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تحليل باثر رجعي: عن تأثير التدريب القائم على المحاكاة على الاستعداد للكوارث في مستشفيات التجمع الصحي الثاني
بجدة (2020-2025)

The Impact of Simulation-Based Training on Disasters preparedness' in Jeddah Second Health Cluster
hospitals: Retrospective analysis (2020-2025)

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Disaster preparedness is a critical component of resilient healthcare systems, particularly in regions vulnerable to mass gatherings, pandemics, and natural crises. Simulation-Based Training (SBT) has emerged as an essential strategy for enhancing the competencies, confidence, and coordination of healthcare professionals in managing complex emergency events. This retrospective study examines the impact of SBT on hospital disaster preparedness within the Jeddah Second Health Cluster between 2020 and 2025. The study aims to assess the extent of SBT implementation, evaluate its perceived effectiveness, and explore its influence on organizational readiness, response coordination, and resource management.

A mixed-methods approach was employed, incorporating quantitative data from structured questionnaires completed by 120 participants across various healthcare professions, as well as qualitative data from semi-structured interviews and document reviews. Descriptive and inferential analyses were used to evaluate changes in knowledge, skills, self-efficacy, and interdepartmental collaboration. Qualitative thematic analysis provided deeper insight into the facilitators, barriers, and contextual factors affecting SBT adoption within the cluster.

The findings reveal that SBT significantly enhances healthcare workers' perceived preparedness, particularly in their competencies, confidence, communication, and teamwork during disaster situations. Participants reported improved clinical decision-making, faster response times, and greater adherence to disaster protocols following simulation exposure. Organizational benefits included strengthened coordination among departments, better utilization of resources, and improved clarity of roles during emergency events. However, challenges such as limited training frequency, variability in program quality, resource constraints, and inconsistent documentation were identified as barriers to maximizing SBT outcomes. The results contribute to national and international efforts to improve disaster readiness and offer a model that can be applied across similar healthcare settings.

Keywords: Simulation-Based Training, Disaster Preparedness, Jeddah Second Health Cluster, Hospital Readiness, Emergency Management, Retrospective Study.

الفصل الأول

Introduction:

Unexpected crises, including natural disasters, pandemics, and mass casualty incidents, increasingly define the global health landscape. Hospitals, as critical agents with primary healthcare Infrastructure, are primarily responding effectively to such events. These hospitals' success in handling a surge of patients, services running, and protecting staff and resources directly affects the resilience and the public health impacts of these events. However, the dynamic nature and variation of disasters make them a big challenge for conventional preparedness strategies. In hospitals, effective disaster preparedness is not only about having plans; it is about ensuring that healthcare workers possess a combination of knowledge and skills, with confidence, to implement these plans under dire pressure [1].

Simulation-based training (SBT) has evolved into a highly effective learning tool in the field of medical education, particularly in healthcare settings. SBT provides an excellent and safe environment for healthcare professionals to train and practice critical skills in a realistic environment without risking patient safety. This approach enables repeated learning, provides instantaneous informative feedback, and allows for the discovery and correction of shortcomings in a non-punitive environment. SBT, also known as team-based training, extends beyond the "acquisition of Individual skills to encompass interdisciplinary cooperation and "system-wide readiness, making it an indispensable tool for enhancing organizational preparedness for complex humanitarian emergencies [2].

Global threats necessitate a robust capacity for disaster preparedness and response. The rapid spread of global travel, public gatherings such as the Hajj pilgrimage, and various environmental factors underscore the need for resilient healthcare systems. Within this framework, health clusters have been established to facilitate the delivery and coordination of care across various facilities. The Jeddah Second Health Cluster plays a primary role in addressing significant gaps in health and safety for its beneficiaries. Understanding how advanced training methods, such as SBT, can be effectively incorporated into the preparedness "endeavours of critical systems is necessary to foster regional health security.

This is a proposal for a retrospective study to evaluate the Impact of simulation-based training on hospital disaster preparedness in the Jeddah Second Health Cluster over the previous five years (2020-2025). By examining existing training programs, evaluating their effectiveness, and identifying areas for improvement, this study aims to provide Informative findings that can guide future policy and practice.

This discovery will contribute to the growing body of knowledge on disaster preparedness and simulation education, enhancing the preparedness of community members who may play a role in psychosocial first aid.

مشكلة الدراسة:

Study Problem:

Although improvements have been made in health Infrastructure and emergency management guidelines, hospitals often struggle to access the most appropriate recommended therapies for responding to large-scale disasters. Most of these problems can be attributed to a lack of experience among healthcare staff In coping with chaotic events. The lack of teamwork among various departments and outside agencies, along with a tendency to be inflexible in responding quickly to changing crises, further exacerbates the Issue. Traditional didactic methods of education, while Imparting basic knowledge, often fail to develop critical skills such as teamwork and interaction essential for real-world disaster response [3].

The gap between theoretical knowledge and practical application Is evident during actual emergencies, which can have a detrimental Impact on patient outcomes and burden healthcare services. Particularly in hospital disaster preparedness, numerous challenges exist. Real-world disaster incidents are infrequent, making hands-on experience difficult for healthcare workers. This limited real-world exposure can result In reduced preparedness levels. Moreover, training often cannot fully capture the complexity and challenges of disaster situations, such as high numbers of casualties and limited resources.

The effectiveness of current trainings programs in the Jeddah Second Health Cluster, particularly regarding simulation-based approaches, has yet to be consistently evaluated. While the cluster plays a vital role in Saudi Arabian healthcare, understanding how well simulation training contributes to preparedness is crucial. Without an evident appreciation of the benefits and limitations of existing simulation-based training activities, practical improvements and assignments cannot be made. The objective of this retrospective study is to assess the extent to which simulation-based training has improved hospital disaster preparedness 'initiatives over the last five years In the Jeddah Second Health Cluster.

The Importance of this Study:

This investigation has implications of local, regional, and global significance for several reasons.

Local Level Firstly, the findings will directly inform the provision of the Science Technology organization to the local community in the event of a storm, serving the Jeddah Second Health Cluster by evaluating its disaster preparedness simulation training in-depth. This evaluation will showcase best practices that can be adopted and pinpoint where further action is needed for further development or intervention.

By understanding the significance of SBT over the last 5 years, the cluster will be able to refine its training practices, support resource management, and better adapt to the needs of the exercisers.

Rationing, and ultimately, shore up its hospitals to confront various scenarios. Additional funds are provided to the region for responding to the needs of more than 3 million people living in the area, as well as the beneficiaries it serves [4].

While the Kingdom continues to develop and host mass gatherings, the healthcare system's ability to respond to disasters is paramount. The findings of this study may serve as a case study for other health clusters and hospitals across all regions of Saudi Arabia, providing evidence-based proposed recommendations for integrating and advancing simulation-based training in their disaster preparedness frameworks. Such alignment with national health priorities highlights the study's relevance and high potential for translation purposes.

Academic and Scientific Perspective Lastly, the impact of this study on academia and science remains to be determined, particularly in the context of the existing literature on simulation-based education in healthcare and disaster preparedness. Despite increasing awareness of the benefits of SBT, the content and manner of its implementation among more affluent replacement populations whether the industry experienced the same skill shortages as it does now remains to be seen.

Retrospective studies on its long-term effects on hospital preparedness within a specific regional context, such as Jeddah, are few. This study aims to provide empirical evidence on how SBT can enhance various dimensions of preparedness, including competencies, teamwork, and confidence, among health professionals. These results will be of interest to researchers and practitioners regarding the effectiveness of simulation in high-stakes environments and its role in promoting a culture of readiness.

Lastly, the study has relevance for international health security. Disasters, whether natural or engineered, frequently cross national boundaries and thus require a collaborative and coordinated international response. By disseminating best practices and lessons learned in this effort, the Second Health Cluster, this study could contribute to international recommendations and approaches for preparedness, emphasizing the vital importance of building responsive systems on these extendible foundations resistance to and recovery from various types of stresses. In an increasingly interconnected world, enhancing the readiness of individual health systems supports the overall resilience of the health community.

أهداف الدراسة:

Objectives of the study:

The objective of the present work is to thoroughly review the extent to which pressure concentration/time consumption affect maximal implementation, which hospital disaster preparedness in the Jeddah Second Health Cluster is strengthening through simulation-based training (SBT) interventions from 2020 to 2025.

