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RESEARCH ARTICLE

Relief and Rescue Operations during Mass Gatherings: A Systematic Review

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ABSTRACT

Large-scale events known as mass gatherings (MGs) present considerable difficulties for emergency management particularly when it comes to providing relief and rescue services. The possibility of mishaps terrorist strikes and public health crises give rise to these difficulties. Ensuring the safety and well-being of participants during such events requires effective management. To compile the most recent information and methods for relief and rescue efforts during MGs is the goal of this systematic review. It looks for practical approaches and draws attention to areas where research is lacking in order to suggest future lines of inquiry. Researchers used databases such as, PubMed, Scopus, Web of Science, and Google Scholar to perform a thorough search of the literature encompassing publications from 2000 to 2023. The terms "mass gatherings", "disaster preparedness", "public health", "emergency management", "relief operations", and "rescue operations" were among them. Inclusion criteria encompassed books, guidelines, and qualitative and quantitative studies on relief and rescue efforts during MGs. The data quality assessment was performed independently by multiple reviewers. The review included 52 sources from various regions, including Canada, Asia, Europe, and America. Significant improvements in the efficiency of relief and rescue operations are attributed to pre-event preparation and multiagency coordination. Developments in technology, including real-time data analysis and communication tools, improve situational awareness and resource allocation. Nevertheless, there are still issues to be resolved, such as unmet educational needs of staff, poor communication, and technical limitations. The review concludes by highlighting the significance of involving multiple agencies and incorporating public health considerations into emergency planning. Further, effective relief and rescue operations during MGs require combining advanced technology, and thorough planning. More qualitative and experimental studies from different geographical contexts can provide valuable insights into region-specific challenges and solutions. This review underscores the critical need for continuous improvement and adaptation in emergency management strategies to safeguard public health and safety during MGs.

INTRODUCTION

Mass gatherings (MGs), defined as events that attract numerous people to a specific location for a specific purpose, are a common feature of modern society, and although they provide opportunities

for social interaction, cultural exchange, and economic activity, the challenge creates unique challenges for public health and safety services (Ahmed et al., 2006). These events, which can include religious pilgrimages such as Arbaeen and Hajj, cultural and music festivals, sports events, and political marches, whether organized or spontaneous, can lead to unexpected events such as structure collapse, security threats, and other types of accidents (Memish et al., 2019, Bistaraki et al., 2019, Wang and Yoon, 2002, Illiyas et al., 2013).

Therefore, effective rescue operations during such gatherings are very important to ensure the safety and well-being of the participants (Arbon, 2007). Rescue and relief provide necessary, appropriate, and timely humanitarian assistance to injured people in critical situations, preventing the deterioration of their condition, and accelerating their early recovery. Rescue and relief are based on quick initial assessment satisfying the basic needs of the injured and providing effective and quick assistance to save lives and provide human dignity (Illiyas et al., 2013, Karami et al., 2019). The body of research on MGs that is currently available emphasizes the complexity and diversity of these occurrences (Vasquez et al., 2015) and the various hazards connected to them (Al Rabeeah et al., 2012, Weng et al., 2023). Further, conditions associated with MGs, including the transmission of infectious diseases in crowded settings (Ahmed et al., 2006, Watson et al., 2007, Al-Tawfiq and Memish, 2014) as well as the requirement to supply food, safe water, and hygienic facilities (Hoang et al., 2020, Skolnik, 2015) hold significant importance. While a number of review studies have been conducted on this topic (Arbon, 2007, Karami et al., 2019, Gabbe et al., 2022, Weng et al., 2023), they were all limited to discussing a single facet and there has not been a thorough investigation of this subject recently. Therefore, considering the importance of this issue, this systematic review was conducted to integrate the existing knowledge to provide a comprehensive understanding of rescue and relief operations, and emergency management strategies during MGs and to identify the areas that need to be improved.

