Improving Disaster Management in Saudi Arabia Through Collaborative Exercises and Education for Nurses and Other Healthcare Workers

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For my great family and friends

﴿وَقُلْ رَبِّ زِدْنِي عِلْمًا﴾

سورة طه الآية ١١٤

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ABSTRACT

Disasters have increasingly been shown to have consequences that require swift and effective action from both authorities and society. Specifically, coordination, collaboration, and cooperation have proven to be recurring challenges in disaster management. Saudi Arabia, where the data for this thesis have been collected, has been exposed to various types of disasters, such as floods, annual religious events, and an ongoing war on the southern border.

This thesis comprises four studies that use both quantitative and qualitative methods with validated tools to investigate whether tabletop exercises can improve the outcome of disaster management among nurses and other healthcare professionals working during disasters in the simulation's context.

Study I utilised a previously used questionnaire to examine the level of knowledge among healthcare professionals tasked with disaster management. The study found that disaster preparedness was knowledge-dependent, with knowledge being associated with confidence and preparedness. In Studies II and III, tabletop exercises were conducted. A questionnaire (CLU) was used to assess how collaboration enables learning that can be applied at the practical and operational levels. Moreover, another tool (CSCATTT) was used to examine how different collaboration factors facilitate crisis management.

The findings demonstrate that the exercises improved practical skills, self-confidence, and the ability to create multi-professional teams, as well as promoting team integration and maturity among personnel. The first three sub-studies were followed by a Delphi study, wherein several experts were interviewed about the role of exercises in the existing disaster medical curriculum in Saudi Arabia. This study revealed the need to strengthen the curriculum with simulation exercises.

This thesis emphasises the importance of collaboration exercises involving all personnel engaged in the management of medical issues following an event. The study highlights that increased knowledge and skills enhance self-confidence to work in critical situations. Additionally, tabletop exercises can develop collaboration among authorities and should be integrated into the current disaster medical curriculum in Saudi Arabia.

Keywords: collaboration exercises, curriculum, disaster education, emergency management, healthcare personnel training, Saudi Arabia

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SAMMANFATTNING PÅ SVENSKA

Katastrofer har i ökande grad visat sig leda till konsekvenser som kräver snabba och effektiva åtgärder både från myndigheter och samhälle. Samordning, samarbete och samverkan har visat sig vara återkommande utmaningar vid katastrofhantering. Saudi Arabien, där data till denna avhandling har samlats in, har varit utsatt för olika typer av katastrofer, såsom, översvämningar, årliga religiösa händelser och pågående krig vid den södra gränsen.

Detta examensarbete omfattar fyra studier som använder både kvantitativa och kvalitativa metoder med validerade verktyg, för att undersöka om tabletopsövningar kan förbättra resultatet av katastrofomhändertagandet under övningar bland sjuksköterskor och annan vårdpersonal som arbetar under katastrofer.

I studie I, användes en tidigare använd enkät för att undersöka kunskapsnivån hos vårdpersonal med uppgift att hantera katastrofer. Studien visade att katastrofberedskapen var kunskapsberoende. Kunskap förknippades med förtroende och god beredskap. I studierna II och III, genomfördes tabletopsövningar. En enkät (CLU) användes för att registrera hur samverkan möjliggör lärande som kan tillämpas praktiskt och operativ nivå, och ett annat verktyg (CSCATTT) användes för att se hur olika samverkansfaktorer underlättar hantering av kriser.

Resultatet visar att övningarna förbättrade personalens praktiska färdigheter, självförtroende och förmåga att skapa multiprofessionella team samt teamintegration och mognad. De tre första delstudierna följdes upp med en delphi-studie i vilken ett antal experter utfrågades om övningars roll i den befintliga katastrofmedicinska läroplanen i Saudi Arabien. Denna studie indikerade behovet av att stärka läroplanen med simuleringsövningar.

Resultaten av denna avhandling visar på vikten av samverkansövningar bland all personal som arbetar med katastrofmedicinsk hantering av en händelse och betonar att utökad kunskap, och färdighet ökar självförtroendet och därmed även viljan av att arbeta med kritiska situationer. Dessutom, kan tabletopsövningar utveckla samverkan mellan myndigheter och bör integreras i den nuvarande katastrofmedicinska läroplanen i Saudi Arabia.

LIST OF PAPERS

This thesis is based on the following studies, referred to in the text by their Roman numerals.

I. Sultan, M. A. S., Løwe Sørensen, J., Carlström, E., Mortelmans, L., & Khorram-Manesh, A. (2020). Emergency Healthcare Providers' Perceptions of Preparedness and Willingness to Work during Disasters and Public Health Emergencies. *Healthcare, 8*(4), 442.

II. Sultan, M. A. S., Khorram-Manesh, A., Carlström, E., Berlin, J., & Sørensen, J. L. (2021). Impact of virtual disaster collaboration exercises on disaster leadership at hospitals in Saudi Arabia. *International Journal of Disaster Risk Science, 12*, 879-889.

III. Sultan, M. A. S., Khorram-Manesh, A., Sørensen, J. L., Berlin, J., & Carlström, E. (2023). Disaster Collaborative Exercises for Healthcare Teamwork in a Saudi Context. *International Journal of Disaster Risk Science, 14*, 183–193.

IV. Sultan, M. A. S., Carlström, E., Løwe Sørensen, Alruwaili, A. S., & Khorram-Manesh, A. (2023). Incorporating Simulations Exercises Using Collaborative Tools into Disaster and Emergency Medicine Curriculum – A Pilot Survey Among Saudi Arabian Professionals. *Journal of Contingencies and Crisis Management,* 1-8.

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ABBREVIATIONS

AFMS	Armed Forces Hospitals
ARAMCO	Saudi Arabian Oil Company
CBPR	Community-Based Participatory Research
CEs	Collaborative Exercises
CLU	Collaboration, Learning, and Utility
COVID-19	Coronavirus Disease 2019
CREEC	Centre For Research and Education in Emergency Care
CRED	Epidemiology of Disasters
CSCATTT	Command and Control, Safety, Communication, Assessment, Triage, Treatment, and Transport
CVAT	Community Vulnerability Assessment Tool
DMT	Disaster Management Teams
DPHEs	Disasters and Public Health Emergencies
EDs	Emergency Departments
GDCD	General Directorate of Civil Defence
HCWs	Healthcare Workers
HDP	Hospital Disaster Preparedness
HEPPU	Hospital Emergency Planning and Preparedness Units
HVA	Hazard Vulnerability Assessment
ICUs	Intensive Care Units

IRB	Institutional Review Board
KSA	Kingdom of Saudi Arabia
MC	Multi-agency Collaboration
MCIs	Mass Casualty Incidents
MERS	Middle East Respiratory Syndrome
MIMMS	Major Incident Medical Management and Support
MRMI	Medical Response to Major Incidents
MoC	Model of Care
MOH	Ministry of Health
NHEOC	National Health Emergency Operations Centre
NGOs	Non-governmental Organisations
NP	Nurse Practitioner
PPE	Personal Protective Equipment
PPPs	Public-Private Partnerships
RHD	Regional Health Directorate
SC	Surge Capacity
SPSS	Statistical Package for The Social Sciences
WHO	World Health Organisation
UNDRR	United Nations Office for Disaster Risk Reduction
3LC	Three Level Collaboration

DEFINITIONS IN BRIEF

Collaboration	The act of working with another person or group of people to create or produce something (Oxford, 2024).
Crisis	A situation in which something or someone is affected by one or more very serious problems (Collins, 2024).
Disaster	A serious disruption to the functioning of a community that exceeds its capacity to cope using its own resources. Disasters can be caused by natural, man-made and technological hazards, as well as various factors that influence the exposure and vulnerability of a community (IFRC, 2024).
Emergency	Something dangerous or serious, such as an accident, which happens suddenly or unexpectedly and requires fast action in order to avoid harmful results (Cambridge Dictionary, 2024).
Hazards	A dangerous phenomenon, substance, human activity or condition. It may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (IFRC, 2024).
Healthcare worker	A healthcare worker is one who delivers care and services to the sick and ailing either directly as doctors and nurses or indirectly as aides, helpers, laboratory technicians, or even medical waste handlers (Joseph and Joseph, 2016).

Power distance	The perceived degree of inequality among people. In high-power-distance society, the "superiors", or those in power, perceive themselves, and are also perceived by others, to be at a higher level and, hence, have a great degree of control over others (Shah, Gao and Mittal, 2015).
Risk	The possibility of something bad happening (Cambridge Dictionary, 2024).
Surge capacity	Hospital surge capacity is defined as the ability of a hospital to expand rapidly and augment services in response to one or multiple incidents, and to manage patients who require unusual or very specialised evaluation or interventions (Djalali, Ingrassia and Ragazzoni, 2016).
Teamwork	A collective of two or more individuals who perform organisationally relevant tasks, share one or more common goals, interact, exhibit task interdependencies, manage boundaries, and are embedded in a broader organisational context (Anderson, 2004).
Vulnerability	The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards (UNDRR, 2024).

INTRODUCTION

In recent years, the world has seen a considerable increase in disasters, public health emergencies, and armed conflicts. This surge has resulted in numerous research publications delving into various aspects of disasters and emergency management. The changing environment of disasters and public health emergencies emphasises the importance of reassessing the principles of preparedness for unforeseen catastrophes. This need is driven by the increasing frequency and complexity of such events, as well as the emergence of new risks and vulnerabilities.

This dissertation aims to examine disaster preparedness among healthcare staff in the Kingdom of Saudi Arabia (KSA), which has been and still is exposed to various disasters. These threats range from global geopolitical upheavals and hybrid conflicts to the ever-increasing impact of climate change and the persistent threat of pandemics. Notable examples include the terror attacks in 1979, political unrest in 1987, numerous stampede disasters during the Hajj between 1990 and 2015, a catastrophic fire in 1997, the collapse of a construction crane in Mecca in 2015, and ongoing armed conflicts along the Saudi-Yemen border since 2015. Additionally, in terms of infectious diseases, even before the coronavirus pandemic in 2019 (COVID-19), the Middle East Respiratory Syndrome (MERS) epidemic significantly affected the KSA, posing substantial challenges for the healthcare sector.

This thesis focuses specifically on the southern part of the KSA, i.e. Najran, where the data for this thesis were collected. The ongoing conflict near the Saudi-Yemen border has highlighted the need to improve preparedness in the healthcare sector of the KSA. Several obstacles, including outdated path-dependent routines, local cultural factors, a lack of collaboration, and inefficient tools, exist in this region. These obstacles may impede the necessary steps towards an improved and well-prepared healthcare sector. Therefore, this dissertation scrutinises the preparedness of the staff at Najran's hospitals, with a particular focus on assessing the impact of certain measures aimed at improving preparedness. The measure of greatest relevance to this thesis is the implementation of collaborative exercises (CEs) to address the existing gaps and deficiencies in disaster management. The ongoing COVID-19 pandemic has provided a stark reminder of the importance of multi-agency collaboration and innovation, both in scientific approaches and practical fronts.

BACKGROUND

The term 'disasters' encompasses both natural events and those caused by human intervention. These include environmental hazards, infectious disease outbreaks, chemical and radiation pollution, and urban destruction. All such disasters have an adverse and direct impact on people's safety and health, their property, as well as social systems and services [1]. Populations affected by disasters often require emergency services to ensure access to basic needs, such as food and healthcare [2]. With the frequency, scale, and impact of disasters intensifying in many regions, it is crucial for all stakeholders involved to reinforce their capacities. This involves not only identifying but also assessing, preparing for, responding to, and effectively recovering from healthcare emergencies as disasters strike the relevant regions, areas, or populations [3].

DEFINITION OF DISASTER, RISK, AND CRISIS

Generally, a disaster is defined as any adverse occurrence that results in widespread human, economic, material, or environmental loss [4, 5]. The World Health Organisation (WHO) provides a more precise definition: ‘A disaster is an occurrence disrupting the normal conditions of existence and causing a level of suffering that exceeds the capacity of adjustment of the affected community’ (p.4) [6]. Disasters caused by natural hazards, such as floods, cyclones, earthquakes, and hurricanes, are brought about by natural phenomena [7]. However, disasters may also be influenced or caused by human actions, including wars, fires, industrial accidents, and infectious diseases. Technological disasters, in particular, are adverse events caused by human actions such as industrial pollution, dam failures, factory explosions, chemical spills, and nuclear radiation [7].

In this work, risk is defined as the potential for loss resulting from a disaster, explicitly outlining the stakes of a given event [8]. Risks result in the loss of lives, damage to property, loss of assets, cessation of services, adverse health impacts, and loss of livelihoods [9]. Risks can affect specific populations, regions, areas, communities, or societies, potentially lasting an extended period. Calculating a risk involves assessing the likelihood or probability of loss of life, property, or environmental damage, with the frequency or severity of loss used to gauge the risk of a disaster.

The occurrence of a disaster can lead to a broader crisis characterised by heavy damage, including a significant loss of life [10]. Al Kurdi [11] posits that 'a crisis occurs when those affected by a disaster encounter intense difficulty and danger'. Additionally, a crisis may arise from sudden unplanned events that disrupt the normal life and operations of those faced with a disaster [12]. In essence, a crisis is experienced when a disaster seriously disrupts the normal functioning of a community or society.

DISASTER AND EMERGENCY MANAGEMENT

Disasters and public health emergencies (DPHEs) can occur anytime and anywhere, with some being inevitable [13]. Hence, it is imperative to respond promptly and efficiently to mitigate the effects. Efficient disaster management systems must possess effective coordination, adaptability, and proficiency in addressing various DPHEs and the associated risks they present. This necessitates that all countries prioritise preparedness for all kinds of health threats.

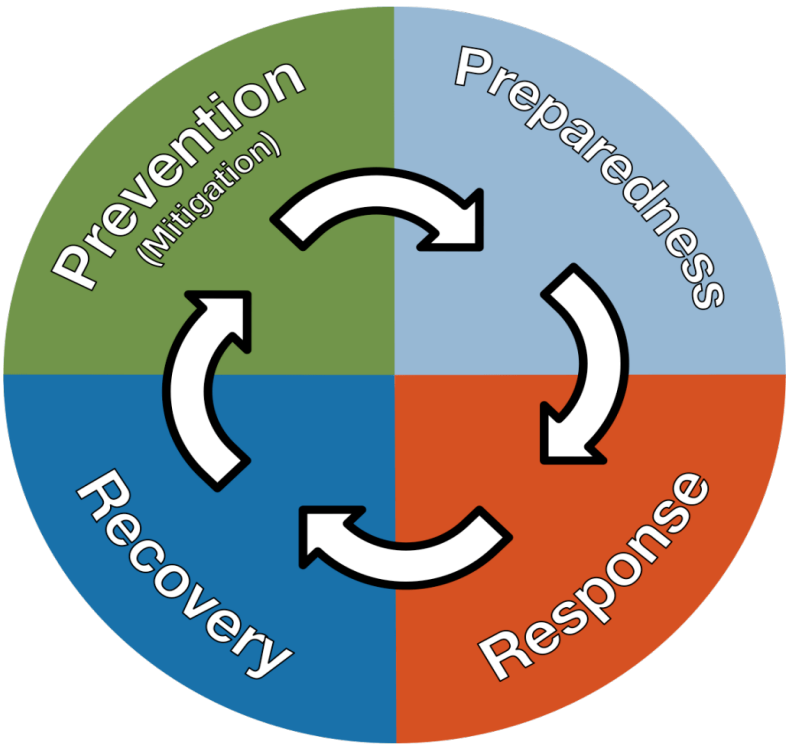

Figure 1 The four phases of a disaster cycle [14].

The disaster cycle, highlighting the elements that enable organisations to prepare for and protect against potential disasters, comprises mitigation, preparedness, response, and recovery phases (Figure 1). This cycle is widely used in global disaster management [15]. The first phase, mitigation, involves stakeholders in disaster and emergency management teams identifying and implementing actions aimed at preventing or reducing the causes, impacts, and consequences of disasters [15]. The second phase, preparedness, involves planning and conducting various educational activities to increase readiness for any unpreventable disasters. The third phase, response, typically occurs after a disaster. Responses aim to protect people and property from immediate threats caused by disasters, crises emerging from disasters, or other emergencies [15]. Finally, recovery, the fourth critical phase, helps individuals, communities, businesses, and organisations return to normalcy or adapt to a new normal after mitigating the adverse effects of a disaster [1, 16]. Thus, a comprehensive disaster and emergency management framework that outlines policies, strategies, and required resources is desirable for effective disaster management [17].

