Conceptualizing A Preparedness Model For Emergency Medical Services In Mass Casualty Incident Response: A Mixed-Methods Study

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Abstract:
One of the most crucial issues in emergency systems is the readiness of emergency medical services for mass casualty situations. An unexpected catastrophe involving multiple injured people that overwhelms the local healthcare system is known as a mass casualty incident. To create a conceptual model, this study sought to determine and verify the elements of emergency medical services preparedness in mass casualty situations. Methods: This study used a mixed-method explanatory approach. Based on the PRISMA guideline, a systematic study was first conducted to identify the elements of emergency medical services preparation in mass casualty scenarios. Second, utilizing in-depth semi-structured interviews and the content analysis method, a qualitative study was created to investigate the components of readiness. Third, an expert panel integrated the elements taken from the two stages of the qualitative investigation and systematic review. Fourth, the Delphi method was used to validate the components that were retrieved. In the Delphi phase, two rounds were completed. Lastly, a group of experts created the conceptual model of emergency medical services readiness in mass casualty situations. Conclusions: Planning and managing mass casualty crises requires an integrated framework and model of emergency medical service preparedness. The components and final model of this study, which can be utilized as a plan to enhance emergency medical service preparation in response to mass casualty crises, were acquired following the methodical scientific steps.
Keywords: Emergency Medical Services, Preparedness, Model, Conceptualizing, Mass Casualty Incident.

INTRODUCTION:

One of the major problems affecting the healthcare system, particularly emergency medical services (EMS), is mass casualty incidents (MCIs). MCIs are defined by the World Health Organization (WHO) as disasters that can quickly surpass the capacity

of local medical resources to provide comprehensive medical care due to the number, severity, and variety of victims. MCIs happen when a healthcare system's ability to provide medical services is exceeded by the demand for those services due to an unexpected incident. MCIs are caused by a variety of factors, including terrorism, armed conflicts, natural catastrophes, and transportation mishaps. MCIs have significant mortality and long-term repercussions, and they frequently wreak havoc on civilizations (Alazmy , 2020).

The emergency response division of the health system is called EMS. EMS systems are regarded by the WHO as essential components of any functional healthcare system. People in a range of medical emergencies receive attention from EMS. Responding to MCIs is one of EMS's most crucial duties. Responsible agencies like the police and fire and rescue teams must make use of resources to extend operations when an EMS response involves significant casualties. Large MCIs may have more victims than regional EMS can handle, necessitating the need for extra help. Disasters occur when there are insufficient resources or when the EMS is involved in a large number of casualties. Routine operations may be created to handle increased capacity in most MCIs. The National Incident Management System (NIMS) and the Incident Command System (ICS) are used in the US to manage MCIs. Every member of the disaster management team and rescue personnel should be knowledgeable with and proficient with NIMS and ICS (Gabbe , 2022).

All stages of MCI management, including prevention, preparedness, reaction, and recovery, are significantly influenced by EMS. To properly manage MCIs, these systems need a well-thought-out strategy and sufficient resources. Life-saving techniques, triage, and transporting injured people to medical facilities are some of the system's most crucial functions. In order to respond to such disasters, the EMS system needs become more equipped. Planning, training, organizing, and raising managers' awareness of this issue are all necessary. As a result, EMS systems need to create a framework using standard indices. The purpose of this study was to determine the elements of EMS preparedness in MCIs and to create a model that may illustrate the many aspects of EMS preparedness in response to MCIs (Azizpour , 2022).

METHODS:

This study used a mixed explanatory approach and was carried out in five stages. The goal of this mixed-method study was to identify the key elements of EMS preparedness in MCIs in several methodical stages and then create a conceptual model that can serve as a framework for representing the key components of EMS readiness in MCIs.

The following were the research questions:

What are the key elements of EMS readiness for MCIs that work well?
Which EMS preparedness model will be used in the end to respond to MCIs?

Emergency medical services (EMS) conceptually:

An Emergency Medical Service can be defined as "a comprehensive system which

provides the organization of staff, facilities, and equipment for the effective, coordinated, and timely delivery of care and emergency services to victims of sudden illness or injury." The goal of emergency medical services (EMS) is to avoid unwanted death or long-term illness by promptly treating victims of unexpected, life-threatening injuries or emergencies. Accessing emergency treatment, receiving care in the community, receiving care on route, and receiving care upon arrival at the healthcare facility are the four primary components of EMS's job. Disaster management is one of the system's key responsibilities in addition to EMS's regular duties (Catlett , 2011; Sulistyadi, 2021).