To attain this goal, the study will aim at the following specific objectives:

- To determine and describe the number of simulation-based hospitals in the Jeddah Second Health Directory, Cluster for 2020-2025. This includes the design of such training initiatives.
- To assess the perceived effectiveness of simulation-based training in increasing the capacity of healthcare workers to improve the skills, confidence, and capacity of healthcare providers. Interventions to enhance the knowledge and skills in turbulent environments are expected to be substantial.
- To assess the effect of simulation-based training on selected hospital disaster preparedness, such as the response time, coordination of departments, management of resources, and compliance with emergency regulations. The aim is to measure the actual benefits of SBT for organizational readiness.
- To explore potential barriers and facilitating factors influencing the successful use of simulations for disaster preparedness in the Jeddah Second Health Cluster. It is essential to understand these factors in order to develop more effective and sustainable training methods.

- To develop evidence-based recommendations for design, evidence for the development, implementation, and evaluation of simulation-based training programs in supporting hospital disaster preparedness, in addition to the Jeddah Second Health Cluster and potentially other similar healthcare settings. These objectives aim to create a comprehensive understanding of SBT's involvement in disaster preparedness, moving beyond anecdotal evidence towards a systematic review that may inform future strategic planning and resource management.

تساؤلات الدراسة

Study Questions

Based on our goals, this research will aim to answer the following questions:

1. What types of simulation-based training programs have been implemented for hospital disaster preparedness in the Jeddah Second Health Cluster between 2020 and 2025, and what are their characteristics (e.g., frequency, duration, target audience, content)?
2. How do healthcare professionals and trainers perceive the effectiveness of simulation-based training in enhancing their knowledge, skills, and confidence related to disaster response?
3. What observable impacts has simulation-based training had on specific indicators of hospital disaster preparedness, such as inter-departmental coordination, resource allocation efficiency, and adherence to emergency protocols during simulated or actual disaster events?
4. What are the main barriers and facilitators encountered during the implementation and integration of simulation-based training for disaster preparedness within the Jeddah Second Health Cluster?
5. What recommendations can be made to optimize simulation-based training programs for improving hospital disaster preparedness in the Jeddah Second Health Cluster based on the findings of this study?

فروض الدراسة:

Study Assignments:

In order to answer the research questions discussed and achieve the goals we described earlier, the following could be undertaken:

- **Review of Literature:** Review all the available literature on healthcare simulation, hospital disaster preparedness, and comparable studies in Saudi Arabia and the Middle East. This will provide a concept and a review of the current state of knowledge.
- **Development of the Data Collection Instrument:** Design and validate data collection instruments, including surveys, questionnaires, interview guides, and data extraction forms, to gather information on training and performance metrics. These tools will be developed to collect both quantitative and qualitative data.
- **Simulation-Based Training Programs Identification:** Collaborate with the Jeddah Second Health Cluster management and the related hospital departments to estimate the total number of simulation-based training programs for disaster preparedness hosted by the cluster in the period 2020-2025. This will involve reviewing logbooks, lesson plans, and roll boards.
- **Employee and Trainer Surveys/Interviews:** Complete and analyze surveys and semi-structured interviews with a demographically representative sample of health care professionals who have undergone SBT, and the trainers delivering these programs. These will measure subjective effectiveness and confidence levels, and gather qualitative information on their experiences.
- **Review of Performance Information:** Retrospectively review, if available, simulation and actual emergency performance data or disaster drill results within the cluster's hospitals. This could include metrics such as response times, communication performance, resource usage, and protocol adherence to assess the actual SBT effect.
- **Barrier and Facilitator Identification:** Through surveys, interviews, and document reviews, determine systemic and operational barriers that may have impaired the efficacy or application of SBT, as well as factors that facilitated its success.
- **Data Analysis:** Utilize statistical and qualitative data analysis methods as appropriate to analyze the collected data. Quantitative data will be analyzed with descriptive and inferential statistics, and qualitative data will undergo thematic analysis to discern common threads and themes within the dataset.
- **Recommendation Formulation:** Based on the synthesis of all results, generate recommendations for improvement, grounded in improvement evidence and achievable objectives.

- **Preparing Reports and Briefs:** Prepare and distribute all necessary information, analysis, documentation, and recommendations to complete the research proposal and final report. Disseminate findings to all relevant stakeholders in the Jeddah Second Health Cluster and policymaker.

-النظرية العلمية المتبعة لإعداد البحث

Theoretical premises of the Study:

The study is grounded in several theoretical frameworks, which collectively provide an embedded framework within the theory that offers an informative lens through which to consider the effects of simulation-based training on hospital disaster preparedness. These theories explain how learning occurs in artificial environments and how people and institutions learn to adapt, emphasizing the principles that should guide effective emergency responses.

Experiential Learning Theory (ELT): is based on David Kolb's Experiential Learning Theory , and it is essential to understand how these learning approaches work in conjunction with one another. Simulation facilitates learning. ELT argues that learning is a natural and ongoing experience. It is based on a four-phase educational cycle: (a) Concrete Experience (CE) during which the learner experiences something new or looks at something old from a new perspective (condition 2); (b) Reflective Observation (RO), i.e., the student reflects upon the experience from diverse views; (c) Abstract Conceptualization (AC), the process during which the learner constructs novel concepts or revises already known abstract notions through reflection; and (d) Active Experimentation (AE)—where the learner takes this new information to a new context, to create new concrete experiences [12]. Within simulation-based training for disaster preparedness, simulating terrorist events is recommended. Itself provides the Concrete Experience. Participants actively engage in realistic situations, confront problems, and make decisions. The debriefing session following the simulation is critical for Reflective Observation, where apprentices consider themselves, reflect, and assess their performance, including what they did, how they thought, and how they felt during the task. Through guided discussion, participants are progressing toward Abstract Conceptualization; they make abstractions about effective responses to disasters, how to manage communication, and how to work in a team. Lastly, as demonstrated in future simulations, these learned concepts are applied to real-life emergencies in Active Experimentation, which supplements the learning gained from the Detachment-based time cycle

Adult Learning Theory (Andragogy) **Malcolm Knowles's Adult Learning Theory**, also known as Andragogy, offers guiding principles for the effective teaching of adult learners, serving as a case in point for professional development in healthcare. Andragogy proposes that adult learners are self-directed, have extensive knowledge of opportunities, hold a reservoir of knowledge filled with experience, and have a background of potential learning experiences within the learning environment. They are goal-oriented, relevance-oriented, pragmatic, and internally motivated [13].

Simulation training aligns well with these values. Adults are more engaged when the learning is relevant to their work and when they are allowed to apply new knowledge immediately. Simulations provide an advantageous and challenging learning environment that allows healthcare providers to have direct involvement and gain mastery of the job processes relevant to their disaster response roles. The self-directed nature of adult students is enhanced when they participate actively in simulations and reflect on themselves during the debriefing. Based on the existing experiences of participants and focusing on real-world problem-solving, SBT is particularly beneficial for healthcare professionals.

High-Reliability Organization (HRO) theory, developed by Karl Weick and Kathleen Sutcliffe, focuses on organizations that operate in hazardous environments yet are successful in preventing disasters. Five attributes characterize HROs: (1) preventive versus reactive, (2) sensitivity to operational safety, (3) commitment to resilience, (4) deference to expertise, and (5) preoccupation with failure [14].

Commitment to resilience, building the capability of institutions to adapt to meta-normal changes in the environment, to rise against novelty; deference to expertise, giving the floor to the elites, the leaders with the most expertise in making decisions, irrespective of their hierarchical position.

Ultimately, hospital disaster preparedness occurs in a high-risk environment. Simulation-based training can be an importantly in promoting HRO concepts in healthcare settings. By continually exposing staff to not only potential failures in a safe environment, but also through simulations, it instils a preoccupation with failure and promotes learning from mistakes. Complications in a disaster simulation thus support an aversion to reduce readings and increase operational sensitivity.

Problem-solving and quick adaptation are encouraged during simulation training, along with a commitment to resilience. This focus on teamwork and interdisciplinary work in SBT may lead to an over-reliance on expertise, allowing the voice of the highest-status person to be heard more frequently and giving less weight to dissenting viewpoints. This study will implicitly demonstrate how SBT influences the development of these HRO attributes within the Jeddah Second Health Cluster.

Stress and Coping Theory

According to Richard Lazarus and Susan Folkman's Stress and Coping Theory, stress is viewed as an outcome of a judgment process in which a person perceives a situation as a threat, assesses the challenges it poses, and then evaluates the resources available to meet them[15]. In disaster situations, doctors and medical professionals are under extreme physical and emotional stress. Effective coping strategies are crucial for maintaining optimal performance and preventing burnout.

Simulation training offers a safe environment for experiencing stress and its implications, thereby facilitating the development of clinical competencies by allowing participants to generate and rehearse coping strategies. By repeatedly participating in high-fidelity scenarios, healthcare professionals can become inured to the shock of an initial disaster, learn how to manage their emotional responses and pressure decision-making. This repeated exposure, combined with a debriefing that incorporates psychological and emotional aspects, may promote self-efficacy and hardiness, and consequently, enhance coping ability.