Although there has been much global research on disaster management, recent studies have received particular attention on the health implications of disasters in the KSA. Studies have shown that the occurrence of disasters caused by natural hazards, such as floods, can result in the emergence of waterborne diseases. Similarly, industrial accidents can expose communities to dangerous substances that have lasting effects on their health [18]. Furthermore, the large gatherings that occur during religious events in locations such as Mecca present distinct health difficulties that are worsened by a catastrophe [19, 20]. To effectively tackle these health challenges, it is crucial to have a comprehensive grasp of the specific local circumstances, cultural subtleties, and the ability of the healthcare system to address such urgent situations.

The KSA has experienced various types of catastrophes, including earthquakes and flooding, as well as human-caused incidents, such as industrial mishaps [21]. Floods are prevalent natural phenomena resulting from unplanned urban expansion, inadequate drainage systems, or the geographical disadvantage of low-lying areas in highly populated regions, such as Jeddah and Mecca. Due to the presence of mountains surrounding these areas, flooding is an inevitable risk [22]. The readiness of the healthcare system to tackle these difficulties, encompassing both physical infrastructure and manpower, is crucial in disaster

management, and the importance of multi-agency collaboration (MC) has become more evident in various contexts.

RISK AND VULNERABILITY ASSESSMENT

The primary aim of any risk and vulnerability assessment is to identify areas of critical concern that should be focused on for mitigation efforts. Vulnerability refers to the capacity of a population that is likely to be affected by a disaster to anticipate, cope with, and recover from the impact of any ensuing risk or hazard [23]. Such an assessment involves identifying threats and their consequences, mapping out barriers to adequate response, and assessing both the vulnerability to and the likelihood of negative effects [1]. A common tool used in this assessment is the Hazard Vulnerability Assessment (HVA). According to Du et al. [24], 'A hazard vulnerability assessment systematically evaluates the damage that could be caused by a potential disaster, the severity of the impact, and the available medical resources during a disaster to reduce population vulnerability and increase the capacity to cope with disasters' (p.2).

Global assessment of risk and vulnerability offers governments and organisations opportunities to identify risks, create crisis management plans, and ultimately reduce the effects of disasters. Vulnerability assessment examines the threats posed by various potential hazards to a population and infrastructure [25]. Through this assessment, the capacity of people to cope with disasters can be improved, ensuring resilience against the effects of hazards. Moreover, risk and vulnerability assessments aid in determining effective adaptation strategies and highlight the potential likelihood of disaster threats [1, 26]. Effective assessments establish potential weaknesses that could result in devastating effects, leading to the development of various mechanisms for assessing risks and vulnerabilities.

In the KSA, for example, the Community Vulnerability Assessment Tool (CVAT) has been applied to measure risks and vulnerabilities at the national level [27]. An assessment also involves data collection regarding likely hazards, critical infrastructure, high-risk areas, and mitigation opportunities. Professionals in disaster and emergency management emphasise the importance of regular and comprehensive risk and vulnerability assessments in the KSA. AlQahtany and Abubakar [28] note that the KSA is ranked 84th on the 2018 Global Climate Risk Index, attributed to factors such as frequent coastal flooding, lack of freshwater sources, high temperatures, and minimal

vegetation cover (p.4). One specific area of risk and vulnerability assessment in the KSA is hospital disaster preparedness (HDP). A study by Alsalem and Alghanim [29] found that the overall level of Saudi HDP was 69.8%, with varying competencies across different aspects of hospitals and locations, such as Riyadh, Jeddah, or Dammam.

AlQahtany and Abubakar [28] also suggest that there is a widespread perspective in Saudi Arabia that risk and vulnerability assessments are essential for building the community's resilience and supporting efforts towards disaster risk reduction. Therefore, the assessment of risks and vulnerabilities should be undertaken by national and local governments to develop efficient strategic action plans and protocols that can address potential gaps leading to devastating effects in disaster situations [9, 30]. While progress is being made, the KSA has adopted master plans for public safety and security to ensure effective disaster management practices.

HEALTHCARE SYSTEM IN THE KSA

The healthcare system in the KSA is divided into governmental and private sectors [31]. The government sector, encompassing approximately 80% of all healthcare, provides services free of charge for citizens under the universal healthcare framework through the Ministry of Health (MOH), other agencies such as referral hospitals and Armed Forces hospitals (AFMS), and the National Guard Health Affairs office [32, 33]. Certain healthcare services, such as those provided by government agencies like the AFMS, Health Services for the Royal Commission in Jubail and Yanbu, the Security Forces Medical Service, National Guard Health Affairs, and Saudi Arabian Oil Company (ARAMCO) Health Services, are exclusively available to agency employees and their families [32, 33]. In contrast, the private sector offers healthcare to both residents and expatriates for a fee [33].

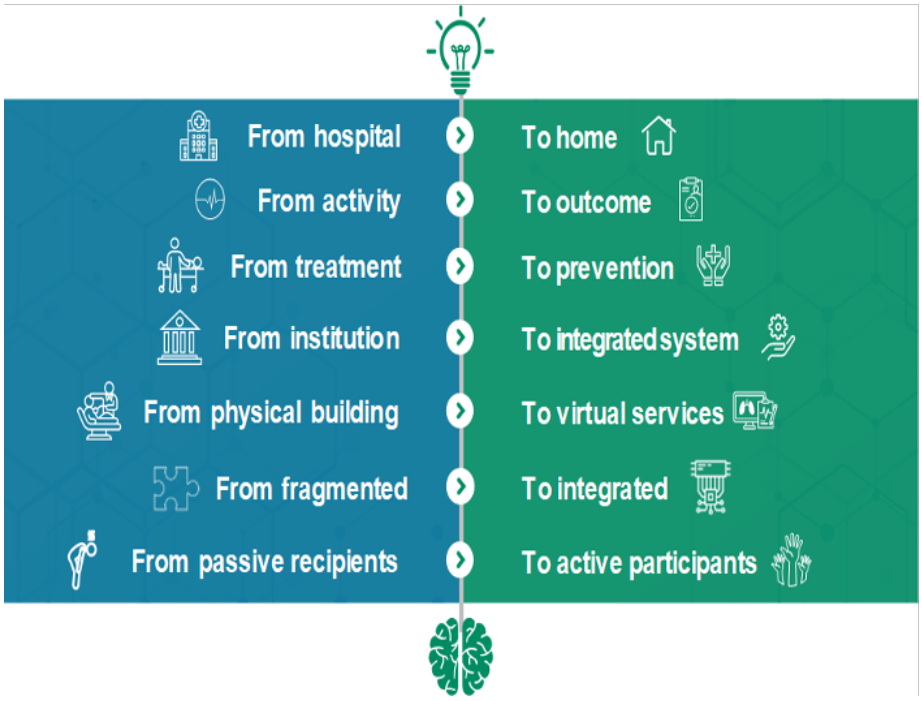

Figure 2 Model of care enablers [34].

The Saudi healthcare sector faces various challenges, including inadequate integration among primary, secondary, and specialist care, as well as an uneven distribution of these services across the KSA [34]. The elevated fatality and injury rates resulting from traffic collisions have significant personal, societal, and financial ramifications, as do the rates of early death from chronic illnesses [35]. Furthermore, it is imperative to enhance governance structures that effectively mitigate obstacles to public health and ensure the provision of high-quality healthcare services while also fostering speed in emergency response [34]. It is vital to resolve the issue of duplicating the provision and payment of health services for the same recipient.

Due to these challenges and the focus on Saudi Vision 2030, the government has implemented measures to promote and protect public health by outlining a comprehensive care system that emphasises preventive care over curative treatment to better address health demands. It aims to create systems of care that function more in people's homes and communities than in hospitals (Figure 2) [34].

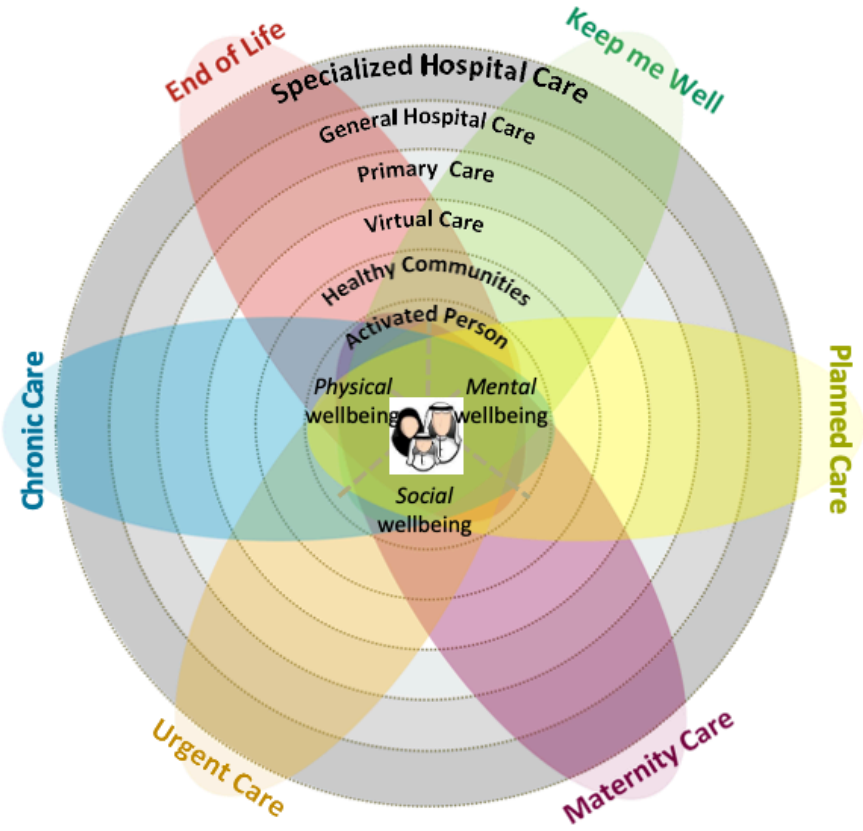

Figure 3 Developing a patient-centric model of care in line with the national vision 2030 [34].

This approach empowers individuals to take control of their health, providing them with knowledge and enabling informed decision-making in their healthcare, thus fully integrating the health system from the user perspective. The focus is on a preventive approach for the whole population, rather than solely a curative one, providing patient-friendly and outcome-focused treatment [31, 34, 36]. The KSA has categorised its healthcare services into six levels and six systems, as shown in (Figure 3). The Model of Care (MoC) breaks down these levels into active people, healthy communities, virtual care, primary care, secondary care, tertiary care, and quaternary care. The systems within these levels include preventive, planned, maternity, urgent, chronic, and end-of-life care [34].

All government medical facilities and information about their locations and services are available on the KSA's MOH website. The Sehhaty platform, launched by the KSA's MOH, facilitates access to health services and transfers between different types of care, enabling residents to access health information and services offered by various entities [31]. The 937 Emergency Call Centre, highlighted by Gurajala [36], is crucial for emergencies, offering free direct medical advice and instructions. Ambulance services, accessible through Call 997 in collaboration with hospitals and health centres, and the Saudi Red Crescent Authority, ensure rapid emergency responses [31]. A range of emergency and ambulance services cater to specific health scenarios and offer rescue services in disasters [37].

The KSA's commitment to disaster and emergency management is exemplified by the establishment of the national health emergency operations centre (NHEOC) [38, 39]. The NHEOC serves as a hub for health information and decision-making in crises, evaluating the effectiveness of centres, hospitals, and public gathering places [40]. As the first of its kind in the eastern Mediterranean region, it acts as an operational and command centre for the rollout of preventive initiatives across the KSA [38].

Additionally, the disaster and emergency management organisation in the KSA relies heavily on master plans. For instance, the Riyadh city government has adopted plans for public safety and evacuation, while the General Directorate of Civil Defence (GDCD) works to protect lives and property, reduce losses, and provide preventive awareness [41]. The Public Health Authority (Wegayah) and collaborations enabled by the National Health Emergency Operations Centre further demonstrate the KSA's efforts to strengthen emergency and disaster management at both national and local levels [42].

RISK OF DISASTER IN THE KSA

The KSA occupies a unique geographical position as the largest nation on the Arabian Peninsula, encompassing approximately 80% of the total land area [43]. Notably, it is home to vast deserts, including the Empty Quarter, the largest continuous sand desert in the world [44]. Situated at the crossroads of three continents (Europe, Asia, and Africa), and being a developing country, it is vulnerable to various disaster events [43].

In recent years, the KSA has faced significant challenges in preparing for and responding to disasters caused by natural and man-made hazards [30, 45]. A striking example of this vulnerability was the Jeddah flood of 2009, known as the "Black Wednesday" event, resulting in 125 fatalities, and causing extensive damage to numerous vehicles and residences. This incident highlighted issues with inadequate drainage infrastructure and delayed emergency responses [46]. Other examples include outbreaks of diseases such as MERS, Ebola, Rift Valley fever, and dengue fever [47, 48]. These events have exposed significant weaknesses within the Saudi healthcare system, leading to calls for strategic improvements to enhance disaster management, control costs, and improve the quality of healthcare services. Consequently, the government has embarked on ambitious plans to restructure and reform the healthcare system [43, 48-50].

Table 1 Summary of disasters in the KSA for the period 1964 – 2023.

Disaster Type	Occurrences	Deaths	Injured	Affected	Damage ('000 USD)
Flood	24	476	98	18,959	2,844,800
Epidemic	3	168	Unknown	571	Unknown
Transportation[1]	20	1,022	546	Unknown	Unknown
Miscellaneous[2]	33	5,842	4,380	317	60,968
Total	80	7,508	5,024	19,847	2,905,768

1 = Fires, industrial accident, chemical spills, building collapses and storms. 2= Road accidents and aircraft crash. Source: EM-DAT [51].

According to the Centre for Research on the Epidemiology of Disasters (CRED) [35], an analysis of data from 1964 to the present (Table 1) reveals that the KSA has experienced 80 major disasters, resulting in approximately 7,508 fatalities, affecting nearly 20,000 individuals, and incurring economic losses estimated at US$ 2.9 billion [51]. Recent trends show an increase in both the human and financial impacts of these disasters. Cities in the KSA that are most susceptible to natural disasters, particularly floods, include Riyadh, Mecca, Jeddah, and Najran, all of which have suffered major calamities previously [43, 45, 52-54]. Therefore, urgent government intervention and the development of comprehensive strategies are imperative to mitigate the ongoing risks associated with flooding and other disasters in the region, as emphasised by previous research [43, 45, 55].

SURGE CAPACITY

Surge capacity (SC) is a crucial aspect of planning and managing disasters and emergencies [56]. SC encompasses four critical elements: staff, stuff (equipment and supplies), structure (facilities), and system, all of which are essential in preparing for disasters [57]. These elements significantly influence the operation of healthcare across three levels: public-based, hospital-based, and community-based. Each level has its distinct limitations and capabilities regarding the emergency response process [58]. The first three components of SC – staff, stuff, and structure – must be dynamically scaled up or down as appropriate during disaster management. Strategic contingency planning is essential for effectively allocating these resources, utilising existing capabilities within organisations or institutions.

The fourth crucial component of SC, the system, encompasses the policies and procedures that dictate the management and quality of staff, stuff, and space [59]. Often, a contingency plan represents this system. It outlines a framework for medical and non-medical management, providing workers with a structured environment for operation. This structure is instrumental in enabling personnel to prioritise their activities properly, ensuring effective response during disasters [59].

TEAMWORK AND COLLABORATION

The term 'teamwork' refers to the practice of working collaboratively towards a common goal, an essential skill across many fields [60]. The team's success hinges on the synergy among its members, who usually bring unique skills, experiences, and perspectives to form a powerful collective [61]. The collective abilities of a group often surpass those of its individual members. When people collaborate to solve problems, brainstorm solutions, and progress in a project, the entire group benefits [62]. The effectiveness of a team depends on its members' ability to cooperate, share information, and consider each other's viewpoints while striving to achieve their shared objective [63]. This success typically requires access to diverse yet complementary skill sets and experiences, allowing members to accomplish the task at hand [64].

