

Infection Control Practices by Nurses during Hajj and Umrah in Saudi Arabia

Salihah Fayi Ali Al-ali¹, Miskah Ahmad Faya Assiri², Mona Mohammad Ibrahim Asiry³, Aishah Ahmed Mohammed Asseri⁴, Areej Mohammed Abdu Asiri⁵, Boshra nasser M alhowiti⁶, Saedah mohmmad musaad alsbaey⁷, Khadijah hassan Mohammed daghasi⁸

1 Nursing, Aseer Cluster West Mahayel 2 Mahayel Aseer

2 Nursing, Aseer Cluster West Mahayel 2 Mahayel Aseer

3 Nursing, Muhayil Asir Health Care Center Mohayil Asir

4 Nursing, Aseer Cluster West Mahayel 2 Mahayel Aseer

5 Nursing, Aseer Cluster West Mahayel 2 Mahayel Aseer

6 Nursing, Second Health Cluster Jeddah

7 Nursing, sulayyil hospital al sulayyil

8 Nursing, Dammam medical complex Dammam

Abstract

Hajj and Umrah are among the largest mass gatherings globally, attracting millions of pilgrims annually to Saudi Arabia. These events pose significant public health challenges, primarily due to the heightened risk of infectious disease transmission resulting from overcrowding and close contact among individuals from diverse global regions. This literature review explores the critical role of nurses in infection control during these pilgrimages, focusing on key areas such as health education, implementation of standard precautions, outbreak management, surveillance, and vaccination campaigns. The findings highlight that while nurses demonstrate a substantial impact on reducing infection risks through proactive measures, gaps persist in knowledge, adherence to practices, and access to resources. Targeted training programs, continuous professional development, and improved infrastructure are essential to enhancing their effectiveness. By addressing these areas, the study underscores the need for a robust, evidence-based approach to infection prevention during Hajj and Umrah, contributing to better health outcomes for pilgrims and supporting global public health security.

Keywords; Hajj, Umrah, Infection control, Nurses, Public health, Mass gatherings, Outbreak management, Health education.

Introduction

Hajj and Umrah are significant Islamic pilgrimages attracting millions of Muslims annually to Saudi Arabia. These mass gatherings pose unique public health challenges, particularly in infection control, due to the close proximity of individuals from diverse global backgrounds (**Nabil Ramadan et al., 2016**). Nurses play a crucial role in maintaining infection control during these events, ensuring the safety of pilgrims and healthcare providers alike (**Alrashdi & Thobaity, 2024**). The deployment of 25,000 healthcare workers, including nurses, during Hajj demonstrates

the scale of efforts to address public health concerns. Nurses actively manage respiratory and gastrointestinal infections, leveraging health education and prevention strategies to minimize outbreaks (**Shafi et al., 2016**). Evidence underscores the importance of ongoing training in infection prevention and therapeutic communication to enhance health outcomes and inform better policy development. By addressing both individual and systemic health challenges, nurses contribute significantly to public health management during one of the world's largest mass gatherings.

A study conducted by Ghabrah et al. (2007) evaluates healthcare workers' (HCWs) infection control knowledge, attitudes, and practices during Hajj. Using a self-administered questionnaire, the research involved 392 HCWs, including nurses (54.8%) and doctors (45.2%), working in hospitals and primary healthcare centers across Saudi Arabia. A significant proportion (81.8%) of HCWs demonstrated correct responses to at least 5 out of 11 knowledge-based questions, indicating a reasonable understanding of infection control. However, critical gaps were noted in specific areas, such as hospital infection control measures. The study observed variability in compliance with infection control practices, with nurses showing slightly better adherence than doctors. Nonetheless, both groups reported inconsistent application of practices, highlighting a need for enhanced training and monitoring (**Ghabrah et al., 2007**). Another study highlights the critical role of nurses in managing tuberculosis (TB) during high-risk mass gatherings like the Hajj. The research involved 540 healthcare workers (HCWs) from 13 hospitals, representing 17 countries, and used anonymous self-administered questionnaires to assess TB-related knowledge, attitudes, and practices. Nurses showed moderate knowledge of TB, with an average score of 52%. However, significant gaps were noted in recognizing multidrug-resistant TB (MDR-TB), understanding latent TB infection (LTBI), and correctly identifying diagnostic protocols. These deficiencies underscore the need for enhanced TB-specific education among nurses (**Alotaibi et al., 2019**).

A study conducted by Alanzi et al. (2019), aimed to investigate the practices of healthcare workers towards MERS-CoV Infection at PHCs in Madinah, KSA during Hajj 1440, 2019 found that nurses exhibited gaps in knowledge and attitudes toward MERS-CoV. However, they demonstrated adherence to good infection control practices. The need for targeted educational programs was highlighted to enhance their understanding and address attitude challenges, particularly in high-risk and crowded environments during Hajj. Training interventions focusing on these areas can significantly reduce transmission risks among healthcare workers and patients (**Alanzi et al., 2019**). An interventional program for nursing staff during the Hajj significantly improved nurses' knowledge of mass gathering-related infectious diseases. Before the program, only 20-28% of participants had adequate knowledge across topics like meningitis, respiratory illnesses, gastrointestinal diseases, and heat exhaustion. Post-training, knowledge scores rose dramatically, with 91-94% achieving adequate understanding immediately after the program, though this declined slightly (58-74%) after three months. Improvements were most pronounced in recognizing causes of diseases and prevention strategies, such as vaccination and risk factor identification. Results also highlighted significant gains in knowledge retention among nurses, particularly those in intensive care units, and underscored the importance of continuous education

tailored to address specific infectious disease risks encountered during Hajj. Education level and work experience also influenced outcomes (**El-Bahnasawy et al., 2014**).