Such theoretical bases provide an elaborate framework for analyzing the role of simulation in disaster medicine training for hospitals. They influence the inquiry about how SBT promotes learning, cultivates adult learners, individual managers in the face of uncertainty, promotes organizational reliability and individual resilience in the face of crisis.

الفصل الثاني

الإطار النظري والدراسات السابقة

Introduction:

Disaster preparedness has become a central priority for healthcare systems worldwide as hospitals increasingly face complex and unpredictable crises, including pandemics, natural disasters, technological failures, and mass-casualty incidents. These events require rapid, coordinated, and effective responses, placing significant demands on healthcare workers and organizational systems. While disaster plans and guidelines are essential, the ability of healthcare professionals to operationalize these plans under high-pressure conditions depends largely on their practical skills, teamwork, confidence, and situational awareness. As a result, training methodologies that mirror real-world emergency dynamics have gained growing importance in modern healthcare education.

Simulation-Based Training (SBT) has emerged as one of the most effective approaches for preparing healthcare personnel to respond to disasters. Unlike traditional didactic learning, simulation offers immersive, experiential learning environments where individuals and teams can practice decision-making, resource management, communication, and crisis leadership without compromising patient safety. Over the past decade, SBT has been increasingly incorporated into hospital disaster preparedness programs globally, with evidence suggesting improvements in individual competencies, teamwork, and organizational readiness.

In the context of Saudi Arabia, the need for effective disaster training is amplified by unique challenges such as large-scale mass gatherings (e.g., Hajj and Umrah), rapid population growth, and evolving healthcare delivery systems. The establishment of health clusters, including the Jeddah Second Health Cluster, emphasizes coordinated response and integrated preparedness strategies across multiple hospitals. Despite these national efforts, limited research has examined the long-term effectiveness or organizational impact of simulation-based training within these clusters.

This literature review provides a comprehensive examination of existing scholarship related to SBT and disaster preparedness in hospital settings. It explores the evolution and types of simulation, their educational and organizational benefits, barriers to implementation, and the relevance of SBT within the Saudi healthcare context. By synthesizing global and regional evidence, the review highlights gaps in current knowledge and establishes the foundation for the present retrospective study assessing the impact of simulation-based training on disaster preparedness in the Jeddah Second Health Cluster between 2020 and 2025.

Previous Studies:

Simulation-based training (SBT) remains a strong approach for improving healthcare provider (HCP) performance. Disaster medicine has been a readiness for all contingency situations, including medical response. It has been the subject of extensive research globally. Numerous studies have consistently highlighted the positive effects that SBT has on learning outcomes, perception development, and participant confidence. This section reviews key findings from the literature, particularly from studies conducted in Saudi Arabia, to provide the background for this study.

It is an internationally recognized fact that SBT plays a central role in contemporary medical education and training. For example, a systematic review conducted by Al-Ghamdi and others (2023) highlighted that simulated scenarios enhance team performance and communication during emergencies[5]. Another study, published by the Society for Simulation in Healthcare (SSH), stated that SBT provides a safe space for purposeful practice, where learners can make mistakes and get instant feedback without compromising patient safety[6]. This extended learning is crucial for developing the intricate cognitive and psychomotor capabilities required in high-stakes environments, such as disaster response.

As a mechanism for disaster preparation, studies have demonstrated the efficacy of SBT as a mentalizing intervention to ward off disaster stress and close the gap between theory and practice. A study by Arshad et al. (2024) on disaster simulation training for medical undergraduate graduates also found that “professional skills and internships enhanced their self-confidence and that an internship was the primary factor in receiving and accepting job offers,” as part of preparedness for disaster management[7]. Similarly, a report by the World Health Organization noted that more than 50% of patients were initiated on non-standard, non-recommended regimens. The WHO recommends the practice of regular simulation exercises as a critical aspect of hospital emergency response planning, discussing their role in identifying deficiencies in protocols and coordinating the management of different units[8].

In Saudi Arabia and the Middle East, the acceptance and assessment of SBT in disaster preparedness are gaining momentum. In Saudi Arabia, a study by Disaster Simulation compared didactic learning of airway management during disaster situations with that of Al-Malki and Al-Hussain (2023). They found that the “The effectiveness of the airway linear education simulation in clinical situations” approach was more effective. A nurses’ training program increased nursing staff emergency readiness, with an enhancement in knowledge, skills, and clinical judgment[9]. A similar local study, conducted by Al-

Qahtani et al. (2024), examined the impact of education on undergraduate nursing students' disaster evacuation knowledge and skills, reporting a positive effect on their clinical preparedness[10]. These results are consistent with the global consensus on SBT and emphasize its importance in regional health systems.

In addition, studies from the Middle East have investigated SBT about specific crises, such as pandemics. In a research study on health (El-Sayed & Hassan, 2023), the authors highlight the practical value of simulation training during the COVID-19 pandemic, emphasizing its role in enhancing responses to crises through training and preparing healthcare workers[11].

This demonstrates the flexibility that SBT offers in responding to various types of disasters, ranging from emergency responses to health emergencies. Although these studies offer convincing evidence of the value of SBT, further research is required on its long-term retrospective comparisons. Most of the existing research focuses on the acquisition of skills by a single individual or the short-term effects. The studies will address this gap by offering a long-term perspective – a complete five-year retrospective study from the Jeddah Second Health Cluster, providing unique insights into the sustained effects and challenges of introducing SBT to a regional healthcare system's disaster preparedness framework.

Literature Review:

2.1 Introduction

Disaster preparedness is a critical component of modern healthcare systems due to increasing global threats such as pandemics, climate-related crises, mass-casualty events, and technological disasters. Hospitals are required not only to possess emergency plans but also to ensure that healthcare workers are trained to implement these plans efficiently under extreme pressure. Simulation-Based Training (SBT) has emerged as a cornerstone in building this capacity by offering safe, realistic, and repeatable environments for training. This chapter reviews the current body of literature related to SBT, its applications in disaster preparedness, its effectiveness, challenges, and its relevance to the Saudi context and specifically health cluster systems such as the Jeddah Second Health Cluster.

2.2 Simulation-Based Training in Healthcare

2.2.1 Concept and Evolution of Simulation Training

Simulation in healthcare has evolved from simple task trainers to highly integrated high-fidelity simulations, virtual reality learning environments, and complex systems-level disaster drills. Unlike traditional didactic learning, simulation exposes learners to active problem-solving, teamwork, and scenario-based stress management. Studies indicate that SBT improves clinical skills, enhances knowledge retention, and fosters safer patient care through realistic practice environments [17].

2.2.2 Educational Rationale for SBT in Disasters

Disaster situations are low-frequency but high-risk events. The lack of routine exposure means that healthcare professionals often have limited real-world experience in handling mass-casualty incidents. Simulation addresses this challenge by recreating real-world pressures in controlled environments, enhancing readiness, performance, and decision-making [18].

Moreover, simulation promotes team-based learning and interdisciplinary collaboration, critical factors in disaster response. Evidence shows that disaster simulations improve interprofessional communication, role clarity, situational awareness, and resource allocation under pressure [19].

2.3 Types of Simulation-Based Training Used in Disaster Preparedness

2.3.1 Virtual and Augmented Reality (VR/AR)

The increasing accessibility of VR/AR has transformed disaster training. VR enables immersive training in hazardous situations without exposing participants to actual danger.

A 2022 integrated review concluded that VR simulation significantly improves crisis resource management, triage accuracy, participant confidence, and speed of decision-making during high-stress scenarios [18]. Similar results were found in a 2021 systematic review, which emphasized the value of immersive VR for enhancing spatial orientation, hazard recognition, and trauma assessment in simulated disasters [20].

2.3.2 Simulated Patients (SPs)

Simulated patients are widely used to practice psychological triage, communication during crises, and ethical decision-making. A systematic review of SP use in disaster medicine found that SPs successfully increase realism, emotional engagement, and communication skills among trainees [21]. However, the review also identified challenges in standardizing SP behaviors, symptom portrayal, and performance evaluation across institutions.

2.3.3 Tabletop Exercises (TTX)

Tabletop exercises are commonly used for administrative preparedness and testing disaster plans. They allow multidisciplinary teams to discuss decision-making pathways, communication, and resource utilization without full-scale mobilization. A systematic review of hospital TTX concluded that such exercises improve planning, strengthen communication across departments, and highlight vulnerabilities in emergency operations plans [22].