Although the terms "teamwork" and "collaboration" are sometimes used interchangeably, disaster research has led to distinct definitions [65]. Finn [66] describes teamwork as the negotiated outcome that motivates individuals in an organisation to act, reason, behave, and work collectively towards a shared

organisational goal (collaboration). Furthermore, Finn et al. [67] define teamwork as the process of uniting different employee groups within an organisation to share a common identity, thereby maximising their contributions to management goals.

However, cultural differences, extensive bureaucracy, decision hierarchies, language barriers, varying goals and objectives, differing expectations in roles and responsibilities, and communication practices can all impact the perception and execution of collaboration, posing challenges to effective teamwork [68]. A successful team adheres to fundamental principles such as open communication, mutual trust, clear roles, and cooperation [60]. When each team member contributes his or her knowledge, ideas, and efforts, the group is more likely to accomplish more, moving closer to its goal and increasing the chances of achieving desired outcomes and overcoming challenges.

Collaboration involves pooling individuals' expertise and time. Research in this area spans various academic and professional sectors. Patel et al. [69] have identified several key elements that are crucial for collaboration, as outlined in their review (Table 2) [69].

Trust is fundamental to partnerships, particularly in disaster and emergency management. It forms the foundation for communication, leadership, and the implementation of security or medical measures in complex situations. While disagreements and challenges are inevitable in collaborative processes, a base of trust facilitates the constructive resolution of these issues. Experienced individuals play a key role in navigating disagreements, using a sense of purpose, and the prospect of proper incentives to foster collaboration. Constraints may also enhance collaboration, with decisive and trustworthy leadership being pivotal in leveraging these constraints to elevate collaborative efforts [69].

Table 2 Key elements for effective collaboration

Key elements	Elaborate
Support	The success of a partnership can be dramatically impacted by having enough resources and support. In contrast, without enough assistance, well-designed teams are likely to fail in their missions.
Tasks	They must be clearly defined to achieve ultimate goals at all levels of response and engagement.
Individuals	These are the folks who communicate with one another to form a team. Performance on the individual level—both socially and technically—is essential for the team's success.
Interaction Process	A collaborative approach requires a setting where participants can interact and learn while coordinating, communicating, and making decisions.
Teams	Teams are made up of individuals who work together towards common tasks and objectives, fulfilling a specific organisational role and advancing business goals.
Context	An important variable in deciding the tasks, types of people, and teams involved in collaboration. It also specifies the type of collaborative assistance necessary.
Overarching Factors	These relate to and interact with the first six elements. They consist of management, time, performance, constraints, experience, goals, incentives, trust and conflict resolution.

In the context of disaster and emergency management, "context" refers to the root cause of a crisis that necessitates a coordinated response. This typically involves deploying on-site response teams, each with well-defined tasks carried out by competent personnel. Since disaster management is inherently multi-agency, it requires interactive processes that foster mutual learning, coordination, communication, and enhanced collective decision-making [69, 70]. These processes depend on a joint evaluation of the crisis, recognising that the characteristics of collaboration and relational dynamics can change, potentially affecting both performance and outcomes. Such recognition underscores the need for adaptability and flexibility in collaborative efforts.

MULTI-AGENCY IN DISASTER MANAGEMENT

The management of disasters necessitates the combined efforts of multiple agencies and professionals, including law enforcement, rescue and fire services, healthcare professionals (e.g. physicians and nurses), and both public and non-governmental organisations (NGOs) [71]. Humanitarian organisations, disaster response agencies, NGOs, military, and volunteer groups must coordinate, cooperate, and collaborate through seamless communication to ensure efficient disaster responses [72]. The concepts of collaboration, cooperation, coordination, and communication are central to working across different agencies and organisations in disaster contexts [73].

Shah et al. [74] argue that the goal of MC is to synthesise different skills, abilities, and competencies to provide optimal mechanisms for disaster response. Martin, Nolte, and Vitolo [75] define collaboration as a 'long-term relationship between organizations, characterized by high levels of interdependency and high risk, requiring significant power symmetry' (p.7). Other terms, such as partnerships, alliances, and coalitions, are often used interchangeably with collaboration in disaster management. Disasters, whether man-made or caused by natural hazards, provide opportunities for diverse agencies and professionals to unite, often involving individuals from different nations with varying abilities, values, norms, and goals [74]. Traditional disaster management approaches, which prioritise first responders, may sometimes fall short [76]. Enabling the sharing of information and the utilisation of each agency's strengths and weaknesses comes through agency coordination, which allows the agencies to cooperate in confronting the catastrophic event. Thus, collaboration ensures a quick and efficient resolution of problems presented by a disaster [77]. Various frameworks and tools are necessary to facilitate this level of cooperation [78].

MC is also crucial for the efficient delivery of relief and rescue efforts. However, coordination challenges can lead to duplicated efforts, delayed responses, and inefficient resource allocation. Zain, Zahari, and Zainol [79] note that these issues can worsen the impact of a disaster on affected populations. Different agencies providing logistics support, such as transportation, storage, and distribution of relief supplies, may struggle with effective information sharing, leading to redundancy and inefficiencies in aid delivery. Nonetheless, multi-agency approaches are increasingly seen as valuable in preventing, preparing for, responding to, and recovering from disasters [80, 81]. In the recent adverse events and disasters that have hit the

KSA, such as the coastal flooding in November 2022, effective MC and coordination have been imperative. This event primarily affected Jeddah, resulting in fatalities, flight delays, school closures, and road blockages. The coordinated response of first responders helped prevent further loss of life or property damage [27, 82, 83].

Countries such as Sweden and the United Kingdom have recognised the benefits of a shared emergency services framework [84-86]. This led to the creation of a framework for prehospital units, later adapted for hospital and clinical settings, based on the Major Incident Medical Management and Support (MIMMS) structure. The CSCATTT acronym, covering critical components of disaster and emergency management – command and control, safety, communication, assessment, triage, treatment, and transport – provides a structured approach for significant incident management [87]. This framework serves as both a planning tool and a means of assessing response effectiveness.

Effective collaboration in disaster and emergency management is multifaceted, involving robust relationships between partners. Elements such as mutual respect, trust, transparent communication, shared values, and common goals are essential for effective collaboration. Practical tools that facilitate interactivity and coordination, such as the CSCATTT framework, are vital. This framework bridges the gap between theory and practice, streamlining collaboration and enhancing the overall efficacy of disaster and emergency management efforts [58, 69, 84, 85].

CSCATTT AS A COLLABORATIVE FRAMEWORK

A collaborative framework is instrumental in building vital connections that facilitate the achievement of a shared objective. In disaster and emergency management, coordination and cooperation often lead to collaboration, with the concepts of "joint" and "shared" being central to this approach. While distinct entities may initiate collaboration and progress along a shared path as they discover common interests, the goal is not typically complete fusion; diversity is key for effectively managing large affected areas with diverse populations [69, 70].

Disasters caused by natural hazards, terrorist attacks, and transportation accidents can result in mass casualty incidents (MCIs) that quickly overwhelm local healthcare facilities [88]. Efficient management of MCIs can be achieved using the CSCATTT framework [89], which aims to enhance coordination,

cooperation, and collaboration among first responders, medical personnel, and other stakeholders. CSCATTT encapsulates core facets of communication and interaction between teams and organisations and addresses overarching factors in disaster and emergency management [70]. This framework acts as a convergence point during interagency collaboration, facilitating essential elements such as coordination, cooperation, communication, information sharing, cross-functional activities, resource pooling, sense-making, empowerment, and goal congruence [56]. It also provides insights into the strengths and weaknesses of teamwork and collaborative efforts [70].

Porthouse et al. [88] highlight that establishing a hierarchical command structure with a single point of contact, known as the incident commander, is crucial in CSCATTT. This entity coordinates the overall response effort and facilitates efficient communication [88]. The control aspect of CSCATTT focuses on regulating resource flow, managing access to the affected area, and establishing safe zones for responders and casualties [90]. Safety protocols within the framework assess risks, implement protective measures, and mitigate dangers to all involved.

Clear and concise communication is vital in CSCATTT [88]. Standardised communication protocols and technologies are used to streamline information flow among various agencies and personnel [90]. Triage systems prioritise care for casualties, and treatment is coordinated based on these priorities. Additionally, the logistical challenge of transporting injured individuals to hospitals is addressed by coordinating transportation resources and routes [86, 91].

Practicing the CSCATTT model may enhance coordination across responding agencies and groups, thus reducing ambiguity and repetitive efforts [77]. The framework supports decision-making by providing a structure for quick, informed decisions [88]. By utilising resources efficiently, it may increase the potential for saving lives. CSCATTT is regarded as adaptable and scalable for various MCIs and emphasises safety, protecting first responders and preventing further injuries during the response. According to Sammut, Cato, and Homer [87], the use of CSCATTT by emergency personnel and healthcare practitioners may lead to better outcomes for both victims and responders.

COLLABORATION CHALLENGES

While collaboration and teamwork offer numerous benefits, they are not without challenges. One primary issue is the potential for ineffective

communication, which can lead to misunderstandings and discord [92]. Conflicts, which are part of human nature, often arise from differing viewpoints or radical perspectives [93]. Cultural differences, particularly in power distance, can exacerbate these conflicts when team members feel they are treated unequally.

Power distance, a cultural dimension, pertains to how a society handles inequalities in power distribution [94]. It significantly influences work-related values, leadership styles, attitudes towards cooperation, and teamwork [95]. Understanding and respecting this cultural characteristic is crucial for effective teamwork and collaboration, especially across cultural boundaries [96]. Arab communities are characterised by high power distances, where authority is respected, and decisions are often made by superiors [96]. Subordinates in such cultures typically follow orders without questioning authority [55], which can sometimes impede teamwork. If team members are hesitant to challenge authority or share their ideas, valuable insights might be lost [97]. This deference to leadership, as suggested in Ghalib's research, can lead to teams being less effective in decision-making processes [64, 95].

The KSA scores high in power distance, reflecting an acceptance of hierarchical authority structures and centralised decision-making [95, 97-99]. This can affect group performance, potentially stifling open dialogue and limiting productivity [97, 98]. In high-power distance cultures, leaders often exercise considerable discretion and expect obedience [100]. Such leadership may discourage initiative-taking or participation in decision-making from team members [101]. Additionally, power distance affects gender norms and views towards women in the workplace. In patriarchal cultures with large power gaps, women aspiring to leadership positions may face resistance or scepticism, posing significant challenges [101, 102].

Coordinating the efforts of team members, especially when they are already working at full capacity, presents another significant challenge [103, 104]. Additionally, any lack of trust within the team can undermine its effectiveness [87, 105]. In the context of the CSCATTT framework, which relies on extensive coordination and cooperation among various parties to respond to MCIs [87], these issues can be particularly problematic, hindering the integration of cooperative efforts [106-109]. A detailed examination of these challenges within the CSCATTT framework can provide deeper insights:

COMMAND AND CONTROL

One of the primary challenges in the command-and-control component of the CSCATTT framework during MCIs is the potential absence of a clear and unified leadership structure. In high-stakes situations involving multi-agency collaboration, establishing a unified chain of command can be particularly challenging [106]. This lack of clear leadership can lead to confusion, delayed decision-making, and ineffective allocation of resources during emergency responses [110]. Ensuring a cohesive command structure is vital to coordinate efforts efficiently and make timely decisions, which are essential in managing the complexities of MCIs effectively.

SAFETY

In the CSCATTT framework, ensuring the safety of all individuals involved in response efforts during MCIs is of utmost importance. However, this safety is frequently compromised due to hazardous environments, unstable structures, and ongoing threats that are characteristic of many MCIs. Rescuers, healthcare workers (HCWs), and victims alike can find themselves in perilous situations. Consequently, a robust and flexible safety plan is essential. This plan must coordinate efforts to assess and mitigate risks while also effectively responding to the precipitating incident [106]. Furthermore, the challenge of aligning safety measures is compounded by the fact that different organisations often adhere to varying safety protocols. This diversity can make it challenging to establish a comprehensive and unified safety strategy [86]. Ensuring the safety of all parties requires not only meticulous planning but also the ability to adapt rapidly to the dynamic conditions of MCIs.

COMMUNICATION

Effective communication is a cornerstone of collaboration, particularly in the context of MCIs. However, maintaining open lines of communication during such emergencies can be challenging due to interruptions or blockages in communication channels. Additionally, interoperability problems between the communication systems of various agencies can significantly hinder the timely dissemination of critical information. The absence of established communication protocols and the use of incompatible technologies can lead to information gaps, misunderstandings and, consequently, delayed response actions [106, 111]. Therefore, ensuring reliable and compatible communication systems across all agencies involved is crucial for efficient coordination and effective management of MCIs.

ASSESSMENT

In MCIs, the effectiveness of medical care and resource allocation is highly contingent on the rapid and precise assessment of injuries. However, this capacity for evaluation can be significantly challenged by the sheer volume of casualties typical of such incidents. The overflow of injured individuals often leads to delays in identifying those who require urgent attention [86]. Furthermore, coordinating the assessment process among various MCs presents its own set of challenges. Ensuring uniformity in triage approaches across different agencies is a complex task, which can directly impact how resources are allocated and care is administered [106]. Effective management of MCIs thus requires not only efficient assessment protocols but also a coordinated approach to triage, ensuring that the most critical cases receive timely attention.

TRIAGE

Triage is a vital component of the CSCATTT framework, especially during MCIs. The success of triage hinges on the expertise of healthcare professionals and the efficiency of the processes in place. In MCIs, medical facilities and personnel often face the challenge of managing an overwhelming number of casualties [86]. This situation can be further complicated by inconsistencies in triage processes or the lack of established procedures. Such discrepancies can lead to disparities in treatment priorities and the utilisation of resources [112]. Therefore, it is essential to have robust and uniformly executed triage protocols to ensure that resources are allocated effectively and that the most critical cases receive prompt attention in the chaos of MCIs.

TREATMENT

In the CSCATTT framework, 'Treatment' involves organising care for victims based on their triage categorisation. However, this process can encounter significant challenges, particularly during MCIs. One major difficulty is ensuring consistent and appropriate treatment across various medical facilities, which may be compounded by limited resources and variations in medical expertise among hospitals [1]. Additionally, the rapidly evolving nature of MCIs can make it challenging to coordinate patient transportation to suitable healthcare institutions while maintaining continuity of care. This necessitates not only effective triage but also a well-coordinated treatment strategy that can adapt to the dynamic requirements of MCIs and efficiently utilise available medical resources and personnel [112].

TRANSPORT

Transportation of injured individuals to medical facilities is a critical component of rescue operations during MCIs. However, this task faces several challenges. Infrastructure damage or traffic congestion, common in disaster scenarios, can significantly impede the efficiency of available transportation resources [113]. Furthermore, coordinating transportation efforts among various agencies can be complex, often resulting in delays in accessing medical care for casualties. Identifying and determining the most appropriate and efficient routes for transporting patients is another critical challenge, especially when dealing with multiple agencies with different protocols and communication systems [114]. Efficiently managing these transportation logistics is essential for ensuring timely medical intervention and can be a deciding factor in the overall effectiveness of the response to MCIs.

DISASTER EDUCATION

The Sendai Framework for Disaster Risk Reduction 2015–2030 emphasises the critical role of education and practice in responding to DPHE. Effective disaster management encompasses understanding, planning for, responding to, and recovering from emergencies and catastrophes [115]. Consequently, education and training are integral to enhancing the resilience of HCWs to DPHE and reducing the loss of life, property, and infrastructure due to disasters [1, 77, 116].

Disaster education covers a wide range of topics essential for comprehensive preparedness. These include risk analysis, hazard recognition, emergency preparedness, evacuation planning, triage systems, communication protocols, and disaster recovery strategies [117, 118]. It is imperative that MCs, first responders, community groups, and educational institutions are well-equipped with knowledge and training in these areas of disaster management [119]. By ensuring that these key groups are informed and proficient in disaster management practices, the overall effectiveness of disaster response and recovery efforts can be significantly enhanced.

