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DISASTER RESPONSE AND PREPAREDNESS:

FOCUS ON HOSPITAL INCIDENT COMMAND GROUPS AND EMERGENCY DEPARTMENT REGISTERED NURSES

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Disaster response and preparedness: focus on Hospital Incident Command Groups and Emergency Department Registered Nurses.

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To Maya, Lea, and Ebba

“Hello! I’m the happiness fairy. I’ve sprinkled happy dust on you. Now smile! This stuff is expensive” -Lea Murphy

ABSTRACT

Background: While disasters per definition are rare, incidents that cause mass casualties that threaten to overwhelm its limited resources are an ever-present risk. Disaster medicine is a specific discipline of medicine dedicated to providing adequate health care to patients of major incidents through the development of preventive-, preparedness-, response and recovery interventions. Emergency department registered nurses are among the first to receive, assess and treat patients of a major incident, highlighting the importance of their preparedness and disaster medicine competencies. However, when an incident threatens to overwhelm health care's resources, a specific type of management group may be required to aid and guide hospital response. The hospital incident command group aids in hospital response through timely decision-making and allocation of resources. Despite these two groups being recognized as vital components of disaster response, little has been known concerning the disaster preparedness of these two groups. emergency department registered nurses' disaster preparedness. The overall *aim* of the thesis was to assess disaster medicine preparedness in Stockholm, Sweden through the evaluation of hospital incident command groups and emergency department registered nurses.

The aim of **study I** was to identify the essential disaster nursing competencies. Sixty-nine specific disaster medicine competencies were identified through a modified Delphi method in which experts within the field of emergency- or disaster medicine reached consensus concerning necessary disaster medicine competencies for emergency department registered nurses.

The aim of **study II** was to assess emergency department registered nurses' self-perceived disaster preparedness using the results in study one as the basis of a questionnaire. A cross-sectional method was used to assess the preparedness of nurses in the study setting. The results of this study indicate that emergency department registered nurses may be less than competent and overestimate their preparedness.

The aim of **study III** was to assess hospital incident command groups' preparedness. This was done through an observational study in which measurable indicators were used to evaluate hospital incident command groups during simulations. The results in this study indicate that proactive decision-making correlates with overall command group response. Shortly after the simulations in study III, an antagonistic incident occurred in Stockholm, Sweden. This provided a unique opportunity to compare planned preparedness with actual preparedness. through exploration of disaster preparedness coordinators' experiences of hospital response during a major incident.

Thus, the aim of **study IV** was to explore registered nurses' experiences as disaster preparedness coordinators (DPC) of hospital incident command groups during an MI. This was done through one focus group discussion with six disaster preparedness coordinators and six follow-up interviews with the same coordinators were conducted. Data were analyzed using inductive content analysis. One main category, *Expectations, prior experiences, and uncertainty affect HICG response during a major incident* and three categories. *Gaining situational awareness, transitioning to management,* and *actions taken during uncertainty were identified.*

The thesis concludes that disaster medicine preparedness in the study setting may be adequate but that response may be dependent upon several factors including the type and timing of the incident, frequency and type of training, education, experience, and the ability to reduce uncertainty in order to make timely and relevant decisions.

LIST OF SCIENTIFIC PAPERS

I. **Murphy J.P.**, Rådestad M., Kurland L., Jirwe M., Djalali A., Rüter A. Emergency department registered nurses' disaster medicine competencies. An exploratory study utilizing a modified Delphi technique. *International Emergency Nursing 43 (2019) 84-91*

II. **Murphy J.P.**, Kurland L., Rådestad M., Magnusson S., Ringqvist T, Rüter A. Emergency department registered nurses' overestimate their disaster competency: A cross-sectional study. *International Emergency Nursing 58 (2021).*

III. **Murphy J.P.**, Rådestad M., Kurland L., Rüter A. Hospital incident command groups' performance during major incident simulations: a prospective observational study. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine. (2020) 28:73*

IV. **Murphy J.P.**, Hörberg A., Rådestad M., Kurland L., Rüter A., Jirwe M. Registered Nurses' experience as disaster preparedness coordinators during a major incident. A qualitative study. *Nursing Open (2021).*

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INNEHÅLL

LIST OF ABBREVIATIONS

DiMI	Disaster management indicator
DPC	Disaster preparedness coordinator
ED	Emergency department
ICN	International council of nurses
HICG	Hospital incident command group
MI	Major incident
RN	Registered Nurse

1 INTRODUCTION

For the last six years or so, I've taught disaster medicine for nursing students. I think that both myself and the students anticipate an exciting and interesting course filled with unlikely "what-if" scenarios. It's safe and perhaps even playful at times. The events we talk about don't happen in Sweden….often.

Twice I've been at a loss for words while standing in front of eager nursing students.

The first time: Instead of delving into those "what-ifs" and near misses that we often discuss at the beginning of the course, we began our course with a minute of silence and then reflections of what had just transpired. On the 7th of April in 2017, two days before the start of my course in disaster medicine, the unthinkable happened. Several innocent people lost their lives to a terror attack. Two days later at 09 in the morning, I and nearly 100 nursing students sat in silence, trying to comprehend the terrible events that had just transpired.

The second time: Two years to the day of the terror attack, on the 7th of April in 2020, I gazed out over the small pictures of nursing students on zoom waiting for me to begin my course. Just days before, I worked on a COVID-19 ward and had seen first-hand what health care was only starting to grapple with. I was tired and I was frightened. The subject of disaster medicine was once again, all too relevant. Yet, at the same time, I was filled with hope and pride over the health care response. Disaster plans were activated. Hospital capacity increased exponentially. Health care professionals seemed to come out of the woodworks to aid and work extra. Health care's response has been nothing short of remarkable.

Sweden has largely been spared when it comes to disasters per definition. Even incidents that threaten to overwhelm health cares' ability to provide quality care for all patients have been somewhat scarce in terms of loss of life. However, as health care still grapples with the challenges of the ongoing Corona pandemic, we are once again reminded that risks exist, and disaster preparedness is essential.

Disaster medicine as an area of research is relatively young. While not starting entirely from a blank canvas, my initial literature searches turned up little research that provided insight as to the state of preparedness in Stockholm, Sweden. This thesis does not provide a definitive answer as to the state of preparedness in Stockholm, Sweden but it does perhaps provide a few insights and factors potentially affecting those at the front line, the emergency department registered nurses, and the managerial group responsible for aiding in disaster response, the hospital incident command groups.

While I've been at a loss for words before, there is plenty to be said both about disaster medicine preparedness and the bravery and action of all those involved.

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2 BACKGROUND

Disasters or major incidents continue to affect millions of people annually, a constitute a threat to society, posing an ever-present threat to health care's ability to provide quality care for those afflicted (1, 2). With nearly 50,000 deaths and 97 million affected by natural, technological, antagonistic, anthropogenic, or disease outbreak events in 2020 alone, disasters and major incidents continue to challenge health care's ability to adequately care for those afflicted (3, 4). Recent trends indicate that natural disasters occur more frequently than in past years, though with less loss of life (5). Similarly, antagonistic events or events that are deliberate attempts at disrupting or causing damage or destruction, terrorism, or other forms of violence have increased in frequency with fewer deaths attributed to them (6). However, as witnessed during the COVID-19 pandemic, hazards, risks, and abilities are not static states. Indeed, globally since the start of the COVID-19 pandemic, nearly 5 million deaths have been attributed to the virus (7). In Sweden alone, the over 1 million coronavirus cases and over 14 thousand fatalities attributed to COVID-19 illustrate some of the challenges the field of health care and disaster medicine face when planning for and mitigating events that threaten health and well-being (8).

Disasters which can be slow, such as the current pandemic, or rapidly developing events, such as antagonistic attacks, are results of an interaction between hazards, which have the potential of inflicting damage or harm to an environment or human beings, risk or the probability of an event happening, the impact of the event (9). A community's vulnerability or susceptibility to negative events and its resilience, or its ability to mitigate and recover from the event are vital factors that often dictate the extent of the event (9, 10). The vast differences in basic prerequisites a community or country have may explain why events of similar character may have vastly different outcomes, ie the balance between hazards, resilience, and resources may differ (1, 11).

Historically, disasters have had little human or economic impact in Sweden (12-15). However, natural hazards such as storms, floods, and epidemics remain ever presents risks for loss of life (3). Indeed these same risks, are seen as perhaps the most likely scenarios that cause widespread loss of life and destruction specific to Sweden(6). Several types of events may cause major incidents (MI) and can be classified as natural, technological, or anthropogenic/caused by humans (16-19) or simply man-made and natural (20, 21) (Table 1). Hazards are anything that may negatively impact the health of a population (9). The comprehensive nature of the hazards identified for Sweden demonstrates the broad levels of preparedness and knowledge required to mitigate the effects of disasters and major incidents (MIs)(6).

Table 1. Categories of Disasters/ Major Incidents

Category	Subcategory	Example
Natural	Meteorological	Cyclones, storms
	Geophysical	Earthquakes, tsunamis, landslides
	Hydrological	Floods, avalanches
	Climatological	Drought, wildfire, extreme temperatures
	Biological	Epidemics/pandemics caused by exposure to living organisms or toxic substances
Anthropogenic	Technological	Food supply, transportation, telecommunications, energy
	Antagonistic	Terrorism, shootings, cyber attacks
	Major accidents	Transport emergencies, extensive fires, chemical, nuclear, radiological, and explosions.

2.1 DISASTERS AND MAJOR INCIDENTS

Using common nomenclature facilitates communication and understanding. Disaster response is often dependent upon relationships or collaborative efforts between different actors (6) and standardized nomenclature is vital in facilizing common goals and collaborative efforts (22). The importance of terms and consensus of definitions is of particular importance considering that disaster response may often be dependent upon cooperative efforts (23). However, a universal consensus concerning the term “disaster” is somewhat evasive (24). One of the reasons there seems to be a lack of consensus on the term disaster has to do with the varying conditions in the different parts of the world. An event that may cause a disaster in one area of the world, may be routine in another (1, 11, 25).

The majority of daily events, traffic accidents, fires, storms, are events that a community can cope with using their own resources (26). However, there are instances when an event is of such magnitude that a community’s ability to respond may be overwhelmed and national or international help may be required (3).

Disasters

According to the Centre for Research on the Epidemiology of Disasters (CRED) a disaster is an event that is so overwhelming, that mitigating the destruction of materials, environment, or loss of human life is dependent upon national and or international assistance (17). The United Nations (UN) further defines disasters as “a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability, and capacity, leading to one or more of the following losses: human, material, economic and environmental” (27). While the World Health Organization (WHO) defines disasters as an event of such magnitude that a community’s ability to respond using their own resource is overwhelmed, resulting in destruction, material loss, and damage as

well as loss of life (28). Similarly, the Center for Research on the Epidemiology of Disaster (CRED) highlights the relationship between needs and resources, stating that a disaster is an event of such magnitude that national or international assistance is required to mitigate the effects of an oft unexpected incident which may often cause destruction and humanitarian distress (17). While definitions differ, a central theme is a balance between resources and needs (17, 27).

Major Incidents

Events with the potential for causing mass-causalities of such proportions that they threaten a community's ability to respond effectively can be classified as major incidents (MI) or disasters dependent upon health care's ability to maintain quality care (23).

A major incident in contrast to a disaster, according to the Major Incident Medical Support System (MIMMS) is any incident that threatens a community's ability to adequately respond and provide quality care and requires extraordinary resources (29). Sten Lennquist, the first professor in Disaster medicine in Sweden, similarly defines MIs and categorizes them into 3 levels; level 1 may be seen as a compensated event, level 2 a non-compensated event despite redistribution of resources, and level 3 an event of such magnitude that resources from other actors and regions need to be mobilized (20).

The definition of an MI used in Stockholm, Sweden's regional disaster plan ("stor olycka" or "särskild händelse") is somewhat broader stating that a major incident is an event that threatens a community's ability to respond adequately yet through adequate redistribution of resources, normal quality care can be maintained (23). In essence, when an emergency or event overwhelms a community's ability to respond effectively, the situation becomes either a major incident or a disaster depending upon the balance of resources and needs (23).

An incident per the Swedish definition can normally only be classified as a disaster after the event and actions taken by the health care sector are assessed in relation to patient outcome (23). Henceforth, terminology in the remainder of this report will be based on the term "major incident" will be used in referring to events threatening public safety and health care's ability to respond.

Disasters may also be defined from a medical standpoint as incidents of such magnitude that medical needs despite the reallocation of resources and collaborative efforts are overwhelmed and exceed health care's ability, thereby resulting in reduced quality of care (9). The definition in Sweden highlights the medical aspect defining a disaster as an event so overwhelming that the acute medical needs outweigh available resources, resulting in the inability to maintain normal levels of quality care despite reallocation of resources (23).

The aim of health care during a major incident is maintaining quality care for everyone through redistribution and allocation of resources, while health care's goal during a disaster entails organizing resources to maintain quality care for as many as possible (25, 30, 31).

2.2 DISASTER MEDICINE

Disaster medicine may be described as the discipline that studies and develops the specific preventive-, preparedness-, response and recovery interventions aimed at mitigating the psychological, somatic effects that cause morbidity or mortality of a major incident with limited resources (24, 25, 32). Furthermore, disaster medicine is the term applied to any situation that threatens to overwhelm health care's limited resources need to provide quality care during an MI (25). As a field of research, disaster medicine is still relatively young and knowledge concerning risks, medical interventions to mitigate the effects of MIs is ever-evolving. Disaster medicine research provides necessary evidence-based knowledge needed to educate, train and develop methods required to treat large numbers of patients with limited resources, disaster medicine aims to reduce death and illness during a major incident (20).

2.2.1 Disaster management

Disaster management concerns the processes and structures for mitigating, preparing responding to, and recovering from a disaster and can be illustrated using the disaster management cycle (Figure 1)(33). The prevention and mitigation phase includes actions taken to avoid or mitigate the adverse impacts of an event while the preparedness phase is characterized by assessment of abilities, planning, training, and education interventions (33, 34). The response phase includes recognition of the event, notification, mobilization, response, and demobilization (34). The recovery phase includes actions taken to return to "normalcy" after the event through replenishment of resources, returning to full capacity function (34).

