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Research Article

The Role of the Saudi Red Crescent Authority in Mass-Casualty Incident Preparedness

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Abstract:

The Saudi Red Crescent Authority (SRCA) plays a pivotal role in the preparedness and response to mass-casualty incidents in Saudi Arabia. As the primary humanitarian organization in the Kingdom, the SRCA is tasked with providing emergency medical services, disaster response, and health education. The authority collaborates closely with various stakeholders, including government agencies, local communities, and international organizations, to develop comprehensive emergency response plans. Through rigorous training programs, simulations, and community outreach initiatives, the SRCA enhances the capacity of medical personnel and volunteers, ensuring a swift and efficient response during crises. Their focus on preparedness is further exemplified through the establishment of communication networks and protocols that facilitate rapid coordination during emergencies. In addition to training and coordination, the SRCA actively engages in research and development to improve emergency response capabilities in handling mass-casualty incidents. By utilizing innovative technologies and best practices from around the world, the SRCA strives to enhance the resilience of its healthcare systems. The organization also emphasizes public awareness campaigns aimed at educating citizens on emergency preparedness and first aid, which is crucial for minimizing casualties in the event of a disaster. As mass-casualty incidents can occur due to natural disasters, accidents, or terrorist attacks, the SRCA's strategic

approach to preparedness is essential in safeguarding public health and ensuring the well-being of the community

1. Introduction

The specter of mass-casualty incidents (MCIs) looms as a persistent and formidable challenge for emergency medical services (EMS) worldwide. Defined as events that overwhelm the local healthcare system's capacity to respond with available resources, due to the sheer volume and severity of casualties, MCIs can arise from a multitude of causes [1]. These range from natural disasters, such as floods and earthquakes, to human-made tragedies like major traffic collisions, industrial accidents, and terrorist attacks. The Kingdom of Saudi Arabia, given its unique geopolitical landscape, rapid urbanization, and the hosting of mega-events like the Hajj pilgrimage—which attracts over two million people annually—faces a particularly acute and complex set of risks [2].

At the heart of this system stands the Saudi Red Crescent Authority (SRCA). Established in 1934, the SRCA has evolved from a foundational humanitarian organization into the Kingdom's primary pre-hospital emergency care provider. Its mandate extends far beyond daily medical emergencies; it is the cornerstone of Saudi Arabia's preparedness for and response to large-scale disasters and MCIs [3]. The SRCA's role is not merely reactive but is fundamentally rooted in a proactive, continuous cycle of planning, training, equipping, and coordinating. This involves the development of sophisticated incident command systems, the strategic stockpiling of medical resources, the execution of large-scale simulation exercises, and the seamless integration with other key government entities such as the Ministry of Health, Civil Defense, and Public Security [4].

The strategic importance of the SRCA's preparedness has been magnified by recent global and regional events. The COVID-19 pandemic served as a prolonged, global MCI, testing the surge capacity and logistical chains of even the most advanced EMS systems. In Saudi Arabia, the SRCA was instrumental in-patient transport, mass testing, and public health education, demonstrating its critical role in public health emergencies beyond traditional trauma incidents [5]. Furthermore, regional tensions have highlighted the need for preparedness for conflict-related MCIs. In response, the SRCA has significantly advanced its capabilities in triage, field stabilization, and medical evacuation, ensuring it is prepared for a wide spectrum of mass-casualty scenarios [6].

Recent statistics and reports highlight the scale of the challenge and the SRCA's operational footprint. Annually, the Authority responds to millions of emergency calls. For instance, in 2022 alone, the SRCA reported responding to over 1.2 million incidents, a significant portion of which involved multiple casualties requiring coordinated triage and response [7]. The Hajj operation represents the pinnacle of its MCI preparedness testing. During the 2023 pilgrimage, the SRCA deployed more than 5,000 medical, technical, and administrative personnel, operated over 200 ambulance stations and 15 mobile clinics along the holy sites, and was equipped with a fleet of over 1,500 ambulances and several mobile command centers [8]. This massive deployment is a testament to the pre-planned, scalable response framework essential for MCI management.