COLLABORATIVE LEARNING

Collaborative learning emerges as a key strategy in preparing for and recovering from disasters. It emphasises group work and discussion, offering a more active and engaging approach compared to passive forms of instruction [120]. This method of learning is particularly effective in the context of DPHE,

as it enhances the abilities of HCWs and MC workers to communicate effectively, solve problems, and think critically [121]. Through collaborative learning, organisations can adapt their plans to changing conditions, hence maintaining flexibility and openness to new solutions. It also enables individuals to work together to adapt and refine their efforts, leading to more efficient and effective outcomes [122, 123].

Stein [124] emphasises the importance of an inclusive and supportive classroom climate for effective disaster education. In the face of tragedy, it is crucial to promote communication, engagement, and information exchange. Collaborative learning techniques, such as group discussions, brainstorming, and practical applications, allow students or trainees to learn about disaster management and response tactics by leveraging the knowledge and expertise of their peers [125-127]. This not only enhances their learning capacity but also strengthens community bonds in DPHE contexts [126, 128].

It is important to differentiate between first- and second-degree learning [124]. First-degree learning involves acquiring information without fundamentally changing core beliefs. In contrast, second-degree learning entails a significant transformation in which communal values are altered to impact real-world emergency responses.

Klabber's [129] perspective on the learning model underscores the importance of multidisciplinary and interdisciplinary approaches. Second-degree learning involves abstract concepts leading to substantial transformation through interaction. Active participation in activities, such as exercises and engagement across organisational boundaries, is crucial to this learning approach. Testing different crisis management models collectively allows learning to be seen as a growth-oriented interaction within an interactive system. Collaborative learning strategies enable the integration of diverse perspectives and expertise, leading to a comprehensive understanding of disaster preparedness and response [129]. They also foster innovative approaches to disaster planning and management by bringing together specialists from various fields [56].

COLLABORATIVE EXERCISES

Achieving an adequate level of preparedness for emergency response requires both real-world experiences and structured educational initiatives [130]. Khorram-Manesh et al. [131] assert that both theoretical understanding and practical skills are essential for effective emergency response. HCWs who

actively engage in emergency management demonstrate comprehensive preparedness, encompassing practical elements [132]. Generally, medical professionals equipped with diverse knowledge and skills exhibit greater confidence and readiness to handle unexpected situations [133].

Andersson et al. [134] and Lupesco et al. [135] note that exercises can enhance staff knowledge and confidence, providing opportunities to practise in a risk-free environment. Various types of exercises, each with its own set of benefits and drawbacks, are available. Real-time, full-scale exercises simulate complete action chains, offering extensive training; however, they can be cost-intensive and logistically challenging. Tabletop activities, such as those incorporating a three-level collaboration (3LC) approach, focus on specific aspects of emergency preparedness and response, offering concentrated training experiences. The Medical Response to Major Incidents and Disasters (MRMI) programme represents a sophisticated option for simulation training [136].

Successful training programmes should integrate multi-agency coordination and cooperation, alongside individual learning and skill development. Klabbers [129] and Berlin and Carlström [137] suggest that such training should occur in environments that allow for mistakes and corrections, facilitating the practical application of new knowledge [138, 139]. This approach encourages active learning, fostering innovation and practical applicability.

Exercises such as 3LC and MRMI emphasise interagency interaction, shared decision-making, and collaboration. Both models have been validated in practice [135, 140]. The 3LC model focuses on teamwork in shared tasks and aims to reduce organisational barriers through the use of simple tools in a condensed setting [136]. In contrast, the MRMI model provides an in-depth analysis of the medical aspects of management and individual decision-making [141]. Both models promote flexibility, improvisation, and joint evaluations in their training methodologies, aiming to enhance synchronous collaboration, raise perceived learning levels, and improve learning outcomes.

DISASTER CURRICULA

An international perspective on disaster education programmes highlights the necessity for standardisation in curricula across various regions. Given that disasters caused by natural and man-made hazards can have widespread impacts on communities and economies globally, disaster education must be

developed with a universal outlook [142-144]. This approach prepares individuals, communities, and governments to handle disasters effectively, thereby mitigating their impact. Recognising the interconnected nature of disasters is a fundamental aspect of a global approach to disaster education [145]. Cascade effects of disasters, such as climate change-related events, pandemics, and man-made calamities, can easily transcend national boundaries. Therefore, curricula that adopt a global perspective must address these interconnected challenges to train individuals and communities for a diverse range of disaster scenarios [146].

For the effective development of global disaster education programmes, collaboration among educators worldwide is essential. International organisations such as the WHO and the United Nations Office for Disaster Risk Reduction (UNDRR) should offer guidance and frameworks for this education [147, 148]. These organisations can facilitate the exchange of best practices, case studies, and lessons learned, enabling countries to benefit from each other's experiences in enhancing disaster curricula.

In the KSA, the approach to disaster curriculum reflects the country's commitment to minimising disaster risk, enhancing emergency preparedness, and bolstering citizen resilience [149]. The country’s frequent experiences with floods, earthquakes, sandstorms, and industrial disasters underscore the need for disaster education programmes tailored to its specific threats and challenges. Considering the KSA's unique culture, history, and geography is crucial when developing its disaster education programmes. Incorporating CEs into these curricula is recommended to ensure that MCs and HCWs are prepared and unified during disasters [150-154]. Such exercises in disaster management education are essential to foster collaboration and solidarity during relief and rebuilding efforts, thereby facilitating effective recovery [154].

THEORETICAL FRAMEWORK

This thesis adopts a definition of collaboration that combines integration and maturity, characterising it as a composite of shared activities and procedures at both organisational and individual levels. Collaboration involves communication that leads to shared responsibility and decision-making [155], enhanced by practical tools such as CSCATTT for planning and evaluation [70]. The research primarily draws upon three theoretical frameworks: (1) the integration of team members by Hall and Weaver [60], (2) the team maturity

model by Sandberg [156], and (3) the mechanistic and organic work theory by Burns and Stalker [157].

Hall and Weaver's [60] framework explores teamwork efficacy, focusing on how diverse team members can achieve shared objectives synergistically. They identify three primary theoretical categories of teamwork within organisations: multi-professional, interprofessional, and trans-professional. Sandberg's [156] model of team maturity evaluates team alignment with organisational goals, categorising teams as immature, mature, or overripe, contributing to HCWs' ability to collaborate effectively [158].

Burns and Stalker's [157] concept of organic and mechanistic organisations contrasts spontaneous communication and flexible management in organic operations with the more linear, fixed approach of mechanistic operations. Organic structures promote creativity and commitment, while mechanistic frameworks focus on clear information exchange and decision-making processes. These frameworks align with Petrie's [159] concept of "idea dominance", which emphasises recognising individual and collective achievements within a team and organisation.

The interplay of integration, maturity, and organic-mechanistic organisation intertwines with collaboration to foster an effective team [160]. Challenges may arise in teams that are non-integrated, immature, or overripe, or within organisational structures that impede effective collaboration [161-163]. Berlin and Carlström's [164] model further illustrates how team members coordinate and organise tasks across three levels: sequential, parallel, and synchronous. However, the absence of organic qualities such as flexibility might lead to challenges during actual events, highlighting the importance of practicing these characteristics for effective collaboration [165].

AIM

The aim of this thesis is to explore the level of preparedness and the outcome of the collaborative exercises (CE's) on disaster management among nurses and other healthcare workers in the southern region of the KSA.

SPECIFIC AIMS

Study I	To evaluate healthcare workers' perceptions of their preparedness and willingness to work during disasters and public health emergencies in the southern region of the KSA.
Study II	To measure the impact of virtual, 3LC course exercises on participants' perceived levels of collaboration, learning, and utility (CLU) in a hospital context.
Study III	To evaluate the development of healthcare teamwork during collaboration exercises, using CSCATTT.
Study IV	To assess and evaluate the need to elaborate on the current disaster and emergency management curriculum in the KSA, according to the elements of CSCATTT, including incorporating disaster exercises using the same collaborative tool.

METHODS

This thesis employs a directed approach, guided by an existing theoretical framework, to support and expand upon established theories. This method highlights insights that may not be apparent from the more experiential perspective that are often associated with naturalistic designs [166]. Directed reasoning progresses from general principles to specific instances. Specifically, it begins with a theoretical foundation, then refines the theory accordingly. The research journey in this thesis is visually represented in Figure 4, which uses knowledge productivity as a methodological framework [167]. This framework was chosen to provide a comprehensive understanding of the research process, illustrating the interplay between research questions, data sources, and their alignment with the critical elements of process evaluation guidance.

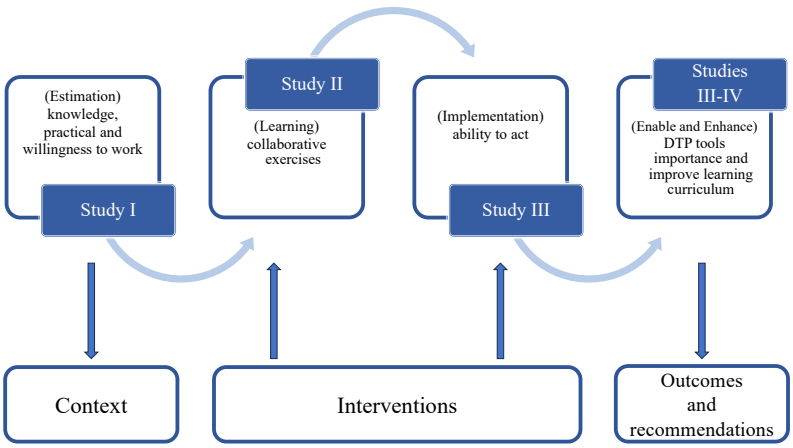

Figure 4 Overview of the studies in the doctoral thesis.

To achieve the objectives of this thesis, a mixed-methods approach was employed depending on its application, drawing from a pragmatist epistemological perspective [168, 169]. This approach prioritises research implications and questions over the choice of methods, leading to the use of various data collection methods that best address the research issues and provide a comprehensive understanding of the research problem [170, 171]. Such an approach was specifically chosen for exploring research problems where a single data source might be inadequate, such as in the evaluation of

CEs. Quantitative data sheds light on the effects and outcomes of CEs, while qualitative data provides deeper insights and explanations [169].

The application of mixed methods in this thesis was driven by several objectives that shaped the overall research design, including the convergence of quantitative and qualitative results for triangulation [172]. Therefore, during the analysis phase, both types of findings were integrated to gain a deeper understanding of the research problem.

POPULATION AND SETTING

The sample population for this doctoral thesis comprises HCWs (nurses, physicians, paramedics/emergency medical technicians and administrative), with varying education levels (diploma, bachelor, master and doctoral). The HCWs belong to ten hospitals affiliated with the MOH in the Najran region of the KSA. Najran's geographical location exposes it to a range of natural and man-made hazards, including flash floods, fires, sandstorms, challenges posed by the COVID-19 pandemic, terrorist attacks, and ongoing armed conflicts along the Saudi-Yemen border. The inclusion criteria for the study encompassed personnel actively engaged in disaster and emergency management from various positions and hierarchical levels, ensuring diversity across age groups and genders. Specifically targeted were those working in emergency departments (EDs), intensive care units (ICUs), hospital emergency planning and preparedness units (HEPPU), and disaster management teams (DMT).

The DMTs included leaders, managers, executives, and department heads responsible for functional tasks across multiple offices, departments, or facilities [173], including medical staff [174]. The sample covered a range of positions, such as hospital directors, medical directors, nursing directors, emergency and disaster directors, public health directors, financial directors, and directors of support services. For studies II and III, participants included those who were present for the entirety of the 3LC courses, ensuring comprehensive immersion in the training. In contrast, HCWs who could not attend the training, left early, or did not complete the survey post-collaboration exercises were excluded.

In studies I and IV, those who did not complete the survey, including individuals absent due to vacation or maternity leave during the study period, and personnel at the consultant or managerial levels were excluded.

OVERVIEW OF THE STUDIES

This PhD thesis utilised two main types of research methodology designs across four studies (see Table 3). The initial study, the process evaluation (Study I), involved quantitative data collection using questionnaires to assess HCWs' perceptions of theoretical knowledge, practical skills, and willingness to work. Quantitative methods offer the benefits of straightforward measurability and broader generalisability during data collection [175]. They are often more reliable due to the reduced influence of researcher bias.

Table 3 Overview of the included studies

Study	Study design	Sample	Data analysis
I	Quantitative (questionnaire)	Healthcare practitioners (*n*=213)	Descriptive statistics and comparative with effect sizes
II	Quantitative (intervention-specific questionnaire)	HCW's including managers/leaders (n=100)	Descriptive statistics
III	Mixed method (observational and semi-structured interviews)	HCW's including managers/leaders in observational (*n*=100) and in qualitative (*n*=20)	Descriptive statistics Directed content analysis
IV	Delphi technique and questionnaire	In Delphi technique (*n*=5) experts in disaster and emergency management, and in questionnaire (*n*=128) HCW's	Descriptive statistics

Quantitative research, using closed-ended questions, presents both advantages and limitations [176]. While allowing for concise data analysis and comparability, it may constrain the depth of responses [175]. Studies II and III were designed to assess the effectiveness of an intervention, incorporating both quantitative (questionnaire and observational) and qualitative (semi-structured interviews) data on the CE and teamwork efficiency. Observational methods enable real-time data collection [177], observing actions and dialogues without relying on self-reports or third-party accounts [178]. This approach yields objective and dependable results, reducing bias and subjectivity.

Semi-structured interviews offer deep qualitative insights [179], exploring participants' thoughts, emotions, and beliefs on specific topics, including sensitive ones [180]. This flexible format allows for probing follow-up questions, ensuring a focus on targeted subjects while preventing extraneous deviations [181].

Finally, Study IV evaluated the current disaster and emergency management curriculum, using qualitative (Delphi technique) and quantitative (questionnaire) data to assess the incorporation of CEs into the curriculum. The Delphi method involves gathering expert opinions through successive rounds of anonymous questionnaires [182], facilitating consensus-building without direct interaction [183]. This method is valued for its straightforwardness and effectiveness in curriculum development [184].

STUDY I

The primary objective of Study I was to assess HCWs' perceptions of their preparedness and willingness to work during DPHE in the southern region of the KSA.

STUDY DESIGN

This study employed a quantitative research design. A survey instrument was utilised to capture specific healthcare scenarios quantitatively. The survey focused on analysing behavioural traits, opinions, and attitudes exhibited by various stakeholders within the healthcare sector. This approach allowed for a structured and measurable assessment of HCWs' perspectives on their readiness and willingness to engage in emergency situations.

INSTRUMENT

Study I utilised a meticulously validated English-language version of the "Fight or Flight" survey. This survey's origins and conceptualisation were detailed in earlier studies [185, 186] and initially developed by the Centre for Research and Education in Emergency Care (CREEC) at the University of Leuven, Belgium. Designed to fill gaps in pandemic literature, the survey underwent refinement through a pilot study in a Belgian hospital and was later validated by a group of disaster medicine experts affiliated with the Flemish disaster management course (including CREEC personnel, emergency nurses, and military personnel). This led to the creation of a multi-centric version of the survey.

While the adapted survey does not directly examine the interplay of fear, stress, and emotion, it does provide essential data potentially linked to these factors. It also offers a comprehensive analysis of various dimensions of DPHE, tailored to the context of this study. The survey thoroughly evaluates numerous aspects within the healthcare sector, delving into the intricacies of the research focus.

The survey comprises two sections with a total of 60 items: the first section includes 12 demographic questions, and the second is scenario-based, featuring four distinct scenarios – "Willingness to go to work", "Knowledge", "Risk", and "Danger". Each scenario is further broken down into 12 dimensions affecting the work environment, presented as questions and illustrative examples. To gauge willingness to work under certain conditions, respondents indicated "yes" or "no". Additionally, they were asked to choose from a list of 10 prearranged conditions that would influence their decision to work during an incident. These conditions include considerations such as family safety, communication, leadership presence, training, updates, provision of personal protective equipment (PPE), financial incentives, access to medical prophylactics, antidotes, and vaccinations (see Appendix A for the full list).

