

Health and Emergency Preparedness for Mass Gatherings at the 2034 FIFA World Cup in Saudi Arabia: A Systematic Review and Targeted Evidence Update

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Abstract

The Fédération Internationale de Football Association (FIFA) World Cups are complex mass gatherings that place simultaneous demands on public-health surveillance, environmental risk management, emergency medical services, crowd safety, and health-system resilience. Saudi Arabia's selection to host the 2034 tournament creates an opportunity to adapt capabilities developed through decades of Hajj operations to the very different context of a global football event. This review synthesises evidence from major mass gatherings and incorporates post-Qatar 2022 and World Cup 2026 evidence to define practical priorities for 2034. The original review searched PubMed, the Medical Literature Analysis and Retrieval System Online (MEDLINE), Scopus, Web of Science, and the Cochrane Library for 2000-2025 and retained 43 records according to the documented screening log. A targeted update undertaken in September 2026 searched PubMed/MEDLINE and primary sources from major international, national, and sporting authorities. Because this update was not a complete rerun of the original four-database strategy, newer evidence was synthesised narratively and was not added to the original screening denominator. Post-Qatar studies support dedicated tournament medical services, improved clinician notification, open-source epidemic intelligence, and wastewater surveillance. World Cup 2026 evidence adds cross-jurisdictional dashboards, port-health surveillance, early-warning systems, pathogen-specific risk assessment, and multi-hazard environmental planning. Contemporary Saudi Hajj operations demonstrate large-scale heat prevention, surge care, referral, and emergency logistics. For Saudi Arabia 2034, the evidence favours an all-hazards model built around heat action plans, interoperable multi-layer surveillance, unified incident command, distributed emergency care, crowd-safety intelligence, mental-health pathways, multilingual communication, and predefined post-event evaluation. The central implementation principle is to strengthen routine national systems rather than construct temporary parallel systems for the tournament.

Categories: Sports Medicine, Emergency Medicine, Public Health

Keywords: digital health, emergency preparedness, fifa world cup 2026, fifa world cup 2034, hajj, health security, heat stress, infectious disease surveillance, mass gathering medicine, saudi arabia

Introduction And Background

The Fédération Internationale de Football Association (FIFA) World Cup is at once a sporting competition, a high-volume travel event, and a major public-health operation. Host systems must be prepared for everyday illness and injury as well as heat and environmental exposure, communicable-disease importation, food and water safety events, crowd-related trauma, mental-health needs, and low-frequency but high-consequence emergencies.

These pressures are magnified by international travel and by the concentration of spectators, teams, staff, volunteers, and media across stadiums, fan zones, transport hubs, hotels, and public spaces [1,2].

FIFA formally selected Saudi Arabia to host the 2034 tournament in December 2024, making it the first single-country host of a 48-team men's World Cup [3].

Saudi Arabia enters this planning cycle with extensive mass-gathering experience through the annual Hajj. Hajj is not a direct model for a World Cup: the populations, movement patterns, venue types, event purposes, and duration differ substantially. Even so, it provides repeated real-world experience in crowd-flow management, heat-risk communication, pre-travel health requirements, emergency transport, surge hospital capacity, and interagency coordination at a very large scale [4,5]. For 2034, the practical task is therefore to adapt proven capabilities rather than transfer Hajj protocols unchanged.

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The evidence base has also changed since Qatar 2022. The World Health Organization (WHO) has described the health-promotion and health-security legacy of the tournament [6], while subsequent peer-reviewed studies have reported medical-service utilisation, player injury and illness, gastrointestinal disease, enhanced infectious-disease notification, open-source epidemic intelligence, and wastewater surveillance.

The World Cup 2026 literature broadens the picture further, adding environmental and occupational heat analyses, applied-epidemiology guidance, pathogen-specific risk assessments, standardised hydration policy, multinational operational reports, and emerging respiratory-virus environmental surveillance [7,8,9].

Together, these sources allow planning for 2034 to rely less on generic preparedness principles and more on observed tournament operations.

This review updates the earlier synthesis through September 2026. Its aim is to identify the health risks, system capabilities, and implementation priorities most relevant to the 2034 World Cup in Saudi Arabia, while clearly distinguishing peer-reviewed findings from expert guidance, official operational reports, and emerging preprints.

Scope, novelty, and practical contribution

The distinctive contribution of this review is to translate Hajj-derived health-system capabilities and recent World Cup operational findings into a Saudi-specific, testable planning framework. The transfer is selective: religious pilgrimage operations offer established models for heat mitigation, field care, transport, and command, whereas FIFA requires additional planning for dispersed match schedules, simultaneous urban demand, fan-zone gatherings, sports-related injury, varied visitor behaviours, and international travel. This distinction shapes the interpretation of evidence and the proposed implementation measures.

Review

Methods

Review Design and Original Evidence Base

The revised flow diagram presents each stage of study selection separately. A total of 7,297 records were identified. After removal of 1,843 duplicate records, 5,454 records underwent title/abstract screening; 4,272 were excluded. The remaining 1,182 reports were sought for retrieval and assessed for full-text eligibility, with no reports recorded as not retrieved. After exclusion of 1,139 full-text reports, 43 studies/references remained in the final evidence synthesis.