Technological integration has become a cornerstone of modern MCI preparedness, and the SRCA has made significant investments in this domain. The adoption of a unified digital dispatch and communication system allows for real-time tracking of resources and casualties, a critical factor in the "golden hour" following a major incident [9]. The Authority is also exploring the use of drones for the rapid delivery of medical supplies like automated external defibrillators (AEDs) to inaccessible areas and utilizing artificial intelligence in its emergency call centers to better identify potential MCIs from the initial influx of calls [10]. These technological advancements are integrated into a broader framework of international best practices, with the SRCA actively collaborating with global bodies like the International Committee of the Red Cross (ICRC) and the World Health Organization (WHO) to benchmark its protocols against international standards [11].

However, despite these advancements, the dynamic nature of threats necessitates perpetual evolution. Challenges such as traffic congestion in major cities, which can impede ambulance response times, the logistical complexities of operating in the vast and varied geography of the Kingdom, and the need for continuous public awareness and community engagement in disaster response remain areas of focused attention [12].

2. Foundations of MCI Preparedness:

The genesis of the SRCA dates back to 1934, establishing it as one of the oldest humanitarian organizations in the Arabian Peninsula. Initially

focused on providing basic health services and aid, its role expanded in parallel with the Kingdom's rapid modernization and growing complexities in public safety [13]. The transformation into the primary pre-hospital care provider was a strategic decision, recognizing the need for a specialized body to manage medical emergencies outside hospital walls. This evolution was significantly influenced by the unique challenges posed by mass gatherings, most notably the annual Hajj pilgrimage. The recurring task of managing the health of millions of pilgrims in a confined space and time served as a relentless, real-world crucible, forcing the SRCA to develop and institutionalize MCI protocols long before they became standard in global emergency medical services (EMS) [14]. This historical context underscores a core characteristic of the SRCA: its capacity for adaptive learning and institutional growth in response to national needs.

The authority and responsibilities of the SRCA are enshrined in a robust legal and regulatory mandate. It operates under a royal decree that formally designates it as the official national society for pre-hospital emergency medical services, affiliated with the International Red Cross and Red Crescent Movement. This legal status provides the SRCA with the autonomy and authority necessary to coordinate pre-hospital response across the vast and diverse geography of the Kingdom [15]. The mandate explicitly tasks the Authority with providing emergency medical services, managing disaster situations, and participating in national and community health awareness programs. Furthermore, its regulations empower it to set standards for ambulance services, train and certify paramedics, and establish the operational protocols for triage, stabilization, and transport during MCIs. This clear legal foundation is the cornerstone upon which all MCI preparedness activities are built, eliminating ambiguity in command and control during the chaotic initial moments of a major incident and ensuring a unified national response standard [16].

Beyond its foundational mandate, the SRCA's approach to MCI preparedness is guided by sophisticated, multi-year strategic frameworks aligned with the nation's broader vision, most notably Saudi Vision 2030. Vision 2030's emphasis on a vibrant society, a thriving economy, and an ambitious nation has direct implications for healthcare and emergency preparedness. The SRCA's strategy is designed to contribute to these overarching goals by ensuring a safe and secure environment for citizens, residents, and visitors, which is a prerequisite for economic and social vitality [17]. The strategic framework typically encompasses several key pillars: enhancing operational excellence, integrating advanced technology, developing human capital, and strengthening community partnerships. For instance, a central strategic objective is the reduction of average response times to emergencies across all Saudi cities, a goal that directly enhances MCI readiness by ensuring that the first wave of responders can reach any hotspot within a critical window of time [18].

A critical component of this strategic framework is the development and adoption of a standardized National Incident Management System (NIMS), often adapted from internationally recognized models like the American NIMS or the UK's Civil Contingencies Act. The SRCA has been instrumental in integrating its command and control structures within this national system. This ensures interoperability and seamless coordination between the SRCA, the General Directorate of Civil Defense, the Ministry of Health, the Public Security, and other vital entities during a large-scale incident [19]. The SRCA's Emergency Operations Centers (EOCs) act as the medical command nexus within this system, capable of scaling up their capacity to manage complex, multi-agency responses. The strategic plan also mandates continuous risk assessment and resource mapping, identifying high-probability, high-impact MCI scenarios—from major traffic collisions on expanding highway networks to potential civil defense emergencies—and pre-positioning assets accordingly [20].