The current study revolves around the unique public health challenges posed by the Hajj and Umrah pilgrimages, particularly concerning infection control due to the dense congregation of individuals from diverse global backgrounds. These mass gatherings amplify the risk of infectious diseases such as respiratory and gastrointestinal infections, creating a pressing need for effective prevention and management strategies. The aim of the study is to examine the role of nurses in infection control during these events, highlighting their contributions to health education, implementation of standard precautions, outbreak management, surveillance, and vaccination campaigns.

1. Infection risks during Hajj and Umrah

The Hajj and Umrah pilgrimages in Saudi Arabia represent significant public health challenges due to the risk of infectious diseases arising from overcrowding and global interconnectivity. These gatherings annually attract millions of pilgrims from diverse regions, creating an ideal environment for the transmission of respiratory, gastrointestinal, and other infectious diseases. Respiratory tract infections (RTIs) are particularly prominent, with studies highlighting elevated risks during these events due to factors like poor hygiene practices and insufficient preventive measures (**Albutti et al., 2023**). Hand hygiene knowledge and practices among pilgrims significantly impact the prevalence of infections. Research comparing Hajj and Umrah pilgrims showed higher hand hygiene compliance among Hajj attendees, correlating with lower respiratory tract infection rates (**Mahdi et al., 2020**). However, disparities in practice persist, as seen in Malaysian pilgrims, whose inadequate preventive behaviors necessitate enhanced educational campaigns (**Dauda Goni et al., 2019**).

Meningococcal disease is another critical concern. Historical outbreaks linked to the Hajj prompted Saudi Arabia to enforce mandatory quadrivalent meningococcal vaccination and chemoprophylaxis, measures credited with preventing subsequent epidemics (**Yezli et al., 2016**). Nevertheless, emerging strains like serogroup X pose ongoing risks, underscoring the need for robust surveillance and updated vaccine strategies (**Yezli, 2018**). Influenza and other respiratory viruses, such as rhinoviruses and coronaviruses, are prevalent among returning pilgrims. Studies from Indian and international cohorts illustrate the high transmission rates of these pathogens, amplified by the dense crowding and shared accommodations during the pilgrimage (**Koul et al., 2018**). Vaccination and health education targeting respiratory hygiene remain pivotal in mitigating these risks. Pneumococcal disease also threatens vulnerable groups such as the elderly and individuals with comorbidities. Despite the availability of effective vaccines, there is no unified policy mandating pneumococcal immunization for pilgrims. Addressing knowledge gaps and implementing evidence-based policies could significantly reduce associated morbidity and mortality (**Yezli et al., 2019**). Gastrointestinal diseases, although less reported compared to RTIs, continue to affect pilgrims due to food contamination and suboptimal hand hygiene. Studies emphasize the importance of alcohol-based hand sanitizers over traditional methods to reduce the prevalence of diarrheal illnesses (**Gautret et al., 2015**).

Severe acute respiratory illnesses, such as those caused by MERS-CoV, remain a latent threat. Enhanced surveillance and vaccination campaigns have been effective in preventing outbreaks among Hajj and Umrah pilgrims (**Hoang et al., 2020**). However, the potential for zoonotic and novel pathogens requires ongoing vigilance. Tuberculosis and other airborne infections are exacerbated by overcrowded conditions during pilgrimages. A prospective study highlights the heightened risk of tuberculosis transmission, necessitating pre-travel screening and post-travel monitoring to mitigate long-term health impacts (**Wilder-Smith et al., 2005**). The globalization of pathogens during Hajj and Umrah is evidenced by the cross-contamination of viruses and bacteria among international pilgrims. This underscores the role of mass gatherings in spreading infections worldwide and the importance of comprehensive health policies, including vaccinations and hygiene practices (**Memish et al., 2015**).

Ultimately, the COVID-19 pandemic introduced unprecedented challenges to the organization of Hajj and Umrah, given their nature as large-scale mass gatherings. The virus's rapid spread via respiratory droplets, combined with the typical demographic profile of pilgrims—many of whom are older and have underlying health conditions—posed severe risks for outbreaks during these events (**Sheerah et al., 2023**). In 2020, Saudi Arabia implemented significant restrictions, including the suspension of Umrah and a scaled-down Hajj, to protect public health. The success of these measures highlighted the importance of early interventions in controlling viral transmission. Countries that adopted swift action to limit travel and mass gatherings saw lower rates of COVID-19 spread associated with returning pilgrims (**Arbaein et al., 2024**). Enhanced health screening, mandatory vaccination, and reduced participant numbers were crucial strategies in mitigating the pandemic's impact on these religious events. In subsequent years, vaccination campaigns were a cornerstone of Saudi Arabia's approach to reopening Hajj and Umrah safely. Pilgrims were required to present proof of vaccination against COVID-19, in addition to other mandatory immunizations, such as those for meningococcal disease and influenza. Strict health protocols, including testing before and after travel, mask mandates, and physical distancing during rituals, were also enforced to minimize risks (**Khan et al., 2024**).

2. Roles of nurses in infection control

2.1. Health education and awareness

Nurses play a critical role in health education, particularly in infection prevention during mass gatherings such as pilgrimages. By educating participants on infection control measures, including hand hygiene, respiratory etiquette, and the use of personal protective equipment (PPE), nurses empower individuals to take proactive steps to protect their health. Research shows that consistent infection prevention education enhances nurses' ability to protect patients and prevent disease transmission (**Rebmann & Carrico, 2017**). This education is pivotal, especially in environments with heightened infection risks. Research indicates that health education significantly reduces the incidence of respiratory and gastrointestinal infections among pilgrims. Alsaahafi and Cheng (2019) investigates the preparedness and practices of healthcare workers (HCWs) regarding Ebola Virus Disease (EVD) during the 2015 Hajj in Saudi Arabia. The study highlighted the significance of HCW training in infection control to mitigate risks during mass gatherings. With regard to knowledge levels among HCWs, Medical practitioners demonstrated higher awareness (76.5%) of EVD compared to nurses (59.6%) and other healthcare workers (56.7%). HCWs who underwent

pre-deployment Hajj-specific training exhibited significantly better infection control practices and knowledge than their untrained counterparts. Training improved awareness of transmission risks and proper handling protocols (**Alsahafi & Cheng, 2019**). Pre-departure seminars and on-site health briefings have proven effective in changing health behaviors. For example, education programs focusing on hand hygiene and the use of PPE have significantly reduced nosocomial infections, demonstrating the impact of nurses as educators (**Angelina, 2021**).