Eligible evidence addressed mass gatherings or major sporting or religious events and reported empirical or operational findings related to communicable disease, environmental hazards, injury, emergency response, crowd safety, health-system preparedness, or health technology. Peer-reviewed original studies, systematic or scoping reviews, and authoritative governmental or intergovernmental reports were prioritised. Editorials and opinion articles were not treated as core systematic-review evidence; where expert synthesis was useful for service design, it is identified as such.

Search Reproducibility and Study Selection

The original search covered the period from January 2000 to December 2025 in PubMed/MEDLINE, Scopus, Web of Science, and the Cochrane Library. Search concepts included mass gatherings, World Cup/football, Hajj, public health, surveillance, environmental heat, crowd safety, and emergency response. The available manuscript does not contain the exact database-specific Boolean strings, search dates for each database, or a dated export of search results. Accordingly, the search cannot currently be independently reproduced, and no reconstructed string is presented as the original executed strategy.

The archived selection totals were 7,297 identified records, 1,843 duplicates, 5,454 records screened, 4,272 title/abstract exclusions, 1,182 reports sought and assessed, 1,139 full-text exclusions, and 43 included sources. The historical documentation does not independently verify the number of unretrieved reports, reasons for full-text exclusion, number of reviewers at each screening stage, or disagreement-resolution procedures. These elements are therefore not asserted retrospectively. The original Figure 1 is retained as submitted, but its labels and exclusion-reason categories should be understood as historical reporting rather than independently auditable source records.

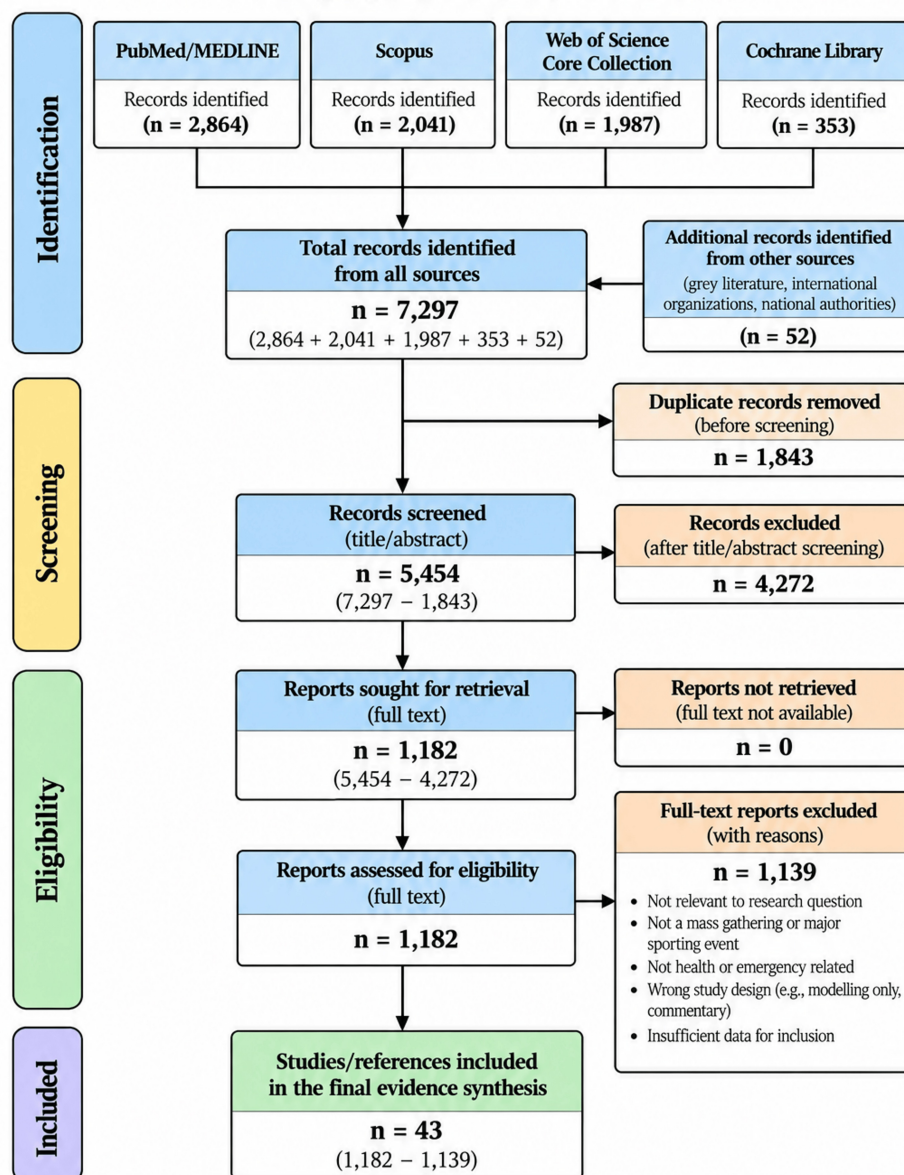


FIGURE 1: PRISMA 2020 flow diagram of study identification, screening, eligibility assessment, and inclusion

The search was conducted in PubMed/MEDLINE, Scopus, Web of Science Core Collection, and the Cochrane Library from January 1, 2000, to September 25, 2026, supplemented by grey literature from international organisations and national authorities.