MATERIALS AND METHODS

Following the recommendations for "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA), the researchers ensured that the review process was thorough and transparent (Moher et al., 2009). The literature review, study selection, data extraction, and data synthesis are some of the crucial steps in this process. Several databases such as PubMed, Scopus, Web of Science, and Google Scholar were thoroughly searched for pertinent literature on rescue operations in MGs. Keywords and Medical Subject Headings (MeSH) pertaining to MGs (such as, "mass gathering", "festival", "sporting event"), emergency management (such as, "disaster management"), relief operations (such as, "emergency medical services", "medical response", "rescue operations", "triage"), and "public health" were joined and subjected to searches using Boolean operators (AND, OR, NOT) (Page et al., 2021). The search was restricted to English-language sources published between January 2000 and December 2023 in order to examine current advancements and trends in this field. Duplicate records were eliminated after the search results were imported into EndNote X7 software. Using predetermined inclusion and exclusion criteria, two impartial reviewers looked over the abstracts and titles. A third referee was consulted or discussed with in order to settle disagreements. The full text of potentially eligible studies was retrieved and reviewed for final inclusion by the same two reviewers.

The criteria for including sources in this review were (1) sources, including guidelines, books, conference papers, and official reports focused on rescue operations during MGs; and (2) observational, empirical, analytical, and case studies on MGs published in peer-reviewed journals. Exclusion criteria included (1) sources that were not directly related to MG; and (2) articles that were not available in full text.

Data extraction was performed using a standardized form to collect relevant information from each source included in the review. Data extracted included: source characteristics (e.g., authors, year of

publication, country), and study design and results. Extracted data was checked by two reviewers to ensure accuracy and consistency (Thomas and Harden, 2008).

A narrative synthesis approach was used to analyze and summarize the findings of the sources included in the review. This synthesis focused on the identification of themes in the texts related to relief and rescue operations in MGs (Chandler et al., 2019).

RESULTS

The initial search yielded a total of 3542 sources. After removing duplicates and screening titles and abstracts, 176 sources were evaluated for eligibility. After a full-text review, 52 texts met the inclusion criteria and were included in the systematic review (Figure 1).

By reviewing the sources, in addition to determining the characteristics of resources, themes such as "types of rescue operations", "the impact of MGs on local health care systems", "the best method for allocating medical personnel during MGs", "triage systems", and "challenges of rescue operations" were extracted that are explained below:

1. Studies characteristics: The included sources were guidelines (11.54%), books (9.61%), review studies (42.31%), case reports (30.77%), qualitative papers (3.85%), and experimental researches (1.92%). The included studies were carried out in different geographical regions, including the United States (23.08%), Asian countries (17.31%), European countries (17.31%), and Canada (1.92%). The rest of the texts were review studies by researchers from different countries that examined MGs in general (40.38%). These sources addressed a wide range of MGs, including religious pilgrimages (13.46%), sports festivals (9.61%), and sports-religious events (5.77%). The rest of the texts examined the MGs in general (71.16%) (Table1).

2. Types of rescue operations: The sources reported different types of rescue operations during MGs, including:

A) Medical assistance: Immediate medical care by on-site medical teams providing first aid, and triage was the most commonly reported intervention (Ahmed et al., 2006, Memish et al., 2019, Karami et al., 2019). Mobile medical units and temporary clinics were often developed to handle the increased demand (Hutton et al., 2020).

B) Crowd management: Effective crowd management strategies, such as the use of barriers, controlled entry and exit points, and real-time crowd monitoring systems, were very important in preventing overcrowding (Arbon, 2007, Vasquez et al., 2015, Lombardo et al., 2008).

C) Responding to disasters: In case of disasters, such as structure collapse or fire, coordinated rescue operations with the participation of local authorities, fire departments, and search and rescue teams were necessary (Soomaroo and Murray, 2012). In addition to equipments, these operations often relied on predetermined emergency response plans and exercises (Hutton et al., 2020, Tierney, 2009, Lund et al., 2011, Turris et al., 2021). Other studies pointed out that communication limitations and breakdowns caused delays in providing care due to disruptions in the coordination of relief efforts (Sharma et al., 2019, Kuday et al., 2023, Farahani et al., 2020).

3. The impact of MGs on local health care systems: The deep and multifaceted effects of MGs on local healthcare centers are mentioned below:

A) Increasing patient load: During MGs, local healthcare centers often face an increase in the volume of patients, which negatively affected their capacity to provide care and increased waiting time (Jenkins et al., 2015, Rahman et al., 2017).