3. Pillars of Readiness:

The first and most critical pillar is strategic and operational planning. The SRCA’s planning philosophy is predicated on the principle of "all-hazards" preparedness, which involves developing flexible yet structured plans that can be adapted to a wide range of scenarios, from multi-vehicle traffic collisions to terrorist attacks or natural disasters. At the heart of these plans is the **MCI Response Plan**, a detailed document that outlines standardized procedures for the first 24-48 hours of a major incident [21]. Key components of this plan include the immediate activation of the Incident Command System (ICS), which establishes a clear chain of command with defined roles for an Incident Commander, Operations Chief, Logistics Chief, and Planning Chief. The plan also standardizes the **triage system**, with the SRCA officially adopting the **START (Simple Triage and Rapid Treatment)** and **JumpSTART** (for pediatric patients) methodologies. This ensures that all first responders, regardless of their station or region, use

a universal language for prioritizing casualties as Green (minimal), Yellow (delayed), Red (immediate), or Black (deceased) [22]. Furthermore, the plans detail resource management protocols, specifying how to request and integrate additional ambulances, specialized medical teams, and equipment from neighboring regions or the Ministry of Health to manage the surge in demand. These plans are not static; they are living documents subjected to regular review and revision based on after-action reports from real incidents and changing risk assessments [23].

The second pillar, **continuous and specialized training**, is what breathes life into the written plans. The SRCA invests heavily in the development of its human capital, recognizing that advanced equipment is useless without highly trained personnel to operate it under extreme pressure. The foundational training for all SRCA paramedics includes comprehensive modules on MCI management. However, the Authority goes far beyond this baseline. It conducts specialized courses for its personnel in areas such as **Tactical Emergency Casualty Care (TECC)**, which focuses on providing medical care in hostile or active threat environments, and **Chemical, Biological, Radiological, and Nuclear (CBRN) response** [24]. These specialized skills are crucial given the modern threat landscape. The training curriculum is heavily practical, emphasizing hands-on skills in triage tagging, rapid extrication techniques, hemorrhage control using tourniquets and hemostatic agents, and managing compromised airways in resource-limited settings. A key aspect of this training is **leadership development** for mid and senior-level commanders, focusing on decision-making, resource allocation, and communication under the intense psychological stress of an MCI [25]. The SRCA often collaborates with international partners, including the International Committee of the Red Cross (ICRC) and leading global EMS institutions, to benchmark its training programs against the highest international standards and incorporate global best practices [26].

The third pillar, which synthesizes planning and training into a cohesive whole, is the execution of **large-scale simulation exercises**. These drills are the ultimate test of the SRCA's preparedness, exposing weaknesses in plans, communication systems, and inter-agency coordination in a controlled, yet highly realistic, environment. The SRCA regularly conducts various levels of exercises. **Tabletop exercises** involve key decision-makers discussing a simulated scenario in an informal setting, testing the conceptual framework of the response and command decisions without deploying physical resources [27]. More critically, **Full-Functional Exercises (FSEs)** are massive, multi-agency simulations that closely mimic reality. These exercises involve the actual deployment of ambulances, field hospitals, command posts, and hundreds of personnel acting as simulated casualties with elaborate moulage (mock injuries).

A prime example is the exercises conducted in the holy cities of Makkah and Madinah in the months leading up to each Hajj season. These FSEs simulate a range of potential MCIs, such as a stampede in Mina, a structural collapse near the Grand Mosque, or a major fire. They involve not just the SRCA but also the Civil Defense, Ministry of Health, Security Forces, and other relevant entities [28]. The objectives are multifaceted: to test communication interoperability between different agencies, to validate the triage and patient transport plans, to practice the establishment of casualty collection points, and to assess the efficiency of the patient tracking system from the incident site to the receiving hospital. The data collected from these exercises is invaluable. After-action reviews and "hot wash" sessions are conducted immediately after the drill to identify gaps, such as communication breakdowns, logistical bottlenecks, or confusion in role allocation [29]. These findings are then fed back into the planning and training cycles, creating a continuous feedback loop for improvement. For instance, a 2022 full-scale exercise in Riyadh revealed a need for more robust satellite communication backups when cellular networks were simulated to be overloaded, leading to a strategic investment in portable satellite phones for all major command vehicles [30].