Participants' perceived knowledge within each scenario was measured using a Likert scale ranging from 1 to 10, where 1 represents the lowest level of perceived knowledge and 10 is the highest.

SAMPLE

The study targeted healthcare professionals working in EDs, ICUs, and HEPPU. It included a diverse group of participants across various age groups and genders. The study's objectives and the necessity for informed consent were communicated to all healthcare personnel through the medical affairs administration of each hospital. A randomised approach was employed in selecting participants, which helped reduce selection bias by avoiding the preferential inclusion of certain groups [187]. This strategy aimed to achieve a representative sample by selecting healthcare randomly personnel from the rosters of ICUs, EDs, and disaster teams/units.

To determine the sample size, a calculation was conducted, resulting in a target of 250 healthcare practitioners. This calculation, performed using a tool by Raosoft Inc., Seattle, WA, USA, was based on an expected precision of 4.5%, a prevalence rate of 50%, and a total population size of 508 healthcare workers.

A 95% confidence interval was used to define the desired level of precision in the sample estimates.

DATA COLLECTION

The data collection for this study was conducted through a self-completion survey, administered using the SurveyMonkey platform. Participation was entirely voluntary, and participants were informed that they could withdraw from the study at any time without any obligation to provide a reason and without facing any consequences.

To minimise response bias, healthcare practitioners were asked to complete the survey on a designated research day. This scheduling approach was strategically planned to reduce any potential influences that might affect their responses. Participants were encouraged to provide accurate and honest information, which was crucial for ensuring the reliability and validity of the data.

In terms of data handling and privacy, informed consent was obtained from all participants prior to their participation. They were assured that their responses would be treated with confidentiality. The collected data were to be analysed, then stored anonymously in a securely locked cupboard at the Department of Research and Studies in Najran, KSA. Access to the data was restricted solely to the main author of the study.

DATA ANALYSIS

To evaluate the coherence of items within the "Fight or Flight" survey subscales, we conducted an analysis of homogeneity. This involved calculating Cronbach's alpha, a widely recognised measure of internal consistency. For this statistical assessment, the Statistical Package for the Social Sciences (SPSS) version 20, provided by IBM, Texas, USA, was utilised.

The calculated Cronbach's alpha for the survey was 0.927, indicating a high level of internal consistency. As highlighted by Brace et al. [188], this value confirms the reliability and validity of the survey's construct, meeting the established criteria for satisfactory internal consistency. The results of the survey were then presented descriptively, using actual numbers and percentages to detail the findings clearly and comprehensively.

STUDIES II AND III

Both Studies II and III were conducted within the same sample settings, focusing on HCWs and investigating the impact of interventions with CEs. The overarching aim of these studies was to assess and measure the effectiveness of the 3LC course exercises on enhancing teamwork within healthcare settings.

Specifically, study II aimed to gauge the impact of virtual 3LC course exercises on participants' perceived levels of collaboration, learning, and utility (CLU) in the context of a hospital environment. This study sought to understand how virtual training exercises influenced HCWs' perceptions and attitudes towards teamwork and their utility in a healthcare setting.

Study III focused on evaluating the development and evolution of healthcare teamwork dynamics by utilising the CSCATTT tool within CEs. The primary goal was to examine how these exercises contribute to fostering effective teamwork among HCWs and to identify any changes or improvements in team collaboration as a result of the training.

STUDIES' DESIGNS

In Study II, a quantitative research approach was utilised, employing a survey design to assess the efficacy of a specific intervention: a structured course exercise model based on the 3LC framework within hospital environments. The study used survey methodologies to determine the degree of success in achieving enhanced learning and the utility of the 3LC model among healthcare professionals. This quantitative method aimed to provide measurable outcomes reflecting the intervention's impact.

Study III adopted a mixed-method approach, combining observational techniques and semi-structured interviews. The study strategically integrated 3LC tabletop exercises, utilising the CSCATTT framework—a collaborative tool derived from the MIMMS course [87]. This approach aimed to generate quantitative data through direct observation of HCWs' performance and interactions during each phase of the simulated scenarios within the 3LC course. Following the course completion, qualitative insights were obtained through semi-structured interviews with participating HCWs. These interviews were a crucial element of the study's multifaceted mixed-method approach, providing in-depth understanding and contextualisation of the observed behaviours and interactions.

COURSE DESIGN

The course design revolves around a collaborative simulation exercise, skilfully integrated with a collaborative instrument to demonstrate stability, transition prowess, seamless interactions, and innovative thinking within a standardised framework. At the core of the course is the 3LC exercise, a validated model specifically chosen for its emphasis on collaboration, interagency engagement, and collective decision-making [164]. This model excels in enhancing team collaborative competencies and boosting perceived levels of learning and utility. It encourages adaptability, improvisation, joint evaluations, and breaking down organisational barriers [131, 189]. Central to the course are tabletop exercises featuring real-life simulated scenarios, navigated using the CSCATTT strategy. The MIMMS framework, which incorporates the CSCATTT approach, covers essential aspects of disaster response: command and control, safety, communication, assessment, triage, treatment, and transportation. The CSCATTT element is celebrated worldwide for its effectiveness and critical role in both military and civilian healthcare contexts [56, 190, 191]. These micro-exercises were meticulously designed to incorporate the CSCATTT framework, thereby standardising DPHE management. The scenarios for the exercises were derived from real-life Saudi hospital situations, situating the exercises in authentic healthcare contexts. This realistic approach ensures that the training is directly applicable to the environments in which the HCWs operate (see Table 4 for more details).

Table 4 The two scenarios adopted from realistic events within a hospital context for 3LC exercise courses in Najran, Saudi Arabia, in October and November 2020

Scenario one (Critical Care Unit Evacuation)	A healthcare team is operating in a critical care unit with ten patients aged 30 to 50, with three different categories.	The event: Hospital management has issued a warning that explosives have been discovered in the hospital's main building, posing a threat to the critical care unit. Moving or disarming the explosives within the next 2-3 hours is not feasible. Patients and employees must be evacuated immediately. The elevators are inoperable due to suspected bombs and triggers. External assistance is not anticipated. Patients must be transported from the 5th floor down to the ground floor using the stairwell. The commencement of the evacuation procedure must begin as soon as possible. The healthcare team is required to promptly provide hospital management with a detailed report within a 15-minute timeframe. The report should include their strategy, priorities, risk assessments, and potential losses.
Scenario two (Mass Casualty)	A healthcare team is dispatched from the hospital to a disaster site nearby.	The event: A post-Ramadan festival is taking place, and there have been reports of automatic guns being fired at the audience. You are notified of the casualties before your team leaves the hospital—approximately 100 people have either been killed or are injured. Although more teams are prepared, your team is the first in line. The area has been secured, and terrorists have been apprehended by the police and military. Approximately 10 ambulances arrive at the same time, including your ambulance. The police have cordoned off the area, which is a park in the town. There are approximately 75 people who are either wounded or dead, lying or sitting in the park. How do you act? You are supposed to submit a report to the hospital administration as soon as possible.

CONCEPTUAL FRAMEWORK

In Study III, two distinct theoretical models are methodically incorporated to assess teamwork development and bridge the knowledge-practice gap. These models are: (1) the integration of team members, as elucidated by Hall and Weaver [60] and (2) the team maturity model, as elucidated by Sandberg [156] (Table 5).

Table 5 Two analytical teamwork models

Model	Categories	Elaborate
Integration of team members	Multi-professional	Each member specialises in a distinct role suited to their expertise
	Interprofessional	Specialised members who interact collaboratively
	Trans-professional	Members with specialised roles who possess the autonomy to engage with other team constituents, readily stepping in for their peers when the need arises [60, 192]. Such interactions are contingent upon specific collaborative elements [56].
Team maturity	Immature	Exhibits loose interconnection between members, subgroup divisions, and a high degree of individualism with minimal focus on objectives and the organisation's mission.
	Mature	Characterised by robust interconnections, forming a coherent unit with a shared focus on primary objectives and the organisational mission.
	Overripe	This team is inflexible and exclusionary, resisting the inclusion of new members [156].

These frameworks not only elucidate the aspirations of high-performing teams but also illuminate the complexities of collaboration and team evolution, considering the varying degrees of integration and maturity [159]. To ensure effective team functioning, organisations should strive for the 'mature' classification [156, 192]. Tools, such as CSCATTT [56], can be instrumental in evaluating team maturity.

INSTRUMENTS

Study II employed an English version of the CLU Scale. This scale is a rigorously validated survey tool of Swedish origin, thoughtfully crafted to measure exercise participants' perceptions of collaboration, learning, and utility. This survey instrument underwent a developmental process guided by experts in the field of emergency and disasters management. The design of the CLU Scale was influenced by various theoretical frameworks, including the differentiation of sequential, parallel, and synchronous collaboration [164], as well as the learning theories derived from the perspectives of Stein [124] and Klabbers [129], which account for the nuances between the first and second learning degrees. Similarly, previous investigations have used the CLU tool for assessing CEs [124, 193]. In addition, the CLU tool has been used in similar studies and collaboration exercises [126, 132, 194]. The survey consisted of two sections comprising 22 items. The first section encompassed five questions related to demographics, while the subsequent evaluation section encompassed 17 items (see Appendix B). This evaluation section was further divided into three dimensions: collaboration (C), learning (L), and utility (U). The collaboration dimension aimed to assess participants' perceived attributes of collaboration. Meanwhile, the learning dimension focused on lessons derived from collaboration, and the utility dimension delved into applying acquired knowledge to real-world scenarios. Participants' perspectives were captured employing a 5-point Likert scale that extends from 1 (strongly disagree) to 5 (strongly agree), enabling nuanced feedback regarding their experiences.

The tool used in Study III is an observation model to monitor each group's performance and procedural evolution across the two scenarios. This tool primarily focused on time within the 13 elements surrounding the CSCATTT framework (see Appendix C). These elements covered the time required for a wide range of tasks, from appointing a leader, setting up the organisation, achieving consensus in the team, distributing tasks among team members, prioritising activities, identifying external resources, assessing the progress of the mission (making new decisions or ending the mission), evaluating the progress of the exercise (need for new inputs after discussion with exercise leaders or cancelling the exercise), making the main decision, triaging, treatment, documentation, and reporting to senior management. Additionally, the second tool used (Study III) was a qualitative approach, involving interviews (see Appendix D). This systematic approach, based on the principles of Holloway and Galvin [181], engaged voluntary HCWs who

participated in the 3LC courses. These interviews seamlessly integrated theoretical models of team member integration and team maturity into the discourse, affording interviewees a comprehensive understanding.

SAMPLE

Studies II and III encompassed healthcare leaders who engaged actively in their roles and were enrolled in the 3LC training courses voluntarily. These participants held diverse positions spanning both the operational and tactical tiers of healthcare management. Notably, the positions represented within the sample included hospital directors, medical directors, nursing directors, emergency and disaster directors, public health directors, financial directors, and directors of support services. The sample size was determined using a power calculation approach (Raosoft Inc., Seattle, WA, USA). With a precision level of 4.5% and a prevalence rate of 50%, both studies aimed to include (n = 100) healthcare managers/leaders and workers in the sample. This size was chosen to ensure robust population representation, considering a total population size of 124 individuals within the specified limits of a 95% confidence interval. The overall sample in the survey of Study II (n = 100) as was the same sample for the observational approach in Study III, while in the semi-structured interviews, the sample size was (n = 20). Due to government regulations, managers and leaders must be Saudis; thus, most of the participants were Saudi nationals.

DATA COLLECTION

The COVID-19 pandemic, which resulted in international airport closures, made it necessary to shift to virtual meetings for data collection. These meetings enabled collaboration between experts from Sweden and Norway and experienced disaster management health practitioners from the KSA. The initial phase of this collaboration involved training five skilled healthcare leaders by these experts. The goal was to provide thorough training in the course scenarios, equipping these leaders with the skills and knowledge necessary for effective on-ground implementation and supervision of the 3LC course stages.

Figure 5 Theoretical lectures from the Saudi side. Photograph by M. Sultan with consent form of participants, Najran, 13 October 2020.

The 3LC training courses were conducted three times, each following a consistent structure that included lectures and tabletop simulation scenarios. These sessions took place between October and November 2020. The first course was held virtually, connecting experts from Sweden, Norway, and Saudi Arabia with participants in Saudi Arabia. This setup created a dynamic online learning environment (see Figure 5).

Figure 6 Theoretical lectures from the Saudi side. Photograph by H. Algraad with consent form of participants, Najran, 18 November 2020

The educational structure of the courses involved delivering theoretical lectures to the enrolled participants. Subsequently, the trainees were divided into four groups, each including a nurse, a leader, a physician, and a support services staff member. These groups engaged in collaborative tabletop exercises within simulated scenarios (see Figure 6). Detailed instructions were provided to guide their participation in these exercises, which involved two carefully designed simulated scenarios (see Table 4 for details).

The exercise leaders presented each scenario with a set timeframe for participant engagement. The Saudi exercise leaders observed, monitored, and recorded the actions and performances of the participants as they embarked on their scenario-based tasks. Upon completion, each team independently presented their approach to managing the scenario. This was followed by a concise review of key points by the exercise leaders. Participants were encouraged to reflect on the scenario, considering alternative strategies and actions for similar situations. Throughout this reflective process, exercise leaders documented all actions and interactions at each team's table meticulously, ensuring a comprehensive record of the exercise proceedings.

STUDY II PROCEDURE

Participants in Study II were informed that their involvement in the study and their responses to the CLU survey would be used solely for research purposes. Participation was entirely voluntary, with an emphasis that they could withdraw at any time without providing a reason and without facing any penalties.

Figure 7 Leaders count the time while the participants are working on scenarios. Photograph by H. Algraad with consent form of participants, Najran, 13 October 2020.

The online CLU survey instruments were integrated within the 3LC platform and distributed individually to each participant (n = 100) via email. Before participating, informed consent was obtained, assuring participants of the confidentiality of the data collected. They were also informed that their data would be processed, analysed, and stored anonymously in a securely locked cupboard at the Department of Research and Studies in Najran, KSA. Access to this data was restricted exclusively to the main author of the study, ensuring data privacy and integrity.

STUDY III PROCEDURE

Observational Approach:

In the observational component of Study III, the performance and procedural evolution of participants (n = 100) in the 3LC simulation training were monitored using an observation model. This model focused on time and 13

pivotal elements of the CSCATTT framework to assess each group's performance and practical progress in two scenarios. An observer was assigned to each group to track these elements specifically (see Figure 7).

Figure 8 One of the trainees (a team leader) presents his team's skills in handling the scenario to the Swedish-Norwegian experts by virtual call through Zoom. Photograph by J. Berlin with consent form of participants, Gothenburg, 13 October 2020.

Following each scenario, exercise leaders conducted comprehensive discussions on the observed performances and practical progress to reach a consensus and identify areas for improvement. Observers paid particular attention to the participants' adherence to the CSCATTT elements, including the identification of a leader and the orchestration of collaborative teamwork.

The effectiveness of commanders in incident management and the team's ability to transition through different response levels were also evaluated. The event sampling technique was employed [195], focusing on relevant behaviours and facilitating "hot wash-up discussions" to analyse observational data and plan enhancements for each scenario (see Figure 8).

Interviews Approach:

Semi-structured interviews were conducted by the lead author, primarily face-to-face, using open-ended questions. This approach, based on Holloway and Galvin's principles [181], involved voluntary HCWs who participated in the 3LC courses. The discussions integrated theoretical models of team member integration and team maturity.

Purposive or convenience sampling was used to select participants who could provide in-depth insights [181]. The introduction of theoretical frameworks before the interviews primed respondents to reflect on their experiences within these concepts [196, 197]. Out of 100 invited participants, 34 consented, with 20 ultimately participating, indicating data saturation through recurring themes [198].

Participants were informed that their involvement was voluntary and solely for research purposes, with the option to withdraw at any time without facing any penalty. Informed consent was obtained before the interviews, ensuring confidentiality in data handling. Data would be stored anonymously in a locked cupboard at the Department of Research and Studies in Najran, KSA, accessible only to the main author.