B) Reduction of resources: The increase in the number of patients often lead to the rapid exhaustion of drugs and medical equipment and disrupted the ability of healthcare centers to provide effective care, which required standard protocols to manage these conditions (Kuday et al., 2023).

C) Disturbance in the provision of routine services: Focusing on emergency care during MGs disrupted routine health services such as vaccinations, delayed elective surgeries and care of patients with chronic diseases, and lead to long-term adverse health consequences in vulnerable populations (World Health Organization, 2015, Ahmed and Memish, 2019, Steffen et al.,2012, Steffen et al., 2023).

D) Psychosocial impact on healthcare workers: Medical personnel may experience significant stress and exhaustion during MGs due to increased workload and the emotional effects of dealing with mass casualties. As a result, resilience training interventions, and increasing preparedness are necessary to increase the ability of healthcare personnel (Koski et al., 2021).

E) Financial pressure: The additional demands created during MGs in health care centers, including increased rescue operation costs and potential loss of revenue from routine services, lead to significant financial pressure on the health care system (Vasquez et al., 2015, Rico, 2021).

3. The best method for allocation of medical personnel during MGs: the efficient and essential ways to allocate medical personnel during MGs are mentioned below:

A) Incident Command System (ICS): It is a standardized and structured approach to the chain of command, control, and coordination of emergency response. It offers an incident-friendly hierarchy that outlines the roles and tasks of response personnel, who may come from multiple departments (Tierney, 2009, Lund et al., 2011, Turris et al., 2021, Khorram-Manesh et al., 2021).

B) Modular Emergency Medical System (MEMS): It includes various modules such as triage, treatment, and transport units, which allocate resources and provide patient care during major events with a flexible and integrated approach (Basavage, 2015, Ranse and Zeitz, 2010).

C) Mobile medical units (MMU): They are the personnel who can be deployed independently or as a support team quickly and flexibly to provide care in MGs. They are equipped with the necessary tools and personnel to deal with various medical emergencies on-site (Fisher et al., 2011).

D) Emergency Medical Teams (EMS): They are groups of health professionals who are quickly deployed in gathering places to stabilize the condition of the patients and provide emergency care at the scene of the accident before coordinating and transporting the patients to the hospital emergency department. These teams often include paramedics, emergency medical technicians, and other first responders (Turris et al., 2021). They are often deployed by governments, NGOs, and international organizations and coordinate with local health authorities (Jenkins et al., 2015, Rico, 2021, Ranse and Zeitz, 2010).

4. Triage systems in MGs: The event area should be divided into different zones based on the expected population density and triage points should be marked near the event area and throughout the venue with clear signs to guide participants. Also, professional medical teams and ambulances should be deployed in high-dense and high-risk areas (Turris and Lund, 2012). Below are some triage best practices in managing health and safety during gatherings:

A) Simple triage and rapid treatment (START): START triage is a widely used system that assesses multiple victims in 30 seconds or less based on the three primary observations of respiration, perfusion, and mental status. This method classifies patients for treatment and transport based on the severity of illness using a color system: red (immediate), yellow (delayed), green (minor), and black (dead) (Fisher et al., 2011, Turris and Lund, 2012).

B) Sort, assess, life-saving interventions, treatment/transport (SALT): SALT triage is a newer and more structured system based on START principles for treating and transporting patients. It

emphasizes life-saving interventions and includes a comprehensive assessment stage that provides the possibility of initial sorting of patients (Turris and Lund, 2012).

C) Smart triage: This simple system emphasizes the use of the START algorithm, special equipment, and visual cues to quickly assess and classify patients. Smart triage is an ideal approach for first responders with minimal training (Turris and Lund, 2012, Simon and Teperman, 2001).

D) Mass Casualty Incident Triage (MCI): It combines elements of various START, SALT, and Smart triage systems for effective management of large-scale gatherings and incidents and emphasizes coordination and communication between responders (Khorram-Manesh et al., 2021, Turris and Lund, 2012).