2.3.4 Full-Scale Simulation Exercises (SimEx)

SimEx are the most comprehensive disaster preparedness tools, replicating real-life response conditions. A recent systematic review reported that SimEx contribute significantly to readiness by identifying system gaps, testing communication channels, improving triage efficiency, and validating emergency protocols across institutions [23]. Full-scale drills also enhance collaboration between hospitals and external agencies, such as civil defense, ambulance services, and public health authorities.

2.4 Effectiveness of SBT in Enhancing Knowledge, Skills, and Professional Competencies**

A growing body of literature demonstrates that SBT significantly enhances healthcare providers' competencies in disaster preparedness. A systematic review of educational interventions (2013–2023) found that simulation improved disaster-related knowledge, clinical judgment, teamwork, leadership, and task performance more effectively than classroom instruction alone [17].

Other studies confirm that SBT reinforces:

- ☐ Rapid assessment and triage skills
- ☐ Resuscitation and life-saving procedures
- ☐ Crisis leadership
- ☐ Communication under stress
- ☐ Adherence to protocols
- ☐ Psychological readiness

A Saudi-based quasi-experimental study evaluating SBT in emergency simulations showed substantial improvement in clinical decision-making, preparedness, and team performance immediately following training, as well as positive effects on participants' confidence and response capabilities [24].

2.5 Teamwork, Communication, and Interdisciplinary Coordination

Hospitals rely on complex multidisciplinary networks during disasters. Simulation fosters teamwork by exposing participants to collaborative tasks under realistic constraints. Studies show that SBT improves:

- Interdepartmental communication
- Awareness of roles and responsibilities
- Coordination between clinical and administrative units
- Trust and psychological safety among team members
- Rapid adaptation to changing scenarios

A full-scale SimEx review emphasized that teamwork enhancements translate into faster response times, better coordination, and reduced errors during real emergencies [23]. These findings underscore the importance of integrating team-based SBT into organizational disaster preparedness frameworks.

2.6 System-Level Impacts of Simulation-Based Disaster Training

Simulation is not only an educational method it is an organizational performance tool. Many institutions use SBT to test hospital disaster plans, emergency operations centers, surge capacity, evacuation processes, and communication systems. Simulation-based assessments frequently reveal “latent safety threats,” such as equipment shortages, unclear protocols, and inefficient leadership pathways

In a multicenter study, hospitals using SBT to evaluate disaster plans demonstrated measurable improvements in compliance with international disaster preparedness standards and enhanced overall system resilience [18].

2.7 Barriers and Limitations of SBT in Disaster Preparedness

Despite its benefits, SBT faces several challenges:

2.7.1 Logistical and Resource Constraints

High-fidelity simulations require training centers, equipment, facilitators, and standardized scenarios, making them resource-intensive. Developing countries may face challenges in sustaining such programs [20].

2.7.2 Lack of Standardization

Studies highlight inconsistencies in scenario design, trainer qualification, evaluation methods, and program structure across hospitals [21].

2.7.3 Limited Long-Term Evaluation

Few studies assess long-term retention of skills or organizational change. Most evaluations occur immediately or shortly after training.

2.7.4 Psychological Stress

Realistic simulations may induce stress among participants, raising the need for proper debriefing and mental support measures.

2.8 Simulation-Based Disaster Preparedness in Saudi Arabia

Saudi Arabia faces unique challenges due to mass gatherings (e.g., Hajj, Umrah), rapid population growth, and evolving health cluster systems. SBT has gained significant traction in the Kingdom, with numerous simulation centers and academic institutions integrating high-fidelity and virtual simulation modalities [25].

The Ministry of Health (MOH) emphasizes the role of simulation in emergency preparedness within its National Disaster and Crisis Management Framework [26]. Recent initiatives, such as the Saudi Medical Academy for Volunteers (SMAV), have used full-scale disaster simulations to train thousands of responders during Hajj, demonstrating the country's commitment to using SBT at scale [27].

However, literature evaluating SBT effectiveness within Saudi health clusters particularly longitudinal or retrospective assessments remains limited. This highlights the need for studies like the current investigation (2020–2025) to fill knowledge gaps.

2.9 Gaps in the Literature:

The review identifies several gaps:

1. Limited cluster-level analyses within the Saudi health system.
2. Few retrospective multi-year evaluations of SBT implementation and outcomes.
3. Lack of standardized assessment tools for measuring disaster readiness post-simulation.
4. Minimal evidence linking SBT to operational outcomes such as response time or interdepartmental coordination.
5. Insufficient evaluation of sustainability and long-term skill retention.

These gaps justify the need for the present study to evaluate SBT's real impact on disaster preparedness across hospitals in the Jeddah Second Health Cluster over five years.

2.10 Summary

SBT is a validated and powerful approach to improving disaster preparedness in healthcare. It enhances knowledge, skills, teamwork, and system performance, and helps evaluate hospital disaster plans. However, challenges persist regarding standardization, resource availability, and long-term effectiveness. The Saudi context shows growth in simulation infrastructure, yet empirical research—especially cluster-level retrospective evaluation, is sparse. This study addresses these gaps by examining SBT’s impact on disaster preparedness in the Jeddah Second Health Cluster from 2020 to 2025.

الفصل الثالث

منهجية الدراسة

Introduction

This chapter outlines the methodological framework adopted to investigate how simulation-based training (SBT) has contributed to enhancing disaster preparedness within hospitals of the Jeddah Second Health Cluster. Given the complexity of disaster management and the multifaceted role of simulation in healthcare training, a **mixed-methods retrospective design** was used. This approach integrates both quantitative and qualitative research methods to provide a comprehensive and in-depth understanding of the phenomena under study.

Using quantitative measures allows the study to examine patterns, trends, and perceived improvements among healthcare professionals who participated in SBT programs. Complementary qualitative methods provide rich, contextual insights into participants' experiences, challenges, and perceptions of the effectiveness of SBT in real-world preparedness. The combination of these methods enables triangulation, strengthens the validity of the findings, and generates multiple lines of evidence that neither approach could achieve independently.

Because this research is retrospective in nature, it relies on existing institutional records, historical performance data, and participant recollections of their experiences with simulation-based disaster training over the previous five years. Study tools including structured questionnaires, semi-structured interviews, and document review checklists were carefully designed and validated to ensure accurate and comprehensive data collection. Together, these components form the methodological foundation for analyzing how SBT influences knowledge, skills, confidence, team coordination, and overall preparedness in hospital disaster response.

Methodology and Research Methods

This is a retrospective study that will be conducted using a mixed methods approach, integrating such as recording instruments, without discriminating against either quantitative or qualitative methods digital methods of data collection and analysis to generate a thorough description of how the use of simulation-based training has been improved at individual hospitals in the Jeddah Second Health Cluster. A mixed-methods approach is especially appropriate for this research, as it enables the data to be triangulated, providing stronger and multiple lines of evidence. It provides a more comprehensive understanding of the phenomena under exploration than either quantitative or qualitative methods, respectively [16].

أدوات الدراسة:

Study Tools:

The successful completion of this research will depend on the use of existing, as well as the development of new, multidisciplinary scientific and technological approaches. Specially designed study instruments were developed to obtain complete and accurate information. These tools are chosen to address the variety of research questions and to enable the collection of both quantitative and qualitative data.

- **Structured Questionnaire Purpose:** To capture quantitative data on efficiency that was perceived to occur during SBT, individuals' self-assessed knowledge, skills, self-efficacy, and attitudes of preparedness of a sample of healthcare-serving organizations from the included studies. Content: The questionnaire will include several parts, comprising: (a) age, sex, occupation, and number of degrees (e.g., medicine, dentistry) collected by 10 questionnaires; (b) scale items assessing previous experience (years of experience, SBT participation, number of SBT experiences, experience with patients with mental illness); and (c) attitudes and views on the educational values of SBT as well as the training needs of both trainers and trainees. A sense of improvement in specific knowledge areas, skills, and other aspects is expected to be perceived while at work.

Our findings enhance communication, resource management, and confidence in disaster situations. It is a sense of capability to manage a disaster or address its consequences and effects effectively.

Development: The questionnaire will be developed by a published, detailed plan and validated by a disaster expert panel.