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Data Charting, Quality Appraisal, and Synthesis

The narrative synthesis reports event/setting, source type, population or operational scope, principal health-security finding, and relevance to Saudi 2034 where these details are available; Table 1 summarises representative post-Qatar and 2026 evidence. No preserved standardised extraction form, duplicate-extraction record, or study-level risk-of-bias worksheets were supplied with the archived review. Thus, a completed formal tool-based appraisal (such as ROBINS-I, Newcastle-Ottawa, or AMSTAR 2) cannot be claimed. The synthesis instead differentiates direct empirical studies, surveillance analyses, operational reports, guidance, and preprints, and discusses their directness and limitations qualitatively.

Because source populations, designs, outcomes, exposures, and reporting denominators differ substantially, no common effect measure was available for defensible pooling. Meta-analysis, meta-regression, pooled confidence intervals, and p-values were not calculated. The evidence is presented by environmental risk, infectious-disease surveillance, clinical/EMS demand, command/crowd safety, and digital health, with

implementation implications distinguished from observed outcomes.

Operational Search Framework for Reproducibility

To make the topic scope explicit, a reproducible prospective search framework is provided here for any future rerun: ("mass gathering*" OR "FIFA World Cup" OR "football world cup" OR "Hajj" OR "sport* event*") AND ("public health" OR surveillance OR outbreak* OR heat OR "emergency medical" OR preparedness OR "crowd safety"). In PubMed, the framework can be translated to title/abstract terms and relevant MeSH headings; syntax and controlled vocabulary would need adaptation for Scopus, Web of Science, and Cochrane. This is an illustrative future-search framework, not a claim that these exact strings were executed in the historical review.

The documented screening arithmetic is internally consistent: 7,297 minus 1,843 equals 5,454; 5,454 minus 4,272 equals 1,182; and 1,182 minus 1,139 equals 43. The retained diagram is the original submitted illustration. To support a future fully reproducible update, the authors recommend retaining dated database exports, a duplicate-removal log, two independent screening decisions per record, a disagreement-resolution log, and a full-text exclusion register. These are specified as prospective quality-assurance measures, not retrospectively claimed completed procedures.

Targeted Post-Qatar and World Cup 2026 Evidence Update

The targeted update was conducted separately from the original systematic search; its coverage and selection process were not equivalent to a new four-database systematic review. Accordingly, the update is not included in the original PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) counts, and its findings are explicitly differentiated from the original 43 included reports.

A targeted update was conducted in September 2026 to capture evidence that could not have been included in the original 2000-2025 search. PubMed/MEDLINE was searched with combinations of the terms "FIFA World Cup," "Qatar 2022," "World Cup 2026," "health," "medical services," "surveillance," "wastewater," "heat," "environmental," "emergency preparedness," and "mass gathering." Primary institutional sources included WHO, the Centers for Disease Control and Prevention (CDC), the Pan American Health Organization (PAHO), the Public Health Agency of Canada (PHAC), Public Health Ontario, the Council of State and Territorial Epidemiologists (CSTE), FIFA, the Saudi Ministry of Health (MOH), and the Saudi General Authority for Statistics (GASTAT). medRxiv was screened for directly relevant World Cup 2026 studies because very recent post-event science may appear first as a preprint. Such records were labelled as preprints and were not treated as equivalent to peer-reviewed evidence. Secondary news reports and social-media posts were replaced by primary or authoritative sources whenever possible.

The update addressed four practical questions: what health outcomes and system-performance findings emerged after Qatar 2022; what environmental, occupational, and infectious-disease risks were identified for World Cup 2026; what surveillance, policy, and coordination mechanisms were used during and after World Cup 2026; and what contemporary Saudi mass-gathering capabilities were demonstrated during Hajj 2025-2026. No pooled effect estimate was attempted because populations, designs, and outcomes were highly heterogeneous. Findings were synthesised narratively by risk domain and then translated into operational priorities for Saudi Arabia.

Evidence-to-Recommendation Translation

For each domain, the narrative separates (i) directly observed clinical or surveillance findings, (ii) modelled or anticipatory risk estimates, and (iii) policy or operational recommendations. A proposed Saudi 2034 action is prioritised when a source describes an actionable hazard or capability, the operational pathway is relevant to football settings, and implementation can be evaluated with a measurable indicator. The accompanying tables link selected evidence to Saudi implications and then link proposed actions to triggers and legacy metrics. This is a transparent qualitative decision framework, not a formal graded-certainty assessment.

Results

Evidence Interpretation

The synthesis distinguishes peer-reviewed observational and clinical studies from institutional surveillance or operational reports, expert recommendations, and preprints. Where available, study design, denominators, outcome ascertainment, and reporting completeness informed interpretation. No uniform quantitative risk-of-bias score was assigned across these incompatible evidence types; therefore, this appraisal should not be represented as a completed instrument-based assessment.

