

## **Disease transmission and mass gatherings: a case study on meningococcal infection during Hajj & Umrah**

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### **Background**

Saudi Arabia (KSA) hosts millions of pilgrims annually for Hajj and Umrah. Umrah attendance exceeded 35 million in 2024. Such mass gatherings pose significant infectious disease transmission risks. Between March and May 2025, 51 invasive meningococcal disease cases linked to Umrah attendance during Ramadan were diagnosed both within KSA and internationally including Gulf countries.

### **Methods**

A meta-population model was developed to assess *Neisseria meningitidis* transmission dynamics during Hajj and Umrah among pilgrims, Makkah and Madinah residents, the broader KSA population, and pilgrims' countries of origin. The model incorporated movement patterns, arrival timing and volume, duration of stay, and meningococcal vaccination coverage rates (VCR). Calibration used data from 1995-2024 to assess meningococcal meningitis (MM) cases under different vaccination scenarios.

### **Results**

Umrah accounts for approximately 90% of pilgrim person-years and over 90% of MM cases among pilgrims. Umrah vaccination impacts outbreak risk: In a scenario in line with Saudi vision to reach 30 million foreign pilgrims by 2030, the probability of an annual outbreak exceeding 100 MM cases during the 2025-2034 period was estimated at 52% with a 10% VCR among domestic and foreign Umrah pilgrims versus <0.01% if the VCR is 90%. High VCR (90%) also reduces expected MM cases across KSA by >80% compared to no vaccination.

### **Conclusion**

Results demonstrate the amplifying effect of mass gatherings on disease transmission and confirm vaccination as a highly effective intervention. Strengthened enforcement of ACWY vaccination requirements for all Umrah pilgrims could significantly reduce outbreak risk and benefit the entire KSA population.