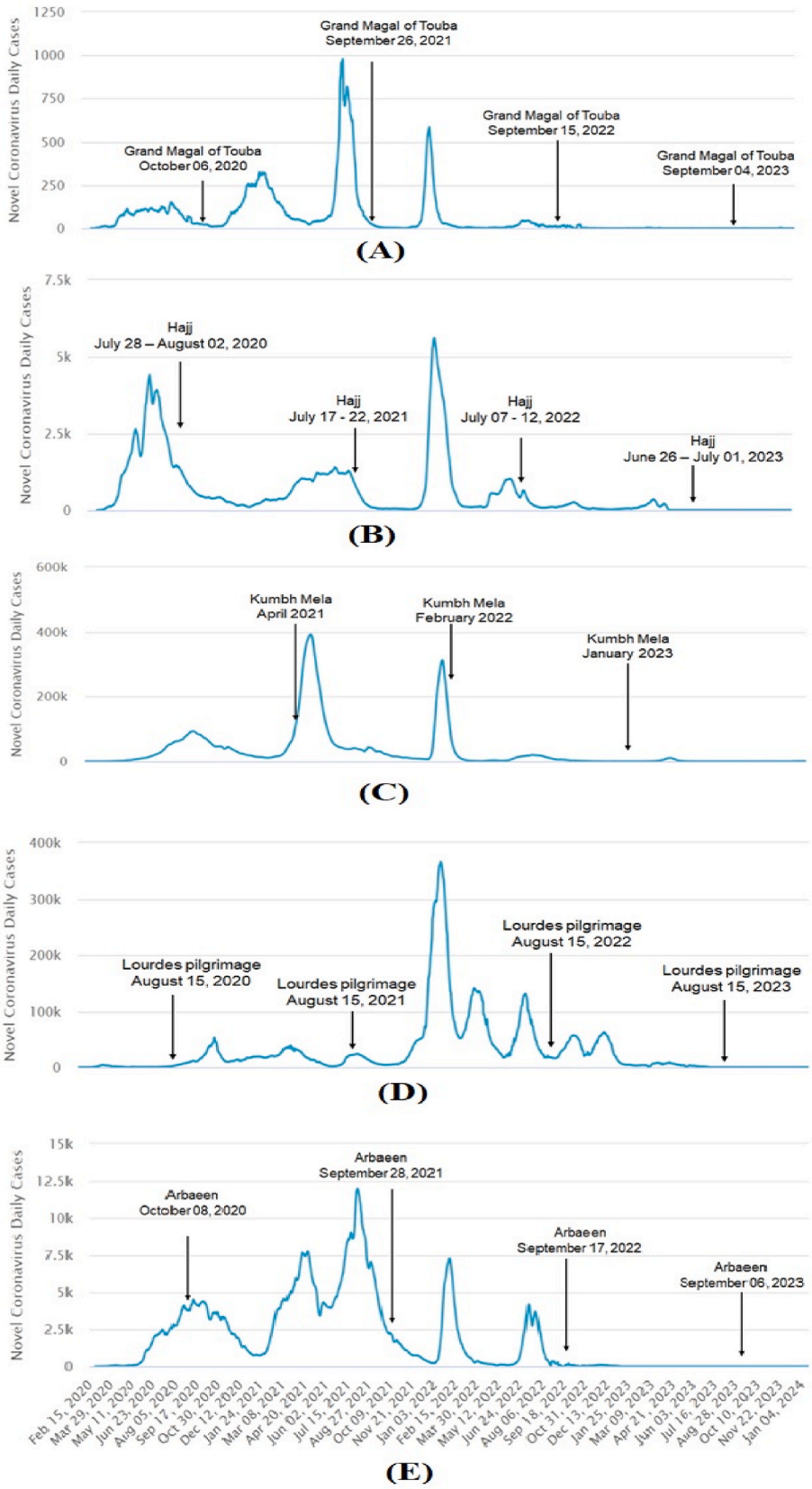

Fig. 2. Daily new confirmed COVID-19 cases per million people in Senegal (A), Saudi Arabia (B), India (C), France (D), and Iraq (E) (Source: https://www.worldometers.info/coronavirus/country/senegal/).