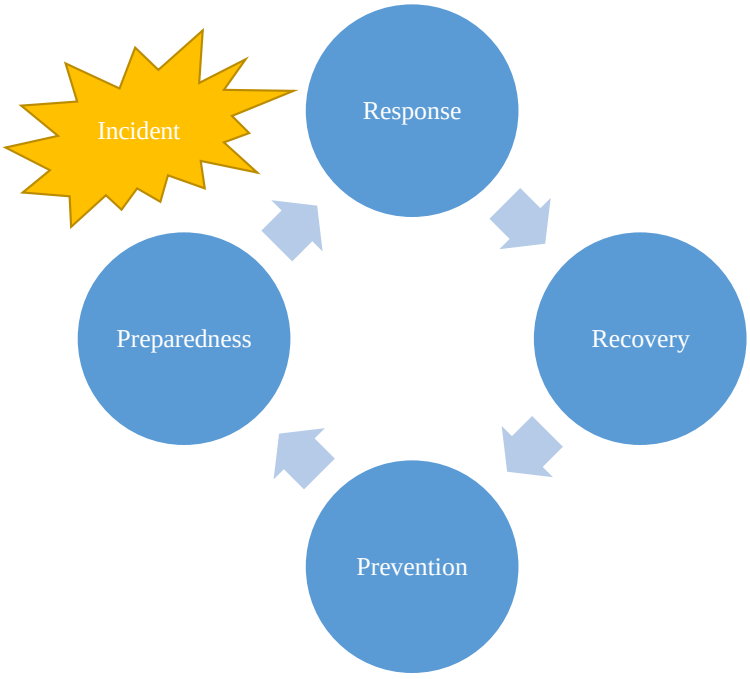

Figure 1. *Disaster management cycle(33).*

Disaster medicine preparedness is based on disaster risk and abilities analysis (6) and concerns health care's ability to minimize mortality and morbidity, provide quality care for those afflicted, manage environmental conditions, facilitate normal health, and ensure the functioning of health services, and protect staff (35). This includes all measures of planning and resource management which concerns human resources, capital resources, and supplies (36). The comprehensive nature of the hazards identified for Sweden demonstrates the broad levels of preparedness and knowledge required to mitigate the effects of MIs and disasters (6). Swedish legislation stresses the importance of disaster preparedness defining disaster medicine preparedness as the ability to manage health care to minimize the effects of a major incident and consists of planning, personnel, equipment, notification routines, specific medical management/leadership, assessment, collaboration, and evaluation (23).

Regional and local disaster plans adopt an all-hazards approach which is broad and general due to a large number of likely events that may cause a major incident, both externally (beyond the physical location of hospitals) and internally (events directed at or directly affecting a hospital (35, 37). Disaster medicine preparedness is ensured through training and education of both management and staff, at local and regional levels, in which the ability to allocate adequate resources and equipment is paramount (23, 38). While all-encompassing and somewhat general, disaster plans are based on specific risk analyses of possible hazards that may cause a MI in Sweden(23).

2.2.1.1 Medical preparedness and response

Hospital disaster preparedness and response is dependent upon multi-sectoral collaborative efforts including rescue services, law enforcement, and medical organization at the incident site (39). To facilitate response, and resource allocation for MIs, the Swedish emergency and disaster response utilizes hierarchical medical command consisting of three levels (23). National Level with a focal point concerning national interests and coordination with other agencies and political decision-makers (Figure 2). The regional level focuses on coordination and management of county resources as well as notification and communication with local hospitals (Figure 2). Medical response includes the formation of the regional strategic command, which is initiated by the Designated Duty Officer (DDO) (23, 39). The regional medical command organizes and facilitates medical response on the regional level by allocating resources and initiating communication with local hospital incident command groups to aid in local hospitals' medical response (40). The Local level encompasses medical management at the incident scene and local hospitals' response (23, 39) highlighting hospital incident command groups as essential actors in disaster response. Based on an all-hazards approach, strategic planning concerns implementing plans based on identified needs including capacity and resources (33).

Figure 2. Disaster management system command levels.

Major incidents often occur with little or no warning and may cause surges of patients with patients presenting with severity of injuries rarely seen in the affected area (41). Often resulting in mass causalities at the incident site, many patients require pre-hospital assessment and care before being transported to hospitals (42). However, experience has shown that between 50-80% of patients from a major incident arrive at the emergency department (ED) many within minutes of the incident as self-presenters, bypassing the pre-hospital organization altogether (33, 43-45). This may result in the less critically injured patients arriving before those with major injuries (45). The combination of these two categories of arrivals may require EDs to quickly increase their operational capacity to receive, prioritize and treat the rapid surge of patients and may require specific medical management (23, 46). This ability to increase the capacity of the ED to manage the sudden influx of patients which may consist of a wide range of medical concerns, is a hospital's surge capacity (47, 48) and may be comprised of five main components: (Stuff), supplies and equipment, (Structure) facilities as well as knowledge of the hospital incident command system, including levels of preparedness and its significance, (System), treatment, triage, reverse triage, command, control, and communications, (Special) preparedness for events and populations that divert from the norm and (Staff), personnel (49-53).

But what happens when what is considered "the norm" merges ever closer to a steady state in which even smaller incidents may tax resources? Since 2006, Sweden's population has increased by 13%(54). During the same period, the number of hospital beds has decreased by 18% (55). Crowding at the ED has become a global challenge and concern (56) and can be defined as patients outnumbering the number of triage rooms or available beds (57) or as a phenomenon in which the number of patients being treated or waiting for assessment is so large that ED staff's ability to deliver optimal health care is threatened. Crowding has been associated with ambulance diversion, medical errors, and increased mortality rates (58, 59). This phenomenon in effect closes the gap between MIs and daily operations meaning that incidents don't necessarily have to be extraordinarily large to cause a discrepancy between

needs and resources. Hospital resources and personnel are in many cases, already operating at or above capacity levels and find themselves in a constant state of insufficient resources (60, 61).

Despite a study concluding that crowding in Sweden is not a concern (56) waiting times continue to increase despite efforts such to minimize waiting indicating that crowding may be an issue that negatively affects a hospital's ability to adequately respond to a sudden influx of patients as a result of a major incident(62, 63). When the number of patients seeking care outnumbers the available physicians, a system that systematically prioritizes patients according to acute medical needs is required. An intervention to improve patient flow, safety, and logistics is triage which is a system for assessing patients to assign the appropriate level of medical care when needs outweigh resources (64). EDs in Sweden have implemented triage systems, however, during a major incident, current triage models during a daily patient flow may be time-consuming and ineffective (65). A type of disaster or on-site triage may be needed. Disaster triage often referred to as sieve triage, is a dynamic and simplified methodology which attempts to minimize mortality by doing the greatest amount for as many as possible(66). A side note: while not often implemented, sieve triage was broadly implemented during the pandemic as a preliminary triage to identify patients that may have been infected by the COVID-19 virus (67). The extenuating circumstances that hospitals may face may be mitigated by comprehensive hospital disaster preparedness (43). Limited resources, acute needs, preparedness of personnel, hospital organization, and command affect a hospital's ability to respond to major incidents underscoring the need for effective hospital preparedness (68-71).

2.2.2 Hospital disaster preparedness

Studies show that well-prepared hospitals may minimize morbidity and mortality caused by major incidents (43, 72-75). Hospital preparedness is dependent upon several factors such as structure, planning, leadership, incident management, organization, training, ability to allocate resources, and establish effective collaboration with regional command (40, 76, 77). Hospital response at the local level is to a large degree affected and reliant on collaborative efforts with regional command. Due to the sudden influx of patients in need of health care during an MI, and the possibility of resources being inadequate, a type of hospital management trained specifically for MI management may be required (75, 78).

Health care and hospitals in Sweden have a legal obligation to not only have a comprehensive, all-hazards approach to disaster plans but to also ensure that they are up to date, functional, and well known to the staff (23, 24). An all-hazards approach is disaster preparedness based on elements of all mass casualty-causing events that are predictable and similar regardless of the type of hazard that causes the MI (79). Commonly in line with the four stages of disaster management (mitigation, preparedness, response, and recovery (Figure 2) disaster plans include descriptions of responsibilities, structures, and organization of hospital response as well as directives for the formation and organization of the specific hospital leadership activated during MIs required for resource and information management (23, 35). In addition, directives stipulate that all organizations and personnel involved in disaster preparedness/response are provided the necessary education and training and preparedness are evaluated (23, 80).

Previous studies have evaluated hospital preparedness through assessment of functional capacity (78) structural (70, 75), and non-structural aspects (81) concluding that vital aspects of preparedness and response are the overarching preconditions as well as the implementation of disaster plans and well-trained hospital leadership or hospital incident command groups (HICG) (81).

2.2.2.1 Hospital incident command group.

Essential for hospital response is the role the hospital incident command group (HICG) plays in managing hospital response throughout the four phases of the disaster cycle, organizing response, and allocating resources(24).

Leadership and management.

Despite a long history of research concerning leadership and management, there is still much debate concerning the definition and distinction of these two terms (82, 83). There is a tendency to attempt to distinguish the two terms in research with "leader" as a formal or informal role in which a person or group exerts influence or guides others on others while "manager" may be a more formal role and may be described as an administrative skill (39, 82). This thesis does not assess individuals in their roles as leaders or managers but rather groups responsible for managing hospital incident response. In the context of this thesis, due to a lack of census, these terms are used to a certain extent somewhat synonymously. However, attempts have been made to distinguish the terms when describing overall structure and process (management) and specific role (leader) (84).

Hospital leadership is essential during an MI. Hospital disaster plans include incident command structure and routines. Execution of hospital disaster plans is dependent upon the management skills of well-trained and structured hospital incident command groups(36). In accordance with directives, HICGs are commonly activated either during a major incident or when there is a perceived imminent risk for one developing (23). Hospital incident command groups are function-orientated commonly consisting of an incident commander, safety officer, public relations officer, and medical/technical officers representing key departments within the hospital, as well as disaster preparedness coordinators (DPC) and are responsible for the hospital's operative decisions during an MI (85, 86). DPCs, in the study setting, are RNs holding strategic managerial parts of a hospital's overall disaster preparedness and response (23). DPCs implement, design, and revise disaster preparedness plans, coordinate and design education and training initiatives, evaluate the preparedness and response of personnel and management groups that aid the HICG decision-making and actions during an MI (23). Necessary actions may include the transfer of patients, evacuation plans, reallocation of resources, and coordinative efforts with agencies and organizations on local, regional, and national levels(23). Adequate response at the management level is reliant on several core competencies such as resource management, knowledge of the organization, communication abilities, leadership abilities, the ability to adapt, and decision-making (87).

In addition to cooperative efforts with the regional command, hospital incident command groups' response is facilitated by disaster response action levels which in the current study consist of three levels (Table 2) (31). Each response level facilitates decision-making and response by amongst other actions, increasing competency through activation of HICG staff

members deemed relevant for incident response (31). The first level of response may be taken proactively when possible risks are identified in order to monitor the situation while the second level of response (partial mobilization), is often decided on when an incident has occurred and the HICG is reinforced with key functions to facilitate response. A major difference between the first two levels of response and the "state of disaster" is the activation of the entire hospital in order to increase its surge capacity. A common action after a state of disaster is declared, is that capacity on ED and wards anticipating an influx of patients is increased by either discharging or transferring patients (45).

While routines and regulations are in place, few studies have evaluated HICG performance and decision-making with those that have, assessing whether action has been taken and to what degree (68, 88). Response and allocation of resources during an MI are often reliant on the decision-making abilities which may be based on scarce and unreliable information (74, 89).

Table 2. Levels of hospital response

Standby	The incident commander and portions of the HICG needed to monitor a given situation are activated.
Partial mobilization	HICG is reinforced with key functions/representatives for specific parts of the hospital deemed relevant for the specific event
State of disaster (full mobilization)	The entire HICG and hospital is mobilized per disaster response plans.

Hospital response is reliant on actions and timely decisions taken in a structural order by the HICG. Few studies in Sweden have focused on the decision-making abilities of HICGs. One study however identified a correlation between performance and decision-making (90). However, little attention has since been given to decision-making and staff performance. Decision-making is a cognitive process and in the clinical setting is a challenge often complicated by risk and uncertainty (91). Decision-making consists of two main two processes: 1; intuitive or reactive, which is quick and reflexive, and based on previous experiences and knowledge, utilizing minimal cognitive sources, 2; and analytical or proactive which is more time-consuming deliberate, and more demanding of cognitive efforts. While the speed of decision-making may initially be critical, accuracy may be jeopardized (92). Reactive decision-making in the context of this study is defined as decisions based on intuition which is quick, reflexive, and based on previous experiences and knowledge while utilizing minimal cognitive sources while in contrast, proactive decision-making entails decisions based on analytical ability which is more time consuming, deliberate, and more demanding of cognitive efforts (92).

Methodology for evaluating HICG disaster preparedness

Despite directives stipulating that hospital preparedness continuously be assessed, a consensus concerning a standardized method for assessment in Sweden is lacking (23). While methods for evaluating hospital response have been suggested and applied, often focusing on capacity factors such as the number of patients treated, there lacks consensus concerning methods for evaluating hospital preparedness, particularly concerning processes such as decision-making (33). However, simulations have been proven to be effective methods for medical training and evaluation (68, 88, 93-95) with studies demonstrating that decision-making and performance can be evaluated using measurable indicators such as the Disaster Management Indicator (DiMI) instrument (68, 88, 94). Experience and expertise tend to correlate with active detection and analysis of data, which aids in gaining situational awareness, as opposed to a passive collection of data thus promoting proactive decision-making (91, 96). Decision-making abilities and response may have a direct impact on patient (36, 97) outcome as the possible sudden surge of patients to EDs may overwhelm available resources including staff (46, 98). Knowledge concerning HICGs' abilities is vital as decisions and actions taken are likely going to affect those first in line to receive patients from an MI, ED RNs.

2.2.2.2 Disaster Nursing

The inherent nature of the chain of medical care ensures that medical personnel at emergency departments are front-line responders (36). RNs represent the largest group of registered health care professionals in Sweden (62, 99), and ED RNs are among the first to receive, assess, and initiate treatment (36, 42). ED RNs and the competencies they possess are recognized as vital and key in disaster management (28).

The term "competency" lacks a universally accepted definition. However, the ICN defines disaster competency as assimilated skills, abilities, and knowledge (28, 100) and stresses the importance of outlining specific disaster medicine competencies specific to the setting. Disaster nursing is defined as the skills, knowledge, and ability to effectively mitigate life-threatening hazards during major incidents (101). Disaster nursing competencies for general RN's have been outlined (28) with the ICN formulating specific disaster competencies domains (epidemiology, physiology, pharmacology, cultural-familiar structures, and psychological issues) for general RNs (100).