A pilot study involving critical care personnel preceded the main data collection phase, which led to the development of a finalised interview guide encompassing demographic information and ten probing questions (see Appendix D). Each interview lasted between 50 to 60 minutes and was recorded and transcribed verbatim. The lead author maintained field and reflective notes throughout the data collection process to document learning moments and reflect on participants' responses.

DATA ANALYSIS

Study II:

In Study II, SPSS version 20, provided by IBM, Texas, USA, was utilised to compute Cronbach's alpha for the CLU survey items. A Cronbach's alpha value of 0.987 was obtained, indicating a strong level of internal consistency and confirming the reliability of the survey [188]. Additionally, regression analysis was conducted to explore significant relationships between independent and dependent variables. A multivariate regression analysis incorporated all relevant variables identified in the bivariate analysis, allowing

for a comprehensive examination of the factors influencing the study's outcomes.

Study III:

For the quantitative data gathered in Study III's observational approach, analysis was performed using Microsoft Excel. The qualitative data collected through interviews were analysed using the directed content analysis method, as outlined by Hsieh and Shannon [166]. This method excels in its ability to enhance and support a theoretical framework, conceptually enriching the existing foundation and focusing on specific research questions [166].

Potter and Levine-Donnerstein [199] suggest treating this approach as a directed analysis strategy, emphasising its utility in developing a deeper understanding of the data. The initial phases of analysis concentrated on comprehensively grasping the nuances of the data, particularly in the context of fostering collaboration among HCWs in the KSA during DPHEs. This in-depth analysis aimed to provide valuable insights into the phenomenon of collaboration in the healthcare sector during emergency situations.

STUDY IV

The primary objective of Study IV was to critically assess and evaluate the need to enhance the current disaster and emergency management curriculum in the KSA. This enhancement involves incorporating elements of the CSCATTT framework and integrating disaster exercises using the same collaborative tool.

STUDY DESIGN

This study employed a dual-methodology approach, utilising both a Delphi study with experts and a survey targeting practitioners in the field of disaster and emergency management.

INSTRUMENTS

The Delphi technique, informed by previous research utilising the CSCATTT instrument, was adopted for this study. It involved a series of statements (refer to Table 6) about the current disaster and emergency management curriculum in the KSA. The main and last authors developed these statements in collaboration.

Table 6 The statements obtained using the Delphi technique.

No	Statements: The current Nursing Curriculum in Saudi Arabia:
1	Covers the essential knowledge in command and control. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
2	Enhances the role of leadership. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
3	Covers all risks areas affecting the KSA (Risk assessment). 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
4	Enhances and enables the learner in the management of diverse risks. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
5	Increases the willingness and confidence of staff to report to work. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
6	Increases knowledge in internal and external communication. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
7	Enhances and promotes multi-agency collaboration. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
8	Enables mutual assessment of the situation with other agencies such as the police, etc. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
9	Offers multi-agency training and exercises. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
10	Offers training in a diverse risk environment, such as a pandemic, mass casualty, etc. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree

11	Increases staff's knowledge and skills in triage. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
12	Increases staff's knowledge and skills in medical treatment. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
13	Increases the coordination and cooperation in transport issues. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
14	Enables e-learning and distance training. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
15	Any shortcoming in the current education is due to the lack of instructors. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
16	Collaborative tools, linking different agencies, is the only change needed. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
17	Does not need any changes and is perfect as it is. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree

Prior to the main study, a pilot test was conducted with a group of 20 individuals experienced in emergency and disaster management. These participants were not included in the study sample. The pilot test aimed to evaluate various attributes of the survey, such as clarity, readability, feasibility, comprehensibility, and suitability for the intended audience. This process, known as assessing face validity, is a crucial preliminary step in survey development, ensuring that the instrument aligns with its objectives and the target audience effectively [200].

The statements derived from this process were incorporated into the survey technique (see Appendix E). Participants were provided the opportunity to rate each statement on a Likert scale ranging from 1 to 5, where the responses corresponded to 1 (completely disagree), 2 (disagree), 3 (I do not know), 4 (agree), and 5 (completely agree).

SAMPLE

In the Delphi study component of Study IV, the developed statements were distributed to a group of five experts specialising in disaster and emergency management. The survey, on the other hand, targeted a cohort of 128 HCWs with experience in the disaster and emergency fields. This sample was chosen to ensure diverse representation across various age groups and genders.

The self-completion survey was administered using the Google Forms website, which provided an accessible and user-friendly platform for data collection. Each participant received information about the study's purpose and objectives, with an emphasis on the voluntary nature of their participation. They were informed of their right to withdraw from the study at any time without facing any consequences.

Additionally, participants were assured of the confidentiality and security of their personal information. They were told that the collected data would be analysed and then stored anonymously in a securely locked cupboard at the Department of Research and Studies in Najran, KSA. Access to this data was restricted solely to the main author, ensuring the privacy and integrity of the collected information.

DATA COLLECTION

In the Delphi technique component of Study IV, a series of statements were emailed to five experts in disaster and emergency management, each boasting extensive experience ranging from 15 to 30 years. These experts participated in three iterative rounds of the Delphi process. The main author was responsible for overseeing the data collection process throughout these rounds.

Following each round, the statements were rigorously reviewed, refined, clarified, and enhanced based on the feedback from the panelists. This iterative process continued until a unanimous consensus was reached among the experts. This consensus validated the feasibility, comprehensibility, and face validity of the statements. The Delphi technique was chosen for its suitability in achieving the research objectives. It facilitates expert consensus, allows for remote participation, offers an iterative framework, reduces cognitive biases, and ensures participant anonymity [184].

The expert panel's feedback, suggestions, and comments were meticulously integrated into the statements. These revised statements were then presented

to the survey participants, including national experts and practitioners in disaster management. Once the survey statements had undergone thorough refinement and face validity assessment, the survey was distributed to the target group of the study. Respondents were invited to evaluate each statement using a Likert scale, providing an opportunity for detailed assessment.

DATA ANALYSIS

The data analysis for Study IV was conducted by the main author, who then shared the de-identified dataset with all collaborating authors for further review. Utilising SPSS version 20, provided by IBM, Texas, USA, an assessment was performed of the homogeneity within the subscales of the survey statements. This assessment involved computing the Cronbach's alpha coefficient.

The computed Cronbach's alpha value of 0.923 indicated strong internal consistency, aligning with the criteria for satisfactory reliability as established by Brace et al. [188]. The results of the analysis were presented descriptively, using actual numerical values and corresponding percentages to articulate the findings and implications of the survey clearly.

ETHICAL CONSIDERATIONS

This thesis adheres to the ethical guidelines of Sweden, where the PhD student is registered, and to the ethical rules and regulations of the KSA, where the studies were conducted, and where the data were stored, analysed, and evaluated. Below is a brief description of the ethical approach for all studies, in compliance with these guidelines.

In general, all studies conform to the guidelines and instructions specified by the Swedish Ethical Review Act ("etikprövningslagen"). This means that the research did not involve any sensitive or unlawful information about participants, who participated voluntarily without exposure to any physical or mental harm. This includes avoiding tests or sampling that require laboratory analysis or registration in a biobank. Participants were assured of the secure storage of the data, the ability to access their data, and the freedom to withdraw from the study at any time for any reason. All data were processed, analysed, and stored anonymously, either in hard or soft copy, in a locked cupboard at the Department of Research and Studies in Najran, KSA, with the main author having sole access.

According to the laws of KSA, collected data must be destroyed within five years unless specified otherwise for research studies aimed at obtaining educational degrees, such as master's or PhDs. These can be continued with updates every six months until the study period is complete. The main author is responsible for notifying the holder with written confirmation of data destruction via email or another memo. When discarding printed material containing confidential information, a chain of custody control process is employed to ensure secure transportation and storage until the material can be recycled into a paper pulp.

Ethical approval for each study was sought from the Institutional Review Board (IRB) at Najran's Regional Health Directorate (RHD) to provide total compliance with existing standards and protocols on social surveys, and granted by the appropriate entity before any data collection commenced as follows:

1. Study I (IRB Log Number 2020-27 E—Date of approval: 1 July 2020).
2. Study II (IRB Log Number 2021-19 E; date of approval: 7 April 2021).
3. Study III (IRB Log Number 2021-19 E; date of approval: 7 April 2021).
4. Study IV (IRB Log Number 2022-12 E; date of approval: 13 December 2022).

RESULTS

This chapter presents a summary of the findings from each study, aiming to provide a comprehensive understanding of all four studies. The goal is to inform the outcomes of CEs and the development of medicine curriculums focused on disaster management, particularly among HCWs teamwork in the KSA.

STUDY I

Study I explored the perceptions and preparedness of 213 HCWs in the southern region of the KSA concerning disasters and emergencies. This region, which frequently faces both man-made and natural hazards, provided a relevant context for the evaluation. The study revealed that, despite having undergone extensive disaster management training, participants exhibited a conditional willingness to provide care. They were generally more willing to respond to natural disasters and seasonal influenza pandemics than to other types of emergencies.

The research highlighted the significant role of advanced educational qualifications in influencing HCWs' willingness to engage in disaster response. While there was evidence of theoretical preparedness among the participants, their enthusiasm for active participation in disaster scenarios varied. Notably, although most participants held university degrees, this did not necessarily translate into a universal willingness to actively engage in disaster response.

Risk perception was identified as a crucial factor affecting frontline healthcare workers' readiness to respond. Concerns about personal safety, the well-being of colleagues, and family responsibilities were particularly pronounced during pandemics. Moreover, experiences in handling specific disasters, such as managing COVID-19 cases, influenced their intentions to continue their jobs under such conditions.

The research emphasised the importance of HCWs having both knowledge and assurance regarding the safety of their families. This dual requirement was deemed essential to bolster their confidence in effectively managing emergencies. The study advocated for tailored disaster-specific training to enhance HCWs' competence and confidence while alleviating their concerns.

Concerns were raised regarding staff refusal to work in certain disaster scenarios, emphasising the need for immediate action to address these issues. The study also investigated the relationship between various factors, such as age, education level, and willingness to work. A small negative correlation was found between the level of education and the fear of danger.

To address these challenges, the study recommended focusing on multi-agency and multi-professional training for HCWs, regardless of their roles. Such training is crucial for enhancing collective disaster response capabilities. The lack of adequate education and training was identified as a significant obstacle to establishing an effective disaster response system. This issue, along with concerns about the availability of PPE and assurances regarding family safety, must be addressed to improve disaster response readiness among HCWs.

STUDY II

Study II involved 100 HCWs who voluntarily participated in the 3LC training courses. This study focused on assessing the impact of virtual disaster collaboration exercises on disaster management within healthcare facilities. It highlighted a favourable perspective on web-based learning, emphasising its effectiveness as an educational approach. The study advocated for the integration of comprehensive disaster management content into class syllabi, encompassing rigorous preparation, practice operations, and simulations. This approach was particularly beneficial for enhancing the skills of healthcare professionals with less experience in emergency departments and units.

The virtual tabletop exercises yielded promising outcomes, with participants overwhelmingly agreeing that these drills emphasised teamwork, enhanced learning, and were applicable to real-life tasks. The findings underscored the importance of collaboration in daily duties and addressing workplace challenges. Moreover, a significant correlation was observed between participation in the activities, improved collaboration, and enhanced knowledge.

Participants perceived the teamwork exercises as instrumental in boosting learning and positively impacting the effectiveness of the 3LC course. The results of multiple regression analysis further confirmed this positive effect, showing a strong correlation between learning aspects and the usefulness of the exercises. The study also highlighted the importance of clear guidance and opportunities for "hot wash-up discussions" during and after exercises as

crucial for effective learning. These discussions proved valuable for making on-the-spot adjustments, conducting collective evaluations, and experimenting with new approaches across different sectors, thus fostering successful crisis management.

The inclusion of teamwork activities in the training was found to contribute to robustness, adaptability, and effectiveness in managing disaster scenarios. These activities were pivotal in bridging academic learning with practical experience, particularly during real-life catastrophes. Participants valued the opportunity for dialogue and reflection, highlighting the importance of open discussions and conversations to complement practical sessions. Such integrative approaches help in incorporating real-life occurrences into academic curricula, thereby enhancing the overall learning experience.

STUDY III

Study III focused on the significant role of culture, knowledge, and skills in managing DPHEs. It involved the observation of 100 HCWs who voluntarily participated in 3LC training courses, complemented by interviews with 20 of these participants.

The study revealed the positive impact of CEs on enhancing participants' knowledge, skills, integration, collaboration, and confidence. The utilisation of 3LC as a collaborative exercise method, coupled with the CSCATTT framework as a collaborative tool, proved effective in facilitating these improvements. The repetitive nature of the training was particularly instrumental in augmenting HCWs' proficiency and confidence in handling DPHEs.

A recurring theme in the study was the critical importance of trust in fostering successful collaboration. Continuous training was seen as a key strategy for building and strengthening trust among HCWs, thereby promoting effective cross-sectoral collaboration in DPHE management. Insights from participant interviews suggested that the combination of 3LC and CSCATTT contributed to improved role distribution, enhanced professional thinking, and reduced fear of errors among healthcare staff. Specifically, CSCATTT was noted for its ability to address organisational barriers, bolster collective skills, and alleviate limitations.

A physician at Hospital D said the following:

'*I learned how to face and how to prepare for disaster according to the given criteria. I learned much more about how to manage a situation well when we are facing a disaster. And it improved our skills and gave us a plan to make our experience much better while we are through exercises. We got much knowledge from that, so it is very beneficial with all the professionals who undergo such an exercise'*.

(Physician ER Hospital D)

In addition, Nursing Director at Hospital E said the following:

'3LC was a very wonderful experience, and I got an opportunity to learn the things, how to put on a practical basis and gain knowledge and skill while doing this exercise; so, it's great, and I recommended for all that they should have these exercises'.

(Nursing Director, Hospital E)

The exercises provided a safe space for multi-agency dialogue, enabling participants to learn from mistakes and experiment with new strategies. The study observed a notable evolution in teamwork integration and maturity, with exercises employing a trans-professional approach. This approach enabled HCWs to adapt to diverse conditions and collaborate towards a shared goal. Immature behaviour, characterised by insufficient knowledge and skills, was recognised as a challenge that could be surmounted through repetitive scenario-based training.

In addition, a hospital director at Hospital E said the following:

'Based on my interpretation of the team at the beginning of the 1st scenario, the plan and the way of thinking were immature. I really have the flexibility and imposed with the team in their own enthusiasm to accept the new concept and we were willing to apply in the area of their practice'.

(Hospital Director, Hospital E)

An understanding of Saudi culture and its influence on emergency management emerged as a crucial aspect. Cultural traits, such as a focus on

continuous improvement and leadership guidance, were found to significantly affect how healthcare teams operate during emergency situations.

The study recommended continuous training to enhance collaboration and teamwork, encouraging HCWs to exchange ideas, knowledge, and skills in disaster management. Furthermore, participants highlighted the importance of public awareness and education in effective disaster management. Utilising CSCATTT elements for public education campaigns in schools, markets, religious venues, and other public places was suggested. This comprehensive strategy aims to improve the overall DPHE management system in the KSA, focusing on both augmenting healthcare professionals' capabilities and increasing public preparedness.

STUDY IV

Study IV focused on identifying gaps in the disaster management curriculum within the healthcare context in the KSA, particularly in relation to DPHEs. The study involved 128 HCWs from the Ministry of Health hospitals in the KSA.

A key finding of the study was the critical need for improved collaboration, coordination, and meaningful cooperation among various agencies, aspects currently underrepresented in the existing curriculum. The study highlighted specific deficiencies in addressing the elements of the CSCATTT framework. Notably, while aspects such as triage, treatment, and transport received some attention, the initial components, such as command and communication, were inadequately covered.

To address these shortcomings, the study suggested integrating collaborative tools into both theoretical and practical aspects of education, including disaster exercises. Emphasising practical, collaborative components in the curriculum was deemed essential for enhancing emergency medicine skills.

Key areas identified for improvement and development included:

a) Enhancing healthcare professionals' knowledge in disaster management and emphasising safety considerations for HCWs during DPHEs.
b) Fostering cooperation among multiple agencies and incorporating extracurricular activities into the disaster management curriculum.

c) Recognising the value of CEs in achieving educational objectives.
d) Updating the current curriculum to incorporate various risk management strategies, improve internal and external communication, ensure effective coordination in transportation matters, and adopt e-learning and remote training methods to address the scarcity of instructors.
e) Acknowledging the need for a global perspective, as the study's findings could be pivotal for other developing countries facing similar challenges in disaster management education.
f) Updating the curriculum to align with global standards, ensuring that the training provided is current, comprehensive, and relevant.