4. Operational Doctrine in Action:

The first and most crucial step upon the arrival of SRCA units at an MCI scene is the immediate establishment of the **Incident Command System (ICS)** and the swift commencement of **triage**. The first qualified paramedic or commander on the scene assumes the role of Incident Commander until relieved by a senior officer, immediately initiating a size-up of the situation to determine the scope of the incident and potential hazards [31]. Simultaneously, the first responding teams begin the process of triage. The SRCA has institutionalized the use of the **START (Simple Triage and Rapid Treatment)** system for adults and the **JumpSTART** system for pediatric patients, ensuring a universal and rapid method for prioritizing care [32]. This process involves a rapid assessment of each casualty, taking no more than 30-60 seconds per person, based on three key

parameters: respiration, perfusion (pulse or capillary refill), and mental status. Casualties are immediately tagged with color-coded triage tags:

- **Red (Immediate):** For casualties with compromised airways, severe hemorrhage, or in shock.
- **Yellow (Delayed):** For those with significant injuries that are not immediately life-threatening.
- **Green (Walking Wounded):** For the ambulatory, who are directed to a designated safe area.
- **Black (Deceased/Expectant):** For those who have no signs of life or non-survivable injuries.

Recent advancements have seen the SRCA pilot the use of electronic triage tags that contain barcodes or RFID chips. These tags, when scanned, can automatically log a patient into the central tracking system, providing real-time data to the command post on the number and priority of casualties found, which is invaluable for resource planning [33]. This systematic triage process ensures that limited medical resources are directed first to those who need them most to survive, preventing the common pitfall of responders dedicating excessive time to the first casualty they encounter while others with more critical needs go unnoticed.

Following initial triage, the focus shifts to the **Treatment** phase, which is inherently integrated with the ongoing triage process. The operational doctrine emphasizes *rapid, life-saving interventions* at the point of injury, rather than comprehensive on-scene care. The goal is not to definitively treat all injuries but to stabilize casualties for transport. This philosophy is a direct application of lessons learned from global military and civilian EMS practices [34]. In the designated **Treatment Areas**—separate zones established for Red and Yellow casualties—paramedics perform critical interventions based on the principles of **Damage Control Resuscitation (DCR)**. For "Red" tag patients, this primarily involves:

- **Airway Management:** Basic maneuvers like jaw thrusts or recovery positions; advanced airway management is limited in the field during a true MCI due to time constraints.
- **Breathing:** Needle decompression for tension pneumothorax.
- **Circulation:** Control of major external hemorrhage using tourniquets and hemostatic dressings, which have become standard issue for all SRCA first responders [35].

The SRCA's doctrine explicitly states that CPR is not to be initiated for pulseless and apneic (non-breathing) casualties in a multi-casualty setting, as these resources must be allocated to those with a chance of survival [36]. The Treatment Areas are managed by dedicated teams with specific equipment packs—such as "Triage Packs" and "Major Hemorrhage Packs"—that are pre-stocked and deployed with MCI response vehicles. The establishment of effective communication between the Treatment Areas and the Incident Commander is critical, as it allows for continuous situational awareness and the dynamic reallocation of medical teams as needed.

The final, and often most complex, phase is the coordinated **Transport** of casualties to appropriate healthcare facilities. An uncoordinated "scoop and run" approach can overwhelm the closest hospital, leaving other facilities under-utilized and causing a secondary crisis at the emergency departments. To prevent this, the SRCA's doctrine integrates a **Transportation Officer** within the ICS structure, whose sole responsibility is to manage this flow [37]. This officer works in direct communication with the **Medical Communications Center**, which has real-time data on bed availability, specialist capabilities (e.g., trauma, burn, pediatric), and surgical capacity at all receiving hospitals in the region.