celebrated in the city of Karbala in Iraq on the 20th Safar, 40 days after Ashura (the 10th day of the first Islamic Month). An estimated 17 to 20 million participants gather in the city, many of them travelling on foot from different parts of Iraq and Iran [41]. In 2020, Iran-Iraq borders were closed to Arbaeen pilgrims and preventive measures including face mask wearing, hand hygiene practices, and social distancing were recommended [42]. In 2021, the Arbaeen was restricted to a total of 40,000 participants, including 10,000 from Gulf countries [43]. The events in 2020 and 2021 coincided with periods of active transmission of COVID-19 (Fig. 2). We found one article mentioning COVID-19 cases related to the Arbaeen pilgrimage among 139 Omani pilgrims with a low proportion of SARS-CoV-2 infection (2.9 %) [19]. However, it cannot be excluded that this might have resulted from an underreporting of cases. Our hypothesis is that testing capacities might be limited in this country.

Our study has some limitations. This is a small review based on 10 studies. Some religious MG lack detailed data support on SARS-CoV-2 transmission, such as the Lourdes pilgrimage, potentially affecting a comprehensive assessment of its impact. Additionally, the quality of some studies is moderate, leading to potential bias and uncertainty, notably regarding underreporting of cases. Therefore, these results do not accurately reflect the spread of the SARS-CoV-2 in all religious MG events which might limit the generalizability of our findings. Differences in COVID-19 infection prevalence during MGs depend on many factors such as the preventive measures applied, the vaccination status of pilgrims, and the circulation status of SARS-CoV-2 virus at the time of the events, including the nature of variants. However, due to the heterogeneity of the studies reviewed, the influence of SARS-CoV-2 variants and preventive measures on the spread of the virus was not thoroughly examined. Moreover, due to the lack of information on the vaccination status of pilgrims, the role of vaccines in preventing COVID-19 disease at MGs was not investigated.

5. Conclusion

During the pandemic, the Hajj or Umrah in Saudi Arabia, the Grand Magal in Senegal, the pilgrimage of Lourdes in France and the Arbaeen in Iraq had limited impact on the transmission of COVID-19 in the respective host countries. In Saudi Arabia, the implementation of public health and social measures, alongside with a comprehensive testing strategy, likely accounted for the success of the COVID-19 countermeasures [44–47]. By contrast, the Kumbh Mela seems to have triggered the rapid increase in COVID-19 cases in India after the event was maintained with little information available about policies and mitigation strategies that were implemented during the event [47]. The transmission of the SARS-CoV-2 virus during religious mass gathering events depends on many factors such as: the number and density of pilgrims, the intensity of circulation of the virus in the hosting country at the time of the event, the intensity of circulation of the virus in countries sending international participants at the time of the event, the transmissibility of virus variants at the time of the event, the various preventive measures adopted, and the immunity status of the pilgrims. It is important to closely monitor the country's epidemic situation, including the nature of virus variants that circulate, in order to prevent the spread of the virus and protect public health by taking the most appropriate preventive measures.

Funding

No.

Availability of data

All the data were extracted from included studies.

CRediT authorship contribution statement

Ndiaw Goumballa: Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Data curation, Conceptualization. **Van Thuan Hoang:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Data curation, Conceptualization. **Jaffar A. Al-Tawfiq:** Writing – review & editing, Validation, Methodology, Investigation. **Cheikh Sokhna:** Writing – review & editing, Validation, Methodology, Investigation, Conceptualization. **Philippe Gautret:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Data curation, Conceptualization.

Declaration of competing interest

No.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.nmni.2024.101442.