These findings underscored the necessity of conducting a comprehensive review and enhancement of the disaster management curriculum in the KSA. The goal is to equip healthcare professionals with the skills and knowledge required for effective DPHE management.

DISCUSSION

This thesis provides an in-depth exploration of the level of preparedness and the outcomes of CEs on disaster management among nurses and other healthcare workers in the southern region of the KSA.

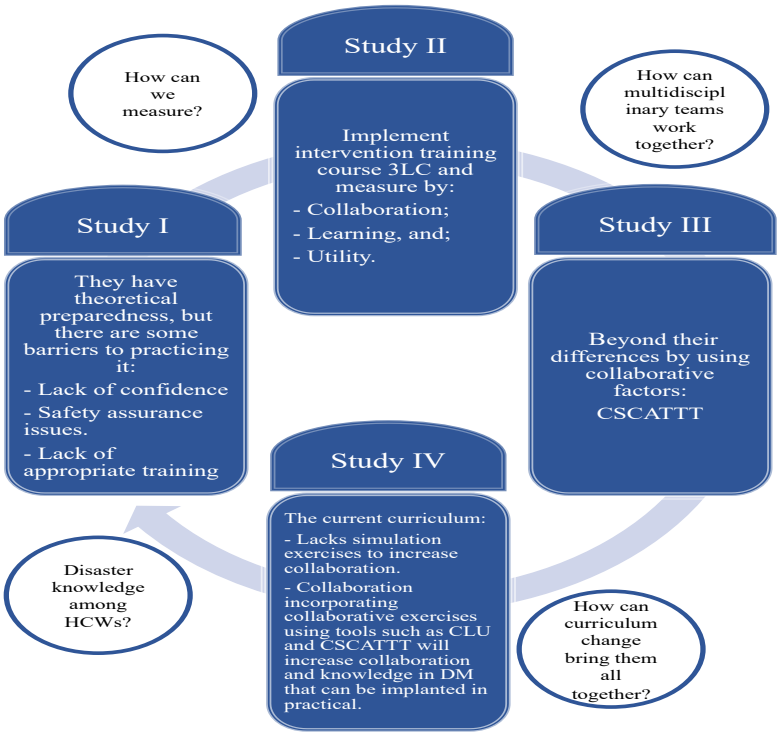

Figure 9 The connection between Studies I–IV.

Through four research papers, each study provides valuable insights into the current state of readiness, the effectiveness of various training and educational approaches, and potential strategies for enhancing disaster response capabilities among HCWs. The connection between Studies I–IV, visually represented in (Figure 9), contributes to the field of disaster preparedness and emergency response, specifically within the healthcare context in the KSA.

BARRIERS TO WILLINGNESS AND WORK DURING DISASTERS

The findings from Study I highlight significant barriers to HCWs' willingness to respond unconditionally during disasters and emergencies, despite undergoing substantial disaster management training. This reluctance points to a potential gap in their understanding of the diverse nature of emergencies and underscores the need to address the unique needs and concerns of healthcare personnel in crisis situations [201].

A crucial factor identified is the adequacy of safety measures, such as PPE and concerns regarding individual security and the well-being of family members. Implementing measures to ensure the protection and welfare of healthcare employees' families during emergencies could play a significant role in alleviating some of the apprehensions that hinder their willingness to respond [202]. Apprehensions about personal safety, concerns for colleagues, and family considerations are highlighted as significant constraints during pandemics [203]. This human aspect of disaster response, often overlooked, is of immense importance in understanding and addressing the barriers to HCWs' readiness [202]. The study also sheds light on the psychological impact of handling pandemic cases on job-retention intentions among frontline healthcare workers. This insight underscores the long-term effects of being on the front lines during a major health crisis, emphasising that addressing safety and well-being concerns is crucial both during and after a crisis [204]. This approach could help mitigate potential burnout and psychological distress among HCWs [202].

Furthermore, the study advocates for a focus on comprehensive teamwork and diverse professional education. Disasters are inherently complex and require a cooperative, cross-disciplinary approach to management. Enhancing united

disaster response involves not only specific medical staff but also the broader healthcare framework and decision-makers [131]. This holistic approach is essential for effective disaster preparedness and response, ensuring that all aspects of healthcare personnel's needs and concerns are addressed [131, 205].

USEFULNESS OF COLLABORATION EXERCISES

Studies II and III underscore the positive impact of CEs on the performance of HCWs. These activities not only facilitate the learning of new concepts and organisational aspects but also enhance understanding of effective communication patterns.

In Study II, the practicality of collaborative education is highlighted, showcasing its direct applicability to real-life healthcare activities. The rationale for studying collaborative education was based on the outcomes of Study I, which underscored the importance of focusing on comprehensive teamwork among staff with diverse educational, cultural, and linguistic backgrounds. This kind of learning proves beneficial for healthcare professionals across various roles, from command positions to operational tasks [206]. These skills are crucial for navigating the complexities of disaster response, transcending the immediate context of disaster management to influence everyday healthcare operations. For command officers, the incorporation of collaboration-focused courses and exercises is particularly valuable [131]. Their role in orchestrating response efforts is significantly enhanced by improved collaborative skills, including communication, coordination, and cooperation [87, 207]. This is essential for a well-coordinated and efficient disaster response [105]. Conversely, for operational staff, the benefits of collaborative education are equally significant. In the often-chaotic environment of a disaster, the role of each team member is critical. Effective communication, prioritisation of activities, and inter-agency collaboration ensure that operational staff contribute meaningfully to the response efforts, collectively strengthening the disaster response system [105].

Based on Hofstede’s [94] findings on power distance and vertical relationships, CEs can be utilised to address cultural challenges, including those present in the KSA. These exercises can assist in establishing seamless transitions between organisations, effectively managing various aspects of an incident and maintaining a stable collaborative network. Robertson, Al-Khatib

and Al-Habib [96] confirmed Hofstede´s [94] findings, emphasizing the need to realize the challenges aligned with the hierarchical levels of each Arabic organisation, hierarchical structure, values, and work beliefs. Furthermore, learning from similar incidents in other organisations can be challenging due to entrenched behavioural patterns and organisational resistance to learning from past errors [131, 208].

Borodzicz and Van Haperen emphasise that in scenarios where not all organisations are present, there is a tendency to focus on specific training tasks to the detriment of the broader context [209]. Employees often willingly engage in familiar tasks but may exhibit passivity towards unfamiliar responsibilities [165, 209]. In contrast to Corbacioglu and Kapucu [210], who propose exercises focused on designated tasks, collaboration exercises are designed to motivate employees and prepare for spontaneous initiatives beyond their immediate responsibilities. This adaptive approach involves identifying, documenting, shifting focus, and reallocating resources as the situation evolves, promoting a more dynamic and responsive approach to disaster management [131, 211].

TEAMWORK INTEGRATION AND MATURITY

Study II revealed that collaboration provides learning that can later be applied within the organisation. However, while this is true when dealing with one organisation, multi-agency management can differ, as it involves several organisations with diverse backgrounds and roles. Thus, collaborative factors such as CSCATTT might be used to connect these organisations and unify their goals (collaboration). The CSCATTT approach provides a standardised framework that has enabled health professionals from different backgrounds to come together as an integrated team, even across different agencies. The results of Studies II and III demonstrated that CSCATTT reduced communication barriers that often hinder collaboration between multi-professional HCWs, as reported by Ohta et al. [212] in their study. According to Horne, Gurney and Smith [213], collaborative tools facilitate a simple assignment division tailored to the specific skills and expertise of each participant. On the other hand, the findings of Study III emphasise the importance of teamwork integration and maturity in the effective management of DPHEs.

Study III underscores the necessity of a trans-professional approach, enabling HCWs to adapt to diverse conditions and collectively strive towards common

objectives. This approach is particularly relevant in the context of the KSA, where cultural and hierarchical traditions significantly influence teamwork dynamics [94, 214]. Linking immature behaviour to inadequate knowledge and skills indicates that developing maturity in HCWs goes beyond age or experience [215]. It involves continuous learning and exposure to a variety of scenarios. This understanding aligns with the concept that ongoing training is instrumental in enhancing HCWs' efficiency and confidence [216, 217]. In addition, Study III revealed that healthcare professionals from different organisations often experience difficulties in working together because of differences in culture, governance, goals, expectations, and communication practices. However, the implementation of the CSCATTT tool has helped improve collaboration between different health professionals in disaster modelling exercises. Naturally, in the KSA, the cultural emphasis on continuous improvement and leadership guidance is particularly important due to the cultural challenges present, necessitating its inclusion in training programmes to bolster the adaptability of healthcare teams.

Leadership plays a critical role in fostering teamwork integration and maturity [218]. Effective leaders not only guide healthcare teams, but also cultivate a culture of continuous improvement and adaptability. Training programmes, therefore, should incorporate modules that enhance leadership skills, focusing on the ability to adapt to dynamic situations and inspire confidence among team members [219]. Furthermore, addressing the emotional well-being of HCWs is essential for achieving maturity in crisis situations. High-stress environments demand not only technical proficiency but also emotional resilience. Training initiatives should therefore include components that focus on psychological support and resilience-building [220]. Integrating such aspects within the disaster management framework is crucial for a holistic approach to healthcare worker preparedness [204, 221].

In summary, the findings from Study III suggest that fostering teamwork integration and maturity among HCWs in the KSA requires a multi-faceted approach. This includes continuous training, leadership development, cultural adaptability, and psychological support, all of which contribute to a more effective and resilient response to DPHEs.

IMPROVING LEARNING ACROSS COURSES AND CURRICULUM

The findings from Study III advocate for the incorporation of collaborative tools into both theoretical and practical aspects of healthcare education. A particular emphasis is placed on disaster exercises that mirror real-life scenarios, providing healthcare workers with opportunities to practise collaboration in a controlled yet realistic setting [222, 223]. Such exercises are critical for involving multiple agencies, reflecting the true complexity and dynamics of disaster response.

The integration of advanced technologies, such as simulation tools and virtual reality, is proposed to enhance the realism and efficacy of these training exercises [224]. This approach allows healthcare professionals to experience and navigate various challenges in an immersive yet controlled environment [131]. Studies II and III support the idea that these activities should be a core component of the disaster management curriculum, directly contributing to the enhancement of disaster and emergency medicine skills. Besides medical expertise, the incorporation of collaborative elements in the curriculum enables healthcare professionals to acquire organisational skills, understand communication patterns, prioritise activities, and become familiar with concepts and abbreviations specific to disaster management [225, 226]. This comprehensive learning approach equips them not only with medical knowledge but also with the capability to function effectively within a collaborative disaster response framework.

Study IV offers several recommendations for enhancing the current curriculum. These include implementing diverse risk management strategies, improving internal and external communication, coordinating transportation efforts, and utilising e-learning and remote training to address the scarcity of instructors [227]. The need for continuous updates to the curriculum is highlighted as essential for keeping pace with evolving challenges [228]. Survey results from Study IV emphasise the importance of incorporating CEs into the disaster and emergency management curriculum. These exercises, which include extensive preparation, practice drills, and simulations, are essential for preparing healthcare professionals for crisis situations [125, 126, 135, 211]. Participants in Studies II and III viewed these activities positively, recognising their efficiency and necessity in crisis preparedness.

The outcomes also stress the importance of precise guidance, opportunities for discussion, and post-activity evaluations as critical components of a successful learning programme. Collaborative resources facilitate these aspects by enabling real-time conversations, discussion boards, and interactive sessions [135, 229, 230]. The emphasis on improvisation, shared assessment, and experimenting with new tactics underscores the role of collaborative resources in enhancing learning programmes [125-127]. These resources serve as adaptable tools, adjusting to emerging challenges and providing a platform for continuous improvement [69, 90]. Participation in activities that simulate real-world disaster scenarios is vital for honing the ability of HCWs to communicate effectively with diverse stakeholders [231]. Understanding the dynamics of command and coordination becomes crucial, influencing how individuals contribute to decision-making processes during emergencies [132, 135].

THE FUTURE AND VISION OF DISASTER MANAGEMENT

Study III acknowledges that the gaps in disaster management education in the KSA likely mirror those in other developing countries. This research extends beyond national boundaries, underscoring the necessity of a global perspective in remedying deficiencies in disaster management training. The collaborative models and best practices identified in this study offer valuable insights that could benefit nations facing similar challenges. Study IV champions the standardisation and international cooperation in disaster management education. Aligning educational methodologies with international standards allows countries to leverage shared knowledge and experiences [232]. Standardisation ensures that healthcare professionals possess universally recognised skills, vital for effective collaboration in multinational disaster response initiatives [233].

The future of disaster management in the KSA, as suggested by Studies I to III, hinges on the continuous training of healthcare workers. This ongoing training is crucial, given its impact on their knowledge, efficiency, and confidence. Future strategies should maintain a dedicated focus on training programmes, integrating cultural nuances to ensure their relevance and effectiveness [234, 235]. Study IV further recommends the incorporation of CEs using the CSCATTT strategy into the standard curricula in order to continually improve role distributions, professional thinking, and alleviate

internal fears among healthcare staff. It is imperative for the KSA to invest in a long-term strategy that not only addresses current challenges but also fortifies a resilient healthcare system that is capable of adapting to future threats [18, 236].

Study III also underscores the importance of public knowledge and engagement in effective disaster management. Implementing CSCATTT components in various public initiatives is proposed as an innovative approach. Achieving this goal requires comprehensive collaboration between health officials, academia, and the broader community [189, 237]. Educational campaigns should target a wide audience, extending beyond medical professionals to the general populace, and be conducted in schools, markets, religious venues, and other public spaces. Public-Private Partnerships (PPPs) can significantly contribute to the sustainability of training programmes [56]. Involving private sector entities in disaster management not only provides additional resources but also introduces a diversity of expertise and perspectives [238]. Such partnerships can drive innovation and ensure that training programmes remain dynamic and responsive to changing needs. Furthermore, incentivising healthcare workers through career advancement opportunities linked to continuous training can foster a motivated and skilled workforce [56, 105]. A forward-looking vision should encompass a robust ecosystem of partnerships, utilising the strengths of both public and private sectors [239].

Enhancing public awareness and involvement through Community-Based Participatory Research (CBPR) methods can also amplify the effectiveness of educational campaigns. Engaging communities in the planning and execution of these initiatives ensures cultural relevancy and responsiveness [240]. Incentives for community involvement, such as recognition or small-scale preparedness grants, can further encourage active participation. The future of disaster management in the KSA should evolve towards a more collaborative, community-driven model, empowering individuals and communities to become proactive partners in building disaster resilience [234, 235].

METHODOLOGICAL CONSIDERATIONS AND CHALLENGES

The methodological approaches adopted in the four research papers of this thesis provide a rich and varied exploration of disaster management and

emergency healthcare. Each study employed methods tailored to its specific research questions, collectively offering an improved understanding of the field. Study I utilised a quantitative approach; this method allowed for an analysis of HCWs' attitudes, behaviours, and opinions across a broad spectrum of healthcare roles [175, 241]. By quantifying these aspects, the study provided an improved understanding of how HCWs perceive and respond to emergency situations [241]. Study II also employed a survey-based approach by using the CLU Scale for a structured evaluation of the effectiveness of these exercises. This added a focused dimension to the research, specifically examining the impact of CEs on disaster management within a health context [137]. In contrast, Study III adopted a mixed-methods approach, combining observational techniques with qualitative interviews. This combination of methodologies allowed for a more nuanced understanding of the dynamics of teamwork in healthcare during disasters [242]. Study IV used a similar hybrid approach, combining a Delphi study among experts with a survey among HCW participants. This methodology bridged the gap between theoretical knowledge and practical application [175, 182, 184, 243]. It enabled the collection of expert opinions and insights while also capturing the real-world experiences and practices of HCWs in disaster and emergency simulations. In particular, studies III and IV demonstrated a commitment to comprehensive research by employing both quantitative and qualitative methods. This approach allowed for a deeper exploration of the knowledge, skills, and competencies within disaster management and emergency healthcare [181, 242]. Despite the varied methodologies, all the studies shared common themes. This thesis focused on essential aspects of emergency healthcare, such as teamwork during disasters and simulations; moreover, it employed surveys as a key tool for data collection. Including practical exercises, such as simulated scenarios and collaborative teamwork, grounded the thesis in practical contexts, linking theoretical concepts to real-life healthcare situations [244].