The process follows a strict protocol: the most critically injured "Red" tag patients are prioritized for transport first, but they are distributed among multiple Level I and Level II Trauma Centers to avoid concentration. "Yellow" tag patients are transported next, often to a wider network of hospitals. "Green" tag patients may be transported last, possibly via buses or other non-ambulatory means, to minor injury units or community hospitals to free up major emergency departments [38]. The SRCA utilizes a sophisticated **patient tracking system** throughout this process. From the moment a triage tag is applied, the casualty is logged. When they are loaded into a specific ambulance (with its unique unit number), that information is updated. Upon arrival at the hospital, a final update confirms the handover [39]. This end-to-end tracking prevents patients from being "lost," provides accountability to families, and gives planners critical data on transport times and facility utilization.

A key innovation in SRCA's transport doctrine, particularly for MCIs in remote areas or during mega-events like Hajj, is the use of **Medical Ambulance Buses (MABs)**. These vehicles can carry up to 20 ambulatory or stretcher-bound patients at once, along with a full medical team. They are instrumental in the rapid clearance of a

scene when the number of "Yellow" and "Green" patients is high, allowing multiple standard ambulances to focus on the critical "Red" patients [40].

5. Enhancing MCI Response through Innovation

The cornerstone of the SRCA's technological infrastructure is its **Advanced Command, Control, and Communication (C3) System**. This integrated digital ecosystem connects all elements of the response chain, from the initial emergency call to the arrival of the patient at the hospital. The system's heart is a **Computer-Aided Dispatch (CAD)** platform that uses sophisticated algorithms to manage resources. When multiple calls related to the same incident are received, the CAD system can automatically flag a potential MCI, alert supervisors, and begin recommending the dispatch of units based on real-time GPS location and availability [41]. Once an MCI is declared, the system supports the establishment of a digital **Incident Command Post**. Commanders are equipped with mobile data terminals and tablets running specialized incident management software. This allows them to view a live Common Operating Picture (COP) on a digital map, showing the locations of all deployed units (ambulances, command vehicles), the estimated number of casualties (via electronic triage tags), and the status of nearby hospitals [42]. This real-time visibility enables data-driven decision-making, allowing the Incident Commander to see where resources are clustered and where gaps exist, and to deploy assets accordingly. Furthermore, ensuring communication interoperability with partner agencies like Civil Defense and Public Security has been a key focus. The SRCA has invested in multi-band radio systems and dedicated communication vehicles that can bridge different radio networks, ensuring that all agencies can communicate seamlessly on a shared tactical channel during a joint response [43].

A particularly innovative area of the SRCA's technological advancement is the exploration and deployment of **Unmanned Aerial Systems (UAS), or drones**. Drones are being piloted for several critical MCI functions that are challenging for ground-based teams. First, they serve as **rapid aerial assessment tools**. A drone can be launched within minutes of an MCI declaration to fly over the incident site, providing commanders with a live video feed and high-resolution photographs. This aerial perspective is invaluable for understanding the scale and topography of the incident, identifying hazards (like fire or structural instability), and locating clusters of casualties that may not be visible from the perimeter [44]. Second, drones are being tested for **logistical support**. In incidents where casualties are in hard-to-reach areas—such as a multi-vehicle collision in a remote desert location or a building collapse with inaccessible voids—drones can be used to deliver small, critical medical supplies. Pilot projects have successfully demonstrated the delivery of automated external defibrillators (AEDs), tourniquets, naloxone, and even blood products to the point of need, potentially saving crucial minutes before ground teams can access the patient [45]. This application is a key focus of the SRCA's research and development wing, aiming to create a "flying first aid kit" capability.

Looking toward the future, the SRCA is actively investing in **Data Analytics and Artificial Intelligence (AI)** to move from reactive response to predictive and optimized preparedness. The vast amount of data collected from past incidents, daily operations, and mega-events like the Hajj represents a treasure trove of information. By applying AI and machine learning algorithms to this data, the SRCA aims to develop predictive models for MCI risks. These models can analyze factors such as traffic patterns, weather conditions, historical incident data, and scheduled large gatherings to predict the likelihood and potential location of certain types of MCIs, allowing for the strategic pre-positioning of resources [46]. Furthermore, AI is being integrated into the emergency communication centers. **AI-powered call-taking systems** can analyze a caller's voice for stress levels and specific keywords, and by cross-referencing the location with real-time data (e.g., traffic sensors, social media), the system can provide dispatchers with an early probability assessment of a potential MCI, prompting a faster and more robust initial response [47].