5. Identified challenges: Despite the progress, challenges remain in terms of resource limitations, coordination and communication, and public health, which are mentioned below:

A) Resource limitation: Limited resources, including medical equipment and personnel, were a common issue, especially in low-income settings (Arbon, 2007, Karami et al., 2019, Lombardo et al., 2008, Jenkins et al., 2015, Ahmed and Memish, 2019, Ranse and Zeitz,2010, Gabbe et al., 2022).

B) Public health concerns: The spread of infectious diseases during MGs brought important challenges that were emphasized in the sources (Memish et al., 2019, Karami et al., 2019, Al-Tawfiq and Memish, 2014, Lombardo et al., 2008, Ahmed and Memish, 2019, Steffen et al., 2023, Tavan et al., 2019).

C) Coordination and communication: Access to advanced technologies such as real-time data analysis tools and communication systems were limited and people's ability to work with them was not desirable (Walker et al., 2008).

Further, effective coordination between different groups of rescuers and timely communication was often faced with bureaucratic (administrative) obstacles and technical issues (Ahmed et al.,2006, Memish et al., 2019, Sharma et al., 2019, Vasquez et al., 2015, Weng, et al., 2023, Hutton et al., 2020, Tierney, 2009, Gabbe et al., 2022).

DISCUSSION

This systematic review has provided a comprehensive overview of current practices and challenges in rescue operations during MGs. In addition, the characteristics of the sources included in the study indicate the need to conduct more qualitative and experimental studies, especially in Asian and European countries, to determine the types of gatherings and problems caused by them and the solutions used in the specific context of different countries.

Regarding the types of relief and rescue operations, the first step was to provide crowd management to prevent overcrowding and crises in MGs by placing barriers and monitoring entry and exit areas (Arbon, 2007, Vasquez et al., 2015). In addition, it is necessary to have personnel present in high-density or high-risk places for triage and providing urgent medical care (Memish et al., 2019, Karami et al., 2019, Hutton et al., 2020). In case of emergencies, it is necessary to use the participation of rescue teams, fire brigade, local forces, and mobile medical units (Sharma et al., 2019, Lund et al., 2011, Turris et al., 2021). Also, in addition to the need to improve communication and coordination between the aforementioned units, it is necessary to improve the readiness of service providers with prior planning and immediate response maneuvers (Hutton et al., 2020, Soomaroo and Murray, 2012, Kuday et al., 2023, Farahani et al.,2020).

Since MGs significantly increased the load of patients, problems such as reduction of resources, disruption of routine services, psychological stress of health care workers, and financial pressure were unavoidable (Hoang et al., 2020, Skolnik, 2015, World Health Organization, 2015, Hoang and Gautret, 2018, Elachola et al, 2018, Martin-Gill et al., 2007). Therefore, the importance of allocating

more funds for the management and reconstruction of resources becomes more clear. Also, the finding indicated the necessity of training personnel in the field of resilience, upgrading support systems according to previous disaster experiences, and using up-to-date knowledge to improve the quality of the immediate responses during such events (Kuday et al., 2023, Jenkins et al., 2015, Koski et al., 2021, Simon and Teperman, 2001, Kanaujiya and Tiwari, 2023).

By reviewing the studies, it was determined that the best method of allocating medical personnel during MGs was through the combination of structural systems (such as the incident command system), the modular system, emergency medical teams, and mobile medical units to show a coherent and flexible response (Rico, 2021, Basavage, 2015, Fisher et al., 2011, U.S. Department of Homeland Security, 2013, Savoia et al., 2012, Scheepers, 2015). Further, the construction of temporary clinics and the use of trained laypeople are effective in managing the increase in demand for medical services, including resuscitation operations during MGs (Karami et al., 2019, Ahmed and Memish, 2019, Ranse and Zeitz, 2010).

In choosing the best triage method, it was found that each of the START, SALT, Smart, and MCI triage systems has its strengths and is suitable for specific scenarios. So, choosing the best method depends on the specific context of mass gathering, available resources, and the level of skill of the respondents (Simon and Teperman, 2001, U.S. Department of Homeland Security, 2013). However, the START and SALT systems were more used due to their simplicity and emphasis on lifesaving interventions to increase the efficiency and effectiveness of medical response during MGs (Lund et al., 2011, Hall, 2011, World Health Organization, 2020, Bower et al., 2015).