While general competencies for emergency nurses have been outlined (102) neither specific disaster nursing competencies nor standardized methods have not been outlined in the current study setting, The lack of specific disaster competencies makes evaluation of ED RNs and designing of education or training programs arduous.

2.2.2.3 Emergency department disaster nursing preparedness

Despite emergency department registered nurses being recognized as vital resources during an MI (100), RNs tend to be less than optimally prepared. The demographics of RNs working on EDs are varied, with both novice RNs working side by side with experienced and specialized RNs (100, 103, 104). While more experienced nurses' may more often hold managerial positions, all RNs on EDs are included in the disaster plans and may be involved

in all areas of disaster response. Previous studies utilizing self-assessments to evaluate disaster preparedness have indicated that nurses on a group level have relatively low levels of preparedness (105-110). In general, nurses tend to be aware of disaster plans (107) but report a lack of trust in the plan (108). Furthermore, RNs lack of ability to respond to a large variety of situations with RNs being least prepared for incidents concerning pandemics and radiological and chemical events(107, 111, 112). Furthermore, nurses tend to lack knowledge of the overall disaster organization (106, 111, 112) and levels of hospital response (107). While studies have determined that RNs' disaster preparedness tends to be low on a group level, several factors are associated with preparedness or competency.

Not surprisingly, among the factors affecting preparedness is experience (108, 110). Either measured in clinical experience or education level, several studies indicate that experience is positively correlated with competence and or preparedness(101, 113). These findings tend to be in line with Benner's model of stages of clinical competency model (114) in which RNs progress through five stages of proficiency. Based on the Dreyfus model of skill acquisition (115), Benner's model describes the development of RNs' competency advancing from novice to proficient as they acquire experience, skill, and knowledge (Table 4). One recent study in the current setting supported this assumption by addressing disaster preparedness among nurses and nursing students, concluding that experience correlates with RNs' disaster preparedness (110). Based on previous research, it appears that RNs' disaster preparedness may be inadequate.

Methodology for evaluating ED RN disaster preparedness

Previous studies provide vital information about the general level of registered nurses' disaster preparedness, however, there lacked studies that assessed ED RN preparedness using study setting specific competencies. Furthermore, while previous studies have shed light on the status of disaster preparedness for RNs these studies typically utilize self-assessments to assess preparedness (105-108, 110-112). The validity of self-evaluations has been a subject of debate with some suggesting that self-evaluations may not be accurate reflections of actual ability (116) while others suggest that self-assessments are valid measurements, correlating accuracy of self-assessments with participants level of expertise (117, 118). Furthermore, a known issue with self-evaluation questionnaires possibly affecting results is lexical ambiguity (119). Terms or items that may have more than one meaning i.e. double-barreled terms, or that may be open to interpretation may negatively affect results (119). Many self-assessment studies concerning disaster preparedness employed a five-point Likert-type scale using a scale based on "familiarity". While the results of these studies and the instruments used are in many cases assumed to be reliable and valid (101, 106, 109, 111) the terminology used for self-evaluations was ripe for review.

3 RATIONAL

Hospitals have an essential role during a major incident. However, in order to fulfill this role in the most optimal way, it must also be recognized that they have essential roles before as well as after a major incident. A hospital's disaster preparedness and ability to respond may potentially affect morbidity and mortality caused by major incidents.

Disaster preparedness plans include directives for the structuring and organization of health care services, as well as stipulating that all organizations and personnel involved in disaster preparedness are provided the necessary education and training (23, 80).

Depending upon the severity, time, and nature of the incident, ED resources may quickly prove to be inadequate. However well-prepared ED RNs are, resources are limited. Hospital response is reliant on adequate incident management and spearheaded by the hospital incident command group. Hospital incident command groups are therefore activated and formed to aid in resource allocation and facilitate hospital response. Decision-making and response at the HICG level are likely to impact patient outcomes (36, 97).

At the time of this study, there had been no comprehensive assessment of hospitals' disaster preparedness. While hospital disaster preparedness has been evaluated through structural and non-structural assessments, little research has focused on preparedness as assessed through hospital incident command groups' response, nor factors that may affect response. Furthermore, disaster preparedness among ED RNs' in the study setting was unknown, nor their perception of their disaster competencies.

This project, therefore, addresses two vital aspects of disaster preparedness essential for minimizing mortality and morbidity caused by an MI; hospital incident command groups' preparedness and emergency department registered nurses' disaster preparedness.

4 RESEARCH AIMS

The overall aim of the thesis was to assess disaster medicine preparedness in Stockholm, Sweden through the evaluation of hospital incident command groups and emergency department registered nurses.

4.1 SPECIFIC AIMS

I. To identify essential disaster medicine competencies for emergency department registered nurses through expert consensus.
II. To assess emergency department registered nurses' self-perceived disaster preparedness
III. To assess associations between decision-making skills and staff procedure skills of hospital incident command groups during major incident simulations using performance indicators as measured by DiMI.
IV. To explore registered nurses' experiences as disaster preparedness coordinators (DPC) of hospital incident command groups during an MI.

5 RESEARCH APPROACHES

Research methodology is comprised of design, approach, and methods(120). The research approach of a study is dependent upon the aim or research question and what data is required to answer the aim (120). Often, the process begins with an observation of a phenomenon the researcher wishes to understand (121), and depending on the type of data needed to answer the aim, an appropriate method is chosen.

In the case of this thesis, the disaster preparedness of emergency department registered nurses was my starting point. There was a lack of knowledge concerning how well-prepared ED RNs were in the study setting. In addition, there was a lack of consensus concerning both what to measure and how to measure ED RNs' disaster preparedness. The second area lacking knowledge concerned hospital incident command preparedness/ response and factors affecting HICG response.

The identification of these knowledge gaps resulted in two main research aspects for this thesis: Disaster preparedness among ED RNs and HICG disaster preparedness as assessed by decision-making and response. To answer the overall research aim, four specific research questions were formulated. Based on the specific aims, two different methodological approaches, quantitative and qualitative were applied.

(Study I): A review of the literature revealed a lack of consensus concerning essential disaster nursing competencies for ED RNs in the study setting. In order to assess ED RN disaster preparedness, ED RNs' disaster competency needed to be identified. To accomplish this, a modified Delphi technique was used.

(Study II): Once competencies were identified; preparedness could then be assessed utilizing a cross-sectional study design.

(Study III): Study III was a prospective observational study that assessed hospital incident command group decision-making and response through the application of an instrument using measurable indicators designed in the study setting.

(Study IV): Once HICGs' response was assessed, understanding factors that affect decision-making and response required exploration of experiences from individuals with unique insight and perspective.

6 THE THESIS

6.1 METHODS

This thesis consists of four studies and used quantitative methods (study I-III) methods and a qualitative method (study IV) (Table 3). The methodologies in this doctoral thesis were guided by the aims and resulted in a combination of quantitative and qualitative approaches being used. While there are epistemological differences in the methods, combing these approaches can provide a general and comprehensive description as well as an in-depth description of disaster medicine preparedness(120, 122, 123).

Table 3 Studies and methodologies included in this thesis

Study	Participants	Method	Analysis method
Study I	32 experts within disaster medicine completed all three rounds	A modified Delphi technique utilizing three rounds was used to identify essential disaster nursing competencies.	Descriptive statistics
Study II	140 emergency department registered nurses.	Cross-sectional study using a questionnaire based on study I.	Descriptive and inferential statistics
Study III	Six hospital incident command groups	Prospective observational study	Descriptive statistics and inferential statistics
Study IV	Six disaster preparedness coordinators.	Face-to-face semi-structured focus group discussions and six individual follow-up telephone interviews	Content analysis with an inductive approach.
Testing the results Study IV	Seven operative members of the HICG during an MI	Semi-structured individual interviews (five telephone interviews and two face-to-face interviews)	Content analysis with a deductive approach.

6.1.1 Quantitative approaches (Studies I-III)

Quantitative methods are typically rooted in numeric data which are used to test a hypothesis, measure a phenomenon or assess associations using statistics (121, 124). In addition, quantitative research can be characterized by how it assess relationships between variables, assessing either causative or correlative relationships, and applying both descriptive and inferential statistics to a sample that represents a larger population (120, 121). Studies I-III present descriptions of the phenomenon with the aid of descriptive statistics. In addition, studies II-III utilize inferential statistics to make inferences about the population based on the data (125).

In quantitative studies, such as I-III, measurement scales can be divided into four categories: nominal, ordinal, interval, and ratio data (121). Statistical analysis depends on the data collected with various analytical non-parametric (nominal/ordinal) and parametric data (interval and ratio) approaches (121). However, there is often debate as to the most appropriate type of analysis when analyzing data. It has been argued that data from, for example, Likert scales should not be expressed as means or standard deviations in as much as the scales themselves can be described as a form of non-parametric data (121).

However, in studies, I, II, and III, the decision was made to treat the data as interval data and present means and standard deviations when presenting descriptive statistics in addition to percentages (study I), as opposed to median which depending on the school of thought, would be more correct. There were two reasons for choosing means and standard deviations. The first, similarly presenting our results to previous, similar research, would facilitate comparison. The second and more important reason for choosing means and standard deviations more accurately reflected the rating of the item.

6.1.2 Qualitative approach (Study IV)

Qualitative methods may be used when attempting to explore or understand concepts, experiences, or perceptions or identifying variables to be used in future studies (120, 124, 126). The purpose of using a qualitative research approach is to gain a deeper understanding of a specific situation or phenomena as well as to present a broad yet condensed description of the phenomenon being explored creating data from the participants' experiences and perceptions (126). A major difference between qualitative and quantitative methods is that, unlike quantitative methods, data is created. The construction of data is often based on interviews in which interpretation of transcribed text follows a rigorous process to ensure trustworthiness, in this case, inductive and deductive content analysis (testing the results) (127, 128).

6.2 ETHICAL CONSIDERATIONS

When conducting research on human subjects, steps must be taken to ensure the safety, well-being, and integrity of all participants before conducting the studies. Paramount is the confidentiality of participants and receiving informed consent prior to data collection. All studies were designed per the principles as stated by the World Medical Association Declaration of Helsinki(129) 2018/2142-31. Ethical approval was applied for studies II-IV

and the supplementary data collection and received waivers from the Regional Ethical Review Board in Stockholm, Sweden.

Specific ethical considerations taken for each study are described separately under critical appraisal for each study.

6.3 SETTING AND PARTICIPANTS

The overarching setting for the doctoral thesis was Stockholm, Sweden. The specific setting for studies II-IV consisted of major hospitals in Stockholm, Sweden.

Careful attention was given to the inclusion of participants for each study with the aims dictating both the methods and participants. The questions posed in each of the studies required participants who had experience and expertise in their respective fields. The overarching aim of the thesis required a diverse study population that was specific to the aims. While a large portion of the participants in study I were located in the study setting, international participants and participants from other parts of Sweden were included. In study II, all participants were registered nurses employed at emergency departments in Stockholm, Sweden at the time of the study. In study III, the participants were the Hospital Incident Command Groups at the major hospitals in the study setting. While the participants for study IV were registered nurses in their roles as DPCs both prior to the MI in 2017, during, and after. For the extra data collection for testing the results for study IV, participants were operative members of the HICG during the major incident of April 7th, 2017 for the six hospitals in study III.

6.4 STUDY I

6.4.1 Background

A review of the literature revealed a lack of consensus concerning essential disaster nursing competencies and few validated instruments for assessing disaster nursing competencies. At the time of planning the studies, there were few studies or doctrines published to guide the identification of competencies that could adequately reflect the prerequisites, both the inherent risks and abilities in the study setting and competencies that should be expected of RNs. However, a few published reports and studies provided a starting point. In 2009, the International Council of Nurses (ICN) convened and identified core disaster nursing competencies that were divided into 10 domains (28) (later revised to eight in 2019 (100), however, these competencies were broad in scope. This lack of specificity was addressed by the Wisconsin Nurses Association which created the Emergency Preparedness Information Questionnaire (EPIQ) (105) that became the starting point for this project. However, the validity of those competencies in the study setting couldn't be guaranteed due to the possibility that preconditions, such as regulations, risk, hazards, and education requirements may differ. Indeed, the ICN implies the need to develop geographical-specific competencies in relation to specific risks, hazards, and probability of events(28, 100). While the EPIQ appeared to closely mirror the prerequisites in Sweden, it was deemed pertinent that opinions of other experts were considered in an attempt to ensure that prerequisites in Sweden were

taken into account. It was thus decided that it was necessary to reach an agreement concerning disaster nursing competencies in order to assess ED RN disaster preparedness.

One way of reaching consensus concerning this question was through a modified Delphi technique. To ensure that the competencies used to assess ED RNs' preparedness were relevant to the study setting and thereby increase the likelihood that results of future studies were valid, a modified Delphi technique was used to identify ED RN disaster medicine competencies.

6.4.2 Design, method, and analysis

Design: The design chosen for this study was a modified Delphi technique. The Delphi technique is described as a technique in which expert opinion is combined to form group consensus concerning an issue where there previously lacked agreement and is therefore assumed to be more valid than the opinion of an individual (130). The Delphi technique is an iterative process including “rounds” in which questions or statements are sent to the panel of experts. The classic Delphi technique often consists of four rounds with the first round used to generate items or questions. As opposed to a classic Delphi study with the first round consisting of an item-generating round, the first round in this study started with statements derived from a validated instrument constructed for assessing RNs' disaster preparedness, hence a modified Delphi. A literature review was conducted to identify available instruments for assessing RN disaster preparedness, and one validated instrument was identified, the (EPIQ) (105). The EPIQ was, after a thorough assessment of the content, used as the base for round one, with kind permission (by the Wisconsin Nurses Association). While highly reliable and valid even in modified forms (101, 109) originally the EPIQ was designed for and applied in a different geographical setting. For study I, statements for round I were derived from the EPIQ questionnaire (105). It was decided that not more than three rounds as suggested would be undertaken to avoid study fatigue (131). Once the method was determined, attention turned to identifying experts.

Experts: In a Delphi study, the study participants are called experts. The term ‘expert’ as defined by McKenna is a specialist within their specific field (132). The selection of the experts took into consideration the type of expert and composition of the panel as well as the number of experts. Heterogeneity is often described as a positive attempt at enhancing the credibility of the results of a Delphi study (133) and possibly ensuring content validity (134). It has been suggested that a panel of experts could consist of scientific experts, individuals with experience within the research area, clinical experts, or the panel could consist of all three types of experts (135). For this study, it was decided that all three types of experts within emergency medicine and disaster medicine were essential to ensure valid expert opinion, a broad spectrum of experts with disaster and or emergency medicine expertise was identified. Attention then turned to inclusion criteria for each of these three categories.