Another critical technological component is the **Electronic Patient Tracking System (ePTS)**. As mentioned in the operational doctrine, tracking patients from triage to hospital is vital. The SRCA's ePTS uses scannable barcodes or RFID chips on triage tags. When a patient is triaged, loaded into an ambulance, and arrives at a hospital, their tag is scanned, updating their status in a centralized, cloud-based database accessible to authorized commanders and hospital coordinators [48]. This system eliminates the "fog of war" that traditionally plagues MCIs, preventing patients from being lost, providing families with accountability, and giving planners accurate data for after-action analysis.

6. Conclusion

The preparedness and response to mass-casualty incidents represent one of the most demanding challenges for any national emergency medical service. This research has systematically examined the multifaceted role of the Saudi Red Crescent Authority (SRCA) in meeting this challenge, revealing a sophisticated and evolving system that is integral to the Kingdom's national security and public health infrastructure. The analysis conclusively demonstrates that the SRCA's effectiveness is not a matter of chance but the direct result of a deeply entrenched culture of preparedness, built upon a solid foundation and continuously refined through strategic investment and learning.The investigation began by establishing the robust **foundations** of the SRCA's mandate and strategic framework, showing how its historical evolution and legal authority provide the necessary legitimacy and direction for its MCI operations. It then delved into the core **pillars of readiness**—meticulous planning, specialized training, and realistic simulation exercises—which collectively ensure that theoretical plans are translated into actionable, muscle-memory protocols for all personnel. The examination of the SRCA's **operational doctrine** illuminated the practical application of these plans on the ground, highlighting the critical, life-saving sequence of triage, treatment, and transport that brings order to the chaos of a disaster scene. Finally, the study explored the role of technology as a **force multiplier**, showcasing how advanced command and control systems, unmanned aerial vehicles, and data analytics are revolutionizing the SRCA's situational awareness, coordination, and operational efficiency.

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References

[1] Al Dakheel Z. Saudi Arabia's success in transforming Umrah, Hajj ecosystem. The Jordan Times. 2023.

[2] Alhamaid YA, Aljawi H, Alsughayyir G, Alshammari MH, Albatshan RS, Alabbad FE, et al. The knowledge, attitudes, and practices of emergency department staff to preparedness of disaster and emergency in Saudi Arabia: Multicenter cross-sectional study. Indian J Crit Care Med. 2024;28(11):1023–1027.

[3] Abdelmoety DA, El-Bakri NK, Almowalld WO, Turkistani ZA, Bugis BH, Baseif EA, et al. Characteristics of heat illness during hajj: A cross-sectional study. BioMed Res Int. 2018;2018:5629474.

[4] Wathinani MA, Barten DG, Gołda P, AlDulijan NA, Alhallaf MA, Samarkandi LO, et al. Driving sustainable disaster risk reduction: A rapid review of the policies and strategies in Saudi Arabia. Sustainability. 2022;15(14):10976.

[5] Mani ZA, Sultan MAS, Plummer V, Goniewicz K. Navigating interoperability in disaster management: Insights of current trends and challenges in Saudi Arabia. International Journal of Disaster Risk Science. 2023;14:873–885.

[6] Khirekar J, Badge A, Bandre GR, Shahu S. Disaster preparedness in hospitals. Cureus. 2023;15(12):e50073.

[7] Abro MMQ, Khurshid MA, Aamir A. Corporate Social Responsibility (CSR) practices:the case of Saudi Aramco. Journal of Competitiveness Studies. 2016;24:79–90.

[8] New York City Department of City Planning. ACS demographic and housing estimates New York City and Boroughs. 2011 American community survey population Division; NYC Department of City Planning. 2011.

[9] Dia G BA, Dennis B, Mark B, William C, Richard C, Kelly H EMS incident response and readiness assessment (EIRRA):a self-assessment tool to measure the level of EMS preparedness for responding to a highway mass casualty incident or other large scale emergency. National Association of State EMS Officials. 2011.