For reducing the challenges of providing assistance in MGs, it is necessary to provide funds to employ sufficient human resources, and have a detailed and evidence-based plan to prepare personnel through regular simulated maneuvers (Ahmed et al., 2006, Karami et al., 2019, Al Rabeeah et al., 2012, Sharma et al., 2019). Also, to reduce risks and ensure a quick and efficient response in emergencies, it is necessary to improve coordination and communication through the implementation of standard protocols and the use of advanced communication and monitoring technologies such as real-time data analysis (Sharma et al., 2019, Vasquez et al., 2015, Weng, et al., 2023, Tierney, 2009). Further, coordinated and joint planning by various stakeholders, including MGs organizers, local authorities, representatives of emergency service providers, and financial suppliers is required to create the Incident Command System (Arbon, 2007, Lombardo et al., 2008, Gabbe et al., 2022), employ mobile medical units, and build temporary clinics with up-to-date equipment (Ahmed et al.,2006, Memish et al., 2019, Vasquez et al., 2015, Hutton et al, 2020, Gabbe et al., 2022) in case of emergencies. Evidence shows that using effective interventions is necessary to address public health concerns (Memish et al., 2019, Al-Tawfiq and Memish, 2014, Lombardo et al., 2008, Tavan et al., 2019). The strict and mandatory implementation of approved public health protocols, the use of health surveillance systems, and the promotion of preventive measures, such as vaccination campaigns, can reduce public health risks in MGs (Karami et al., 2019, Ahmed and Memish, 2019, Steffen et al., 2023).

To solve the limitations of language and databases in this research, it is suggested to conduct other studies to engage more languages and databases.

In conclusion, this study highlighted the importance of rescue and relief efforts to support victims and resource supply chain management in addressing the immediate health needs of participants in MGs. These findings also emphasized the need for comprehensive planning, coordination between stakeholders, and the integration of advanced technologies such as real-time data analysis and communication systems, to increase the effectiveness of these operations. Consequently, while significant progress has been made in improving rescue operations in MGs, continued efforts are needed to address existing challenges and utilize new technologies.

It is suggested that future research should focus on evaluating the short- and long-term impact of the integration of emerging technologies such as artificial intelligence in emergency management systems on the efficiency of rescue operations in meeting safety and public health outcomes in MGs. It is also necessary to research the psychological impact of MGs on emergency responders. Also, conducting more qualitative and experimental researches on different types of events in Asian and European can provide valuable insights into the specific challenges of that area, as well as the best ways to solve those challenges.

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Conception and design, acquisition and interpretation of data, and drafting the article: Dr Mahbobeh Abdolrahimi

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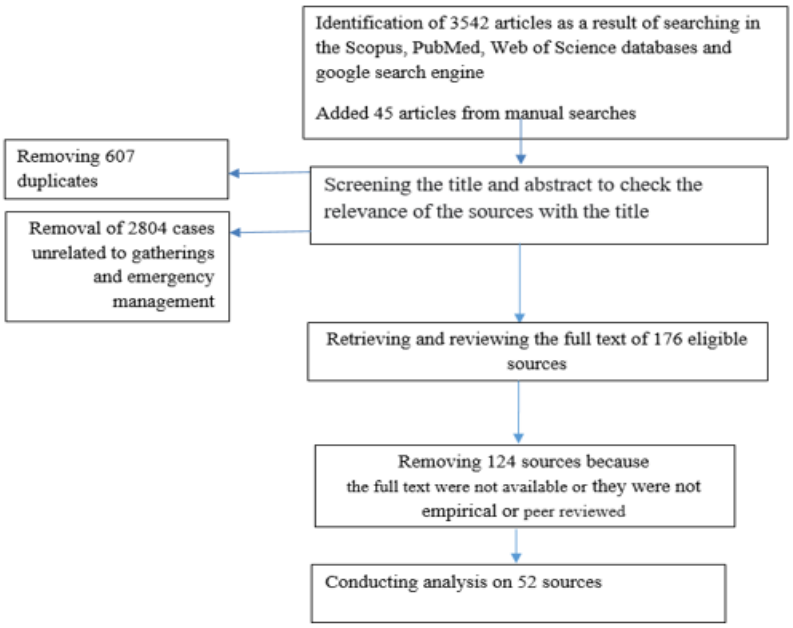