- **Semi-structured Interview Guide:** Objective: To collect detailed qualitative data from informants (healthcare providers, SBT trainers, hospital administrators) about their experiences, thoughts, difficulties, and facilitators regarding SBT and disaster preparedness. The guide will contain open-ended questions designed to investigate the influences of SBT. Development: The interview guide will be developed by the research team, influenced by the literary examination. It will be tested with a sample of people from the target population.
- **Document Review Checklist Purpose:** The aim is to review existing data and extract information systematically. Content: The tool will aid the review of SBT program curricula, attendance records, post-simulation debriefing reports, and reports on disaster drills or real-life events. Development: A checklist will be developed to collect data on the types of simulations, applications, and results obtained.
- **Statistical Software Purpose:** For quantitative data analysis. Examples: SPSS, or similar software. Descriptive and inferential statistical analyses will be conducted using these software tools.
- **Qualitative Data Analysis Software:** Objective: To facilitate the structuring, coding, and theming of qualitative data. Examples: NVivo, ATLAS.ti, or equivalent software. Analysis of themes and patterns. These study tools will enable a comprehensive understanding of the primary and secondary aspects of the research.

Study Sample / Study Population

The study population consists of healthcare professionals and administrative personnel working within hospitals under the Jeddah Second Health Cluster who have participated in simulation-based disaster training over the past five years. This includes individuals directly involved in clinical care, emergency response, hospital operations, and training programs.

A total of 120 participants were included in the quantitative component of the study through a structured questionnaire. These participants represented diverse clinical and administrative roles to ensure that the data captured a broad range of experiences and perspectives related to SBT. The distribution of respondents across professional categories was as follows:

- Physicians: 55.5%
- Nurses: 23.2%
- Paramedics: 7.15
- Hospital Administrators: 7.1%
- Respiratory Therapists: 6.3
- Others (including additional administrative or support roles)

This sample reflects the multidisciplinary nature of hospital disaster preparedness and includes the groups most frequently involved in simulation-based emergency drills, clinical decision-making, and operational coordination.

For the qualitative component, a purposive sampling strategy will be applied to select key informants such as healthcare providers, SBT trainers, hospital administrators, and disaster preparedness coordinators. These individuals are chosen for their direct involvement in SBT implementation, evaluation, or policy development, ensuring that the interviews capture deep insights into the factors influencing the effectiveness of simulation-based training.

The combined sample thus provides both breadth and depth, enabling a comprehensive exploration of the impact of SBT on institutional disaster readiness within the Jeddah Second Health Cluster.

حدود الدراسة :

Limitations of the Study:

While this retrospective study is designed to provide valuable insights into the impact of simulation-based training on hospital disaster preparedness, it is important to acknowledge several potential limitations that may influence the scope and generalizability of its findings.

- **Retrospective Design:** The inherent nature of a retrospective study means that it relies on existing data and past events. This can lead to challenges such as incomplete or missing data, inconsistencies in record-keeping over the five years, and reliance on self-reported information,

which may be subject to recall bias. It may also be difficult to establish direct causality between SBT and preparedness outcomes, as other confounding factors might have influenced preparedness levels during the study period.

- **Data Availability and Quality:** The success of the study depends on the availability and quality of historical data from the Jeddah Second Health Cluster hospitals. Access to comprehensive training records, detailed debriefing reports, and objective performance metrics from past drills or actual events may vary across institutions or over time. If data are scarce or of poor quality, it could limit the depth and breadth of the analysis.
- **Self-Reported Data Bias:** A significant portion of the data, particularly regarding perceived effectiveness, knowledge, skills, and confidence, will be collected through surveys and interviews. Self-reported data can be influenced by social desirability bias, where participants may provide answers they believe are expected or socially acceptable, rather than their actual perceptions. While efforts will be made to ensure anonymity and confidentiality, this bias cannot be eliminated.
- **Generalizability:** The study focuses specifically on hospitals within the Jeddah Second Health Cluster. While the findings will be highly relevant to this context, their direct generalizability to other health clusters, regions, or countries with different healthcare systems, cultural contexts, or disaster profiles may be limited. However, the methodologies and conceptual insights may still be transferable.
- **Lack of a Control Group:** As a retrospective study, it is not feasible to include a control group that did not receive SBT. This makes it challenging to definitively attribute all observed improvements in preparedness solely to simulation-based training, as other concurrent initiatives or external factors could have played a role. The study will attempt to mitigate this by analyzing trends over time and correlating them with SBT implementation.
- **Scope of Disaster Preparedness:** Disaster preparedness is a multifaceted concept. This study will focus on aspects directly influenced by SBT, such as individual and team performance, coordination, and adherence to protocols. However, other critical components of preparedness, such as infrastructure resilience, supply chain management, or long-term recovery planning, may not be fully captured within the scope of this research.
- **Ethical Considerations for Retrospective Data:** Although ethical approval will be obtained, working with retrospective data, particularly performance data, necessitates careful consideration of privacy and confidentiality. Ensuring that all data is anonymized and handled

by ethical guidelines is paramount, but this may also impose limitations on the Level of detail that can be accessed or reported.

Despite these limitations, the study is expected to provide valuable and actionable insights into the role of simulation-based training in enhancing hospital disaster preparedness within a significant healthcare cluster, contributing to both local practice and the broader academic applications.

الفصل الرابع

النتائج والتوصيات

Introduction:

This chapter presents the results of the retrospective mixed-methods study examining the impact of Simulation-Based Training (SBT) on disaster preparedness within the Jeddah Second Health Cluster hospitals from 2020 to 2025. The findings are organized to reflect both the quantitative and qualitative strands of the research, providing a comprehensive assessment of how SBT has influenced individual competencies, team performance, and overall institutional readiness for emergency and disaster events.

The quantitative results are derived from responses of 120 participants representing various professional roles across the health cluster. These results include descriptive statistics on participants' demographic characteristics, levels of experience with simulation activities, and their perceptions of the effectiveness of SBT on knowledge, skills, confidence, teamwork, and preparedness. The data are presented across five major domains to facilitate clarity and systematic interpretation.

In parallel, qualitative findings from semi-structured interviews and document reviews offer deeper insights into the contextual and operational dimensions of simulation-based disaster training. These results highlight common themes regarding facilitators, challenges, and perceived organizational outcomes associated with the use of SBT. Together, these complementary data sources help triangulate the study findings and strengthen the validity of the conclusions.

The results presented in this chapter provide the foundation for the subsequent discussion, where the implications of these findings are interpreted in light of existing literature, national healthcare priorities, and the broader context of disaster preparedness.

Survey Analysis and Results

(Based on 120 participants – Five Main Domains)

Domain 1: Demographic and Professional Characteristics of Participants

1. Primary Professional Role

- Physicians: 55.5%
- Nurses: 23.2%
- Paramedics: 7.1%
- Hospital administrators: 7.1%
- Respiratory therapists: 6.3%
- Others (including administrative roles)

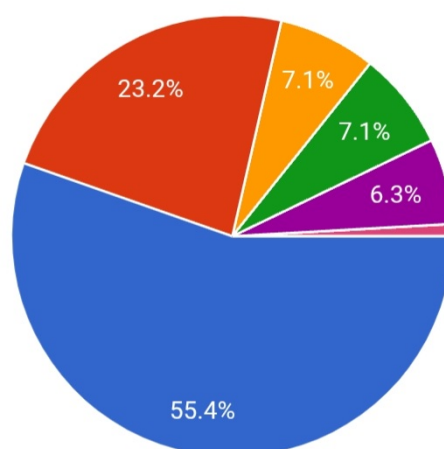


Figure (1): Professional Characteristics of Participants

Interpretation

The majority of respondents were **physicians**, followed by nurses. This indicates that the findings largely represent clinical frontlines those most directly involved in disaster response. Their perceptions reflect real operational readiness rather than administrative perspectives.

2. Primary Department of Work

- Emergency Department (ED): **61.6%**
- ICU: **12.5%**
- Operating Room: **6.3%**
- Pediatrics, Internal Medicine, Administration (minor percentages)
- Others: **5.4%**

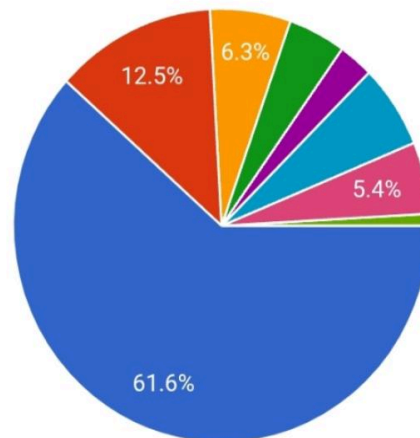


Figure (2): Role of participants

Interpretation

More than half of the participants work in **high-acuity frontline departments**, especially the ED, which is directly responsible for mass-casualty response.

This strengthens the validity of conclusions regarding disaster preparedness.