On-site education provided by nurses includes real-time demonstrations and reinforcement of hygiene practices, which have been linked to improved compliance among both healthcare workers and the public. A study in a tertiary hospital revealed that education significantly enhanced nurses' knowledge of infection control practices, though adherence remains a challenge without ongoing training and resources (**Salem, 2019**). This emphasizes the need for consistent monitoring and feedback mechanisms. The role of health workers in preventing respiratory infections among Hajj pilgrims is crucial. They are responsible for designing and delivering health education campaigns that emphasize basic hygiene, mask usage, cough etiquette, and social distancing. Health workers also evaluate pilgrims' knowledge, attitudes, and practices, tailoring interventions to address gaps. They actively engage in pre-departure orientations and on-site health monitoring, ensuring compliance with preventive measures. Their efforts significantly enhance the adoption of protective behaviors, ultimately reducing infection rates during the pilgrimage (**Goni et al., 2020**). A qualitative study of Indonesian nurses revealed that their effectiveness depends on competencies in ethical healthcare delivery, adherence to legal requirements, and strategic workforce coordination. Results showed that nurses emphasized the importance of therapeutic communication, particularly through platforms like WhatsApp, for effective collaboration with teams and stakeholders. Continuous training, resource allocation, and adherence to cultural and ethical practices were identified as essential for improving care quality (**Setiyarini & Kertia, 2024**).

2.2. Implementation of standard precautions

Nurses play a pivotal role in implementing standard infection control precautions during the Hajj and Umrah pilgrimages in Saudi Arabia. These precautions, including hand hygiene, the use of personal protective equipment (PPE), and safe injection practices, are critical in preventing hospital-acquired infections (HAIs) and ensuring the safety of both patients and healthcare providers (**Mahfouz et al., 2013**). Compliance with hand hygiene practices is the cornerstone of infection prevention. Studies in Saudi Arabia show varied compliance rates among nurses and other healthcare workers. For example, a study at Aseer Central Hospital found that 41% of healthcare workers failed to comply with hand hygiene protocols (**Mahfouz et al., 2013**). Regular training and reminders significantly improve compliance (**Mahfouz et al., 2014**). Proper use of PPE minimizes direct exposure to infectious agents. A study in Buraidah revealed barriers such as discomfort and patient stigma that deterred PPE use, despite its effectiveness (**ALjohani & Sulaiman, 2021**). Training sessions have been shown to improve knowledge and adherence to PPE protocols.

The prevention of bloodborne infections like Hepatitis B and C relies heavily on safe injection practices. Inadequate training on the proper disposal of sharps is a common gap identified in healthcare settings (**Sangeetha et al., 2015**). Nurses trained in these practices demonstrate significantly better compliance, reducing risks for both patients and themselves. Studies also emphasize the importance of continuous education in infection control. A project in the U.S. demonstrated that targeted training significantly improved nurses' knowledge and compliance with

standard precautions (**Ard, 2016**). Similarly, nurses in Najran, Saudi Arabia, who received formal hand hygiene training, showed better knowledge and practices (**Al-Qahtani, 2023**). Implementing multimodal strategies, such as education combined with feedback and systemic changes, has proven effective. A study at King Fahd Hospital demonstrated a significant increase in compliance with hand hygiene and a decrease in HAIs following such interventions (**Al Kuwaiti, 2017**).

The Kingdom of Saudi Arabia (KSA) has made significant investments in implementing these practices to protect millions of pilgrims. The KSA conducts extensive public health campaigns to educate healthcare workers and pilgrims about infection prevention. These campaigns focus on vaccinations, respiratory hygiene, and safe injection practices, reducing the risk of disease outbreaks (**Razavi et al., 2018**). Saudi Arabia's investments in advanced care units for infectious diseases, including isolation wards and rapid diagnostic labs, play a crucial role. These facilities are pivotal during Hajj to contain infections like MERS-CoV and influenza (**Shafi et al., 2016**). Studies highlight significant reductions in HAIs during Hajj. For instance, catheter-associated infections dropped from 3.73 to 1.75 per 1,000 patient-days following a comprehensive hand hygiene intervention (**Al Kuwaiti, 2017**). These efforts serve as a model for global mass gathering health management.

2.3. Surveillance and early detection

Nurses are pivotal in the surveillance and early detection of infectious diseases, performing a wide range of roles that include patient monitoring, data collection, and case reporting to public health authorities. Their involvement ensures timely interventions that are critical for preventing disease outbreaks and mitigating public health crises (**Kim & Cho, 2023**). Modern infectious disease surveillance systems rely heavily on the contributions of nurses. For example, the establishment of surveillance mechanisms during Hajj, where millions of pilgrims gather, demonstrates the effectiveness of real-time infectious disease tracking. Nurses play a crucial role in identifying high-risk individuals, implementing isolation measures, and ensuring targeted interventions (**Beggs-Yeager et al., 2021**).