Characteristics and Evidentiary Strength of Included Sources

The 43 legacy inclusions reported in the PRISMA pathway should not be conflated with the number of sources cited after the separate 2026 targeted update. The updated narrative incorporates heterogeneous source classes, including peer-reviewed observational studies and reviews, public-health surveillance analyses, governmental risk assessments, event-operational reports, sporting-body guidance, and an explicitly labelled preprint. Table 1 identifies study setting and principal findings for selected recent sources; it is not a complete 43-study extraction matrix. Direct tournament utilisation and surveillance data provide stronger event-specific descriptive support than pre-event projections or expert guidance, whereas generalisability to Saudi 2034 remains conditional.

Environmental and Climate Risk

Heat is a central planning hazard for any large outdoor event in Saudi Arabia, although the final 2034 calendar and match schedule will determine the timing and intensity of exposure. Risk is not confined to players. It also affects training grounds, queues, fan zones, transport interchanges, security posts, outdoor workers, volunteers, and visitors with chronic disease. Evidence from mass-gathering sport shows that heat burden depends on temperature, humidity, solar radiation, clothing, exertion, acclimatisation, hydration, access to shade, and the speed with which heat illness is recognised and treated [10,11]. Planning should therefore be based on venue- and activity-specific heat-health action plans linked to Wet-Bulb Globe Temperature (WBGT) or another validated index rather than ambient temperature alone.

The 2026 World Cup provides a useful comparator because it was a geographically dispersed 48-team tournament. Esh et al. identified expected extreme-heat exposure in 14 of 16 host cities, with historical maximum WBGT values ranging from 21°C to 35°C, and also highlighted altitude, air pollution, seasonal allergens, and travel demands [7]. Their companion paper translated these hazards into practical preparation and mitigation strategies [8].

Grundstein et al. extended the analysis to workers and reported that hot-humid venues such as Houston, Miami, and Monterrey often approached maximum WBGT values near 31°C; shade reduced peak exposure by approximately 2°C–3°C and reduced time above critical thresholds [12]. FIFA also adopted three-minute hydration breaks midway through each half for every World Cup 2026 match irrespective of weather conditions [13]. Although that policy is not a controlled effectiveness study, it shows how a tournament organiser can standardise a simple preventive measure across all venues.

Saudi operational data support a prevention-first approach. The MOH reported a 90% reduction in heat-exhaustion cases during Hajj 2025 compared with the previous season and attributed the decrease to stronger prevention, awareness, and intersectoral action [14]. Because year-to-year weather and attendance differ, this should not be interpreted as a causal effect estimate. During Hajj 2026, the MOH reported 466 heat-exhaustion cases through the tenth day of Dhul-Hijjah while delivering more than 1.2 million health services [15]. Taken together, these observations show both the persistence of heat-related demand and the feasibility of large-scale prevention and surge response.

Communicable-Disease Surveillance and Outbreak Control

Post-Qatar 2022 studies provide direct evidence for layered surveillance. Ibrahim et al. evaluated Qatar's Notification Enhancement Project, which combined system assessment, healthcare-worker training, improved notification tools, reminders, and feedback. Reporting activity increased from 2.5% during January–May 2022 to 29.0% during June–October and 41.4% during November–December [16]. The lesson is operational as much as technical: surveillance improves when clinicians understand what to report, how to report it, and why timely reporting matters.

Sallam et al. evaluated Epidemic Intelligence from Open Sources (EIOS) during the tournament. Among 2,543 captured signals, 0.85% were judged relevant to public health, and three required a national response [17]. EIOS is therefore best viewed as a complementary early-warning layer that depends on disciplined triage and verification, not as a substitute for clinical or laboratory surveillance.

Environmental surveillance provided an independent signal stream. El-Malah et al. monitored five wastewater treatment plants serving World Cup locations between October 2022 and January 2023. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and enterovirus ribonucleic acid (RNA) were detected, but poliovirus was not detected. SARS-CoV-2 concentrations tracked population density and reported clinical cases, with peaks coinciding with the group stage [18]. Together with systematic-review evidence on digital surveillance at mass gatherings [19], these findings support an architecture in which syndromic reporting, laboratory diagnostics, event-based intelligence, wastewater or other environmental monitoring, and hospital-capacity data feed a shared operational picture.

World Cup 2026 added a more explicit risk-stratification model. Public Health Ontario rated measles, food- and waterborne disease, and mpox as moderate risks in its Toronto hazard identification and risk assessment [20]. PHAC separately assessed 14 pathogen groups and identified measles as the highest importation concern among the groups evaluated [21].

CSTE guidance recommended formal integration of epidemiology into incident command, multi-source data fusion, syndromic and wastewater surveillance, traveller and worker-health monitoring, and enhanced monitoring before and after local event activity [22]. These approaches support pathogen-specific triggers and response thresholds rather than broad undifferentiated screening.

During the tournament, the CDC coordinated public-health readiness across all 11 United States (U.S.) host sites, used a cross-jurisdictional dashboard for disease, heat, and air-quality trends, and operated through 20 port-health stations. Its World Cup incident-management structure functioned alongside concurrent Ebola, hantavirus, and measles response activity [23,24].