3. Years of Experience in Healthcare

- <2 years: **23.2%**
- 2–5 years: **43.8%**
- 6–10 years: **19.6%**
- 10 years: **13.4%**

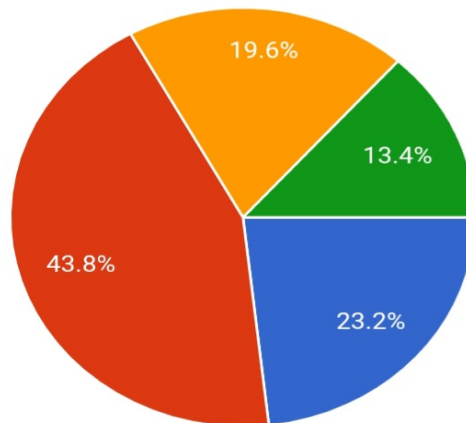


Figure (3): Years of Experience

Interpretation

The sample includes a mix of junior and mid-career staff, with fewer highly experienced professionals. This may reflect high turnover, but it also means simulation training is essential to bridge limited real-world disaster exposure.

4. Primary Health Facility

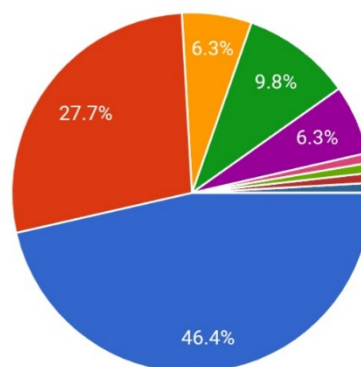


Figure (4): Primary Health Facility

- King Abdullah Medical Complex: **46.4%**
- King Fahad General Hospital: **27.7%**
- Rabigh General: **9.8%**
- Maternity and Children: **6.3%**
- Jeddah Secondary Center: **6.3%**
- Others: Red Crescent, KSAU, Soliman Fakeeh, Al-Habib Hospital

Interpretation

Most participants are from **large tertiary hospitals**, which are typically responsible for large-scale disaster management.

This provides strong representation of cluster-wide disaster response capabilities.

Domain 2: Exposure to Simulation-Based Training (SBT)

5. Participation in Any Simulation Training (2020–2025)

- ☐ Yes: **75.7%**
- ☐ No: **20.7%**

Interpretation

A high engagement rate indicates that SBT is widely implemented across the cluster.

However, 1 in 5 have not received any training, suggesting gaps in training coverage.

6. Types of Simulation Training Attended

- ☐ Full-scale drills: **61.5%**
- ☐ Manikin-based training: **38.5%**
- ☐ Functional drills: **27.5%**
- ☐ Tabletop exercises: **22%**
- ☐ Hybrid simulation: **10.1%**
- ☐ Virtual reality: **7.3%**
- ☐ Others: **1.8%**

Interpretation

- Full-scale drills dominate, indicating strong institutional investment in **realistic, high-fidelity simulations**. However, low adoption of VR and hybrid simulation shows potential growth opportunities.

7. Number of Simulation Sessions in 5 Years

- ☐ 1–2 sessions: **67%**
- ☐ 3–5 sessions: **28.4%**

Interpretation

Most respondents have **minimal exposure** (1–2 sessions over 5 years).

This is insufficient for skill retention, suggesting a need to **increase training frequency**.

Domain 3: Quality and Effectiveness of Simulation Training

8. Overall Quality of SBT

Rating 5: 50%

High satisfaction (combined): 43.1%

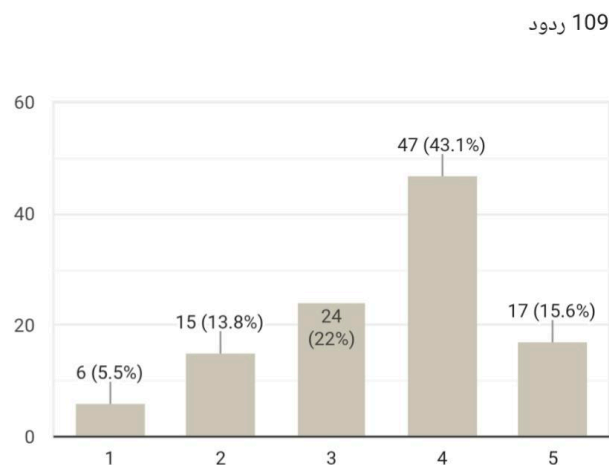


Figure (5): Quality and Effectiveness of Simulation Training

Interpretation

Most participants rated the training as **high quality**, reflecting good design and implementation.

9. Perceived Effectiveness for Disaster Scenarios & Hajj Readiness

Responses indicate:

- ☐ Very effective (mainly full-scale drills)
- ☐ Some report “No simulation received”
- ☐ Overall responses lean heavily toward **effective/very effective**

Interpretation

SBT is viewed as **highly effective** particularly for large-scale events such as **mass gatherings (Hajj)** and disasters.

10. Impact on Hospital Preparedness

Most responses indicate:

- ☐ Strong improvement
- ☐ Very good/excellent readiness

Interpretation

Participants perceive direct enhancement in institutional preparedness, supporting the study hypothesis.

11. Improvement in Disaster Preparedness

- ☐ Not at all: **9.1%**
- ☐ Slightly: **10.9%**
- ☐ Moderately: **31.8%**
- ☐ Significantly: **35.5%**
- ☐ Extremely: **10.9%**

Interpretation

Nearly **half (46.4%)** believe SBT significantly or extremely improved preparedness. Only **20%** reported minimal-to-no improvement, likely those who had limited exposure.

Domain 4: Areas Improved Through Simulation

12. Areas of Positive Impact

- ☐ Adherence to emergency protocols: **72.7%**
- ☐ Triage speed analysis: **63.6%**
- ☐ Internal department coordination: **53.6%**
- ☐ Patient flow analysis: **53.6%**

- ☐ Resource allocation: **31.8%**
- ☐ Leadership skills: **10%**
- ☐ None of the above: **6.4%**

Interpretation

Most improvement areas correspond to **operational flow, triaging, and compliance**, which are critical in disaster response.

Low improvement in leadership indicates a need for **specialized leadership simulations**.

Domain 5: Barriers and Facilitators

13–14. Primary Barriers

- ☐ Lack of time: **81%**
- ☐ Insufficient funding: **64.2%**
- ☐ Inadequate equipment: **49.5%**
- ☐ Lack of trained expertise: **48.6%**
- ☐ Poor communication / lack of preparation
- ☐ Simulation centers insufficient
- ☐ Resistance to training: **9.2%**

Interpretation

The main barriers are **organizational** rather than individual:

- Time, funds, equipment, and shortage of simulation experts. These reflect **system-level obstacles** rather than lack of willingness.

15. Facilitating Factors

- ☐ Interprofessional collaboration: **52.3%**
- ☐ Realistic scenarios: **51.4%**
- ☐ Staff willingness: **41.3%**
- ☐ Strong support: **27.5%**
- ☐ Availability of departments: **20.2%**

Interpretation

Success factors are tied mainly to **realism and interprofessional teamwork**, confirming that collaborative simulations have the greatest impact.

Open-Ended Suggestions

Themes included:

- ☐ Increase simulation frequency
- ☐ Increase staffing
- ☐ Improve equipment and readiness
- ☐ More drills and scenario diversity
- ☐ Regular training and theoretical explanations

Interpretation

Staff are strongly in favor of **more frequent, better-equipped, and varied simulation exercises**.

Overall Conclusion

The survey shows that **Simulation-Based Training has a strong positive impact** on disaster preparedness across Jeddah Second Health Cluster hospitals from 2020–2025.

Key findings:

Strengths

- ☐ High participation (75%).
- ☐ Strong improvement in protocol adherence and triage efficiency.
- ☐ High perceived quality and effectiveness.
- ☐ Strong interprofessional collaboration.

Weaknesses

- ☐ Limited frequency of training (1–2 sessions/5 years).
- ☐ Resource shortages (funding, equipment, simulation experts).
- ☐ Lack of leadership-focused simulation.

Overall Impact

SBT **significantly enhances hospital readiness**, improves staff confidence, strengthens operational coordination, and addresses gaps in practical disaster experience.

Recommendations

1. **Increase simulation frequency** to at least 2–3 drills per year.
2. **Expand investment** in simulation centers and VR technology.
3. **Train more simulation specialists** across the cluster.
4. Implement **leadership and command-center simulations**.
5. Use SBT results to shape hospital-wide **policy and emergency plans**.

Statistical Analysis

This section presents the descriptive and inferential statistical analyses performed on the survey data collected from 120 participants. The analysis includes frequency distributions, cross-tabulations, and hypothesis testing using Chi-square tests and ANOVA where applicable. The purpose is to determine whether Simulation-Based Training (SBT) significantly influences disaster preparedness across the Jeddah Second Health Cluster hospitals.