Moreover, hospital-based surveillance systems often depend on infection control nurses to detect, report, and respond to infectious conditions, such as meningitis and influenza. A study in Mpumalanga Province, South Africa, highlights how hospital-based nurses' timely interventions effectively contained cholera outbreaks, underscoring their value in outbreak surveillance (**Durrheim et al., 2001**). The use of computer-based surveillance systems has expanded the capacity for early disease detection, particularly for central nervous system infections like meningitis. These systems analyze laboratory data and patient records to identify potential outbreaks, showcasing how nurses can harness technology for effective disease monitoring (**Gundlapalli, 2006**). Community-based surveillance also benefits significantly from nurses' expertise. For instance, a school-based syndromic surveillance system in Taipei successfully identified early cases of influenza-like illness and enterovirus, demonstrating how nurses' involvement in community settings can enhance public health interventions (**Weng et al., 2015**). Nurses also contribute to virological diagnostics by ensuring timely testing and reporting of infectious diseases. This approach was critical during the 2009 H1N1 influenza pandemic, where laboratory diagnostics provided early warnings, enabling appropriate public health responses (**Schweiger & Buda, 2012**). The role of nurses extends to addressing bioterrorism threats and emerging infectious diseases. They provide frontline detection and epidemiological insights, ensuring that public health systems are prepared to respond swiftly to intentional or unintentional biological events (**Veenema & Töke, 2006**). Nurses' effectiveness in surveillance also depends on

continuous training and coordination with microbiological laboratories. Collaborative efforts ensure that infection control measures are up-to-date and responsive to emerging threats (**Takano, 2001**). Advances in rapid detection technologies, such as real-time influenza detection, have further empowered nurses in primary care settings to provide accurate surveillance data to public health entities. These innovations enhance the timeliness and accuracy of disease outbreak detection (**Temte et al., 2017**).

The Kingdom of Saudi Arabia (KSA) has implemented comprehensive infectious disease surveillance and control measures during Hajj and Umrah to mitigate health risks associated with these mass gatherings. These efforts include mandatory vaccinations, real-time surveillance systems, and health education campaigns. For example, meningococcal vaccination is required for all pilgrims, along with chemoprophylaxis for travelers from the African meningitis belt, reducing the risk of outbreaks during these gatherings (**Yezli et al., 2016**). Advanced surveillance systems and public health strategies are employed to monitor diseases like influenza and MERS-CoV. During Hajj, the government collaborates with international health agencies to ensure compliance with vaccination requirements and deploys electronic surveillance tools for real-time monitoring of health conditions among pilgrims. This approach enhances the timely detection and management of health risks, as demonstrated in the significant containment of respiratory diseases during the Hajj seasons (**Al-Tawfiq & Memish, 2014**). The KSA also focuses on pre-travel health education for pilgrims, highlighting preventive measures such as vaccination, hand hygiene, and face mask use. Health authorities actively disseminate guidelines on minimizing disease spread and maintain emergency response plans. These strategies, coupled with collaboration with the World Health Organization and other agencies, position Saudi Arabia as a global leader in managing health challenges during mass gatherings (**Memish et al., 2014**).

2.4. Vaccination campaigns

Vaccination is a cornerstone of infection control during Hajj and Umrah. Nurses play a pivotal role in administering vaccines such as the quadrivalent meningococcal vaccine, influenza vaccine, and, more recently, COVID-19 vaccines (**Barría, 2021**). The Kingdom of Saudi Arabia (KSA) has established robust immunization policies to mitigate the risk of communicable diseases. Key vaccines, such as the quadrivalent meningococcal vaccine, influenza vaccine, and, recently, the COVID-19 vaccine, are mandated for pilgrims. Nurses play a pivotal role in administering these vaccines, ensuring compliance, and addressing hesitancy. These measures are particularly significant in preventing outbreaks and maintaining public health (**Al-Tawfiq et al., 2017**).

The implementation of the quadrivalent meningococcal vaccine is among the most successful interventions. After meningococcal outbreaks in the late 20th century, the KSA mandated meningococcal vaccination for all pilgrims, significantly reducing associated infections during mass gatherings (**Yezli et al., 2016**). Nurses stationed at health centers and entry points ensure that all arriving pilgrims comply with vaccination requirements, often providing on-the-spot vaccinations to those who have not been immunized. Influenza also remains a significant health concern during Hajj and Umrah due to the respiratory infections common in crowded settings. Saudi health authorities recommend annual influenza vaccinations for all pilgrims, particularly those with underlying health conditions or the elderly. Nurses not only administer these vaccines but also engage in health education campaigns to promote their uptake, reducing the burden of influenza during these gatherings (**Zeitouni et al., 2015**). Finally, the emergence of COVID-19 added a new layer of complexity. Saudi Arabia prioritized COVID-19 vaccinations for all Hajj and Umrah attendees. Nurses were instrumental in mass vaccination drives, ensuring timely

immunization of millions of pilgrims. This effort extended to educating the public on vaccine safety and addressing concerns about side effects, which helped overcome vaccine hesitancy (**Alqahtani et al., 2022**).

To complement these vaccination efforts, Saudi Arabia early recognized the need to use electronic health surveillance systems that monitor vaccination status in real-time. Nurses contribute to these systems by documenting immunization records and identifying gaps in coverage, which helps ensure compliance with health requirements (**Madani & Ghabrah, 2007**). This data-driven approach allows for targeted interventions and efficient management of health risks. Health education remains a cornerstone of these initiatives. Nurses provide information on the importance of immunization, addressing myths and misconceptions that deter vaccine uptake. During pre-travel consultations and at vaccination centers, nurses play a crucial role in fostering trust and ensuring informed decision-making among pilgrims (**Sridhar et al., 2015**). The KSA's policies also extend to healthcare workers (HCWs) who serve pilgrims. Nurses working in these environments are required to receive meningococcal, influenza, and hepatitis B vaccinations to prevent nosocomial infections. Compliance among HCWs ensures a safer healthcare environment during the pilgrimage season (**Madani & Ghabrah, 2007**). Despite these successes, challenges remain. Studies have shown variability in vaccine uptake among pilgrims, influenced by factors such as awareness and accessibility. Addressing these gaps requires continuous collaboration between Saudi health authorities and international organizations to enhance compliance through global awareness campaigns (**Alotaibi et al., 2021**).