The expert group consisted of three categories. The first group, academic experts consisted of international and national experts. An academic expert was defined as an individual that had earned advanced degrees (masters or higher) in disaster or emergency medicine and was a researcher within their field. The inclusion criteria for the second group (disaster preparedness coordinators) were that these experts all currently held the position of disaster

preparedness coordinators either at the regional or local level, i.e. The inclusion criteria for the third group, (clinical experts), were registered nurses currently employed at emergency departments in Stockholm with at least two years of clinical experience from the ED.

Once the criteria for the experts had been agreed upon, the number of experts was discussed. There is a lack of consensus concerning an optimal number of experts (136), and a review of the literature reported a large variety concerning the number of experts in Delphi studies (134).

Both purposeful sampling and snowball technique was used to identify experts based on their knowledge and experience with the fields of emergency and disaster medicine. The research team's knowledge of the field was used to identify experts in the first two groups (academic experts, and DPCs) while experts in the third group (ED RNs) were identified by six local DPCs. The strategic selection of experts included international experts representing seven different countries (Norway, Canada, Iran, Finland, Israel, and South Africa) and resulted in two academic groups or four groups total; international academics, national academics, DPCs, and ED RNs.

A total of 40 experts were recruited with 32 completing all three rounds. Participation in this modified Delphi study was quasi-anonymous. Experts were made aware of the other individual experts participating in the study but not how individuals responded. Quasi-anonymity may act as a motivator for experts' participation yet ensures that individual influence on others was minimized (130).

Prior to the first round, the questionnaire was modified to better reflect the study setting e.g., items concerning legislation and terminology. In addition, items with more than one variable were divided into several items to avoid "double-barreled" items, i.e., items that contain more than one question.

What constitutes an adequate consensus level has been debated. The irony of the Delphi method is that there is a lack of consensus as to what the level of consensus should be. However, it has been suggested that higher levels of consensus, expressed as a percentage, may add validity to the results as opposed to the lowest level of majority consensus which could indicate more disagreement among experts and negatively affect the validity of identified competencies. However, the level of consensus can be said to be arbitrary and dependent upon the researcher's subjective assessment of the importance of what is to be agreed upon (131). This being said, given that patient care is likely to be affected by competency levels of those providing care, correct identification of essential disaster nursing competencies was deemed important therefore in this study, 75% consensus level was chosen as recommended (131).

Analysis of the data was conducted at the end of each round using descriptive statistics; frequencies, means, and standard deviations. Results for each round were trichotomized in ratings 4-5, 3, 1-2 (137, 138). An item was considered to reach expert consensus when 75% of the participants rated it 4 or higher or 2 or lower on the five-point Likert-type scale. Data was first imported to a Microsoft Excel spreadsheet and then to the statistical software package for Mac, SPSS version 23 (IBM SPSS statistics North Castle, New York, USA) for the analyzes. The Delphi flowchart illustrating the process is presented in the figure below.

Item means were used as feedback after every round in order to allow experts the ability to gauge group opinion of the specific items.

6.4.3 Results

After the first round, 53 of 59 items reached consensus. Experts were encouraged to leave written comments, opinions, or suggestions. Comments from the experts, which primarily concerned formulating the items to better reflect the Swedish context, and discussions within the research group resulted in 17 new items. In accordance with Delphi protocol, the six statements that had failed to reach consensus, either positive or negative with an additional 17 new statements, in total 23 items were sent to the experts in round 2. Sixteen of the 23 items in round 2 reached consensus and no new ones were added. In round 3, only one of the seven items reached consensus. After three rounds, 62 disaster competencies and 7 knowledge-based items were identified by achieving 75% 4-5 ratings through expert consensus (Figure 3). The 69 competencies aligned with the preexisting domains of the EPIQ instrument. These competencies became the basis of competencies used to evaluate emergency department registered nurses in study II.

	Pre-Delphi ➡	Round I ➡	Round II ➡	Round III
Participants		40	36	34
Response rate		90%	94%	94%
Drop out		4	2	2
Round activity	Translation and modification of the EPIQ tool. 45 items expanded to 59.	Questionnaire with 59 items sent to experts. ⬇ 53 items reached 75% consensus. 17 new items	A total of 23 statements sent in round II. ⬇ 16 statements reached consensus.	Seven items sent out. ⬇ One reached consensus.

Figure 3: Delphi rounds

6.4.4 Critical appraisal of Study I

This study was evaluated using the critical appraisal guidelines outlined by Polit and Beck 2010. Their guidelines consist of 6 dimensions that should be assessed: *substantive, theoretical, methodologic, interpretative, ethical, and stylistic. (125).*

The *substantive dimension and theoretical dimension* concern the study's relevance, i.e., if the study is worthwhile and there is a conformity between the research question and the method used. There was a lack of consensus concerning disaster nursing competencies in the study setting. While a validated instrument had been identified, it had been developed for general RNs in another context. In an effort to ensure that the competencies to be used in study II were relevant, it was decided that using a method in which opinions from several experts may combine to form group consensus may be well suited for the aim of the study. The utilization of a modified Delphi technique was motivated by several factors. The main reason is the assumption that group expert opinion is more valid than that of an individual. Another is that this method may reduce the risk of individual experts feeling pressured by individuals or majority opinion as a result of face-to-face methods. Moreover, using the Delphi technique as opposed to face-to-face methods such as consensus conferences, or nominal group technique, aided in overcoming geographical and logistical barriers (139).

The *methodological dimension* concerns the research design, sample, data collection, and analysis. Once the method had been agreed upon, the choice of participants was guided by the research aim. In an attempt to ensure that all aspects of disaster nursing would be considered, international experts were included. The number of participants, rounds, and level of consensus were guided by a review of the literature concerning these aspects and are outlined in the published article. In addition, a researcher with extensive experience was consulted and guided the methodological aspects of the study (MJ). While the method chosen was deemed to be relevant, there is a possibility that results may have differed had a traditional Delphi method been chosen as opposed to the modified Delphi in which items/ competencies for analysis were presented in the first round.

The *ethical dimension* concerns the rights and safety of the participants. All participants were provided with written information about the study in which they were informed that participation was voluntary and that they could withdraw participation at any time without consequences. Within the expert panel, participants were guaranteed quasi-anonymity to facilitate data collection and participation, however, they were guaranteed that their responses were confidential and individually anonymous and could not be connected to any specific participant. Furthermore, they were guaranteed confidentiality and anonymity in the published study. Ethical guidelines according to the Declaration of Helsinki and the Regional Ethics Committee were meticulously reviewed. After careful consideration and thorough discussion with experienced researchers in the local ethics committee at Sophiahemmet University, we concluded that this study would not expose anyone to harm, and ethical review by the ethical review board was not necessary according to the Swedish Ethical Review Act (2003:615).

Interpretative dimension concerns the interpretation of the data, the inferences of the results as they pertain to the framework, and the identification of limitations in the study. The findings of this study provided the bases of competencies that were deemed essential for RNs

that may be required to provide health care during an MI. While the Delphi method ensures consensus, there is little evidence that this translates to correct answers being identified or the validity of the items that reached consensus. And while face or content validity has at times been assumed (134, 140), this is also uncertain and better assessed with other methods, such as those performed in study II.

The sample size of Delphi studies is also a subject of contention with little scientific evidence guiding the number of experts needed. Rather, importance is placed on the choice of experts in relation to the subject under investigation. For this reason, a purposive sample based on predefined inclusion criteria and complimented with a snowball technique was used. While there is no consensus as to how many experts are required to ensure validity, previous research aided in the decision to include 40 experts. Both a broad range of experts and balance between the different groups of experts was sought. A challenge in study I was ensuring an equal balance of the four diverse groups. To ensure balance, the size of the groups was constructed to have a similar number of experts in each group. Another known challenge of Delphi studies is the retainment of participants. To minimize drop-out, the Delphi rounds were limited to three to minimize the risk of study fatigue. Further efforts to minimize drop-out, included controlled group feedback in which opinions of the group were shared. Expert group opinion was shared in the form of means. These efforts may have aided in a relatively high participation retention rate of 80% (32/40).

Presentation and stylistic dimension concern how succinctly the results were presented. Rigorous attention was given to the transparency of the reporting of each round in the results in the article. Several meetings and continual redrafting of the manuscript were measures taken in an effort to ensure that the results were understood.

6.5 STUDY II

Study II aimed to assess emergency department registered nurses' disaster preparedness. The competencies identified in study I were applied to assess ED RNs' disaster preparedness.

6.5.1 Background

Several previous studies assessing RNs' reported that their disaster preparedness was moderate to suboptimal(105-110). The status of ED RNs' disaster preparedness in Stockholm, Sweden was unknown. One previous study in this research setting assessed registered nurses' self-perceived disaster preparedness(110). While providing insight, the participants in this previous study did not include ED RNs, and the variables used to assess disaster competency were broad. Due to the inherent structure of health care and studies reporting that patients' from MIs first contact are with ED RNs, it was decided that a study assessing ED RNs' disaster preparedness using an instrument consisting of disaster nursing competencies specifically designed for the study setting was appropriate in study II.

6.5.2 Design, method, analysis

This study sought to assess ED RNs' self-perceived disaster competency and assess correlations between competency and demographic variables as well as to assess their self-perception of preparedness.

Method: Study II had a descriptive design using a cross-sectional method. Data collection was facilitated through an online questionnaire. Participants were sent a closed link to the online questionnaire.

The questionnaire

The questionnaire used in this study is based on the competencies identified in study I. Modifications prior to the use of the questionnaire in study II consisted of item expansion (i.e. original questions that contained more than one focus were split into several items. In addition, items concerning CBRN were added as questions specific to the study setting. Similar to the EPIQ, a Likert scale was used to assess ED RNs' self-perceived preparedness. Likert scales and Likert-type scales, first developed by Renis Likert (141), are common psychometric item scoring instruments often employed to quantify participants' attitudes, beliefs, or options. Items are often formed as statements from which participants state their level of agreement (119). To aid in the quantification of results, Likert- type scales typically consist of five to seven-point scales for participants to gauge their opinion for an item. Five-point Likert scales were deemed to be the most appropriate in this study to both expedite the time it takes to complete the questionnaire and to facilitate comparison of results from previous studies.

This study eschewed the Likert-type scale assessing "familiarity" commonly used in previous studies as the term could be seen as ambiguous. There was concern the individual interpretation level of "familiarity" could be highly subjective, possibly negatively affecting the accuracy of the results. I then decided to correspond Benner's five stages of clinical competence to the five-point Likert- type scale (114). These stages are more clearly defined which may aid in a more homogenous interpretation of the Likert scale when using self-assessment as a form of data collection. Lexical ambiguity of words can affect participants' mutual understanding and negatively affect the validity of the results. A Likert scale in which each step corresponded to Benner's five stages of clinical competence (1=Novice, 2= Advanced beginner, 3= Competent, 4=Proficient, 5= Expert)(114) (Table 4) was used to increase the participants' mutual interpretation of the scale. To assess comprehension of the questionnaire and the Likert-type scale used, a pilot study was conducted with registered nurses enrolled in advanced nursing programs in emergency medicine and ambulance care. A total of 15 pilot questionnaires were returned resulting in further refinement of items and time estimates that concluded that the questionnaire required between 7-20 minutes to complete.

Table 4. Rating individual competencies based on Benner's stages of clinical competency .

Novice:	No experience, ability in the clinical setting is limited and inflexible. Usually needs verbal or written cues. May have theoretical knowledge. Normally less than a year of clinical experience.
Advanced beginner:	Somewhat skillful and efficient. Has knowledge and "know-how" and some limited prior, practical experience. Often guided by rules and regulations. May require occasional written or verbal coaching.
Competent:	Reasoned response. Has some mastery. Is efficient, confident in the specific area. Establishes a plan based on analytical, conscious, and abstract contemplation. Usually after 2-3 years
Proficient:	Intuitive response as opposed to reasoned response but not intuitive decision making. Reasoning is still a key factor. Time may be lost. Usually after between 3-5 years.
Expert:	Non-reflective. Intuitive response and intuitive decision-making without need for reflection. Based on theoretical knowledge and clinical experience. 5 plus years.
Likert scale: 1= Novice, 2= Advanced Beginner, 3= Competent, 4= Proficient, 5=Expert	

While the EPIQ instrument in its various forms has demonstrated high levels of internal consistency as measured by Cronbach's alpha, a test for internal consistency should be run for each use (120). In study II the decision was made to explore any possible underlying dimensions within the data and an exploratory factor analysis (EFA) was conducted upon completion of data collection. EFA is a data reduction technique that is used to assess the dimensionality of items. Factor loadings can be seen as a measure of how well items correlate with an underlying factor or domain. For this study, a factor loading of 0.5 (considered high) was chosen. Since it was assumed that items would correlate and the size of the data set was assessed to be large, oblique Promax rotation was used (121). The EFA reduced the number of items from 60 to 46 and dimensions from 12 to 3.

The questionnaire displayed a high degree of reliability and had a strong internal consistency (Cronbach's alpha 0.989). A plausible explanation for the high alpha value may be the refinement of the original EPIQ, using a new scale of measurement, as well as conducting n EFA.

Participants: Six of seven major EDs participated (One hospital declined to participate). All registered nurses with active employment in EDs in the study setting were invited to participate. Since all nurses, regardless of the number of clinical years or experience are part of their hospitals' disaster response plan, there were no exclusion criteria other than that participants had to have a hospital-provided email address to which a link to the study could

be sent. Emails were sent to potential participants through department representatives with DPCs encouraging participation. DPCs were consulted ahead of data collection in an effort to increase participation at their respective hospitals. Heads of emergency departments were provided detailed information on the aim of the study as were DPCs for their respective hospitals. According to figures provided by the EDs, 372 registered nurses were provided a link to the google forms survey. Three reminders were sent before the questionnaire submission period was closed. A total of 141/372 responded with one participant neglecting to mark that they had given informed consent to the study resulting in 140 completed questionnaires. Data were collected between the 10th of January and 19th of February 2019 using a questionnaire based on the results of study I.

The questionnaire: The original questionnaire consisted of items that were grouped in 12 domains or factors. The instrument in this study was refined for the ED RN and was found to have a high degree of reliability and had a strong internal consistency.