A conceptual perspective on readiness :

The ability to effectively predict, respond to, and recover from the effects of likely, imminent, or current hazards, events, or circumstances is known as preparedness. It is created by governments, professional response and relief groups, communities, and people. To guarantee efficient coordination throughout the event response, preparedness is a constant cycle of planning, organizing, training, equipping, exercising, assessing, and taking corrective action. In the context of emergency management, preparedness is best described as the ability to react to a crisis, disaster, or other emergency (Al-Shaqsi, 2010).

Mass casualty occurrences (MCIs) conceptually:

An overwhelming event, which generates more victims at a time than locally available resources can manage using routine procedures" is the definition of a mass casualty incident (MCI). It necessitates extreme emergency plans and extra help. A wide range of incidents, including natural and man-made disasters, terrorist attacks, car crashes, etc., can result in MCIs. The number of victims significant enough to interfere with the regular operation of healthcare services is what distinguishes an MCI, regardless of the origin of the incident. MCIs can be categorized into various levels based on the nature of the reaction or the quantity of possible victims (Razzak , 2002; Staupe, 2018).

Emergency Medical Services Systems:

Decontamination is a delicate operation that calls for specialized logistics and equipment that are outside the purview of most EMS systems, and EMS has complicated tasks in triage, treatment, transfer, and other incident management procedures, which is one of the reasons this issue came up in the qualitative study and expert panel. In the majority of emergency systems, the fire department, the army, the safety units of factories and refineries, and others are in charge of decontamination, depending on the type of risk. However, because of the availability of resources, equipment, rescue team integration, and regional policies, this component must be allowed in some EMS systems. Regional rules are crucial because of the intricacy of CBRNE occurrences, and this element might not be recognized worldwide in an EMS environment. However, regional and national policies have an impact on this matter (Lomaglio, 2020; Ivankova, 2006).

Additionally, many emergency systems still have advantages and disadvantages in some nations, such as a common emergency contact number, a common triage and treatment system, and tactical teams. Though there may be variations in how they are

applied, the remaining elements such as the unified command, improved communication, education and training, physical and psychological factors, and so forth are present in most EMS systems as the primary markers of preparedness. However, to create a model with trustworthy indicators for planning and policymaking, the components of EMS preparation in MCIs were investigated in multiple stages in this study (Saadatmand , 2023; Vaismoradi , 2019).

EMS response and readiness models in MCIs developed:

EMS response and readiness models in MCIs have been developed using a variety of techniques. These include computer modeling, conceptual modeling, dynamic modeling techniques, and modeling with cause-and-effect interactions. The goal of Lee's study was to model how emergency relief supplies would be distributed for disaster response activities. This study focused on the necessity to provide emergency relief supplies to victims of natural catastrophes such hurricanes, earthquakes, and terrorism to safeguard their lives and health (Letizia et al., 2020).

To assess the best ways to convey relief supplies to different distribution locations, the research team created a modeling framework for disaster response that simulated and examined the supply chain of relief supplies and distribution activities. The supply chain for relief resources and distribution point operations were modeled in the disaster response simulation model. The findings demonstrated that the model could assess a variety of disaster scenarios, assess plans and regulations for disaster response, and find more effective strategies for first responders and government organizations (Saadatmand, 2023).

A simulated model of EMS services in MCIs was created in a different study. This study employed object-oriented simulation software to enhance emergency medical services. A computer virtual simulation model was created for this study. The findings demonstrated that the integrated deployment of EMS, combined with the expansion of emergency networks and specialized life-saving techniques, is the most effective aspect of this approach in providing care for the injured (Guetterman , 2021).

The pre-hospital professionals created a profile of the actual injured. These profiles were created in a medical emergency model in which the system responded to actual casualties just once. Emergency services operations, such as triage, evacuation, and medical procedures, were the main focus of the medical emergency response model. The victim's respiration, heart rate, and motor reaction were taken into consideration when making medical judgments, such as whether to treat them on the spot or transport them. Ultimately, a road accident-related simulated model was created that demonstrated how resources could impact the outcome of these situations (Keeney , 2011; Karle , 2006).