2.5. Management of outbreaks

Management of Outbreaks: In the event of an infectious disease outbreak, nurses take on leadership roles in containment efforts. They implement isolation protocols, provide direct patient care, and coordinate with other healthcare professionals to mitigate the spread of infection. For example, during the Hajj, nurses were instrumental in managing respiratory outbreaks, emphasizing the need for respiratory hygiene and the use of face masks to reduce pathogen transmission (**Jefferson et al., 2023**). COVID-19, a global health crisis, further underscored the importance of nurses in outbreak management. During the pandemic, nurses led initiatives in isolation units, ensuring strict adherence to infection control protocols. In Saudi Arabia, efforts during the Hajj were amplified, with nurses playing a significant role in implementing quarantine measures and ensuring safe interaction between pilgrims (**Jokhdar et al., 2020**). In addition to isolation protocols, nurses addressed psychological needs during outbreaks. The pandemic highlighted the mental strain on both healthcare workers and patients. Nurses provided critical psychological support to reduce stress among isolated patients and their families, which was vital for maintaining patient morale and adherence to isolation requirements (**Duan & Zhu, 2020**). Technology also played a role in managing COVID-19 outbreaks during Hajj. Nurses utilized electronic health records to monitor patient conditions in real-time, ensuring swift identification and management of emerging cases. These tools improved decision-making and optimized resource allocation, such as ICU beds and ventilators (**Khan et al., 2021**).

Collaboration with international health bodies enhanced Saudi Arabia's response during outbreaks. Nurses coordinated with organizations like the World Health Organization to implement evidence-based practices and share data, ensuring a robust response to global health threats. This cooperation also facilitated the training and capacity-building of nursing staff (**Alabbasi et al., 2022**). The success of outbreak management in Hajj and Umrah underscores the importance of integrating nurses into leadership roles in health systems. Their ability to adapt,

lead, and provide care in challenging circumstances is invaluable. As seen during the COVID-19 pandemic, their roles go beyond clinical care to encompass advocacy, education, and systemic coordination, forming the backbone of effective outbreak responses (**Sharma & Ahwal, 2020**).

2.6. Training and capacity building

Continuous professional development in infection control is a cornerstone of public health strategies during mass gatherings such as Hajj and Umrah. Saudi Arabia has prioritized training and capacity-building for nurses, recognizing their pivotal role in managing and preventing infectious diseases. These efforts include specialized training programs, workshops, and simulation exercises to ensure that nurses remain at the forefront of infection control practices. A study in Makkah hospitals during Hajj highlighted that training significantly improves healthcare workers' adherence to infection control protocols, leading to better patient outcomes (**Madani et al., 2006**). Saudi Arabia's healthcare initiatives have demonstrated the impact of targeted infection control training like Ebola (**Alsahafi & Cheng, 2019**). The introduction of electronic surveillance systems has complemented these training programs. Nurses trained in using these systems can monitor patient data in real-time, ensuring rapid identification of infectious disease cases. This integration of technology and training enhances overall healthcare response efficiency (**Alslamah & Abalkhail, 2022**).

Capacity-building extends to nursing students, who represent the future of healthcare. In Saudi Arabia, nursing students undergo rigorous infection control workshops and practical training. A multi-institute study showed that these programs significantly improved students' knowledge, attitudes, and practices related to infection prevention, ensuring they are well-prepared for clinical challenges (**Albarmawi et al., 2024**). Simulation-based training is another effective method implemented in Saudi Arabia. By recreating real-world scenarios, nurses can practice responding to complex situations such as managing respiratory infections during Hajj. These simulations improve critical thinking and preparedness, as shown in studies emphasizing their impact on nurses' performance (**Ghabrah et al., 2007**).

Workshops focusing on emerging threats, such as Middle East Respiratory Syndrome Coronavirus (MERS-CoV), have been pivotal. Nurses trained in MERS-CoV management demonstrated greater confidence and competence in applying infection control measures, which is critical during Hajj, where large gatherings heighten the risk of outbreaks (**Rabaan et al., 2017**). Saudi Arabia's infection control programs also prioritize psychological safety and supportive environments for nurses. Training sessions often include stress management techniques and psychological support to help nurses handle the pressures of working during mass gatherings, improving both mental health and job performance (**Colet et al., 2018**). To ensure sustained improvements, Saudi Arabia has institutionalized infection control policies that mandate periodic refresher courses. These initiatives have been successful in keeping healthcare workers updated on best practices, as seen in studies where trained nurses showed significantly higher compliance with infection control measures (**Alojaimy et al., 2021**).

Conclusion

This review underscores the pivotal role of nurses in safeguarding the health of millions of pilgrimages during Hajj and Umrah. However, the persistent gaps in knowledge, resource availability, and adherence to standardized practices highlight the need for innovative strategies to enhance healthcare delivery during these events. To address these challenges, it is recommended that Saudi Arabia invest in the integration of advanced digital health technologies, such as AI-

driven surveillance and predictive analytics, to enable real-time monitoring and response to emerging health threats. Additionally, fostering an interdisciplinary approach by incorporating cultural competency and behavioral science into nursing education will empower healthcare professionals to engage more effectively with diverse populations, ensuring both compliance and trust.