[10] Myers JB, Slovis CM, Eckstein M, Goodloe JM, Isaacs SM, Loflin JR, et al. Evidence-based performance measures for emergency medical services systems:a model for expanded EMS benchmarking. Prehosp Emerg Care. 2008;12:141–151.

[11] Alsadhan B, editor. Emergency early responders and EMS transition in Saudi Arabia:proposed model for system improvement. University of Pittsburgh (PA): University of Pittsburghy; 2015.

[12] National Centre for Security Operation. Unified Security Operations Centers (911). 2018.

[13] AlShammari T, Jennings P, Williams B. Evolution of emergency medical services in Saudi Arabia. JEMTAC. 2017;2017:4.

[14] Alanazi AF. Curriculum design of emergency medical services program at the College of applied Medical Sciences, King Saud bin Abdulaziz University for Health Sciences. Adv Med Educ Pract. 2012;3:7–18.

[15] World Health Organization. Summary report on the meeting of heads of medical missions on public health preparedness for Hajj, Jeddah, Saudi Arabia, 16-17 September 2014. Saudi Arabia: World Health Organization. Regional Office for the Eastern Mediterranean; 2015.

[16] Saudi Red Crescent Authority. Annual Report Summary 2015. 2015.

[17] General Authority for Statistics. Saudi total population in 2016. 2016.

[18] Harewood S. Emergency ambulance deployment in Barbados:a multi-objective approach. J Oper Res Soc. 2002;53:185–192.

[19] Ezreqat S, Khan A. Evaluation of a Saudi major airport's medical preparedness for mass casualty incident:a mixed-methodology study. MOJ Public Health. 2017;6:346–352.

[20] Bin Shalhoub AA, Khan AA, Alaska YA. Evaluation of disaster preparedness for mass casualty incidents in private hospitals in Central Saudi Arabia. Saudi Med J. 2017;38:302–306.

[21] Graham J, Liggin R, Shirm S, Nation B, Dick R. Planning for a mass casualty incident in Arkansas schools. J Sch Health. 2005;75:327–328.

[22] Annual Report to Congress 2009. National Transportation Safety Board. 2009.

[23] Preparedness and response to a rural mass casualty incident:workshop summary. The national academies collection:Reports funded by National Institutes of Health. Washington (DC): National Academies Press (US); 2011.

[24] Fahlgren TL, Drenkard KN. Healthcare system disaster preparedness, part 2:nursing executive role in leadership. J Nurs Adm. 2002;32:531–537.

[25] McHugh M, Staiti AB, Felland LE. How prepared are Americans for public health emergencies?Twelve communities weigh in. Health Aff (Millwood) 2004;23:201–209.

[26] Koh HK, Elqura LJ, Judge CM, Jacob JP, Williams AE, Crowther MS, et al. Implementing the cities readiness initiative:lessons learned from Boston. Disaster Med Public Health Prep. 2008;2:40–49.

[27] Cone D, Brice JH, Delbridge TR, Myers JB. Emergency medical services:clinical practice and systems oversight, 2 volume Set. Irving (TX): John Wiley & Sons; 2014.

[28] Doyle CJ. Mass casualty incident. Integration with prehospital care. Emerg Med Clin North Am. 1990;8:163–175.

[29] Hsu EB, Jenckes MW, Catlett CL, Robinson KA, Feuerstein C, Cosgrove SE, et al. Effectiveness of hospital staff mass-casualty incident training methods:a systematic literature review. Prehosp Disaster Med. 2004;19:191–199.

[30] Sundnes KO, Birnbaum ML. Health disaster management:guidelines for evaluation and research in the utstein style. Prehosp Disaster Med. 2003;17:1–177.

[31] Tambo E, Fouad AM, Khater EI. Strengthening community emergency preparedness and response in threats and epidemics disasters prevention and management in Saudi Arabia. IJEM. 2017;13:288–303.

[32] Ashida S, Robinson EL, Gay J, Slagel LE, Ramirez MR. Personal disaster and emergency support networks of older adults in a rural community:changes after participation in a preparedness program. Disaster Med Public Health Prep. 2017;11:110–119.