References

[1] Hoang VT, Gautret P. Infectious diseases and mass gatherings. Curr Infect Dis Rep 2018;20(11):1–12.
[2] Sokhna C, Mboup BM, Sow D, Camara G, Dieng M, Sylla M, et al. Communicable and non-communicable disease risks at the Grand Magal of Touba: the largest mass gathering in Senegal. Trav Med Infect Dis 2017;19:56–60.
[3] Sridhar S, Gautret P, Brouqui P. A comprehensive review of the Kumbh Mela: identifying risks for spread of infectious diseases. Clin Microbiol Infect 2015;21:128–33.
[4] Che Mat NF, Edinur HA, Abdul Razab MKA, Safuan S. A single mass gathering resulted in massive transmission of COVID-19 infections in Malaysia with further international spread. J Trav Med 2020;27:taaa059.
[5] Kim HJ, Hwang HS, Choi YH, Song HY, Park JS, Yun CY, et al. The delay in confirming COVID-19 cases linked to a religious group in Korea. J Prev Med Public Health 2020;53:164–7.
[6] Badshah SL, Ullah A, Badshah SH, Ahmad I. Spread of novel coronavirus by returning pilgrims from Iran to Pakistan. J Trav Med 2020;27:taaa044.
[7] Gerbaud L, Guiguet-Auclair C, Breysse F, Odoul J, Ouchchane L, Peterschmitt J, et al. Hospital and population-based evidence for COVID-19 early circulation in the east of France. Int J Environ Res Publ Health 2020;17:7175.
[8] National Heart, Lung and Blood Institute. Study Quality Assessment Tools https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools (accessed February 17, 2024).
[9] Bagias C, Sukumar N, Weldeselassie Y, Oyebode O, Saravanan P. Cord blood adipocytokines and body composition in early childhood: a systematic review and meta-Analysis. Int J Environ Res Publ Health 2021;18:1897.
[10] Goumballa N, Dieng M, Sokhna C, Gautret P. Lack of SARS-CoV-2 among Grand Magal de Touba pilgrims consulting for respiratory symptoms in October 2020. Trav Med Infect Dis 2021;39:101916.
[11] Goumballa N, Hoang VT, Diouf FS, Mbaye B, Parola P, Sokhna C, et al. Risk factors for symptoms of infection and the acquisition of pathogens among pilgrims at the Grand Magal of Touba, 2017-2021. Trav Med Infect Dis 2022;49:102418.
[12] Goumballa N, Sambou M, Bassene H, Dieng M, Aidara A, Fenollar F, et al. High influenza A prevalence but no SARS-CoV-2 among 2021 Grand Magal pilgrims in Touba, Senegal. Trav Med Infect Dis 2021;44:102189.
[13] Diouf C, Ouaddane I, Goumballa N, Sambou M, Bassène H, Dieng M, et al. Circulation of SARS-CoV-2 virus among pilgrims at the 2022 Grand Magal of Touba. J Trav Med 2023;30:taad024.
[14] Jokhdar H, Khan A, Asiri S, Motair W, Assiri A, Alabdulaali M. COVID-19 Mitigation plans during Hajj 2020: a success story of zero cases. Health Secur 2021;19:133–9.
[15] Alahmari AA, Khan AA, Alamri FA, Almuzaini YS, Alradini FA, Almohamadi E, et al. Hajj 2021: role of mitigation measures for health security. J Infect Public Health 2022;15:1350–13544.
[16] Kandeel A, Fahim M, Deghedy O, BahaaEldin H, Roshdy WH, Khalifa MK, et al. Comparative analysis of COVID-19 and influenza prevalence among Egyptian pilgrims returning from Hajj and Umrah in 2022: epidemiology, clinical characteristics, and genomic sequencing. Arch Publ Health 2024;82:6.
[17] Kandeel A, Fahim M, Deghedy O, Alim W, Roshdy WH, Khalifa MK, et al. Incidence, risk factors, and whole-genome sequence of SARs-CoV-2 and influenza virus among the Egyptian pilgrims returning from Umrah mass gathering in Saudi Arabia, April-May 2022. J Infect Public Health 2022;15:12901296.
[18] Assiri AM, Alsuraihi H, Alshahrani AMM, Alzaid SZ, Albarraq AM, Asiri S, et al. Viral aetiology of severe acute respiratory illness among patients admitted during the 2022 peri-Hajj period. Int J Infect Dis Reg 2023;8:28–30.