Mexico City's SIAT-CDMX (Sistema de Información para la Alerta Temprana-Ciudad de México) combined routine surveillance with reports from stadium medical posts and FIFA Fan Festivals; by the end of June 2026, 382 public-health alerts had been processed and 311 resolved, with priority alerts assessed within approximately two hours [25].

PAHO also issued dynamic regional risk assessments: Bundibugyo Ebola risk was assessed during the tournament context [26], and measles risk was reassessed after the mass-gathering period [27]. The broader lesson is that threat assessment must remain active during and after the event rather than ending with a pre-tournament risk register.

Medical Services, Injuries, Trauma, and Mental Health

Qatar 2022 provides direct evidence on tournament medical demand. Schumacher et al. described dedicated services for approximately 832 athletes, about 1,300 delegation members, and match officials; 167 individuals were assessed in the central polyclinic, and diagnostic imaging was the most frequently requested service [28]. A later operational retrospective by FIFA and Aspetar clinicians described a 24/7 Medical Command Centre, 118 standardised clinics across tournament settings, coordinated referrals and ambulance movements, and a hub-and-spoke model for spectator care [29]. This supports a networked design in which standardised venue care is linked to centralised specialist and diagnostic capacity rather than duplicated at every site.

Player surveillance identified 82 time-loss injuries among 705 consenting players, with an overall injury-event incidence of 5.6 per 1,000 hours and a match incidence of 20.6 per 1,000 hours. Only 15 time-loss illnesses were recorded, most of them respiratory infections [30]. For spectators and visitors, Shams et al. analysed 2,179 stool samples submitted during the Qatar World Cup period. An organism was identified in 424 samples, acute diarrhoea/gastroenteritis was the leading presentation among confirmed cases, and *Salmonella* and *Escherichia coli* were the most frequent pathogens [31]. Although laboratory-tested patients represent only a subset of all attendees, the findings reinforce food-safety inspection, gastrointestinal syndromic surveillance, and rapid access to diagnostic testing.

Trauma planning must cover routine injuries as well as mass-casualty scenarios. Evidence from emergency medical services (EMS) preparedness and trauma at different types of mass gatherings supports venue medical posts, staged ambulance assets, designated receiving hospitals, tested escalation criteria, and clear transfer pathways [32,33]. Mental health should be embedded in this same routine service structure.

Mass gatherings can be associated with anxiety, sleep disruption, acute stress, substance-related presentations, and worsening of pre-existing mental illness [34]. A 2026 expert review focused on the men's World Cup highlighted compressed schedules, prolonged residential camps, cultural adjustment, intense scrutiny, and interpersonal or online violence as possible stressors for players and staff [35]. Because that source is expert synthesis rather than tournament outcome data, its most appropriate use is to inform confidential referral pathways, multilingual psychosocial support, safeguarding, and continuity with team and community mental-health services.

Command, Crowd Safety, and Health-System Resilience

Mega-event health security depends on command relationships that are agreed before the event and rehearsed under realistic conditions. Hajj experience shows the importance of integrating health, security, transport, civil defence, and crowd operations, while post-2015 crowd-management reforms have included engineering changes, movement scheduling, and real-time monitoring [4]. A World Cup requires these capabilities to operate across a dispersed network of stadiums, fan zones, airports, railway stations, hotels, and inter-city travel corridors. Medical incident command should therefore link venue command posts with regional emergency operations centres and national public-health leadership, using common escalation thresholds and interoperable communications.

The 2026 tournament offers a contemporary multinational example. PAHO's Health Security Working Group linked Canada, Mexico, the United States, and FIFA and held eight meetings by May 2026 to discuss lessons from previous events, event-based surveillance, security coordination, and mass-gathering preparedness [36]. CSTE recommended that epidemiologists be formally embedded within incident-command planning

and operations structures [22].

Mexico subsequently incorporated event surveillance into routine public-health systems, and formal post-event evaluation began in September 2026 to reconstruct the response, identify effective practices and operational gaps, and define lessons for future emergencies [37]. For Saudi Arabia, after-action evaluation should be built into the 2034 governance model before the tournament starts.

Saudi Digital Health and Contemporary Hajj Operational Capacity

Saudi health-system transformation provides infrastructure that can support World Cup operations if it is connected to event workflows. Vision 2030 reforms have emphasised integrated care, digital health, telemedicine, and system-level performance improvement [38]. A Saudi Multidisciplinary Hajj task force has also described potential uses of artificial intelligence for prediction, triage, decision support, and operational efficiency, while stressing governance, ethics, interoperability, and data quality [39]. For 2034, the strongest near-term uses are likely to be interoperable dashboards, teleconsultation, clinical decision support, resource forecasting, multilingual communication, and logistics rather than unvalidated autonomous systems.

Hajj 2026 demonstrates the scale of current operational capacity. GASTAT recorded 1,707,301 pilgrims, including 1,546,655 international pilgrims [40]. The MOH activated 30 additional health units and reported more than 3,000 emergency vehicles and response units, 11 air ambulances, 526 emergency dispatch points, and more than 7,700 field emergency personnel [41].