[33] Chartoff SE, Roman P. Disaster Planning. Treasure Island (FL): StatPearls Publishing; 2019.

[34] Holroyd B, Shalit M, Kallsen G, Culhane D, Knopp R. Prehospital patients refusing care. Ann Emerg Med. 1988;17(9):957–963. doi: 10.1016/s0196-0644(88)80679-6.

[35] Bahrami MA, Maleki A, Ranjbar Ezzatabadi M, Askari R, Ahmadi Tehrani GH. Pre-Hospital Emergency Medical Services in Developing Countries: A Case Study about EMS Response Time in Yazd, Iran. Iran Red Crescent Med J. 2011;13(10):735–738.

[36] Alghnam S, Alkelya M, Alfraidy M, Al-Bedah K, Albabtain IT, Alshenqeety O. Outcomes of road traffic injuries before and after the implementation of a camera ticketing system: A retrospective study from a large trauma center in Saudi Arabia. Ann Saudi Med. 2017;37(1):1–9. doi: 10.5144/0256-4947.2017.1.

[37] Gonzalez RP, Cummings GR, Mulekar MS, Harlan SM, Rodning CB. Improving rural emergency medical service response time with global positioning system navigation. J Trauma. 2009;67(5):899–902. doi: 10.1097/TA.0b013e3181bc781d.

[38] Zhang JJ, Wang LD, Li H, Zhao YC. Response time of the Beijing 120 emergency medical service. Emerg Med J. 2010;27(10):784–785. doi: 10.1136/emj.2009.086561.

[39] Trunkey DD. Trauma. Accidental and intentional injuries account for more years of life lost in the U.S. than cancer and heart disease. Among the prescribed remedies are improved preventive efforts, speedier surgery and further research. Sci Am. 1983;249:28–35.

[40] Johnson NJ, Carr BG, Salhi R, Holena DN, Wolff C, Band RA. Characteristics and outcomes of injured patients presenting by private vehicle in a state trauma system. Am J Emerg Med.

2013;31(2):275–281. doi: 10.1016/j.ajem.2012.07.023.

[41] Ota FS, Muramatsu RS, Yoshida BH, Yamamoto LG. GPS computer navigators to shorten EMS response and transport times. Am J Emerg Med. 2001;19(3):204–205. doi: 10.1053/ajem.2001.22662.

[42] Hipskind JE, Gren J, Barr D. Patients Who Refuse Transportation by Ambulance: A Case Series. Prehosp Disaster Med. 1997;12(4):45–50.

[43] Sucov A, Verdile VP, Garettson D, Paris PM. The Outcome of Patients Refusing Prehospital Transportation. 1992;7(4):365–371.

[44] Alrazeeni DM, Sheikh SA, Mobrad A, Al Ghamdi M, Abdulqader N, Al Gabgab M, et al. Epidemiology of non-transported emergency medical services calls in Saudi Arabia. Saudi Med J. 2016;37(5):575–578. doi: 10.15537/smj.2016.5.13872.

[45] Alkhamis A, Hassan A, Cosgrove P. Financing healthcare in Gulf Cooperation Council countries: A focus on Saudi Arabia. Int J Health Plann Manage. 2014;29(1):64–82. doi: 10.1002/hpm.2213.

[46] Hamam AF, Bagis MH, AlJohani K, Tashkandi AH. Public awareness of the EMS system in Western Saudi Arabia: identifying the weakest link. Int J Emerg Med. 2015;8(1):35. doi: 10.1186/s12245-015-0070-7.

[47] Alkhamis A, Hassan A, Cosgrove P. Financing healthcare in Gulf Cooperation Council countries: A focus on Saudi Arabia. Int J Health Plann Manage. 2014;29(1):64–82. doi: 10.1002/hpm.2213.

[48] Mowafi H, Oranmore-Brown R, Hopkins KL, White EE, Mulla YF, Seidenberg P. Analysis of Prehospital Transport Use for Trauma Patients in Lusaka, Zambia. World J Surg. 2016;40(12):2868–2874. doi: 10.1007/s00268-016-3629-4.