[19] Al Lawati T, Al Lawati ZT, Al Bahrani B, Al Awaidy S. COVID-19 Among Omani pilgrim returnees from the Ashura mass gathering. Cureus 2023;15:e36003.
[20] Al-Tawfiq JA, Memish ZA, Zumla A. Mass religious gatherings events and COVID-19 -easing of COVID-19 restrictions and a staged approach to scaling up the Umrah pilgrimage. Trav Med Infect Dis 2021;40:101986.
[21] Saudi Press Agency. Health Minister announces success of health plans for Hajj 2022 n.d. https://www.spa.gov.sa/viewfullstory.php?lang=en&newsid=2369461. [Accessed 17 January 2024].
[22] Patel AK, Mukherjee S, Leifels M, Gautam R, Kaushik H, Sharma S, et al. Mega festivals like MahaKumbh, a largest mass congregation, facilitated the transmission of SARS-CoV-2 to humans and endangered animals via contaminated water. Int J Hyg Environ Health 2021;237:113836.
[23] Business Insider India. Kumbh Mela attended by 3.5 million pilgrims as India becomes the second most COVID-19 affected country in the world.https://www.who.int/about/accountability/results/who-results-report-2020-mtr/country-story/2020/safe-practices-during-the-pilgrimage-to-the-grand-magal-of-touba-in-senegal-during-the-covid-19-pandemic.
[24] World Health Organization. Safe practices during the pilgrimage to the Grand magal of Touba in Senegal during the COVID-19 pandemic. https://www.who.int/about/accountability/results/who-results-report-2020-mtr/country-story/2020/safe-practices-during-the-pilgrimage-to-the-grand-magal-of-touba-in-senegal-during-the-covid-19-pandemic. [Accessed 15 January 2024].
[25] Ministère de la Santé et de l'Action Sociale du Sénégal. Album Magal SNEIPS 2020 : Communication pour la prévention des risques sanitaires durant la période du Grand Magal de Touba. https://www.sante.gouv.sn/mediatheque/phototheques/album-magal-sneips-2020-communication-pour-la-pr%C3%A9vention-des-risques. [Accessed 15 January 2024].
[26] Ministère de la Santé et de l'Action Sociale du Sénégal. Grand Magal de Touba édition 2020 : Le SNEIPS à la grande mosquée de Touba pour échanger avec les membres du Dahira Moukhadimatoul Khidma sur les mesures de prévention contre les risques sanitaires. https://www.sante.gouv.sn/mediatheque/phototheques/grand-magal-de-touba-%C3%A9dition-2020-le-sneips-%C3%A0-la-grande-mosqu%C3%A9e-de-touba. [Accessed 15 January 2024].
[27] World Health Organization. Bureau régional pour l'Afrique 2024. Appui de l'OMS à la gestion de la COVID-19 lors du Grand Magal. https://www.afro.who.int/fr/appui-de-l-oms-a-la-gestion-de-la-covid-19-lors-du-grand-magal (accessed January 15, 2024).
[28] Al-Tawfiq JA, Kattan RF, Memish ZA. Escalating the 2022 Hajj during the third year of the COVID-19 pandemic. J Trav Med 2022;29:taac059.
[29] Memish ZA, Steffen R, White P, Dar O, Azhar EI, Sharma A, et al. Mass gatherings medicine: public health issues arising from mass gathering religious and sporting events. Lancet 2019;393:2073–84.
[30] Hoang VT, Gautret P, Memish ZA, Al-Tawfiq JA. Hajj and Umrah mass gatherings and COVID-19 infection. Curr Trop Med Rep 2020;7:133–40.
[31] Yezli S, Khan A. COVID-19 social distancing in the Kingdom of Saudi Arabia: bold measures in the face of political, economic, social and religious challenges. Trav Med Infect Dis 2020;37:101692.