Flowchart of the steps of checking and entering sources into the study

Table 1: Characteristics of the sources included in the study

Author	Year	Place	Source Kind	Methodology	Mass gathering kind
Ahmed et al.	2006	Asia	Article	Review	Religious
Memish et al.	2019	Not specified	Article	Review	Religious-sport
Bistaraki et al.	2019	Europe	Article	Qualitative study	Sport
Wang and Yoon	2002	Asia	Article	Case study	Sport
Illiyas et al.	2013	Asia	Article	Case study	Religious
Arbon	2007	Not specified	Article	Review	Not specified
Karami et al.	2019	Not specified	Article	Review	Not specified
Al Rabeeah et al.	2012	Not specified	Article	Review	Religious-sport
Sharma et al.	2019	Asia	Article	Experimental	Religious
Vasquez et al.	2015	United States	Article	Case study	Sport
Weng et al.	2023	Not specified	Article	Review	Not specified
Watson et al.	2007	Not specified	Article	Review	Not specified
Page et al.	2006	Europe	Article	Case study	Not specified

Hoang et al.	2020	Not specified	Article	Review	Religious
Skolnik	2015	United States	Book	-	Not specified
Tsouros and Efstathiou	2007	Europe	Article	Case study	Sport
World Health Organization	2015	Europe	Guideline	-	Not specified
Hoang and Gautret	2018	Not specified	Article	Review	Not specified
Elachola et al.	2018	Asia	Article	Case study	Religious
Lombardo et al.	2008	Not specified	Article	Review	Not specified
World Health Organization	2020	Europe	Guideline	-	Not specified
Hutton et al.	2020	Not specified	Article	Review	Not specified
Soomaroo and Murray	2012	Not specified	Article	Review	Not specified
Tierney	2009	United States	Book	-	Not specified
Lund et al.	2011	Canada	Article	Case study	Not specified
Turris et al.	2021	Not specified	Article	Review	Not specified
Kuday et al.	2023	Not specified	Article	Review	Not specified
Farahani et al.	2020	Not specified	Article	Review	Not specified
Jenkins et al.	2015	United States	Article	Case study	Not specified
Rahman et al.	2017	Asia	Article	Case study	Religious
Ahmed and Memish,	2019	Not specified	Article	Review	Not specified
Steffen et al.	2012	Not specified	Article	Review	Not specified
Steffen et al.	2023	Not specified	Article	Review	Not specified
Koski et al.	2021	Europe	Article	Qualitative study	Not specified
Rico	2021	United States	Guideline	-	Not specified
Khorram-Manesh et al.	2021	Europe	Book	-	Not specified
Basavage	2015	United States	Article	Case study	Sport
Ranse and Zeitz	2010	Asia	Article	Case study	Not specified
Fisher et al.	2011	Asia	Article	Case study	Not specified
Turris and Lund	2012	Not specified	Article	Review	Not specified
Simon and Teperman	2001	United States	Article	Case study	Not specified

Gabbe et al.	2022	Not specified	Article	Review	Not specified
Tavan et al.	2019	Not specified	Article	Review	Not specified
Walker et al.	2008	Not specified	Article	Review	Not specified
Martin-Gill et al.	2007	United States	Article	Case study	Not specified
Kanaujiya and Tiwari	2023	Asia	Article	Case study	Religious
U.S. Department of Homeland Security, Agency FEM	2013	United States	Guideline	-	Not specified
Savoia et al.	2012	United States	Article	Case study	Not specified
Scheepers	2015	Europe	Book	-	Not specified
Hall et al.	2011	United States	Book	-	Religious-sport
World Health Organization	2020	Europe	Guideline	-	Not specified
Bower et al.	2015	United States	Guideline	-	Not specified