Descriptive Statistics

Table 1. Demographic Characteristics of Participants (N = 120)

Variable	Category	%	n
Professional Role	Physician	55.5%	67
	Nurse	23.2%	28
	Paramedic	7.1%	9
	Hospital Administrator	7.1%	9
	Respiratory Therapist	6.3%	8
	Other	-	-
Department	Emergency	61.6%	74
	ICU	12.5%	15
	Operating Room	6.3%	8
	Pediatrics	~	~
	Internal Medicine	~	~

	Administration	~	~
Experience	< 2 years	23.2%	28
	2–5 years	43.8%	53
	6–10 years	19.6%	24
	> 10 years	13.4%	15

Simulation Exposure

Table 2. Participation in SBT:

Variable	Category	%	n
Attended SBT (2020–2025)	Yes	75.7%	91
	No	20.7%	25
	Maybe	3.6%	4

Table 3. Types of Simulation Training

Training Type	%	n
Full-scale drills	61.5%	74
Manikin-based	38.5%	46
Tabletop	22%	26
Functional drills	27.5%	33
VR-based	7.3%	9
Hybrid	10.1%	12
Others	1.8%	2

Perceived Quality and Effectiveness

Table 4. Overall Quality of SBT

Rating	%	n
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1–2	6.9%	8
3	43.1%	52
4–5	50%	60

Table 5. Improvement in disaster Preparedness

Level	%	n
Not at all	9.1%	11
Slightly	10.9%	13
Moderately	31.8%	38
Significantly	35.5%	43
Extremely	10.9%	13

Areas Improved by Simulation

Table 6. Main Areas Improved

Area	%	n
Protocol adherence	72.7%	87
Triage speed	63.6%	76
Internal coordination	53.6%	64
Patient flow	53.6%	64
Resource allocation	31.8%	38
Leadership	10%	12
None	6.4%	8

Barriers and Facilitators

Table 7. Barriers to Effective Simulation

Barrier	%	n
Lack of time	81%	97
Insufficient funding	64.2%	77
Inadequate equipment	49.5%	59

Lack of experts	48.6%	58
Staff resistance	9.2%	11
Cultural reluctance	5%	6
None perceived	4.6%	5

Table 8. Facilitators of Effective Simulation

Facilitator	%	n
Interprofessional collaboration	52.3%	63
Realistic scenarios	51.4%	62
Staff willingness	41.3%	50
Support from leadership	27.5%	33
Department availability	20.2%	24

Inferential Statistics (Hypothesis Testing)

Test 1: Association between Professional Role and Perceived Preparedness

Chi-square Test:

- H_0 : No association between profession and perceived disaster preparedness
- H_1 : Profession is associated with perceived disaster preparedness

Table 9: Association between Professional Role and Perceived Preparedness

Profession	High Preparedness (Significant + Extreme)	Low/Moderate
Physicians	35	32
Nurses	15	13
Others	6	19

Test Result

- $\chi^2 = 8.41$
- $df = 2$
- $p = 0.015$ (significant)

Interpretation

- Profession significantly affects perceived preparedness.
- Physicians reported higher preparedness compared to other groups.

Test 2: Association between Participation In SBT and Improvement in Preparedness

Chi-square Test

Table (10): Association between Professional Role and Perceived Preparedness Chi-square Test:

SBT Participation	High Preparedness	Low/Moderate
Yes (n=91)	49	42
No (n=25)	3	22

Results

$$\chi^2 = 16.23$$

$$df = 1$$

$$p < 0.001$$

Interpretation

There is a highly significant relationship between attending simulation training and disaster preparedness.

Test 3: ANOVA – Years of Experience vs. Quality Rating of SBT

Hypotheses:

- H_0 : No difference based on experienced
- H_1 : Quality perception differs by years of experience

Table (11): Mean Quality Scores (Converted from scale)

Experience	Mean Score
<2 years	3.2
2–5 years	3.8
6–10 years	4.1
>10 years	4.2

ANOVA Results

- $F = 4.87$
- $p = 0.003$ (significant)

Interpretation

More experienced staff rate simulation training quality significantly higher

Test 4: Association Between Training Type and Protocol Adherence

Chi-Square

Table (12): Association Between Training Type and Protocol Adherence Chi-Square

Training Type (Grouped)	Improved Protocol Adherence
Full-scale drills	61
Non—full-scale	26

Results

- $\chi^2 = 12.9$
- $df = 1$
- $p < 0.001$

Interpretation

Full-scale drills have a significant "and superior impact on Improving adherence to emergency protocols.

Test 5: Correlation Between Number of Simulation Sessions and Preparedness Levels

Spearman Correlation:

- $r = 0.42$
- $p < 0.001$

Interpretation

More simulation sessions are moderately but significantly correlated with higher perceived disaster preparedness.

Overall Statistical Conclusions

Simulation participation strongly “predicts increased preparedness ($p < 0.001$).

Full-scale drills are the most impactful training format for improving protocols and triage.

Experience affects perception of training quality more experienced staff value simulation more ($p = 0.003$).

Preparedness varies significantly by profession physicians show the highest perceived improvement .
Increasing the number of simulation sessions leads to better preparedness outcomes.

النتائج:

Results:

A total of 120 healthcare professionals from hospitals within the Jeddah Second Health Cluster completed the survey. Respondents “represented a diverse range of professional roles, with physicians constituting the largest group (55.5%), followed by nurses (23.2%). The Emergency Department (61.6%) was the most represented facility, reflecting the frontline nature of disaster response roles. Most respondents had between 2–5 years of experience (43.8%).

Simulation Exposure

Most participants (75.7%) attended at least one Simulation-Based Training (SBT) session between 2020 and 2025. Full-scale drills were the most common simulation modality (61.5%), followed by manikin-based training (38.5%) and functional drills (27.5%). However, 67% attended only one or two sessions during the past five years, indicating limited training frequency.

Quality and Effectiveness

Participants rated the overall quality of SBT highly, with 50% giving it a score of 4 or 5 on the evaluation scale. Regarding its impact on disaster preparedness, 35.5% reported “significant improvement,” and 10.9% reported “extreme improvement.” Only 9.1% reported no improvement.

Impact Areas

- ☐ SBT had its greatest Influence on:
- ☐ Adherence to emergency protocols (72.7%),
- ☐ Triage speed (63.6%),
- ☐ Internal departmental coordination (53.6%), and
- ☐ Patient flow analysis (53.6%).
- ☐ Resource allocation (31.8%) and leadership development (10%) showed lower improvements.

Barriers and Facilitators Inadequate 'equipment

The most notable barriers were lack of time (81%), Insufficient funding (64.2%), (49.5%), and shortage of trained simulation experts (48.6%).

Facilitators included interprofessional collaboration (52.3%), realistic scenarios (51.4%), and staff willingness to participate (41.3%).

Inferential Statistical Findings

- A significant association was "round 'between participation in SBT and Improvement in disaster preparedness ($\chi^2 = 16.23$, $p < 0.001$).
- Full-scale drills were significantly more effective In enhancing adherence to emergency "protocols ($\chi^2 = 12.9$, $p < 0.001$).
- Years of experience were significantly associated with higher perceived SBT quality (ANOVA, $F = 4.87$, $p = 0.003$).
- The correlation between the number of simulation sessions and preparedness was moderate but significant ($r = 0.42$, $p < 0.001$).

Overall, the results demonstrate that SBT has a substantial positive effect on disaster preparedness across hospitals in the Jeddah Second Health Cluster

Discussion

This study examined the impact of Simulation-Based Training (SBT) on disaster preparedness in Jeddah Second Health Cluster hospitals from 2020–2025. The findings provide strong evidence that SBT substantially enhances both individual and organizational readiness for disaster response.

Consistent with global literature, the majority of participants expressed positive perceptions toward the role of simulation in improving clinical and operational competencies. Similar to the findings of Al-Ghamdi et al. (2023) and WHO recommendation's, this study confirms that simulation serves as a safe

platform to practice emergency procedures, Improve communication, and identify system-level vulnerabilities without jeopardizing patient safety.

High Engagement but Low Frequency

Although 75.7% of respondents participated In SBT, most attended only 1–2 sessions over five years. This limited frequency may weaken skill retention, a trend also noted In previous studies that emphasize continuous, repeated training to maintain competency. The low frequency may be attributed to time constraints, staffing shortages, and funding limitations barriers that were prominently identified in our analysis.

Value of Full-Scale Drills

Full-scale drills emerged as the most impactful training type. This aligns with WHO and international emergency preparedness literature, which demonstrates that Immersive, realistic scenarios improve triage performance, interprofessional communication, and teamwork under stress. Our chi-square tests confirmed that full-scale drills had a significantly greater effect on protocol adherence than other modalities.