Analysis: Descriptive and non-parametric analyses were conducted. The Mann-Whitney u-Test, Kruskal-Wallis, were used to assess differences between group means. Correlation analysis of competencies and demographic data was conducted using Spearman's tau-b correlation. Similar to study I, means and standard deviations were used both to facilitate comparison of previous studies and to more accurately reflect the ratings of the competencies.

6.5.3 Results

Less than competent?

The instrument used in study II consisted of one overall domain Total Disaster Competency, and three main dimensions, Staff, stuff, structure, system; CBRN; and Specific patient groups). Given that each step of the Likert-type scale corresponded to the specific stages of Benner's model (1=Novice, 2= Advanced beginner, 3= Competent, 4=Proficient, 5= Expert (114)), the corresponding means for the participants indicate that their disaster competency as assessed by the TDC (M=2.34) is closer to "advanced beginner" than "competent". Further analysis sheds light on the more specific aspects of disaster competency. ED RNs competency moved closer to "competent" (M= 2.89) when concerning aspects of disaster medicine, they may come into contact more frequently with i.e. (Staff, stuff, structure, system) and were significantly lower concerning aspects they had little or limited contact with (Specific patient groups M= 2.17 and CBRN M=2.00). Education and experience were correlated to higher levels of competency across all dimensions and TDC. The TDC increased based on experience (up to M= 2.99) and education (up to M=3.07).

Of particular interest is the ED RNs' self-perceived overall disaster preparedness. A single item asked RNs to assess their overall disaster preparedness. RN's self-perception of overall preparedness (M=2.74) was significantly higher than the TDC (M=2.34). Means ranged from 1.14 to 3.47 indicating that ED RNs' perception of their competency was between novice and competent. These means were also positively associated with demographic factors such as education and experience with the notable exception of having formal disaster medicine education being inversely correlated to competency meaning, that those who formal disaster education rated their preparedness lower than those that had no formal education.

6.5.4 Critical appraisal of Study II

As with study I, this study was evaluated using the critical appraisal guidelines outlined by Polit and Beck 2010 (125). Their guidelines consist of 6 dimensions that should be assessed: *substantive, theoretical, methodologic, interpretative, ethical, and stylistic.*

The *substantive and theoretical dimension* of study II concerns its congruence between the research question and the method used. Since earlier studies indicated that RNs' had medium to low levels of preparedness (105-107, 109, 110) and that ED RNs' preparedness in the study setting had yet to be evaluated, this study aimed to assess ED RNs' disaster preparedness. While using a validated instrument is seen as beneficial, the validity can't be taken for granted when used in other settings (121). The methodology of this study, a cross-sectional study is based on previous studies, and while the results may be seen as a baseline measurement of ED RN disaster preparedness unique to the study setting, using a similar method and instrument may facilitate comparison to other studies.

The *methodological dimension* concerns the appropriateness of the design as it relates to the study, selection of participants, sample size, and methods for statistical analysis and is guided by the aim. Using the competencies that reached consensus in study I, this study set out to assess ED RNs' disaster preparedness at a particular time. Given this starting point, and the aim of the study, a cross-sectional study was chosen. A cross-sectional study is a study in which a phenomenon is measured at a single point in time without manipulating or interfering with what is being measured (120). While potentially providing vital information in which results may be described and inferred, the potential for making causal inferences is limited.

One valid question that could be raised concerning this study and indeed the conclusions made is; are studies based on self-assessments accurate reflections of actual ability? Research indicates that there is a discrepancy in the relationship between self-perception and objectively measured abilities (116). Studies have shown that there is often either no relationship or a negative relationship between self-assessed competencies and objectively evaluated competencies (142, 143). Indeed, the biggest discrepancy between these two types of evaluations was for those who were least skilled yet demonstrated high levels of competency (144). That being said, there is evidence that higher levels of expertise correlate to more accurate assessments (117). Given the evidence that self-assessments may not accurately reflect true ability (and may be overestimated), there is reason to believe that the levels of disaster competencies amongst ED RNs assessed in study I might be even lower than indicated.

Reliability of an instrument concerns how consistent an instrument measures while validity assesses how well an instrument measures what is intended to be measured (120). While distinctly different, these two measures are closely associated. An instrument's validity depends on its reliability however, reliability is not dependent upon validity (119).

To assess reliability, Cronbach's alpha was calculated. Cronbach's alpha is used to measure the internal consistency or the underlying construct of an instrument and is connected to the interrelatedness of the items used in the questionnaire (145). However, it has been argued that Alpha alone may not be sufficient on its own when determining if items in a questionnaire measure the same thing but may be complemented by factor analysis (146).

Alpha values >.90 are often desirable and may indicate high levels of reliability, however extremely high values such as the one produced in this study it may also indicate redundancy of items, i.e., that items test the same thing but might be formulated in a way that masks this (119, 145). Careful attention was given to the formulation of items prior to the study and re-evaluated after conducting the EFA and Cronbach's alpha. It was determined that while items may be similar, they ultimately measure decidedly different aspects. The reduction to three dimensions plus the added clarity of scales and items may have been a contributing factor for the high level of Cronbach's alpha, and indicate that this instrument may be a psychometrically sound questionnaire for assessing registered nurses' self-assessed disaster preparedness. The items included in the final instrument after EFA were scrutinized by the research team.

Validity of a study concern how sound the results are and are interlinked with the chosen method, sample of participants, and reliability of the instrument used (120). Methods for analysis chosen were in accordance with the type of data (non-parametrical) produced. However, means and standard deviations were reported, allowing for comparison with other studies while also more accurately indicating subtle differences. Once the analysis was conducted, the results as well as the chosen methods, interpretation, and presentation of the results, were thoroughly discussed within the research group. Rigorous attention was given to the presentation of the results in order to present the findings clearly and succinctly. Given the hypothesis that the instrument used in this study measures what it is intended to measure, and based on the high alpha values, it could be concluded that the instrument used is both reliable and valid (119).

The *ethical dimension* concerns the rights and safety of the participants. All participation was voluntary and anonymous, and participants were informed that they could decline participation without consequences. Information concerning the study was provided to the heads of the departments as well as included in the online instrument. Informed consent was collected by participants indicating that they had read the information concerning the study by marking that they had read and agreed to consent. No personal data was collected. Data that could be connected to specific hospitals was not used. The study received a waiver from the Regional Ethics Review Board (DNR 2018/2142-31).

The *Interpretative dimension* concerns the interpretation of the findings and justifiable inferences of the study. In particular, the results concern the response rate, how concisely results were presented, and internal consistency. The response rate could be seen as a limitation. Despite collaboration with DPCs and three friendly reminders being sent to participants 140 of 372 ED RNs participated, resulting in a response rate of 38%. While the response rate may be seen as low, it is on par with other similar studies (101, 104, 147). An analysis of response rate was conducted within the research group and through conversations with DPCs with study fatigue being identified as a possible reason for response rate. According to information we received, staff had recently partaken in a number of studies. After discussions with the statistician, no systematic reasons for the response rate were identified that would explain the difference between those that responded and those that chose not to respond. Furthermore, the sample size was deemed large enough by the statistician to allow for correlation analysis. The representativeness of the participants in the study was also discussed and was assumed to adequately represent the population. However,

a systematic dropout analysis might have added new or deepened understanding of the results. Another possible limitation is the lack of validity concerning corresponding the results as expressed by means, to levels of competencies. This has yet to be assessed and further studies concerning this issue would be warranted.

Presentation and stylistic dimension concerns how succinctly results were presented. Several meetings within the research group and continual redrafting of the manuscript were measures taken to ensure that the results were correctly and succinctly presented. In order to produce a concise and focused result, not all results analyzed were included in the final manuscript that was ultimately published. Furthermore, careful attention was given to the description of the study setting and participants to aid in the reader's assessment of the generalizability of the results. Generalizability concerns how broadly applicable the findings of a study are in other settings (120). Given similar prerequisites in other settings, these findings may have good generalizability.

6.6 STUDY III

6.6.1 Background

A fundamental prerequisite when attempting to mitigate the effects of an MI is the availability of resources or the ability to allocate resources. Depending on the type of MI, there is an impending risk that acute needs may outweigh available resources. Previous research has concluded that disaster plans, competent personnel, and hospital incident command structure and knowledge are vital in disaster management(70, 75, 78). While previous research has shed light on hospital preparedness, little attention had been given to HICG processes and decision-making. Few instruments have been developed for this specific purpose. However, one instrument the Disaster Management Indicator (DiMI) was developed to facilitate the assessment of structure and processes (88).

In the fall of 2016 Six major hospitals held similarly themed antagonistic MI simulations. Five of the simulations concerned bomb blasts in public areas while a sixth concerned an antagonistic attack of a single person at the participating hospital. Each of the hospitals' disaster preparedness coordinators facilitated both their own simulation as well as aided the other simulations.

6.6.2 Design, method, analysis

Design/Method:

Study III was a prospective observational study and aimed to assess possible associations between decision-making skills and performance of hospital incident command groups. Six major hospitals held similarly themed antagonistic MI simulations during the fall of 2016. Five of the simulations concerned bomb blasts in public areas while a sixth concerned an antagonistic attack of a single person at the participating hospital.

Participants. Participants were the HICGs activated during the simulations. While each command group consists of several functions and members, individuals were not evaluated, rather decisions and actions taken by the HICG were evaluated.

Data collection. The authors JM and AR collected data in study III through observation of six simulations during the fall of 2016. Data collection was facilitated through the use of the Disaster Management Indicator (DiMI) instrument, an evaluation tool based on process modeling and consensus by the Swedish National Board of Health and Welfare (88). The DiMI consists of 22 measurable indicators divided equally into two groups: 11 indicators measuring structural procedure skills and 11 measuring decision-making skills. The 11 decision-making skills consist of two sub-groups, reactive and proactive decision-making indicators. Indicators were scored on a scale from 0 – 2. A value of 0 indicates the standard for the indicators was not completed. A value of 1 indicated that the standard for the indicator was partially completed while a value of 2 indicated that the standard for the indicators was completed.

JM and AR collected all completed DiMI instruments (one from each of the two observers) and cross-referenced them with each other for each of the simulations. In addition, DiMI documentation was cross-referenced with documents provided by the DPCs.

Analysis. Data were transferred to Microsoft Excel for Mac version 16.33 for preliminary analysis, and then to Statistical Package for Social Sciences (SPSS) version 25 (IBM SPSS Statistics North Castle, New York, USA) JASP version 0.9.2 (JASP Team ® 2018). ANOVA and Kruskal Wallis tests were used for analyzing differences in means between decision-making and staff procedure skills. Associations between groups of decision-making and staff-procedure skills were analyzed using Spearman's rho correlation coefficient.

6.6.3 Results

This observational study resulted in the identification of significant differences in proactive and reactive decision-making. Proactive decision-making abilities were significantly lower than reactive decision-making abilities. Furthermore, this study indicated that while not significant ($p= 0.051$) decision-making and staff skills were associated. While this provided unique and vital information concerning the inner working of the HICG during simulations, factors affecting decision-making and response were not assessed. It was theorized in accordance with previous studies that HICG response during an MI might differ in comparison to simulations and that several factors might be attributed to that and HICGs' general response. Hence, the aim of study IV.

6.6.4 Critical appraisal of Study III

As with studies I and II, this study was evaluated using the critical appraisal guidelines outlined by Polit and Beck 2010 (125).

This was the second study conducted and as a Ph.D. student. A review of the literature revealed few studies focusing on HICG decision-making. Moreover, no studies assessing proactive decision-making and response had been identified. as with studies I and II, a positivist approach was applied. Similarly, this study could be seen as a baseline measurement of HICG decision-making and response. Concerning *substantive and theoretical dimensions,* this study focused on assessing HICGs' decision-making and possible associations with staff skills based on disaster preparedness plans in a real-time setting using

measurable indicators. Thus, an observational study was determined to be the most appropriate.

In terms of the *methodological dimension which concerns research design, data collection, data analysis, and sample,* a rigorous and systematic approach was applied. The approach followed was outlined in a previous observational study utilizing the DiMI (88). The sample was limited to all participating major hospitals (n=6) within a limited time frame. While the sample size may be considered small, it represents all major hospitals in the region. All hospitals used similar antagonistic scenarios for their simulations which facilitated comparison of results from each simulation. Two researchers collected data in real-time during simulations and cross-referenced notes with each other. Initial descriptive data analysis was conducted by JM. Inferential statistics were conducted in conjunction with a statistician. This study reported means and medians, and associations using non-parametric analysis. The possibility of analyzing data using the more powerful parametric analysis was discussed yet dismissed as it was deemed that that numerical data used was equated with categorical data, i.e. actions either correctly completed, partially completed, or not at all.

Ethical dimension. Participants in this study were the HICGs (study III) and the DPC (study IV). In study III, Members of the HICGs were assured anonymity and confidentiality, and that the group, as opposed to individuals, was assessed. information was provided to DPCs who then provided members of the HICG information concerning the study and received informed consent. Information concerning individual hospitals was re-coded to ensure that individual HICGs could not be identified. In study IV, participants were informed in writing and verbally and informed consent was given before the start of the study. Participants were ensured that they could withdraw participation without consequence. Confidentiality was guaranteed and it was agreed that due to the small sample size, codes that are normally assigned to participants in the reporting phase would not be used. Ethical approval was applied for and received a waiver from the Regional Ethics Review Board (DNR 2016/1530-21/5).

The *Interpretative dimension* concerns the interpretation of the results, the possible implications for further studies, and identifying limitations in the study. The associations identified, in particular, proactive decision-making and their association to overall response were born from arduous statistical analysis of the means of each individual indicator from each respective group and their associations with both other individual indicators and groups of indicators. These early analyses were discussed both within the group and with the statistician before further analysis of proactive and reactive decision-making was conducted. A multitude of discussions concerning analysis and results were held before final results were agreed upon within the research group. Another possible limitation is the DiMI instrument has not been tested for validity concerning its ability to assess response or preparedness. While used in previous studies, future studies assessing the DiMI's reliability and validity are needed.

Presentation and stylistic dimension. The discussions concerning the results guided the presentation of the study. Once final results were agreed upon, visuals in the form of tables were added to aid in the understanding of variables that could be seen as somewhat abstract. Study III was conducted in Stockholm, Sweden using an instrument constructed in Sweden.

Applying the results in other settings should be done with caution and with regards to prerequisites, regulations, and organizational structure in other contexts.