By the tenth day of Dhul-Hijjah, the system had delivered more than 1.2 million services, managed 41,782 emergency-department cases, admitted 4,901 patients, and performed advanced cardiac and surgical procedures [15]. These figures are not a direct forecast of World Cup demand, but they demonstrate an established platform for distributed care, referral, transport, and surge operations that can be adapted and stress-tested for 2034. The principal post-Qatar and World Cup 2026 findings used in this update are summarised in Table 1. The evidence summarised in the table is supported by references [7,8].

Source	Setting/design	Key finding	Implication for Saudi 2034
Schumacher et al. [28]	Qatar 2022 medical services	167 individuals assessed in the central polyclinic; imaging was the most requested service	Link standardised venue care with centralised specialist diagnostics
Ibrahim et al. [16]	Qatar infectious-disease notification project	Reporting activity rose from 2.5% to 41.4% across 2022 implementation phases	Train clinicians and optimise reporting workflows before the event
Sallam et al. [17]	Qatar event-based surveillance	2,543 signals; 0.85% were public-health relevant; three required national response	Use open-source intelligence as a triaged complementary layer
El-Malah et al. [18]	Qatar wastewater surveillance	SARS-CoV-2 signal tracked population density and clinical cases; poliovirus was not detected	Integrate environmental surveillance with clinical and laboratory data
Serner et al. [30]	Qatar player injury/illness surveillance	82 time-loss injuries in 705 players; 15 time-loss illnesses	Plan sports-medicine, imaging, and respiratory-infection pathways
Esh et al. [7,8]	World Cup 2026 environmental evidence	Extreme heat expected in 14 of 16 host cities; altitude, air quality, allergens, and travel also relevant	Adopt multi-hazard environmental medicine and travel planning
PHAC [21]	Pre-event pathogen risk assessment	Measles was the highest importation concern among assessed pathogen groups	Use pathogen-specific risk assessment and vaccination/surveillance triggers
CDC [23]	U.S. World Cup 2026 operations	Coordination across 11 host sites, a cross-jurisdictional dashboard, and 20 port-health stations	Build interoperable surveillance and national-local command links
PAHO [25]	Mexico City post-event surveillance report	382 alerts processed; 311 resolved; priority alerts assessed within about two hours	Embed early warning in routine systems and retain the capability as legacy
Saudi MOH/GASTAT [15,40]	Hajj 2026 operations	1.707 million pilgrims; >1.2 million services by day 10; large EMS and field-care deployment	Demonstrates scalable Saudi surge, referral, and logistics capability
Grimm et al. [29]	Qatar 2022 operational retrospective	24/7 Medical Command Centre; 118 standardized clinics; hub-and-spoke referral model	Standardise venue care and centralise command and reporting
Grundstein et al. [12]	World Cup 2026 occupational heat study	Hot-humid venues often approached maximum WBGT near 31°C; shade reduced peak exposure	Include workers in venue-specific heat action plans
Public Health Ontario [20]	Toronto infectious-disease HIRA	Measles, food/waterborne disease, and mpox rated moderate; post-event evaluation recommended	Use local hazard ranking and define post-event evaluation
CSTE [22]	World Cup 2026 applied-epidemiology guidance	Incident-command integration; syndromic/wastewater surveillance; traveller and worker health; pre/post monitoring	Embed epidemiology in incident command and a common operating picture
FIFA [13]	World Cup 2026 player-welfare policy	Three-minute hydration breaks midway through each half in every match	Operationalise simple standardised prevention measures
PAHO [26,27]	Dynamic regional risk assessments	Ebola assessed during tournament context; measles reassessed after mass gatherings	Maintain dynamic threat assessment during and after the event
Simon et al. [42]	Canadian team environmental surveillance (preprint)	174 valid air filters; 13 respiratory-virus genetic detections	Emerging feasibility signal; not core peer-reviewed evidence

TABLE 1: Key post-Qatar 2022 and World Cup 2026 evidence incorporated in the targeted update

HIRA, hazard identification and risk assessment; PHAC, Public Health Agency of Canada; CDC, Centers for Disease Control and Prevention; PAHO, Pan American Health Organization; CSTE, Council of State and Territorial Epidemiologists; MOH, Ministry of Health; GASTAT, General Authority for Statistics; EMS, emergency medical services; WBGT, Wet-Bulb Globe Temperature.

Integrated Lessons From Qatar 2022 and World Cup 2026

Four themes recur across the updated evidence. First, surveillance is strongest when several imperfect signals are combined.

Qatar’s notification, EIOS, and wastewater studies show how clinician reporting, open-source intelligence, and environmental sampling can complement one another, while World Cup 2026 demonstrated cross-jurisdictional dashboards and field early-warning reporting [23,25].

Second, preparedness is more valuable when it strengthens routine systems and leaves a durable capability after the event [6,25].

Third, tournament-specific clinical resources work best when they are connected to national services through pre-agreed command, referral, and transport pathways [28,29]. Fourth, environmental surveillance may eventually extend beyond wastewater.

A September 2026 preprint following the Canadian men’s team across five host cities reported 13 respiratory-virus genetic detections among 174 valid air filters, with some signals coinciding with operational precautionary actions [42]. Because this work was not yet peer-reviewed and involved one team, it should be treated as a feasibility signal rather than evidence for routine deployment.