This thesis reflects a blend of theoretical approaches that play a prominent role in the results. Specifically, they provide a lens through which the maturity and integration of healthcare teams in disaster management scenarios are examined. The studies used the 3LC exercise model, which is consistent with Sandberg's Team Maturity Framework's [156] explanation of the stages of team maturity. This model facilitated the growth and maturation of healthcare teams in collaborative simulation exercises, aligning with Phattharapornjaroen et al.'s [105] findings. Hall and Weaver's [60] concept of teamwork integration is exemplified through the application of the 3LC exercise model. This model not only aligns with the learning and challenge aspects, but also aims to

integrate healthcare teams in simulated disaster scenarios seamlessly. In Studies I and II, team integration is subtly interwoven into the survey and collaborative aspects, respectively. Study IV employs a Delphi study, which, while structured, allows for iterative feedback and refinement [245]. This method displays elements of both mechanistic and organic characteristics, providing flexibility within a structured framework [184]. By examining these dichotomies, a somewhat richer understanding of how organisational theories subtly influence methodological choices in disaster research is gained. This multifaceted approach, as highlighted by Sellnow et al. [246], enriches our comprehension of the dynamics of disaster management, particularly in the context of team development and integration within healthcare systems.

The concept of trustworthiness in research is critical, particularly in a field as impactful as disaster management. Each of the studies in this thesis employed methods that contribute to the trustworthiness of their findings, aiming to achieve credibility, dependability, confirmability, and transferability. Study I, which examines the perceptions of HCWs, employs a quantitative survey method. This approach seeks credibility by reporting the survey's dimensions and scenarios, aiding in establishing the study's dependability and confirmability. The detailed methodology outlined allows for potential replication, which is a key aspect of research trustworthiness [175, 243]. Study II utilised the CLU Scale for quantitative data collection and broadly used instruments to support the study's credibility, as outlined by Tracy [247]. In Study III, a mixed-methods approach involving observations and interviews was adopted. The triangulation of data from these diverse sources bolsters the study's credibility, as it allows for corroboration and a multifaceted view of the findings [169, 172]. The application of Hall and Weaver's and Sandberg's frameworks further contributes to trustworthiness by elucidating the intricacies of collaboration and team dynamics in terms of integration and maturity. Finally, Study IV employs a mixed-method approach incorporating a Delphi study and a survey. The Delphi technique, which gathers insights from experts, ensures the credibility of the findings. Additionally, the survey's focus on aspects of the disaster and emergency curriculum enhances the transferability of the research [182-184, 245]. By involving expert opinions and targeting specific curriculum elements, this study contributes to a somewhat broader understanding of disaster management education. Each of these methodological approaches contributes to the trustworthiness of the research. They collectively contribute to credibility, dependability, confirmability, applicability, and transferability across various settings, which is paramount in the field of disaster management research.

LIMITATIONS

One major limitation in this study is the initial focus on one profession, i.e. “nursing", which stemmed from the author’s background as a nurse practitioner (NP). However, during the project, the need for involvement of other healthcare workers in the collaboration process was recognised, resulting in a change in the study’s aim from focusing solely on nurses in the beginning to including other professions. In addition, this project specifically examined HCWs employed in MOH hospitals, excluding HCWs employed in other organisations such as ARAMCO Medical Services, Security Forces hospitals, National Guard hospitals, and the Armed Forces Hospitals of the KSA. The data for these studies were only gathered in the Najran region, which constitutes one out of the thirteen regions in the KSA. Consequently, while the findings may be transferable, there exists a constraint in terms of the capacity to extrapolate them to all areas of Saudi Arabia.

In Study II, the survey achieved a 100% response rate, indicating that every participant provided a reply. There is a remarkable difference in response rates between different parts of the world, and the reasons behind this difference need to be clarified. In the western world, response rates are declining [248], but in some countries, such as China, response rates are often very high. Some of the questions in this study involved politically sensitive topics, and surveys sponsored by a government agency are likely to elicit ‘I don't know’ answers. High response rates may indicate a fear of negative effects [249]. The reason for the high response rate in this study is still unknown and has to be compared to other surveys in the KSA and analysed.

Another limitation might be the initial focus on the concept of willingness in Study I, rather than collaboration. However, upon further study of collaboration, I realised that collaboration often has a subtle yet significant connection to willingness, particularly within teams as opposed to individuals. People tend to enjoy working in teams where members work collaboratively [250]. Furthermore, teamwork is crucial for handling difficult situations. Therefore, it can be assumed that willingness will improve as closer collaboration is achieved. The KSA has quite a hierarchical society, which is also reflected in the work environment in hospitals. However, with closer collaboration during teamwork, the hierarchical structure can flatten, which is also something that could improve willingness to work in a fairer manner.

The author's extensive background in healthcare services and pre-understanding of the lack of knowledge in disaster management among Najran's HCWs might also have impacted the choice of subjects and objectives. However, this thesis is inspired by the approach of directed reasoning [251], indicating that pre-knowledge is quite important to understand the context.

CONCLUSION

Education, collaboration exercises, teamwork, and disaster-specific curricula have all been discussed to bolster HCWs' resilience and readiness in the face of disasters. These discussions have illuminated some important aspects of this process, with a focus on multi-agency and multi-disciplinary training for HCWs, regardless. The results align with the understanding that HCWs' willingness to respond to emergencies depends on various factors, including knowledge, skills, and confidence. Additionally, factors such as education, age, and experience influence their willingness to work under threatening circumstances. To ensure their safety and well-being, educational initiatives and measures are necessary.

The virtual tabletop exercises have yielded promising outcomes, with participants overwhelmingly agreeing that these drills emphasised teamwork and enhanced learning, making them practical for real-life tasks. There was an obvious link between participation in these activities, enhanced collaboration, and knowledge improvement. This illustrates that learning depends on collaborative practices, and engaging in such exercises can foster the development of attributes that individuals can then employ in their daily lives. The findings present the potential for implementing distance learning in the field of disaster management, especially in a global context where the frequency of disasters and public health emergencies is on the rise. Collaborative tabletop exercises in disaster management improve knowledge, skills, self-confidence, and team-building abilities. While the CSCATTT framework promoted collaboration, communication, and coordination among HCWs, the findings emphasise augmented knowledge and practical skills during scenario plays, as well as exposure to diverse hazards. This underscores the importance of continuous education and training. In particular, this thesis highlighted the significance of tabletop exercises, such as 3LC, incorporated with collaborative factors, as one of the alternative exercises in education and training curricula for disaster response agencies in the KSA.

Further research and involvement from educational institutions are needed to incorporate CEs into the current educational initiatives effectively.

FUTURE PERSPECTIVES

This thesis offers insight into both the strengths and weaknesses of disaster preparedness in the KSA, considering that the outcomes have global implications.

The use of diverse training mechanisms, particularly those emphasising multi-agency collaboration, exposure to diverse hazards, and the implementation of simulation exercises, together with the use of different tools to measure outcomes such as CLU and CSCATTT, present promising approaches that could be used in other countries facing similar situations and infrastructure challenges.

In addition, the thesis highlights the possibility of conducting virtual exercises, which also enables the incorporation of diverse hazards and partnerships with other groups and voluntary organisations involved in disaster management. These routines, guidelines, and instructions should also be targeted for future research. As everyone's opinion, knowledge, and participation matters, reflective seminars offered by 3LC exercises can improve teamwork and reduce power distance, observed in many organisations. Educating instructors who can manage both virtual simulations and the dynamic of power among participants is mandatory.

Finally, this thesis proposes the establishment of a reference model for reporting on such collaborative learning exercises in disasters and public health emergencies, which can be used nationally, drawing from current studies in the KSA. In this way, it aims to catalyse future research endeavours that can continue to enhance and improve disaster preparedness not only in the KSA but also in other countries. The idea is to protect HCWs and the welfare of the populations they serve in a manner that enables them to better withstand and manage diverse global needs.

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APPENDIX

Appendix A

Instrument of Study I (Fight or Flight)

Fight or Flight questionnaire/ Part One

Fight or Flight questionnaire	**Supportive Services**			**Nurse**			**Administrator**			**Physician**		
Age												
Gender	Female		Male	Female		Male	Female		Male	Female		Male
Highest level of education	Secondary	College	University	Secondary	College	University	Secondary	College	University	Secondary	College	University
Relationship	Married		Single	Married		Single	Married		Single	Married		Single
Children	Yes		No	Yes		No	Yes		No	Yes		No
Children living with you?	Yes		No	Yes		No	Yes		No	Yes		No
Function	Leader		Executer	Leader		Executer	Leader		Executer	Leader		Executer

Regular patient contact	Yes	No	Yes	No	Yes	No	Yes	No
Regular work at emergency units (ED, ICU, etc.)	Yes	No	Yes	No	Yes	No	Yes	No
Do you have training in:	Disaster Management		Disaster Management		Disaster Management		Disaster Management	
	Epidemic/pandemic		Epidemic/pandemic		Epidemic/pandemic		Epidemic/pandemic	
	Chemical incidents		Chemical incidents		Chemical incidents		Chemical incidents	
	Nuclear incidents		Nuclear incidents		Nuclear incidents		Nuclear incidents	
	Mass casualty incidents		Mass casualty incidents		Mass casualty incidents		Mass casualty incidents	
Your specialty			ICU/ED				Consultant Critical care	
			Ordinary ward				Consultant other specialty	
			Outpatient clinic				Trainee Anaesthesiology	
			Technical				Trainee another department	
			Administrative				Trainee Emergency Medicine	

Comments				

Fight or Flight questionnaire/ Part Two

1. **Evaluation of scenarios**

Scenarios	**Do you go to work?**				**Knowledge**	**Risk**
All scenarios affecting your hospital and working area	Yes, unconditionally	Yes, under certain circumstances a–j #	I have serious doubts, probably not	I will certainly not respond	My knowledge on the scenario; 1–10 (10 is highest)	The risk for this ir happen is 0–1
Natural disaster (e.g. flooding)						
Bombing (e.g. terrorist threat)						
Seasonal influenza pandemic						
Special flu pandemic (e.g. bird flu)						
SARS/COVID-19						
Ebola outbreak						
Smallpox						
Chemical incident						
Biological incident (e.g. anthrax)						
Nuclear incident						

Dirty bomb						
Mass shooting (e.g. Paris)						

2. # If you answered "Under certain circumstances", then which of the following can make you go to work? Please insert one or more options from a-j under the heading "under certain circumstances"

a. If I know my family is safe and taken care of;
b. If I am sure good communication lines with my family are available;
c. If my boss comes to work as well;
d. If I am trained to handle the situation;
e. If I get regular updates on the evolution of the incident;
f. If adequate personal protective equipment (PPE) is provided;
g. If I get paid extra for it;
h. If I can get antivirals (e.g. Tamiflu) for free;
i. If I can get antidotes for free;
j. If I can get my vaccinations for free.

Other comments

Appendix B

Instrument of Study II (CLU survey)

No	Items
1	Gender: ☐ Male ☐ Female
2	Age: ☐ 22-30 years ☐ 31-40 years ☐ > 40 years
3	Your Specialist:
4	Education Degree: ☐ Bachelor ☐ Master ☐PhD
5	Experience: ☐ 1-5 years ☐ 6-10 ☐11-15 ☐ > 16
6	The exercises were focused on collaboration. 1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.
7	Sufficient forms of discussions were provided. 1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.
8	There were opportunities to improvise. 1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.
9	Personnel in need of exercise participated. 1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.
10	I performed well-known activities. 1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.
11	Collaboration was initiated immediately. 1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.
12	Clear instructions of collaboration were presented.

	1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.
13	My points of view were regarded. 1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.
14	I learned new things during the exercise. 1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.
15	I learned about the organisational aspects of other actors. 1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.
16	I learned about the communication patterns used by others. 1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.
17	I learned about how others prioritise activities. 1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.
18	I learned about concepts and abbreviations used by others. 1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.
19	Based on what I learned, the exercises were useful to real-life activities. 1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.
20	Based on what I learned, the exercises were useful to command officers. 1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.
21	Based on what I learned, the exercises were useful to ordinary operative staff. 1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.

22	Based on what I learned, the experiences from the exercises impact my daily work. 1- Strongly disagree. 2- Disagree. 3- Neutral. 4- Agree. 5- Strongly agree.

Appendix C

Instrument of Study III (Approach 1: observational elements)

No.	Items	Time in minutes
1	Appointing a leader	
2	Measuring the time to set up the organisation	
3	Achieving consensus in the team	
4	Distributing tasks among team members	
5	Prioritising activities	
6	Identifying external resources	
7	Assessing the progress of the mission (making new decisions or ending the mission)	
8	Evaluating the progress of the exercise (need for new inputs after discussion with exercise leaders or cancelling the exercise)	
9	Time to reach the main decision	
10	Time to triage	
11	Time to provide treatment	
12	Time to perform documentation	
13	Time to report to senior management.	

Observed by:……..

Appendix D

Instrument of Study III (Approach 2: interview questions)

Interview questions:

Age:

Profession:

Years in the profession:

1. How many exercises have you been a part of? Tell me about your experience of these exercises?
2. What is your opinion about exercises and preparedness? Do exercises improve preparedness?
3. What is your overall impression of the table-top exercises?
4. How well did it improve preparedness on a scale of 1-5, where 1 is poor, and 5 is excellent?
5. If you compare the two scenarios, did the team develop from scenario one to two? Please elaborate\ clarify.

I will present the integration of the team member theory by (Hall and Weaver, 2001).

6. Based on the theoretical concept, if you compare the two scenarios, did the team develop from scenario one to two? Please elaborate\clarify.

I will present the team maturity theory by Sandberg (1997).

7. Based on the theoretical concept, if you compare the two scenarios, did the team develop from scenario one to two? Please elaborate\ clarify.
8. Do you suggest any special type of exercises, aims, participants, in order to improve preparedness in your context?
9. Saudi Arabia is a country experiencing different types of public health challenges. Do you have any vision on how to improve preparedness in the society in terms of exercises? Other aspects?
10. Do you want to add anything to this interview?

Appendix E

Instrument of Study IV (survey items)

N	Statements: The current Disaster Medicine Curriculum in Saudi Arabia
1	Gender: ☐ Male ☐ Female
2	Age: ☐ 22-30 years ☐ 31-40 years ☐ > 40 years
3	Your Specialist:
4	Education Degree: ☐ Master ☐ PhD ☐ Postdoctoral
5	Experience: ☐ 1-5 years ☐ 6-10 ☐11-15 ☐ > 16
6	Nationality: ☐ Saudi ☐ non-Saudi
7	Covers the essential knowledge in command and control during emergencies and time critical events. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
8	Enhances the role of leadership. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
9	Covers probable risk areas engaging the healthcare sector in Saudi Arabia. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
10	Enhances and enables the learner in the management of diverse risks. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
11	Encourages the willingness and confidence of staff to report to work.

	1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
12	Clarifying internal and external communication during emergencies. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
13	Enhances and promotes multi-agency collaboration. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
14	Enabling a joint assessment and understanding of the situation across sectors. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
15	Enables extracurricular activities such as organising multi-agency training and exercises. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
16	Offers training in a diverse risk environment, such as a pandemic, mass casualty, etc. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
17	Increases learners' knowledge and skills in triage. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
18	Increases learners' knowledge and skills in medical treatment. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree

19	Increases learner's knowledge about the coordination and cooperation in transport issues. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
20	Enables e-learning and distance training. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
21	Identifying shortcomings in the current education is due to the lack of instructors. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
22	Clarifying collaborative tools and linking various agencies, are one of the changes needed. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree
23	Does not need any changes and is sufficient as it is. 1: completely disagree, 2: disagree, 3: I do not know, 4: agree, 5: completely agree