References

- Alabbasi, K.H., Kruger, E. and Tennant, M., 2022. Strengthening Saudi Arabia's primary health care through an e-referral system: a case study. *Clinics and practice*, 12(3), pp.374-382.
- Alanzi, M.E., Albalawi, M.A.H., Kabrah, S., Aljehani, Y.T., Okashah, A.M., Aljohani, Z.D.E. and El Sayed, S., 2019. Knowledge, Attitudes, and Practices (KAPs) of healthcare workers towards MERS-CoV infection at PHCs in Madinah, KSA during Hajj 1440, 2019. *Am J Microbiol Res*, 7(4), pp.122-129.
- Albarmawi, M., Al Hadid, L., Alnjadat, R. and Aljabery, A., 2024. A multi-institute, follow-up, observational study measuring nursing students' adherence to infection prevention and control protocols in Saudi Arabia. *Frontiers in Medicine*, 10, p.1282723.
- Albutti, A., Mahdi, H.A., Alwashmi, A.S., Shaban, R.Z. and Rashid, H., 2023. Hand hygiene knowledge and practices, and rates of respiratory tract infections between Hajj and Umrah pilgrims: a comparative study. *International Maritime Health*, 74(2), pp.92-97.
- Aljohani, H.S. and Sulaiman, A.A., 2021. Assessment of Health Care Workers' Knowledge and Practice Toward Infection Standard Precautions in Primary Health Care setting, Buraidah, Saudi Arabia. *Middle East Journal of Family Medicine*, 7(10), p.81.
- Alojaimey, R.S., Nakamura, K., Al-Sobaihi, S., Tashiro, Y., Watanabe, N. and Seino, K., 2021. Infection prevention and control standards and associated factors: Case study of the level of knowledge and practices among nurses in a Saudi Arabian hospital. *Journal of Preventive Medicine and Hygiene*, 62(2), p.E501.
- Alotaibi, A., Almudarra, S.S., Algarni, H.S., Bakhsh, Y., Dafaalla, Z.M.E., Alhowail, N.A. and Assiri, A.M., 2021. Adherence to Vaccine Requirements among Hajj Pilgrims in Saudi Arabia, 2017-2019. *Tropical Health and Medical Research*, 3(2), pp.86-97.
- Alotaibi, B., Yassin, Y., Mushi, A., Maashi, F., Thomas, A., Mohamed, G., Hassan, A. and Yezli, S., 2019. Tuberculosis knowledge, attitude and practice among healthcare workers during the 2016 Hajj. *PloS one*, 14(1), p.e0210913.
- Al-Qahtani, A.M., 2023. Clean hands, safe care: how knowledge, attitude, and practice impact hand hygiene among nurses in Najran, Saudi Arabia. *Frontiers in Public Health*, 11, p.1158678.
- Alqahtani, F.M., Kamel, S.A., Almudarra, S. and Mathkour, A.A., 2022. Vaccination against Influenza among Health Care Workers in Al Mashaer during Hajj 2019 (1440 H); Uptake and Barriers. *Middle East Journal of Family Medicine*, 7(10), p.112.
- Alrashdi, M.M. and Al Thobaity, A., 2024. Exploring the experiences, motivations, and skillsets of nurse volunteers during Hajj: implications for enhancing volunteer programs. *BMC nursing*, 23(1), p.44.

- Alsahafi, A.J. and Cheng, A.C., 2019. Health care workers' awareness and infection control practices about Ebola virus disease in Hajj 2015. *Journal of Infection and Public Health*, 12(5), pp.720-725.
- Alslamah, T. and Abalkhail, A., 2022. The national strategies for and challenges in infection prevention and control of the healthcare system in the Kingdom of Saudi Arabia (review study). *Vaccines*, 10(8), p.1302.
- Al-Tawfiq, J.A. and Memish, Z.A., 2014. Mass gathering medicine: 2014 Hajj and Umra preparation as a leading example. *International Journal of Infectious Diseases*, 27, pp.26-31.
- Arbaein, T.J., Alharbi, K.K., Alfahmi, A.A., Alharthi, K.O., Monshi, S.S., Alzahrani, A.M. and Alkabi, S., 2024. Makkah healthcare cluster response, challenges, and interventions during COVID-19 pandemic: A qualitative study. *Journal of Infection and Public Health*, 17(6), pp.975-985.
- Ard, D.A., 2016. Utilizing Pre-education Assessment and a Targeted Education Module to Enhance Nurse Knowledge of Standard and Transmissible Precautions.
- Beggs-Yeager, C., Sharts-Hopko, N. and McDermott-Levy, R., 2021. The role of nurses in surveillance to enhance global health security: A delphi study. *Nursing outlook*, 69(6), pp.1021-1029.
- Colet, P.C., Cruz, J.P., Cacho, G., Al-Qubeilat, H., Soriano, S.S. and Cruz, C.P., 2018. Perceived infection prevention climate and its predictors among nurses in Saudi Arabia. *Journal of Nursing Scholarship*, 50(2), pp.134-142.
- Dauda Goni, M., Hasan, H., Naing, N.N., Wan-Arfah, N., Zeiny Deris, Z., Nor Arifin, W. and Abubakar Baaba, A., 2019. Assessment of knowledge, attitude and practice towards prevention of respiratory tract infections among hajj and umrah pilgrims from Malaysia in 2018. *International journal of environmental research and public health*, 16(22), p.4569.
- Duan, L. and Zhu, G., 2020. Psychological interventions for people affected by the COVID-19 epidemic. *The Lancet. Psychiatry*, 7(4), p.300.
- Durrheim, D.N., Harris, B.N., Speare, R. and Billingham, K., 2001. The use of hospital-based nurses for the surveillance of potential disease outbreaks. *Bulletin of the World Health Organization*, 79(1), pp.22-27.
- El-Bahnasawy, M.M., Elmenawy, N.Z.E.A.A. and Morsy, T.A., 2014. An interventional program for nursing staff on selected mass gathering infectious diseases at Hajj. *Journal of the Egyptian Society of Parasitology*, 44(2), pp.405-424.
- Gautret, P., Benkouiten, S., Sridhar, S., Al-Tawfiq, J.A. and Memish, Z.A., 2015. Diarrhea at the Hajj and Umrah. *Travel medicine and infectious disease*, 13(2), pp.159-166.
- Ghabrah, T.M., Madani, T.A., Albarrak, A.M., Alhazmi, M.A., Alazraqi, T.A., Alhudaithi, M.A. and Ishaq, A.H., 2007. Assessment of infection control knowledge, attitude and practice among healthcare workers during the Hajj period of the Islamic year 1423 (2003). *Scandinavian journal of infectious diseases*, 39(11-12), pp.1018-1024.
- Ghabrah, T.M., Madani, T.A., Albarrak, A.M., Alhazmi, M.A., Alazraqi, T.A., Alhudaithi, M.A. and Ishaq, A.H., 2007. Assessment of infection control knowledge, attitude and practice among healthcare workers during the Hajj period of the Islamic year 1423 (2003). *Scandinavian journal of infectious diseases*, 39(11-12), pp.1018-1024.
- Goni, M.D., Hasan, H., Wan-Arfah, N., Naing, N.N., Deris, Z.Z., Arifin, W.N., Baaba, A.A., Aliyu, A. and Adam, B.M., 2020. Health education intervention as an effective