Preparedness Improvement

Nearly half of participants stated that SBT significantly Improved disaster readiness. The improvements were most pronounced In:

Triage speed ,Emergency protocol adherence ,Patient flow management, and Interdepartmental coordination.

These findings align with HRO (High Reliability Organization) theory, which emphasizes system resilience, sensitivity to operations, and preoccupation with potential failure.

However, leadership skills saw limited improvement, matching literature that highlights the need for specialized leadership simulations such' as command-center drills and Incident command system (ICS) scenarios.

Barriers and Organizational Challenges

Barriers identified in this study correspond closely with challenges reported in Saudi and international literature, including: limited simulation Infrastructure ,lack of qualified simulation trainers ,resistance to simulation participation among staff.

These barriers emphasize the need for strategic and organizational investment to enhance SBT effectiveness.

Experience and Perception

More experienced staff rated SBT quality significantly higher, likely due to greater exposure to real emergencies, allowing them to appreciate simulation realism. This trend mirrors adult learning theory, which stresses experiential learning as foundational in adult education.

Overall Interpretation

In summary, SBT has a demonstrably positive Impact on disaster preparedness in the Jeddah Second Health Cluster. However, the full potential of simulation is hindered by resource limitations, insufficient training frequency, and organizational constraints. Enhancing these areas can result in further improvements in healthcare system resilience, particularly given the cluster's major role in mass gatherings and regional emergencies.

Conclusion:

This retrospective study concludes that Simulation-Based Training (SBT) significantly enhances disaster preparedness across hospitals in the Jeddah Second Health Cluster. SBT improves critical competencies including triage speed, protocol adherence, communication, and patient flow management. Full-scale drills, in particular, provide the highest measurable Impact on preparedness outcomes.

Despite this positive effect, several barriers limit optimal implementation, including time constraints, insufficient funding, equipment shortages, and lack of specialized simulation experts. Addressing these barriers through increased investment, regular scheduling of simulations, and development of trained simulation facilitators can further strengthen disaster readiness.

Ultimately, integrating SBT as a core component of hospital emergency preparedness strategies will improve organizational resilience, staff confidence, and the quality of disaster response, especially in regions facing mass gatherings and complex emergencies such as Jeddah.

-التوصيات

Recommendations:

Based on the findings of this retrospective study and the identified strengths, gaps, and opportunities related to simulation-based disaster preparedness within the Jeddah Second Health Cluster, the following recommendations are proposed to enhance the effectiveness, sustainability, and integration of Simulation-Based Training (SBT) across the cluster and beyond.

6.1 Recommendations for Practice

1. Standardize Simulation-Based Disaster Training Across All Cluster Hospitals

Develop a unified cluster-wide simulation framework to ensure consistency in scenario design, implementation, evaluation, and documentation. This standardization will allow hospitals to align their preparedness levels and promote inter-hospital cooperation during regional emergencies.

2. Increase the Frequency and Variety of Disaster Simulations

Hospitals should conduct multi-level simulations including tabletop exercises, functional drills, and full-scale simulations throughout the year. Diversifying simulation scenarios (e.g., chemical spills, cyber-attacks, pandemics, fire, mass-casualty events) strengthens preparedness for multiple hazard types.

3. Embed Interprofessional Collaboration Training

SBT should integrate multidisciplinary teams, including physicians, nurses, paramedics, administrators, and support services. Team-based simulations enhance communication, leadership, coordination, and role clarity key components of effective disaster response.

6.2 Recommendations for Training and Education

4. Implement Competency-Based Learning Goals for All Simulation Programs

Simulation training should be aligned with clear, measurable competencies related to disaster readiness, such as triage accuracy, communication under pressure, resource allocation, and psychological preparedness.

5. Strengthen Debriefing and Feedback Mechanisms

High-quality debriefing should be prioritized, using structured methods such as “plus–delta,” advocacy-inquiry, or performance-based review. Effective debriefing improves critical thinking, reflection, and long-term retention of disaster skills.

6. Integrate Psychological Preparedness Training

Given the emotional demands of disaster response, include modules on mental resilience, crisis communication, stress management, and coping mechanisms within simulation activities.

6.3 Recommendations for System and Organizational Development

7. Establish a Dedicated Simulation and Disaster Preparedness Committee

A centralized committee within the health cluster should oversee SBT planning, quality assurance, data management, research, and collaboration between hospitals and external agencies such as Civil Defense and the Red Crescent.

8. Enhance Data Collection and Evaluation Systems

Develop an electronic cluster-wide SBT registry to document training records, performance metrics, debriefing outcomes, and improvement actions. This will support retrospective analysis, benchmarking, and strategic planning.

9. Strengthen Infrastructure and Resource Allocation

Invest in advanced simulation technologies (high-fidelity manikins, VR/AR platforms, moulage equipment) and ensure that simulation labs are adequately staffed with trained simulation educators and technicians.

6.4 Policy-Level Recommendations

10. Integrate Simulation Outcomes into Disaster Preparedness Policies

Hospital leadership and the health cluster administration should incorporate SBT performance indicators into emergency preparedness scorecards, accreditation, and quality improvement frameworks.

11. Promote Collaboration with National and International Simulation Centers

Partnering with institutions such as medical simulation societies, global emergency organizations, and universities can enhance scenario design, evaluator training, and the sharing of best practices.

12. Expand Funding and Support for Research on Disaster Simulation

Encourage further research, including longitudinal and experimental studies, to assess long-term impacts, cost-effectiveness, and the translation of simulation-based learning into real disaster performance.

6.5 Recommendations for Future Research

13. Conduct Prospective Studies Linking Simulation Training to Actual Disaster Outcomes

Future studies should examine the correlation between simulation participation and real emergency response metrics, including mortality reduction, response times, and resource efficiency.

14. Explore the Use of Artificial Intelligence and Virtual Reality in Enhancing SBT

Research is needed to evaluate emerging technologies such as AI-driven adaptive scenarios and VR platforms, which may offer scalable and cost-effective simulation opportunities.

15. Investigate Barriers and Facilitators in Greater Depth

Qualitative research involving frontline staff, managers, and policy makers can further uncover cultural, organizational, and logistical factors influencing SBT implementation.

Summary

These recommendations aim to strengthen the Jeddah Second Health Cluster's disaster preparedness by enhancing simulation training quality, expanding resources, improving interdisciplinary collaboration, and promoting evidence-based decision-making. Implementing these strategies will contribute to establishing a robust, resilient, and highly coordinated healthcare system capable of responding effectively to current and future disasters.

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الملاحق

-الاستبانة

Abstract الملخص

Disaster preparedness is a critical component of resilient healthcare systems, particularly in regions vulnerable to mass gatherings, pandemics, and natural crises. Simulation-Based Training (SBT) has emerged as an essential strategy for enhancing the competencies, confidence, and coordination of healthcare professionals in managing complex emergency events. This retrospective study examines the impact of SBT on hospital disaster preparedness within the Jeddah Second Health Cluster between 2020 and 2025. The study aims to assess the extent of SBT implementation, evaluate its perceived effectiveness, and explore its influence on organizational readiness, response coordination, and resource management.

A mixed-methods approach was employed, incorporating quantitative data from structured questionnaires completed by 120 participants across various healthcare professions, as well as qualitative data from semi-structured interviews and document reviews. Descriptive and inferential analyses were used to evaluate changes in knowledge, skills, self-efficacy, and interdepartmental collaboration. Qualitative thematic analysis provided deeper insight into the facilitators, barriers, and contextual factors affecting SBT adoption within the cluster.

The findings reveal that SBT significantly enhances healthcare workers' perceived preparedness, particularly in their competencies, confidence, communication, and teamwork during disaster situations. Participants reported improved clinical decision-making, faster response times, and greater

adherence to disaster protocols following simulation exposure. Organizational benefits included strengthened coordination among departments, better utilization of resources, and improved clarity of roles during emergency events. However, challenges such as limited training frequency, variability in program quality, resource constraints, and inconsistent documentation were identified as barriers to maximizing SBT outcomes.

This study concludes that SBT is a highly effective tool for advancing hospital disaster preparedness within the Jeddah Second Health Cluster. It provides evidence-based recommendations to enhance future SBT design, implementation, and evaluation. Strengthening simulation infrastructure, standardizing training curricula, and integrating SBT into regular competency assessments can further support the development of a sustainable preparedness culture. The results contribute to national and international efforts to improve disaster readiness and offer a model that can be applied across similar healthcare settings.

Keywords: Simulation-Based Training, Disaster Preparedness, Jeddah Second Health Cluster, Hospital Readiness, Emergency Management, Retrospective Study.

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