These findings support an all-hazards framework for 2034 built around six operational pillars: environmental and occupational heat protection; integrated surveillance and laboratory response; venue and referral medicine; unified incident command and crowd safety; digital interoperability and multilingual communication; and health legacy with formal post-event evaluation. The framework should be tested through football-specific simulations and precursor tournaments. Performance indicators should include detection time, ambulance response, transfer time, bed availability, heat alerts, laboratory turnaround, crowd-density thresholds, communication speed, and workforce heat protection.

Priority Health-Security Actions for Saudi Arabia 2034

The recommended actions, operational triggers, and desired legacy outcomes are summarised in Table 2. The table is intended as an implementation framework rather than a ranked list of interventions. Supporting evidence for these actions is provided in references [4,5].

Priority	Pre-event action	Tournament trigger/metric	Desired legacy
Heat and environment [7,8]	Venue-specific heat action plans; shade, cooling, hydration, and workforce rotation	WBGT or validated heat index, air quality, heat-illness rate	Permanent heat-health capability for future mass gatherings
Infectious disease [22,20]	Pathogen risk assessment; vaccination advice; laboratory surge plans; wastewater pilots	Cluster alerts, laboratory confirmation, environmental signal	Interoperable national epidemic-intelligence platform
Medical network [28,29]	Map venue posts, diagnostic hubs, receiving hospitals, and transport corridors	Response/transfer time, bed occupancy, imaging demand	Improved emergency referral and teleconsultation networks
Crowd safety [4,5]	Density monitoring, egress modelling, drills, and accessible routes	Density/flow thresholds and incident escalation	Safer crowd-management standards for future events
Command and communication [22,23]	Unified incident command, common operating picture, multilingual templates	Time to verify/communicate an alert; interagency handoff	Routine multi-agency emergency operating procedures
Mental health and safeguarding [34,35]	Confidential referral, multilingual support, and safeguarding protocols	Demand, wait time, serious-risk escalation	Sustained sport and event mental-health pathways
Evaluation and legacy [6,22]	Define key performance indicators and after-action methodology before the tournament	Daily performance review and formal post-event evaluation	Measurable retained capability and continuous improvement

TABLE 2: Priority health-security actions for the 2034 World Cup in Saudi Arabia

WBGT, Wet-Bulb Globe Temperature.

Implications for FIFA 2034 Preparedness

In operational terms, Saudi planners should test venue-specific heat thresholds, syndromic and laboratory reporting, interoperable command, crowd-flow escalation, ambulance dispatch, receiving-hospital capacity, and multilingual communications through football-specific simulations. Hajj systems offer tested capacity

for surge response and interagency coordination, but World Cup spectator mobility, event geography, timing, recreational behaviour, and medical case mix require separate assumptions and prospective validation. These recommendations are evidence-informed priorities, not measured effects of interventions in Saudi 2034.

Public-Health Implementation Implications

Planning can be organised into four phases: (1) baseline capability and hazard mapping, including host-city heat, air quality, infectious-disease, transport, and hospital capacity; (2) interagency protocol design and simulation, with named decision owners and tested escalation thresholds; (3) tournament surveillance and clinical operations with routine performance review; and (4) independent after-action evaluation and retention of effective capabilities. Each phase should include visitor accessibility, multilingual communications, workforce safety, privacy safeguards, and equitable emergency access.

The operational scorecard should specify definitions and denominators before 2034. Suggested indicators include heat-related presentations per 10,000 attendees, time from syndromic signal to epidemiological verification, laboratory turnaround, ambulance dispatch-to-scene and scene-to-hospital intervals, hospital diversion or surge-bed utilisation, crowd-density escalation events, and completion of after-action recommendations. These measures would allow prospective testing of the proposed framework without presenting predictions as established outcomes.

Discussion

The proposed Saudi 2034 framework should be regarded as an evidence-informed planning synthesis rather than a validated prediction of event-specific morbidity. Differences between Hajj and a multi-city football tournament require local needs assessment, prospective simulation, defined governance, and evaluation against prespecified performance indicators before recommendations are operationalised. The updated evidence changes the emphasis of the earlier review in several important ways. Qatar 2022 can now be described using empirical post-event data rather than preparedness narratives alone. The available studies show how clinicians reported disease, how open-source signals were triaged, how wastewater surveillance behaved during changes in population density, what medical services were used, and what injuries and illnesses occurred.

World Cup 2026 adds a different type of evidence: risk assessments across multiple jurisdictions, applied-epidemiology guidance, a standardised hydration policy, occupational heat analysis, cross-jurisdictional U.S. surveillance, Mexico City's early-warning system, dynamic infectious-disease risk assessments, and formal post-event evaluation [12,22]. The convergence of these independent sources strengthens the case for routine-system interoperability and planned after-action learning.

Saudi Arabia's principal advantage is that mass-gathering medicine is already an operational discipline rather than a one-off project. Hajj 2025-2026 demonstrates repeated deployment of heat prevention, emergency transport, field care, hospital referral, and high-volume public communication. The challenge is translation rather than simple replication. World Cup attendees will differ from pilgrims in age distribution, travel patterns, event objectives, sporting injuries, alcohol and substance exposure, and expectations for digital services. Stadium-based incidents may also occur simultaneously in several cities. Preparedness should therefore be based on football-specific demand modelling, scenario exercises, and precursor events rather than direct extrapolation from Hajj attendance figures.