- means for prevention of respiratory infections among Hajj pilgrims: a review. *Frontiers in Public Health*, 8, p.449.
- Gundlapalli, A.V., Tang, H., Tonniere, C., Stoddard, G., Rolfs, R.T., Evans, R.S. and Samore, M.H., 2007. Validity of electronic medical record-based rules for the early detection of meningitis and encephalitis. In *AMIA Annual Symposium Proceedings* (Vol. 2007, p. 299). American Medical Informatics Association.
- Hoang, V.T., Gautret, P., Memish, Z.A. and Al-Tawfiq, J.A., 2020. Hajj and Umrah mass gatherings and COVID-19 infection. *Current tropical medicine reports*, 7(4), pp.133-140.
- Jefferson, T., Dooley, L., Ferroni, E., Al-Ansary, L.A., van Driel, M.L., Bawazeer, G.A., Jones, M.A., Hoffmann, T.C., Clark, J., Beller, E.M. and Glasziou, P.P., 2023. Physical interventions to interrupt or reduce the spread of respiratory viruses. *Cochrane database of systematic reviews*, (1).
- Jokhdar, H., Khan, A., Asiri, S., Motair, W., Assiri, A. and Alabdulaali, M., 2021. COVID-19 mitigation plans during Hajj 2020: a success story of zero cases. *Health security*, 19(2), pp.133-139.
- Kemp, A.E., 2016. Mass-gathering events: the role of advanced nurse practitioners in reducing referrals to local health care agencies. *Prehospital and disaster medicine*, 31(1), pp.58-63.
- Khan, A., Alahmari, A., Almuzaini, Y., Alturki, N., Aburas, A., Alamri, F.A., Albagami, M., Alzaid, M., Alharbi, T., Alomar, R. and Abu Tayli, M., 2021. The role of digital technology in responding to COVID-19 pandemic: Saudi Arabia's experience. *Risk Management and Healthcare Policy*, pp.3923-3934.
- Khan, A.A., Balkhi, B.S., Alamri, F.A., Alsaleh, G.S., Al-Tawfiq, J.A. and Jokhdar, H., 2024. Vaccinations for Hajj: Enhancing health and global health security. *Travel Medicine and Infectious Disease*, p.102784.
- Kim, S.Y. and Cho, M.K., 2023, May. Concept Analysis of Nursing Surveillance Using a Hybrid Model. In *Healthcare* (Vol. 11, No. 11, p. 1613). MDPI.
- Koul, P.A., Mir, H., Saha, S., Chadha, M.S., Potdar, V., Widdowson, M.A., Lal, R.B. and Krishnan, A., 2018. Respiratory viruses in returning Hajj & Umrah pilgrims with acute respiratory illness in 2014-2015. *Indian Journal of Medical Research*, 148(3), pp.329-333.
- Madani, T.A. and Ghabrah, T.M., 2007. Meningococcal, influenza virus, and hepatitis B virus vaccination coverage level among health care workers in Hajj. *BMC infectious diseases*, 7, pp.1-6.
- Madani, T.A., Albarrak, A.M., Alhazmi, M.A., Alazraqi, T.A., Althaqafi, A.O. and Ishaq, A.H., 2006. Steady improvement of infection control services in six community hospitals in Makkah following annual audits during Hajj for four consecutive years. *BMC infectious diseases*, 6, pp.1-9.
- Mahdi, H., Alqahtani, A., Barasheed, O., Alemam, A., Alhakami, M., Gadah, I., Alkediwi, H., Alzahrani, K., Fatani, L., Dahlawi, L. and Alsharif, S., 2020. Hand hygiene knowledge and practices among domestic hajj pilgrims: implications for future mass gatherings amidst COVID-19. *Tropical Medicine and Infectious Disease*, 5(4), p.160.
- Mahfouz, A.A., Al-Zaydani, I.A., Abdelaziz, A.O., El-Gamal, M.N. and Assiri, A.M., 2014. Changes in hand hygiene compliance after a multimodal intervention among health-