6.7 STUDY IV

6.7.1 Background

The results of study III spurred a deepening interest in HICG decision-making and response. Registered nurses often hold strategic managerial roles, overseeing staffing, training, and clinical outcomes (148, 149). One essential role in the group of HICG staff is the role of the DPC which in the study context is held by registered nurses. In addition to an operative role in the HICG when activated, DPCs form and revise disaster preparedness plans based on risk and vulnerability analysis reports to aid in hospital response stipulated by national regulations (23). Furthermore, DPCs initiate training, plan exercises, and simulations as well as evaluate hospital disaster preparedness in accordance with regulations (23).

Study III assessed disaster preparedness using a quantitative method. Originally, the aim of study IV was to explore HICG disaster preparedness from a qualitative perspective, by interviewing DPCs on their opinion concerning the performance of the HICGs during the antagonistic simulations in study III. While HICGs are commonly activated as a precautionary measure, sudden antagonistic incidents, and activation of HICG in response to them, are a rare phenomenon in the study setting. On the 7th of April 2017, Stockholm, Sweden was struck by an antagonistic MI (150). Due to both rarity of the event and given that the hospitals involved in the response to the MI had recently held exercises in a similar theme, it was theorized that more vital and new information could be gained by changing the aim. Planned preparedness had previously been assessed in study III. However, the HICGs' disaster preparedness in relation to an actual incident was unknown. Planned preparedness and actual preparedness may differ and this had not been explored in the study setting due in part to the rarity of these types of events. It was decided that the knowledge possibly gained through exploring DPCs experiences during an actual antagonistic MI and comparing it to planned preparedness in study III would provide more accurate and more beneficial knowledge. Thus, a new aim was formulated.

6.7.2 Design, method, analysis

The aim of Study IV was to explore registered nurses' experiences as disaster preparedness coordinators of hospital incident command groups during an MI. Each hospital has a DPC. The inclusion criteria were DPCs as operative members of the HICG in leadership roles during both simulations in 2016 and the major incident in April 2017.

This study utilized a qualitative descriptive design with semi-structured interviews. In order to facilitate rich and descriptive data, a face-to-face focus group discussion was utilized. The main objective for conducting an FGD was to gain insight of a specific incident from individuals that had in-depth knowledge and experience of this particular MI. FGDs have been reported to facilitate group interaction and discussion, providing rich data and enriching information about the event (151). Due to the rarity of the event and to stimulate memories through interactive dialog between the participants, an FGD focus group discussion (FGD) was conducted at a neutral location followed by individual follow-up telephone interviews.

A total of 6 participants from 6 different hospitals were included or 100% of the study population. One DPC was excluded due to being a part of the research team and instead, the assistant DPC took part in the focus group discussion.

Data collection

Utilizing a semi-structured interview guide, one face-to-face focus group discussion (FGD) with the five DPCs and one assistant DPC was held on June 11th of 2018 with individual follow-up interviews conducted during the fall of 2018 using the same interview guide as in the focus group discussion. The FGD and individual interviews are described in study IV (152).

Due to a lack of previous studies concerning the phenomenon, an inductive qualitative content analysis as described by Elo et al was conducted (127, 153). To ensure the trustworthiness of the results, the analysis scheme was adhered to (127). According to Elo et al, the analysis consists of three phases. (I) preparation, (II) organization and,(III) reporting (127).

Preparation phase: The interviews were digitally recorded and transcribed verbatim. The data created was derived from the transcribed interviews. Thereafter, the text was re-read several times while listening to the interviews to ensure a comprehensive understanding of the material.

Organization phase: Investigator triangulation was used to minimize bias (154). Four researchers were involved in the analysis phase to minimize bias and ensure the validity of the results. Three of the researchers were PhDs with prior extensive qualitative research experience. AH was an experienced researcher and an expert in emergency medicine. MR was an expert in disaster medicine as both a researcher and disaster preparedness coordinator. MJ was an associate professor with extensive experience as both a researcher and educator in qualitative methods. Open coding was carried out and discussed between authors. From there, categories and subcategories were identified, and discussions were repeatedly carried out until consensus was reached. Codes were divided into seven subgroups which then formed three categories and one main category.

Reporting phase: The reporting of the results was presented in a way that mirrored the data collected which seemed to closely mirror the experience of how the event unfolded according to the DPC, meaning the results were presented linearly and supported by quotations from the participants.

6.7.3 Findings

One main category (Expectations, prior experience, and uncertainty affect HICG response during a major incident), three categories (gaining situational awareness, transitioning to management, and actions taken during uncertainty), and seven subcategories were identified. A common thread throughout the interviews was feelings of uncertainty. While the DPCs were quick to understand the severity of the incident, the juxtaposition of the avalanche of unconfirmed information and the lack of contact with regional command added to their uncertainty and affected decision-making and management of the incident. Uncertainty,

however, was not solely an effect of lack of communication but also connected to their expectations as they pertained to training and prior experience. Measures to reduce uncertainty and promote positive action included declaring "state of disaster" which ensured that all available staff was kept and disaster plans initiated. This included the transfer of patients from sections on the ED that could expect patients from the MI. This in turn resulted in patient overload for other sections of the ED, possibly risking patient safety.

6.7.4 Critical appraisal of Study IV

There is a clear shift of approach in this study as compared to the first three studies. In study IV we were interested in investigating HICG response and decision-making. Study IV explored experiences of a specific and unique phenomenon in comparison to previous simulations, of which only a few select individuals have adequate insight.

Elo et al's (2014) outline for assessing trustworthiness was used for evaluating study IV. As opposed to reliability and validity of the results in quantitative studies, trustworthiness in qualitative research, in which ***credibility, dependability,*** and ***transferability*** are key aspects is used to address the quality of qualitative studies (127).

Credibility refers to how well the research process and data align with the aim of the study (120) and includes the choice of and the number of participants for the study (155). The choice and number of participants are reliant upon the specific aim of a study. The research question, according to Elo and Kyngäs (2008) dictates what should be created and analyzed. Due to the aim of Study IV in which explores DPCs' experiences of HICGs' response during a major incident, a qualitative research method using a semi-structured focus group- with individual follow-up interviews were conducted (126, 153).

The study, in which DPCs' experiences of the HICGs during a terror attack were explored, could fulfill the criteria for a case study. Case studies are in-depth investigations of a specific event that attempt to comprehend specific and vital issues, often collecting data in real-life settings, drawing from both present and past experiences of the participants (120, 156). Indeed, discussions within the research group were held after the analysis was completed. However, due to the quality of dialog and the amount of data produced, it was decided that to report and publish it as a case study would not be possible due to the limiting guidelines for reporting case studies in scientific articles.

It could be argued that one limitation of this study is the sample size (n=6) and number of interview minutes. Despite there being a lack of consensus concerning the number of participants required for qualitative studies, there is a tradition of incorporating both variation and number of participants until saturation is achieved (120). Saturation, which was originally applied in grounded theory (120) has been defined as being achieved when there is evidence of data redundancy, i.e., further interviews add no new, data, codes, themes, or information (157). However, it has been suggested that saturation may be an inaccurate concept for other qualitative methodologies outside of grounded theory since saturation is highly subjective (157, 158). The discussion about saturation seems to be centered around uncertainty, and an effort to minimize the risk of codes or information being missed, often leading to a "more is better" approach (159). Given these aspects, it has been suggested that

information power, as opposed to saturation could be applied when assessing sample size (158).

Information power is a concept that assesses sample size in qualitative research and suggests that the amount of rich information is inversely related to the number of participants required. Information power is assessed by the criteria: *study aim, sample specificity, quality of dialog, analysis strategy, and theory* (158). In this study, credibility was assessed through information power as defined by Malterud, Siersm, and Guassora (158) as opposed to saturation.

Study aim: The number of participants required is directly related to the specificity of the aim, i.e., a broad and general aim would require both a large variation and most likely a large sample size. However, if the aim were more specific the specificity of the aim would require less variation and fewer numbers of participants possessing that particular experience or knowledge (158). The aim of this study was focused on comparing planned preparedness and the response to a specific and rare event that required participants with a specific skill set.

Sample specificity: To adequately answer the narrow aim of the study, participants with very specific insight, knowledge, and experience were required. A first step in addressing credibility in study IV was the choice of participants. An essential aspect of study IV was also incorporating a nursing perspective. To adequately answer this, participants had to have in-depth knowledge of disaster plans, have actively planned and facilitated training (simulations) and evaluation as well as have been operational members of the HICG during the specific terror attack. Purposive sampling was used to identify and include the participants. After discussions with the research team, it was decided that those who best could answer the aim of the study and who fulfilled the requirements were the DPCs. In the study context, there are only six DPCs. However, one of them was a member of the research team and was replaced by the assistant DPC who fulfilled the pre-determined criteria, thus encompassing 100% of the study population. Even though the sample was small, it was decided that these six participants were the only ones that without bias fulfilled the specific criteria. The authors of this study concluded that the combination of the narrow aim and specificity of the participants were relevant and adequate.

Quality of dialog: The quality of dialog is dependent upon the quality of communication between the interviewer and participants. This is based on the interconnectedness of rapport between them, interviewer skills, and participants' communication skills. JM and MR conduct research on the subject matter and have a prior understanding and interaction of and with the participants. Preunderstanding in combination with open-ended questions can help extract data (126). The preunderstanding of the subject matter in combination with the choice of data collection method (FGD) may have aided in feelings of security while individual interviews may have enabled the participants to feel more secure to share information they may not have been willing to divulge during the focus-group discussion (160). Rapport with the participants was deemed to be good due to previously established contact. Participants' ability to adequately articulate throughout the interview was also deemed to be good with nearly all dialog being relevant to the aim. It was thus concluded that the quality of dialog was strong.

Analysis strategy: Analysis strategy concerns the strategy of analysis for the study and takes into consideration whether the analysis is a cross-case, which requires more variation and larger sample size, or case which motivates a smaller sample size(158). This study focused on a single, rare, and specific incident, which more closely mirrors a case, supporting a smaller sample size. Even though the subject could be sensitive in nature, the DPCs knew each other well, and therefore, it was decided to hold a focus group discussion which facilitates the collection of experiences in a nonthreatening and permissive environment (120) Focus group discussions also benefit of encouraging participants to share points of view and experiences which also can stimulate memories and dialog (120).

Prior knowledge may be advantageous when interpreting the meaning of statements and creating data (151). However, there is a risk for bias, therefore investigator triangulation was used to ensure the credibility of the data(154). The author group was constructed to include insider and outsider perspectives (161) and consisted of a mix of four RNs, two of which had in-depth knowledge of disaster medicine and two whose knowledge was more geared toward the method used, and two physicians with disaster medicine research experience. The mix of these researchers and their various perspectives were meant to ensure that the coding and categories were representative of the content. Analysis of the content was guided by the aim as suggested by Elo et al (2014). Credibility of the results was enhanced by the use of quotations and figures (127).

Theory: Due to a lack of established theory concerning the subject of our study, no theoretical background was applied. This could be seen as a limitation. While studies with a theoretical background may support a smaller sample size, according to Malterud, studies with small sample sizes may still have new and vital results within the discipline(158). A lack of established theory was assessed to not have a negative impact on either the results or the sample size due to the specific aim, sample specificity, quality of dialog, and analysis strategy.

Dependability concerns the stability of the data and results created over time (120). The interview guide was developed primarily by three individuals (JM, MR insider perspectives, and MJ with outsider perspective) to create a guide that would facilitate rich data collection. Adding to dependability, all interviews were conducted (and transcribed by the same person (JM)) using a pre-determined semi-structured interview guide that allows for flexibility for issues that may arise. MJ and JM conducted the FGD, allowing for insider and outsider perspectives. Quality of data was assumed to be high due to the rigid attention given to the interview guide and the established trust between the participants and interviewer. Another aspect of dependability concerns sample size. As mentioned, sample size in this study was assessed by information power. While there are no general recommendations concerning sample size, an indication of adequate samples size is when no new data was produced despite time allotted for follow-up interviews thus indicating that the sample size was adequate and relevant to the narrow and specific aim of the study.

Transferability refers to how applicable the study's findings in a specific setting can be in other settings or groups (120). Transferability cannot be assumed to be achieved by simply ensuring credibility and dependability of the results, rather transferability is determined by the reader (162). However, the reader is assisted by a detailed contextual description of the

study setting and participants and a detailed description of the method and analysis. Efforts were taken to provide a detailed description of these aspects to facilitate transferability. These efforts may aid in transferability despite the specificity of the aim and participants.

Ethical considerations: In study IV, participants were informed in writing and verbally and informed consent was given prior to the start of the study. Participants were ensured that they could withdraw participation without consequence. Confidentiality was guaranteed and it was agreed that due to the small sample size, codes that are normally assigned to participants in the reporting phase would not be used. All personal data concerning participants' identification was removed and replaced with codes that were kept separately from the data. Ethical approval was applied for and received a waiver from the Regional Ethics Review Board (Study IV: DNR 2016/1530-21/5). It was assumed that no sensitive information would be collected. However, when conducting qualitative interviews, there is a risk that participants may share information that may be sensitive (163). This risk was discussed before conducting the interviews and participants were provided an opportunity to talk "off the record" about possibly sensitive revelations.

Reflection of sample size: While the quality of the results is neither defined nor limited to empirical aspects but rather the trustworthiness of the study (127) the sample size of this study could still be seen as a limitation. Therefore, an additional data collection was carried out while the manuscript was under consideration for publication and after study IV was published.

6.8 TESTING THE RESULTS OF STUDY IV

6.8.1 Background

After study IV was submitted, there was concern that the sample size may be too small. It was therefore discussed if the data could be supplemented by conducting more interviews and including it in the study. However, after thorough discussions in the research team, it was deemed to be methodologically problematic doing this for several reasons, primarily concerning bias (discussed in the critical appraisal of testing the results). Instead, after study IV was submitted for publication and then subsequently accepted, an additional data collection was conducted using deductive content analysis to test the results from study IV.

6.8.2 Design, method, analysis

Method: Similar to the design of study IV, this study used a qualitative descriptive design with semi-structured interviews. However, as opposed to focus group discussions and complementary individual interviews as was used in study IV, all interviews were individual interviews.

Participants: A purposive sampling technique was used to identify participants. The inclusion criteria were members of the HICGs holding either an analytical or a leadership role during the terror attack in 2017 (150). A total of 13 potential participants were identified with seven agreeing to participate. Six physicians (n=6) and one RN participated (Table 5).

Table 5 Description of the participants n=7

Gender (man/woman)	5 (71%) /2 (29%)	
Profession (physician/ RN)	6(86%)/1(14%)	
	Mean (years)	Range (years)
Age	55	45-62
Years as members of the HICG	8	1-17
Years in profession	25	16-32

Data collection. Semi-structured, individual interviews were conducted (163) using the same interview guide used in study IV (152). The individual interviews ranged from 20:15-45:26 minutes and resulted in 245 minutes of interviews.