Environmental planning should be dynamic and should protect the entire event workforce, not only players and spectators. Once tournament dates and match schedules are known, heat-health thresholds should trigger graded actions such as schedule adjustment where feasible, standardised hydration opportunities, cooling, shade, workforce rotation, fan-zone controls, and rapid cooling protocols. The occupational heat study from World Cup 2026 shows that workload, acclimatisation, and shade materially affect risk [12], while FIFA's universal hydration breaks show how organisers can institutionalise a simple preventive measure [13]. Environmental dashboards should incorporate heat and air quality and, where relevant, allergens.

Travel and circadian disruption should also be treated as medical-operational issues, particularly when teams and spectators move repeatedly between cities [7,8]. Infectious-disease preparedness should be designed as an interoperable surveillance ecosystem rather than a single reporting platform. A Saudi World Cup dashboard could combine routine syndromic and notifiable-disease systems with laboratory results, targeted environmental surveillance, event-based intelligence, validated pharmacy or absenteeism signals, heat and air-quality data, and real-time hospital and EMS capacity. Every stream requires predefined thresholds, named verification responsibility, and clear escalation routes. Privacy, data minimisation, cybersecurity, and role-based access should be part of the architecture from the outset. Artificial intelligence may assist anomaly detection and demand forecasting, but accountable epidemiological review should remain central [19,39].

Medical network design is the second major implementation priority. Venue medical posts should stabilise

and manage common acute presentations, while selected hubs provide imaging, specialist sports medicine, emergency surgery, cardiology, infectious-disease assessment, and critical care. Referral destinations, transport corridors, and surge beds should be mapped against event schedules and tested during simulations. Mental-health and safeguarding pathways should be accessible to spectators, staff, volunteers, and teams, with culturally and linguistically appropriate support. Public-facing communication should be coordinated across health, event, transport, and security authorities so that advice remains timely and consistent [42].

The review also supports a stronger concept of health legacy. WHO's Qatar 2022 report and PAHO's Mexico City experience show that a mega-event can accelerate durable improvements in surveillance, workforce capability, health promotion, and interagency coordination [6,25]. For Saudi 2034, legacy indicators should be specified before the tournament and measured afterwards. Relevant indicators include retained surveillance interoperability, workforce competencies, emergency-response times, laboratory surge capacity, accessible venue standards, and sustained prevention or physical-activity initiatives [43,44,45].

Limitations

Additional methodological limitations include the absence of preserved complete database-specific search strings, duplicate independent-screening records, a reproducible exclusion-reason register, and study-level formal risk-of-bias worksheets for the original review. The reconstructed PRISMA arithmetic is not a substitute for contemporaneous screening documentation. These gaps constrain reproducibility and the certainty of claims framed as systematic-review findings.

This review has several limitations. The underlying systematic search was completed through 2025, whereas the 2026 component was a targeted update rather than a complete rerun of Scopus, Web of Science, and the Cochrane Library. Newer sources were therefore not added to the original screening denominator. The revised PRISMA pathway preserves the aggregate counts documented in the legacy screening log. Although the transition from 1,182 reports sought for retrieval to 1,182 reports assessed permits a reconstructed "not retrieved" count of zero, the source materials did not preserve reason-specific counts for the 1,139 full-text exclusions; those details therefore remain unavailable and were not fabricated.

The evidence is heterogeneous and includes observational studies, reviews, official operational reports, policy documents, and one explicitly identified preprint, which limits quantitative comparison. The targeted update prioritised primary and authoritative World Cup-related health sources but cannot guarantee capture of every local statement or rapidly changing web publication. As of September 2026, no comprehensive peer-reviewed U.S. tournament-wide dataset was identified that reported spectator morbidity, heat illness, hospitalisations, or outbreaks across all host sites. Finally, Hajj and World Cup populations differ substantially; transferability of Saudi mass-gathering capabilities should therefore be tested prospectively through football-specific exercises and pilot events.

Future Evidence-Strengthening Programme

The pre-2034 research agenda should include a new preregistered multi-database search with retained full Boolean strings, independent dual screening, reason-coded full-text exclusions, standardised data extraction, and design-specific appraisal instruments. Such work would enable an auditable systematic update and more explicit evidence grading. Until then, the present synthesis uses transparent source-type distinctions and avoids statistical pooling across incompatible outcomes.

Conclusions

Saudi Arabia's 2034 World Cup can build on three complementary assets: long-standing Hajj mass-gathering experience, national health-system transformation, and an expanding body of empirical and operational evidence from Qatar 2022 and World Cup 2026. The most defensible approach is to extend and connect routine public-health and clinical systems rather than create a temporary technology-heavy parallel structure for the tournament.

Heat action plans, layered surveillance, laboratory readiness, unified incident command, distributed emergency care, crowd-safety intelligence, mental-health pathways, and multilingual risk communication should operate as one tested framework. Performance indicators and a formal after-action evaluation should be defined before the event so that the tournament leaves measurable improvements in Saudi health security and mass-gathering medicine beyond 2034.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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