[32] Khan A, Alsofayan Y, Alahmari A, Alowais J, Algwizani A, Alserehi H, et al. COVID-19 in Saudi Arabia: the national health response. East Mediterr Health J 2021;27:1114–24.
[33] Basahel S, Alsabban A, Yamin M. Hajj and Umrah management during COVID-19. Int J Inf Technol 2021;13:2491–4955.
[34] Cariappa MP, Singh BP, Mahen A, Bansal AS. Kumbh Mela 2013: healthcare for the millions. Med J Armed Forces India 2015;71:278–81.
[35] Rocha ICN, Pelayo MGA, Rackimuthu S. Kumbh Mela religious gathering as a massive superspreading event: potential culprit for the exponential surge of COVID-19 cases in India. Am J Trop Med Hyg 2021;105:868–71.
[36] Shukla S, Khan R, Ahmed Y, Memish ZA. Conducting mass gathering events during the COVID-19 pandemic: a case study of Kumbh Mela 2021 as a potential "super spreader event.". J Trav Med 2021;28:taab160.
[37] La Dépêche.fr. Lancement de la saison à Lourdes : "l'année du redécollage", selon le recteur Mgr Olivier Ribadeau-Dumas. https://www.ladepeche.fr/2022/03/31/lancement-de-la-saison-a-lourdes-lannee-du-redecollage-selon-le-recteur-mgr-olivier-ribadeau-dumas-10206641.php (accessed January 15, 2024).
[38] Bleu France. Pèlerinage du 15 août : pèlerins et malades sont de retour à Lourdes. 2022. https://www.francebleu.fr/infos/societe/les-pelerins-et-les-malades-sont-de-retour-a-lourdes-1660147909. [Accessed 15 January 2024].
[39] Mróz F. The Impact of COVID-19 on pilgrimages and religious tourism in Europe during the first six months of the pandemic. J Relig Health 2021;60:625–45.
[40] Le Point. Lourdes: des milliers de pèlerins participent à la procession aux flambeaux. https://www.lepoint.fr/societe/lourdes-des-milliers-de-pelerins-participent-a-la-procession-aux-flambeaux-14-08-2022-2486330_23.php. [Accessed 15 January 2024].
[41] Al Ansari F, Al Ansari M, Hill-Cawthorne GA, Abdulzahra MS, Al Ansari MB, Al Ansari B, et al. Arbaeen public health concerns: a pilot cross-sectional survey. Trav Med Infect Dis 2020;35:101546.
[42] The Arab Weakly. Iraq to allow 40,000 foreigners to attend Arbaeen pilgrimage. https://thearabweekly.com/iraq-allow-40000-foreigners-attend-arbaeen-pilgrimage. [Accessed 15 January 2024].
[43] Alarabiya News. Iraq caps Arbaeen foreign pilgrim numbers at 40,000 as COVID-19 precaution n.d. https://english.alarabiya.net/coronavirus/2021/09/05/Iraq-caps-Arbaeen-foreign-pilgrim-numbers-at-40-000-as-COVID-19-precaution (accessed January 15, 2024).
[44] Hashim HT, Babar MS, Essar MY, Ramadhan MA, Ahmad S. The Hajj and COVID-19: how the pandemic shaped the world's largest religious gathering. Am J Trop Med Hyg 2021;104(3):797–9.
[45] Al-Tawfiq JA, Memish ZA, Zumla A. Mass religious gatherings events and COVID-19 -easing of COVID-19 restrictions and a staged approach to scaling up the Umrah Pilgrimage. Trav Med Infect Dis 2021;40:101986.
[46] Al-Tawfiq JA, El-Kafrawy SA, McCloskey B, Azhar EI. COVID-19 and other respiratory tract infections at mass gathering religious and sporting events. Curr Opin Pulm Med 2022;28(3):192–8.
[47] Alahmari AA, Khan AA, Alamri FA, Almuzaini YS, Alradini FA, Almohamadi E, et al. Hajj 2021: role of mitigation measures for health security. J Infect Public Health 2022;15(11):1350–4.