Analysis: This study was performed to test the findings from study IV and utilized a deductive content analysis. A categorization matrix was developed from the result in study IV as described by Elo & Kyngäs (153), and the data, i.e., the transcribed complementary interviews were reviewed for its content in relation to the matrix. In the analysis, the three phases as described by Elo et al (127) were used to ensure trustworthiness. *In the preparation phase*, the interviews were transcribed verbatim, and an overall understanding of the material was reached material through multiple readings of the interviews. *In the organization phase*, after achieving overall understanding, the categorization matrix was applied to the transcribed interviews, and an analysis of and comparison of categories and differences were conducted to test the results in study IV. In the *reporting phase*, the categories were discussed with the authors AH, JM and MJ until consensus was reached.

6.8.3 Preliminary Results

The deductive content analysis of the complimentary interviews did not result in any new categories. However, the analysis identified some new aspects to the previously identified categories in study IV. Listed below are the categories where slightly different aspects under the existing categories were uncovered.

Transitioning to management

An opinion from one participant differed slightly from the results in study IV. In study IV, the participants experienced uncertainty concerning the communication channels used and expressed frustration. However, participants in the complimentary interviews felt that communication tools worked surprisingly well.

#2 "No, I remember being positively surprised by how well it worked….because it was something was a bit concerned about beforehand because it's not our normal way of communicating and there's always a bit of concern"

Actions taken during uncertainty.

While several participants confirm that actions such as deciding on a state of disaster as the level of response may have been an exaggerated and unnecessary response, one participant further explained why this decision may indeed have serious consequences.

#7 "Deciding on state of disaster was done in order to increase capacity by sending patients home. This was a dangerous decision and may have cost lives"

However, this category was also highlighted from a slightly different perspective. Several participants expressed that aspects of psychological treatment may have been neglected to a certain extent. This concerned the fact that HICGs may not have taken into account the length of time the psychological units of the HICG were active.

"#1" The psychological unit was that part of our disaster preparedness that was pressed and they were active for several weeks…it escalated during the evening, night, the need for psychological care escalated for a week"

Another was concerned with how patients from the incident site without apparent somatic injuries were registered and initially treated as "normal" medical patients.

#5 "We had quite a lot of disaster-related patients but they were registered as normal dizziness or regular cardiac palpitation (patients) though in reality they had been at the incident site and had developed anxiety and came in. So, they should have been tagged at the ED as being a part of the terror incident"

Concerning their perception of actual preparedness, many echoed the opinions in study IV, that preparedness was at acceptable levels citing experience, training, time of day, and competence as being vital components, However, one participant perceived that the status of their hospital's level of preparedness was far worse now than at the time of the incident citing a lack of training, competence and a lack of recognition concerning the importance of the HICG citing the pandemic as a possible explanation.

#6 "it's far worse now… we don't' have the preparedness we had five years ago. We should be happy that no large-scale events have occurred" "we haven't had exercises"

6.8.4 Critical appraisal of testing the Results to Study IV

When assessing study IV from an empirical standpoint, on the surface, one could see the empirical support to be a limitation in study IV, possibly affecting the validity of the results. While there is a lack of agreement within the scientific community concerning the number of participants or interviews needed to ensure valid results, the decision was made to conduct further interviews. However, several methodological issues arouse one of which concerned

recall bias. One suggestion was to conduct a new data collection and include them in the original study. However, there were several concerns for this suggestion. The first is sampling bias (120). In the original study, it was deemed important to illuminate RNs as DPCs experiences. The participants in study IV were a homogenous group with shared specific attributes. The new participants consisted primarily of physicians but with varied backgrounds, and levels of experience than the first group of participants, particularly in regard to the original aim of the study.

The second issue of concern was recall bias (164). Nearly three and a half years had passed between the original interviews and the interviews conducted in the fall of 2021. While the event under investigation was a rare incident, the possibility of participants erroneously recalling details or not being able to remember certain aspects or recall bias was discussed (164).

A third issue discussed was confirmation bias. It was difficult, if not impossible, to re-analyze the "old" interviews together with the additional interviews using an inductive analysis method due to potential confirmation bias (164). Based on these reflections, a decision was made to allow the submission process of the original and now published study to continue. However, while deductive content analysis was chosen for this purpose, inductive content analysis could have been conducted if new data had been uncovered.

The method of data analysis was also intensely discussed. Interview bias and in particular confirmation bias was a concern. The aim of the supplementary data collection was to assess the results in study IV. The same interview guide was used to aid in this. It was decided that an inductive approach in the true sense would be difficult and subject to confirmation bias. Since a new analysis was going to be based on knowledge gained in study IV, a deductive content analysis approach was applied (120). We once again were guided by Elo et al.'s (2014) outline for trustworthiness with all interviews being transcribed verbatim, read through several times while listening to the audio recordings in an attempt to fully understand the material. In an attempt to minimize bias, investigator triangulation was used with MJ and AH assessing the results. Discussions went back and forth until a consensus concerning the results was reached.

Conclusion

The supplementary data collection appears to strengthen the results in study IV. No new categories were discovered. However, some aspects that fell under the categories, shed slightly different perspectives. This could be due to the different roles and professions of participants. The decision to not include the new interviews in the original study was supported in part due to potential recall bias. Indeed, a common comment that materialized during the analysis process throughout the interviews was "I don't remember" when it came to more specific questions.

These results could support the notion that saturation may have been reached in study IV and that information power was sufficient. Nonetheless, an argument could be made that the new perspectives from largely different professionals under the existing categories paint a more complete picture. However, given the difference in time between the interviews, the decision to not include the new data in the original study has been assessed to be more methodically sound.

7 SYNTHESIS OF THE FINDINGS

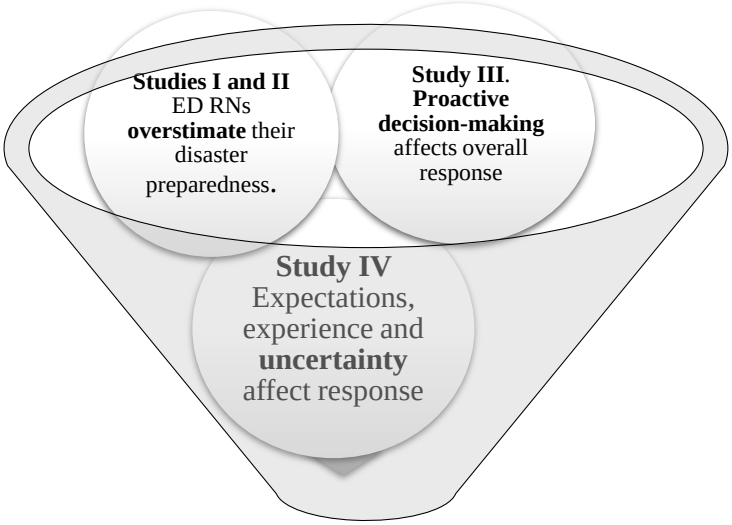

Figure 6: Synthesis of the findings

Undertaking these studies has provided two vital and unique aspects concerning disaster medicine preparedness. First, these studies provide a baseline measurement of disaster preparedness of the ED RN´s tasked with the responsibility of patients, leadership, and resources during an MI. Secondly, the findings of these results identified factors that may impact disaster medical preparedness and response. The synthesis of these studies can be seen as method triangulation (120) in as much as more than one scientific method was used to evaluate and understand disaster preparedness.

Three categories based on the findings of these studies could summarize disaster medicine preparedness in the study setting: *overestimated*, *reactive*, and *possibly adequate* (Figure 6).

Overestimated: The results in study II indicate that ED RNs assessed their disaster competencies to be moderate to low yet, this may an overestimation. In addition, while some participants in study IV expressed that HICG disaster preparedness was adequate or even good others expressed that disaster preparedness might not be at adequate levels citing several factors that affect preparedness.

Reactive: The results of study III indicated HICGs were largely effective during simulation exercises but perhaps reactive. In study IV, HICGs were to a certain extent similarly reactive

during the MI. However, factors affecting response were uncovered through DPCs' experiences of both simulations and the MI in study IV. In particular expectations, and prior experiences caused uncertainty when unfolding events were misaligned possibly explaining the reasons for reactive decision-making. This uncertainty may have been a factor affecting decision-making and response.

Uncertain: Medical response to MIs in the study setting may be seen as adequate. The "asterisk" is based in part on study IV participants' own words. The results in study IV indicate that disaster preparedness may be adequate but that disaster preparedness may depend on several factors; the ability to reduce uncertainty, the type and timing of the incident i.e., day of the week, and time of the MI. Furthermore, the frequency of training and education may likely affect preparedness. However, preparedness may negatively be impacted by factors such as a lack of recognition of the importance of disaster preparedness or the need to prioritize more immediate needs of health care, such as providing resources and education as a result of the ongoing pandemic.

8 DISCUSSION

These studies aimed to assess the level of disaster medicine preparedness in the study setting. The synthesis of these four studies indicates that disaster preparedness in the study setting may be adequate yet may be contingent on several factors, timing and place of the incident as well as the type of incident, as well as ED RNs disaster competencies, HICGs's decision-making ability during uncertainty Major Incidents are rare and disasters even rarer (3, 12). What constitutes a disaster lacks consensus in as much as the term disaster is contextual based and dependant upon cultural, geographical, and economical factors indicating that disaster medicine preparedness is dependant upon the pre-conditions, risks, and abilities in the given context (1, 27). This includes not only potential risks but the resources, knowledge, skills, and abilities of those actors involved in disaster preparedness and response.

Emergency Department Registered Nurses' disaster preparedness.

Health care disaster preparedness entails preparing for incidents that it may lack experience for. This places a higher demand on both ED RNs and hospital incident command groups. As supported by the results in study II, adequate and realistic training and education programs providing knowledge and skills to act are vital. Study II, in line with guidelines suggesting an all-hazards approach, evaluated ED RNs' disaster preparedness. Overall preparedness as assessed by self-perceptions indicated that ED RN self-assessed disaster preparedness is moderate to low.

Factors affecting disaster nursing competency. The results demonstrated that several factors affect competency and preparedness. Among them, training and education were positively associated with higher levels of competency. Higher levels of competency were also associated with competencies that ED RNs often incorporate in their daily activities, such as for the domain "Staff, Stuff, Structure, System". Conversely and perhaps not surprisingly, in situations where ED RNs lacked experience, such as with patients presenting with biological or chemical signs or symptoms, RNs assessed their competency as relatively low. Similarly, patient groups that ED RNs rarely treat i.e. children, mirrored lower levels of competency. Similar to other studies (165) this highlights the need for disaster training and education however, the majority of RNs in study II reported the frequency of training as once or less than once a year and had lower levels of disaster competency than those that trained more frequently. Indeed, studies support that even short and frequent exercise is positively correlated with higher levels of disaster preparedness (166), an opinion echoed by members of the HICG in study IV as well. In addition to education and training, clinical experience was significantly correlated with competency. Clinical experience is a factor that may be difficult to affect. However, management could affect the retainment of personnel through interventions. This in turn may increase the general level of staff clinical experience and disaster competency of nursing staff as well as increase the quality of patient care (167, 168).

While many of these factors may explain the moderate to low levels of disaster competencies, a unique result with study II with a possibly significant impact is ED RNs' tendency to overestimate their competencies. Overestimating competencies may have a negative impact

on patient care and safety (143, 169, 170) in as much as RNs may not actively attempt to fill knowledge gaps necessary to improve their competency.

Improving Ed RNs' disaster preparedness for rare incidents is not without challenge. While training and education may be effective interventions (166) previously reported in study IV, training may not always be a priority, which negatively impacts competency and preparedness. Hospital management's subjective view on disaster preparedness seems to impact preparedness according to participants in study IV. It has been suggested that creating specific legislation for disaster nursing may improve RNs' preparedness (171). Indeed, this sentiment was echoed in study IV. Hospital management's subjective view on disaster preparedness seems to impact the amount of training and time given to preparedness according to participants in study IV. While there is legislation stipulating the need for disaster preparedness plans in the study setting (23), there is no specific legislation for disaster nursing nor are the education needs nor the frequency of training requirements stipulated. More stringent legal requirements may aid in ensuring a higher lowest level of preparedness among both RNs and HICG groups.

ED RNs are among the first to receive, assess, and initiate treatment for patients from an MI (36, 172). Therefore, ED RNs may also be among the first to be exposed to and receive notice of an event. Their knowledge and abilities may very well play vital roles in mitigating morbidity and mortality particularly if they are able to quickly gain adequate awareness of the situation and apply proactive actions to facilitate resource management. Indeed, the results of study I have indicated that an essential ED RN competency is detection and response to an event. This includes basic first aid measures in regard to various mechanisms of injury including recognition of the type of event and suspected exposure to chemical and biological agents. Adequate knowledge of various mechanisms of injury and epidemiology of them may aid in both resource management and accurate reporting to the HICG as evidenced by members of the HICG recalling that they were initially notified of the MI by an ED RN manager in study IV.

Hospital incident command reactive decision-making yet adequate response?

Disaster medicine preparedness and response are also dependent upon disaster plans for a variety of scenarios, an all-hazards approach (79). A focal point in studies III and IV was to gain a deeper understanding concerning HICG disaster preparedness and response. This was to be accomplished through assessments of HICG disaster preparedness based on simulations as well as an exploration of factors that may affect preparedness. Based on hospital disaster plans, participating hospitals had held simulations in an antagonistic theme in the fall of 2016. As stated, the original plan was to evaluate HICG through an observational study and then conduct a qualitative interview study based on the results in study III. However, before those interviews could be conducted, a few months after the simulations, an antagonistic attack had been carried out in the same study setting. This provided a unique opportunity to study actual HICG response and compare it to planned preparedness.

The results of study III could be seen as a baseline measurement, concluding that proactive decision-making correlated to overall response and suggesting that HICG response may be characterized as being reactive. However, to do these results justice and paint a more accurate

picture of the state of preparedness as measured in study III, the results should be viewed in a larger scope. While there is limited research using measurable indicators to evaluate HICG preparedness, there are studies that when compared to the results in study III indicate that not only is HICG disaster preparedness adequate but is improving. A first study using the DiMI to assess staff procedure skills reported an initial mean score of 11.1 (max score=22) for the 11 measurable indicators (173) while another previous study also using the DiMI reported mean scores of 15 for decision-making and 17 for staff skills (88). Concluding what equates to adequate preparedness or response could be subject, however, a previous study using these indicators stated that a score of 11 for a set of indicators was adequate (94). Put into perceptive of these earlier studies, with the results of study III (mean scores for the overall performance of 17.16 for decision-making and the 19.66 for staff skills), it could be concluded that overall HICG response during the simulations is more than adequate. These results could even suggest that while proactive decision-making is associated with overall performance, even proactive decision-making, while significantly lower than reactive decision-making may be adequate in most cases, with the exception of indicator 11 (plan for patients with postponed appointments and operations formulated). However, despite apparent improvements in HICG response, proactive decision-making remains a challenge.