EMS response dynamic model:

In reaction to MCIs, a model known as the EMS response dynamic model was created in China. The purpose of this study was to determine the EMS-MCI modeling in Shanghai, enhancing rescue effectiveness in MCIs and offering a potential approach for prompt decision-making in these situations. Using the Vensim DSS program and intervention scenarios, this model was created by modifying the accident scales, the

distribution of ambulances and emergency medical personnel, and the effectiveness of command and organization. The findings demonstrated that the mortality rate was considerably reduced by raising the number of ambulances and enhancing the effectiveness of the command and organization (Calder , 2018; Lee , 2009).

created a scenario-based computer simulation model of EMS response in tunnel-related traffic events. In order to develop a simulation model based on the approach of emergency response plans, data pertaining to the general features and components of MCIs were gathered in this study based on a theory. This approach used realistic incidents from past experiences to present a disaster response simulation model. The ability to save and preserve hospital life, pre-hospital time indicators, organizational and command efficiency, and EMS response components in MCIs were the primary variables in this study (Su S, 2003; Yu W et al., 2018).

Recommendations:

- The mixed method's findings show that to improve EMS systems' preparedness for MCIs; several components must be strengthened. A basic model was ultimately created after the components taken from this investigation were thoroughly identified using several methods. These findings can theoretically be applied to EMS planning and policies in the realm of catastrophes because of the thorough and scientific approach of this study and the extraction of validated findings. The findings of this study can also be applied in practice and staff training by EMS systems and Partner organizations. The method of this study can be used more than single approaches because of the significance of the mixed method in obtaining rich results in the field of disasters. Additionally, the research methods and techniques can serve as a model for future studies in crucial fields like disasters where reliable and essential results are required.
- To provide a prompt and efficient reaction, it would be preferable to create preparedness plans in an easy-to-understand manner given the complexity of management and operational planning in the majority of MCIs. The purpose of this study was to develop a straightforward conceptual model that illustrates the key elements of MCIs' EMS readiness. The primary goal of this study was to create a model that would cover the crucial readiness indicators of EMS systems in response to MCIs in an easy-to-use manner. This was achieved by avoiding the use of simulation, computers, and special software techniques, which were employed in the studies. There might be more elements that are specific to states and regional policies, even if most of the components were found and verified in this study. For instance, certain variables were linked to areas with certain geographic and meteorological characteristics that dominate the EMS response. Nevertheless, the components of EMS readiness in MCIs were simply introduced and presented in this study as a model, and the model's efficacy was not empirically assessed. As a result, it is advised that this model's efficacy in managing MCIs in real-world scenarios, simulations, and practical exercises be evaluated.

- Limitations: One of the restrictions during the systematic review phase was the inability to search publications using some electronic databases, such Web of Science (WOS). Unfortunately, we had to disregard many databases that were unavailable throughout the search because of Iran's political and economic restrictions. We were concerned about this matter since we might have overlooked certain studies.

Future Studies:

Future studies are recommended to empirically test and validate the proposed preparedness model in diverse settings and healthcare systems. Conducting implementation studies, simulation-based evaluations, and comparative analyses across different countries and EMS structures could enhance the generalizability and applicability of the model. In addition, quantitative studies examining the relationships between the identified preparedness components and actual EMS performance outcomes during mass casualty incidents are suggested. Such research may contribute to refining the model and supporting the development of standardized, evidence-based guidelines for emergency medical services preparedness.

CONCLUSION:

The EMS function may be severely overburdened by MCIs, which are complicated situations. Enhancing EMS preparedness in MCIs is a complex process that is impacted by national and local circumstances. Better comprehension of the plans and policies in simulated environments and actual incidents can be greatly impacted by creating a model with several approaches to enhancing EMS readiness in MCIs. The created model can serve as a foundation for putting EMS management techniques into practice in MCIs. emphasizing that effective response depends not only on operational capacity but also on strategic planning, interagency coordination, workforce competency, communication systems, and continuous training and evaluation. The integration of evidence from systematic review, qualitative inquiry, and expert consensus ensured that the developed model is both theoretically grounded and practically applicable. Moreover, the conceptual model provides a structured framework that can assist policymakers, emergency planners, and EMS administrators in identifying strengths and gaps within current preparedness systems. By adopting this model, EMS organizations may enhance their ability to anticipate, respond to, and manage mass casualty incidents more efficiently, ultimately reducing morbidity and mortality. Finally, although this study offers a comprehensive preparedness model, future research is recommended to test and adapt the model in different geographical and organizational contexts. Empirical validation through real-world implementation and simulation-based studies may further refine the model and contribute to the development of standardized guidelines for EMS preparedness in mass casualty incidents. Such efforts will support resilient emergency medical systems capable of responding effectively to complex and large-scale emergencies.

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