- care workers from intensive care units in Southwestern Saudi Arabia. *Journal of epidemiology and global health*, 4(4), pp.315-321.
- Mahfouz, A.A., El Gamal, M.N. and Al-Azraqi, T.A., 2013. Hand hygiene non-compliance among intensive care unit health care workers in Aseer Central Hospital, south-western Saudi Arabia. *International Journal of Infectious Diseases*, 17(9), pp.e729-e732.
- Memish, Z.A., Assiri, A., Turkestani, A., Yezli, S., Al Masri, M., Charrel, R., Drali, T., Gaudart, J., Edouard, S., Parola, P. and Gautret, P., 2015. Mass gathering and globalization of respiratory pathogens during the 2013 Hajj. *Clinical Microbiology and Infection*, 21(6), pp.571-e1.
- Memish, Z.A., Zumla, A., Alhakeem, R.F., Assiri, A., Turkestani, A., Al Harby, K.D., Alyemni, M., Dhafar, K., Gautret, P., Barbeschi, M. and McCloskey, B., 2014. Hajj: infectious disease surveillance and control. *The Lancet*, 383(9934), pp.2073-2082.
- Nabil Ramadan, E. and Ahmed Ibrahim Zahra, N., 2016. Pilgrims' Awareness regarding Health Hazards during Hajj. *Egyptian Journal of Health Care*, 7(3), pp.256-270.
- Rabaan, A.A., Alhani, H.M., Bazzi, A.M. and Al-Ahmed, S.H., 2017. Questionnaire-based analysis of infection prevention and control in healthcare facilities in Saudi Arabia in regards to Middle East Respiratory Syndrome. *Journal of infection and public health*, 10(5), pp.548-563.
- Razavi, S.M., Mardani, M. and Salamati, P., 2018. Infectious diseases and preventive measures during hajj mass gatherings: A review of the literature. *Archives of Clinical Infectious Diseases*, 13(3).
- Rebmann, T. and Carrico, R., 2017. Consistent infection prevention: vital during routine and emerging infectious diseases care. *OJIN: The Online Journal of Issues in Nursing*, 22(1).
- Salem, O.A., 2019. Knowledge and practices of nurses in infection prevention and control within a tertiary care hospital. *Annals of Medical and Health Sciences Research* 4p.
- Sangeetha, S., Harshika, Y.K. and Seema, P., 2015. Standard Precautions: An Assessment of Awareness among Health Care Personnel in a Teaching Hospital, South India. *Journal of Evidence based Medicine and Healthcare*, 2(6), pp.638-44.
- Schweiger, B. and Buda, S., 2012. Erkennung von Influenzaausbrüchen und Rolle der virologischen Diagnostik.
- Setiyarini, S. and Kertia, N., 2024. Experiences of Indonesian nurses as Hajj health personnel in caring for Hajj pilgrims: A qualitative study. *Belitung Nursing Journal*, 10(5), p.554.
- Shafi, S., Dar, O., Khan, M., Khan, M., Azhar, E.I., McCloskey, B., Zumla, A. and Petersen, E., 2016. The annual Hajj pilgrimage—minimizing the risk of ill health in pilgrims from Europe and opportunity for driving the best prevention and health promotion guidelines. *International journal of infectious diseases*, 47, pp.79-82.
- Sharma, T. and Ahwal, S., 2020. Managing Covid 19 patients: nurses role and considerations. *Journal of Perioperative & Critical Intensive Care Nursing*, 2(158), pp.1-7.
- Sheerah, H.A., Almuzaini, Y. and Khan, A., 2023, June. Public health challenges in Saudi Arabia during the COVID-19 pandemic: a literature review. In *Healthcare* (Vol. 11, No. 12, p. 1757). MDPI.
- Sridhar, S., Belhouchat, K., Drali, T., Benkouiten, S., Parola, P., Brouqui, P. and Gautret, P., 2015. French Hajj pilgrims' experience with pneumococcal infection and vaccination: a knowledge, attitudes and practice (KAP) evaluation. *Travel medicine and infectious disease*, 13(3), pp.251-255.

- Takano, Y., 2001. Importance of a network construction with each division and clinical laboratory in the hospital--from a ground of the infection control nurse. *Rinsho byori. The Japanese Journal of Clinical Pathology*, 49(8), pp.789-792.
- Temte, J.L., Barlow, S., Schemmel, A., Temte, E., Hahn, D.L., Reisdorf, E., Shult, P. and Tamerius, J., 2017. New method for real time influenza surveillance in primary care: a Wisconsin Research and Education Network (WREN) supported study. *The Journal of the American Board of Family Medicine*, 30(5), pp.615-623.
- Veenema, T. and Töke, J., 2006. Early detection and surveillance for biopreparedness and emerging infectious diseases. *Online journal of issues in nursing*, 11(1).
- Weng, T.C., Chan, T.C., Lin, H.T., Chang, C.K.J., Wang, W.W., Li, Z.R.T., Cheng, H.Y., Chu, Y.R., Chiu, A.W.H., Yen, M.Y. and King, C.C., 2015. Early detection for cases of enterovirus-and influenza-like illness through a newly established school-based syndromic surveillance system in Taipei, January 2010~ August 2011. *PloS one*, 10(4), p.e0122865.
- Wilder-Smith, A., Foo, W., Earnest, A. and Paton, N.I., 2005. High risk of Mycobacterium tuberculosis infection during the Hajj pilgrimage. *Tropical Medicine & International Health*, 10(4), pp.336-339.
- Yezli, S., 2018. The threat of meningococcal disease during the Hajj and Umrah mass gatherings: a comprehensive review. *Travel Medicine and Infectious Disease*, 24, pp.51-58.
- Yezli, S., Assiri, A.M., Alhakeem, R.F., Turkistani, A.M. and Alotaibi, B., 2016. Meningococcal disease during the Hajj and Umrah mass gatherings. *International Journal of Infectious Diseases*, 47, pp.60-64.
- Yezli, S., Saeed, A.A.B., Assiri, A.M., Alhakeem, R.F., Yunus, M.A., Turkistani, A.M., Booy, R. and Alotaibi, B.M., 2016. Prevention of meningococcal disease during the Hajj and Umrah mass gatherings: past and current measures and future prospects. *International Journal of Infectious Diseases*, 47, pp.71-78.
- Yezli, S., Saeed, A.A.B., Assiri, A.M., Alhakeem, R.F., Yunus, M.A., Turkistani, A.M., Booy, R. and Alotaibi, B.M., 2016. Prevention of meningococcal disease during the Hajj and Umrah mass gatherings: past and current measures and future prospects. *International Journal of Infectious Diseases*, 47, pp.71-78.
- Yezli, S., van der Linden, M., Booy, R. and AlOtaibi, B., 2019. Pneumococcal disease during Hajj and Umrah: Research agenda for evidence-based vaccination policy for these events. *Travel medicine and infectious disease*, 29, pp.8-15.
- Zeitouni, M.O., Al Barrak, A.M., Al-Moamary, M.S., Alharbi, N.S., Idrees, M.M., Al Shimemeri, A.A. and Al-Hajjaj, M.S., 2015. The Saudi Thoracic Society guidelines for influenza vaccinations. *Annals of thoracic medicine*, 10(4), pp.223-230.