These findings, while unique in that are assessments of planned disaster preparedness in the study setting during a specific time frame, are in line with other studies using similar indicators albeit with slightly varying methods. Similar results were also reported in a previous study even though the study population was regional command instead of HICG. Decisions made in the early phases of a MI were significantly higher than those in later phases of an incident (174). In addition, yet another study, this in the same study setting, also reported similar results concluding that decision-making correlated to overall response (88). The summation of these studies would indicate that not only is HICG preparedness adequate but steadily improving.

Response in the face of uncertainty

While study III could indicate that HICG preparedness is improving, taking these previous studies (88, 173, 174) into account with the results of study III, one could conclude that reactive decisions appear to characterize decision-making during MIs and may be a systematic challenge. Indeed, HICGs in studies III and IV were quick to understand that a major incident had taken place and intuitively decided on their hospitals' state of response, as indicated by the significantly higher means of this indicator as well through the interviews. Participants in study IV confirmed that they immediately understood the severity of the situation and reacted quickly, reporting to their designated workplaces and initiating the formation of the HICG as well as activating disaster plans and establishing the level of hospital response. In study III, HICGs often made timely decisions. As an example, according to the indicator assessing "deciding the on the level of preparedness", this decision should be made within three minutes. The high mean score in study III indicates that this was often accomplished. However, in the real-life setting during the MI in 2017, this particular decision often took more time according to DPCs. Similar to no-notice simulations, members of the HICG may not have been anticipating an MI (38). In comparison, prior to the simulations, members were informed of the date and approximate time of the planned simulation. This may explain why some decisions were able to be made relatively quickly

during the simulations. Participants were to a certain degree prepared, despite not knowing what the actual scenario would be. During the MI, members of the HICG started receiving notice of the incident around 14:50 on a Friday. While many expressed that they quickly understood the severity of the situation and that the "state of disaster" response was taken nearly immediately after notification, not all hospitals reacted quite as quickly, taking longer than three minutes. Several factors may have affected the timeliness of this decision. Assembling members of the HICG necessary to make decisions may have taken more time than during the simulations. In addition, some participants expressed a lack of experience may have affected the time to make this decision.

Simulations

Relying on previous experiences is a common tactic when making decisions (175). Undoubtedly clinical or practical experience of MIs is vital in managing limited resources during an MI (175). Generally speaking, more experience correlates to higher levels of competency or preparedness and proactive decision-making (91). However, what if what you're preparing for is so rare, that there is a lack of experience? In lieu of real-life experience, disaster preparedness is reliant on education, training, application of relatable experiences, intuition, and rational reasoning in order to make accurate and adequate decisions (176). Simulation exercises are common forms of training and evaluation and may facilitate decision-making (93, 177). However, this may be contingent on how well they align with not only risks and hazards but also with likely processes of collaborative efforts within the target group as well as with collaborative efforts with local and regional actors. While there is a growing body of research reporting positive effects of simulations for developing medical and disaster management competencies (38, 93, 166) retention of knowledge has been questioned and the effectiveness of disaster simulations has come into question (178). Indeed, the results of study IV to a certain extent raise this question as well. Despite simulations in a similar theme being held a short time prior to the actual MI uncertainty and lack of trust were prevalent throughout much of the HICGs response.

Uncertainty, the one thing that is certain

Uncertainty is ever-present in normal day-to-day activities for leaders and clinicians (179). The rarity of MIs of this nature may exacerbate stress and uncertainty. While standardized plans and training may facilitate positive action (166, 173), there is a risk that if the situation differs from previous training, uncertainty can be exacerbated. Heavy reliance on structure and predetermined routines may render a HICG temporarily paralyzed exacerbating uncertainty and reactive decision-making (180). The results in study IV tend to support this. When faced with new or unexpected situations, uncertainty resulted. This uncertainty was most evident when it came to the paradoxical overflow of information coming from various channels to the HICG and the lack of confirmed information from channels HICGs had been trained to rely on. Participants in study IV commented on the fact that a major challenge was gaining situational awareness. Gaining situational awareness is paramount when attempting to make reliable and adequate decisions concerning a hospital's response and is dependent upon the gathering of reliable information (45). Indeed, this seems to be a common challenge with a previous study citing a lack of information from the pre-hospital setting as being a reason for delayed decision-making (174, 181). The difficulty of decision-making as it

concerns information overflow from a variety of sources can be seen as a predictable truism(182) In study IV, participants expressed that gaining situational awareness was to a certain degree an unexpected challenge. Many explained that this was in part due to expectations based on simulations. During the simulations, there was a near-constant flow of reliable information from the regional command. During the actual MI, participants expressed that there was very little information from the regional command. This in combination with an overflow of unconfirmed information from media and social media compounded feelings of uncertainty. Reducing uncertainty facilities decision-making and positive action.

Three types of uncertainty can be identified (183). The first two, lack of knowledge concerning the specific and lack of empirical knowledge can be combined while the third can be seen as being born of these two, in which lack of self-awareness and lack of knowledge is difficult to discern. These three types of uncertain within health care can arise from five dimensions 1) complexity which concerns the nature of the event; multi causality, contingency and unpredictability 2), qualities of information, i.e. clarity, accuracy, completeness, and trustworthiness, 3), probability, 4) structure of information and 5) lay epistemology which concerns an individual's beliefs concerning the event (184). Several of these dimensions were prevalent during the MI with HICGs attempting to reduce uncertainty.

Uncertainty reduction concerns the ability to decipher a given situation often through the gathering of information (185). This effort by the HICGs was evident as expressed by the participants in study IV. While knowledge concerning the type of event was prevalent, there was uncertainty as to the size of the event and the number of patients that could present. A breakdown of communication between agencies is a common challenge during MIs (186). This lack of this information from a trusted source exemplified the second (trustworthiness of information) and fourth (structure of information) dimensions of uncertainty and was a reason for the "state of disaster" response according to participants. In lieu of reliable information, reducing uncertainty in order to facilitate positive action often requires actions such as information gathering, rational reasoning, and intuitive decision-making (186). Intuition-based decision-making has been reported to be the less desirable form of decision-making with a study attributing intuitive decision-making to suboptimal decisions (187). The distinction between these two types of decision-making was not always evident in the studies. However, some participants did express the HICG was forced to rely on rational reasoning in the face of a lack of confirmed information. Indeed, regardless of the type of decision-making used, with the exception of the one hospital that did not declare a state of disaster, the vast majority of participants in study IV and the follow-up data collection upon further reflection concluded that this decision was an overreaction with one participant reflecting that this one action alone may have had fatal consequences. What is of particular interest concerning this decision is that in contrast to recommendations that decisions ought to be evidence-based, this particular decision does not appear to have been evidence-based but based on uncertainty.

A lack of or breakdown of communication was one example of how misalignment of expectations and reality caused uncertainty. The overflow of willing personnel to aid in response was described as an inhibitor to effective response as were actions taken by another authority namely the decision to stop all collective traffic. Indeed, several participants

commented on this as an aspect that wasn't taken into account. Many had not anticipated this action and expressed that there was uncertainty as to how transportation of patients and getting personnel to the hospital were to be carried out. This particular challenge could exemplify the need for more comprehensive training and education as this particular action was outlined as a likely response from law enforcement (19), While HICGs often quickly adapted and improvised plans or found alternative solutions, these were actions that were time-consuming and may have negatively impacted adequate care of patients had the scenario been larger in scope.

While some participants expressed confidence in HICGs' abilities to adequately respond, many were cautiously optimistic, stating that the next major incident is just a question of time.

There is the possibility that competencies have changed. Similarly, studies III and IV could also be seen as assessments of preparedness in relation to specific points in time. It would not be unreasonable here either to assume that certain aspects of disaster preparedness have evolved or changed. Indeed, one participant during the supplementary interviews concluded that levels of preparedness have decreased due to a lack of training as a result of the COVID-19 pandemic. While the timing and the size of the incident, competencies of those involved in disaster response vital factors likely to affect the outcome of MI, frequent training and education are aspects that may likely affect response and patient care.

Given the risks and abilities in the study setting, an oft-repeated reflection is that the next major incident is just a question of time. While elements of this thesis indicate that disaster preparedness is improving and may be adequate (study III), other elements raise potential red flags (studies II and IV). There are a multitude of interconnected factors likely to affect response. Due to this and stated limitations of this thesis, conclusively stating what the level of disaster medicine preparedness is in Stockholm, Sweden is not possible. However, this thesis provides new knowledge concerning specific aspects of disaster response in Stockholm, Sweden; the possibly reactive nature of hospital incident command response, and a first baseline measurement of those likely to be among the first to encounter patients from an MI, emergency department registered nurses disaster preparedness.

9 CONCLUSIONS

The aim of this thesis was to assess vital aspects of disaster medicine preparedness and contribute to the increasing amount of knowledge concerning ED RNs preparedness as measured by competency and HICGs preparedness.

From these four studies, the following conclusion can be made:

Preparing for MI that may severely impact resources, is a challenge. ED RNs, while expected to play vital roles in mitigating the effects of an MI may lack sufficient skills, ability, and knowledge to adequately respond depending upon the type of and size of the incident. ED RNs tend to be better prepared for incidents that mirror mechanisms of injury they treat daily while incidents that rarely occur such as CBRN-E incidents may present more of a challenge. A careful conclusion concerning ED RNs' disaster preparedness is that the disaster competencies they possess are in need of improvement. In addition, there is a risk that ED RNs overestimates their competencies, which could lead to adverse events for patients.

Aiding in the mitigation of the effects of an MI is the HICGs whose responsibly is leading hospital response and resource management. Similar to ED RNs, knowledge, skills, and abilities the HICG is reliant on training, education, and experience. Decision-making abilities may be characterized as reactive. This too could be a result of either a lack of realistic training, a lack of knowledge, or a lack of uncertainty reduction abilities. When faced with uncertainty, there was a tendency to overcompensate by declaring a state of disaster. While the intention was to improve response, declaring a state of disaster was seen as an overaction that may risk patient safety. An adequate measured response that prepares for a surge of patients while also providing continued quality care for all patients in the face of uncertainty and is a balancing act, getting it right may be a challenge but is vital.

That being said, this thesis concludes that while areas of disaster preparedness may be in need of improvement, hospital response appears to have improved and new knowledge concerning ED RNs' disaster competencies provides a baseline from which further improvements are possible. The knowledge gained from these studies could aid in strategic long-term investments for the enhancement of competencies for both hospital incident command groups and emergency department registered nurses.

10 CLINICAL IMPLICATIONS

This thesis provides new knowledge concerning vital aspects of disaster medicine preparedness that may be of real-world value when it concerns MI management and may be very applicable in clinical settings. The knowledge gained from these studies highlights several aspects of disaster medicine preparedness that might not be well known, shedding new light on areas ripe for adjusting or improvement with the aid of interventions addressing these needs. The following bullet points provide suggestions as to how the findings in this thesis may be utilized in clinical settings.

- The DiMI has been implemented in disaster plans
- Each hospital received individualized feedback from study III and could be used in interventions.
- Identified disaster nursing competencies could be used as a framework for education and training programs.
- The results indicate that frequency of training is correlated to competency. The frequency of training and education could be increased to improve the retention of skills. This would increase both competencies and self-awareness.
- Realistic simulations, training, and education programs for the HICG could include the following:
    - Epidemiology of various forms of MIs. This could limit uncertainty and facilitate proactive decision-making.
    - Specific measures within the education and training programs that provided uncertainty reduction training, which may facilitate expedient decision-making.
    - An overflow of information is likely to be an aspect of medical management during MIs. Analytical abilities specifically address this challenge should be incorporated in education and training programs to facilitate situational awareness.
    - Measures to increase autonomy in the chance that plans and incidents don't align or communication is faulty or absent.
- Further implementation of an instrument such as the DiMI could aid in timely decision-making and reduce uncertainty.
- The amount of information from social media was overwhelming. A function to aid in identifying correct information coming from the various media and social media platforms could be implemented disaster plans to facilitate situational awareness.
- Improving the competencies of ED RNs and HICGs could minimize the risks for adverse events and more successfully mitigate morbidity and mortality.

11 FUTURE RESEARCH

The studies in this thesis have provided new knowledge and insight concerning disaster medicine preparedness. However, several areas of disaster preparedness have yet to be explored.

- An expert group reached consensus concerning essential disaster competencies for ED RNs. However, a consensus group discussion, nominal group technique (NGT), or classic Delphi technique concerning ED RN competencies could be motivated. The instrument used in this thesis, while mirroring many of the hazards and risks in the study setting could be refined to include various forms of trauma for example. "Trauma" is a broad term and the mechanism of injury for trauma patients normally treated at EDs such as blunt force trauma such traffic accidents or falls, for example, may differ significantly from bomb blasts.
- A qualitative interview study with leaders of HICGs with the aim of identifying essential competencies and qualities of hospital incident group members could aid in education programs.
- In study II, only ED RNs' disaster preparedness was assessed. ED physicians were not included. Their disaster preparedness is unknown. Studies assessing ED physicians would be of immense value.
- Longitudinal studies that follow the development of ED RNs' disaster competencies after the implementation of training or education interventions.
- Adjusting and refining the DiMI through expert consensus could aid in a more accurate measurement of the HICG preparedness and response.
- Studies utilizing virtual reality simulations may more accurately assess ED RNs' disaster competencies

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In the last article written for my doctoral thesis, “uncertainty” emerged as a central category not only for factors affecting HICG performance or the body of work as a whole. I came to understand that uncertainty has most certainly been omnipresent throughout this doctoral odyssey. I suppose like most odysseys, the quest starts with optimism, enthusiasm, excitement, and perhaps a tinge of fear of the unknown. Armed with a team of knowledgeable and experienced supervisors, the road ahead seemed paved, straight, and comprehensible. Oh, to be wonderfully oblivious as to the challenges ahead. The fact that I’m here is due to the guidance and support of a number of people.

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