Flexible Surge Capacity in Disasters and Major Incidents

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Gothenburg 2024

Cover illustration: The image was generated with the assistance of AI.

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ISBN: 978-91-8069-683-8 (PRINT)
ISBN: 978-91-8069-684-5 (PDF)
http://hdl.handle.net/2077/79338

Printed in Borås, Sweden 2024
Printed by Stema Specialtryck AB

'It always seems impossible until it's done'

- Nelson Mandela -

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ABSTRACT

In the face of the escalating frequency of disasters and major incidents, the imperative for surge capacity expansion becomes apparent for effective emergency response. However, existing preparedness measures often hinge on available resources and prove insufficient when confronted with disaster dynamics. The thesis aims to assess the feasibility and applicability of the "flexible surge capacity" (FSC) concept, focusing on leveraging community resources and collaboration among various entities across different disaster etiologies. The research method employed a descriptive construction of the FSC concept to establish its framework for generalization and evaluation. Subsequently, a pragmatic approach integrating both qualitative and quantitative research methods using online surveys, direct observation, and semi-structured interviews was adopted to explore the implications of the concept. The findings reveal the promising feasibility and applicability of the FSC concept in urbanized communities. Facilities of interest expressed willingness to participate, and the concept implementation demonstrated effectiveness in alleviating overcrowded hospitals during the Coronavirus 2019 pandemic and facilitating hospital evacuation through the Three-level Collaboration exercise. Additionally, educational initiatives led to significant improvements in staff engagement and system sustainability. In conclusion, FSC, aligning with the proactivity philosophy of the World Health Organization, proves instrumental in optimizing the use of community resources and fostering effective collaboration in disaster management.

Keywords: surge capacity, leadership, multiagency collaboration, disaster preparedness, hospital evacuation, exercise

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SAMMANFATTNING PÅ SVENSKA

Med ökningen av antalet katastrofer och allvarliga händelser, blir behovet av snabba och effektiva insatser alltmer påtagligt. Denna avhandling syftar till att pröva tillämpningen av "flexibel kapacitetsökning" (Flexible Surge Capacity=FSC) med avseende genomförbarheten vid katastrofhantering. Fokus i avhandlingens delstudier är samverkan mellan olika enheter och integrering av samhällsresurser.

Metod

För att tydliggöra FSC-konceptet fastställdes först dess betydelse och teoretiska ramverk. Med denna utgångspunkt har det i avhandlingens delstudier värderats hur konceptet kan operationaliseras. Ett pragmatiskt tillvägagångssätt antgogs där såväl kvalitativa som kvantitativa forskningsmetoder har använts. Det har inkluderat onlineundersökningar, direkta observationer och semistrukturerade intervjuer.

Resultat

Resultaten visar lovande möjligheter att implementera FSC-konceptet i urbaniserade samhällen. Lämpliga faciliteter i samhället visade villighet att delta vid hanteringen av katastrofer. FSC-konceptet operationaliserades framgångsrikt vid hantering av överfulla sjukhus under pågående Coronavirus 2019-pandemin. Under simuleringsövningar där större sjukhus evakuerades tillämpades konceptet. Avhandlingen visar också att anpassade utbildningsinitiativ resulterar i betydande förbättringar i personalengagemang och systemhållbarhet.

Slutsats

Sammanfattningsvis visar sig FSC, i enighet med Världshälsoorganisationens proaktivitetsfilosofi, bidra till att optimera användningen av samhällets resurser och främja en effektiv samverkan vid hantering av katastrofer.

LIST OF PAPERS

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

I. Phattharapornjaroen, P. et al. Developing a conceptual framework for flexible surge capacity based on complexity and collaborative theoretical frameworks.

   Public Health. 2022; 208: 46-51. doi:10.1016/j.puhe.2022.04.012. Epub 2022 Jun 7. PMID: 35687955.

II. Phattharapornjaroen, P. et al. The Feasibility of Implementing the Flexible Surge Capacity Concept in Bangkok: Willing Participants and Educational Gaps.

   Int J Environ Res Public Health. 2021;18(15):7793. doi: 10.3390/ijerph18157793. PMID: 34360083.

III. Phattharapornjaroen, P. et al. Community-based response to the COVID-19 pandemic: a case study of a home isolation center using flexible surge capacity.

   Public Health. 2022; 211: 29-36. doi: 10.1016/j.puhe.2022.06.025. Epub 2022 Jul 13. PMID: 35994836.

IV. Phattharapornjaroen, P. et al. Assessing Thai Hospitals' Evacuation Preparedness Using the Flexible Surge Capacity Concept and Its Collaborative Tool.

   Int J Disaster Risk Sci 14, 52–63 (2023). https://doi.org/10.1007/s13753-023-00468-z

V. Phattharapornjaroen, P. et al. The impact of the three-level collaboration exercise on collaboration and leadership during scenario-based hospital evacuation exercises using flexible surge capacity concept: a mixed method cross-sectional study. BMC Health Serv Res. 2023 Aug 14;23(1):862. doi: 10.1186/s12913-023-09882-x.

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ABBREVIATIONS

3LC	Three Level Collaboration
ACFs	Alternative Care Facilities
COVID-19	Coronavirus 2019
CSCATTT	Command and control, Safety, Communication, Assessment, Triage, Treatment, Transport
CRED	Center for Research on the Epidemiology of Disasters
DRR	Disaster Risk Reduction
FSC	Flexible Surge Capacity
HIC	Home Isolation Center
ICS	Incident Command
MIMMS	Major Incident Medical Management and Support
PHCCs	Public Primary Healthcare Centers
SDGs	Sustainable Development Goals
UN	The United Nations
UNDRR	The United Nations Office for Disaster Risk Reduction
WHO	The World Health Organization

DEFINITIONS IN SHORT

Field specific terms

Disaster	An abrupt and severe occurrence that induces substantial disruption to the normal functioning and operational dynamics of a community or society, resulting in extensive human, material, economic, and environmental setbacks. These adversities surpass the affected entity's capacity to manage and recover through its inherent resources [1].
Major incident	An event that demands an extraordinary response due to its scale, complexity, or potential impact on public safety. It can be part of, or lead to, a disaster [2].
Contained incident	The incident is characterized by its discrete and focal nature, despite the potential for substantial scale, and necessitates a targeted local response. Examples of such events include bombing or hurricanes [3].
Population-based incident	The incident impacts a broad and diverse demographic within a specific geographic area, extending beyond immediate localities. The incidents may include natural causes like widespread floods, or pandemics. [3].

Mitigation	The process involves reducing the adverse impacts of a hazardous event [1].
Hospital evacuation	The acts of relocating individuals and assets temporarily to secure locations before, during, or after the onset of a hazardous event with the primary goals of safeguarding lives and assets (can take one to several days) [1].
Surge capacity	The ability of organizations or systems to rapidly and effectively expand their operations, resources, and capabilities in response to an increased demand of needs during crisis [4,5].
First/primary surge capacity	The initial and immediate response capabilities that organizations, particularly in healthcare and emergency services mobilize in the earliest stages of a crisis [6].
Second/secondary surge capacity	Capacities and capabilities that organizations employ during the subsequent phases after the first surge are addressed and a sustained demand requires continuous responses [6].
Flexible surge capacity	Untapped resources inherent within the community possess the advantages of being locally accessible and adaptable to needs, allowing for a dynamic scaling of capacity based on the incident and its associated impacts [7].

Collaboration	The act of goal alignment, resource-pooling, cross-functional activity, and information sharing for empowerment, and sense-making among collaborative independent organizations [8-11].
Coordination	The act of working together in an efficient and organized way by pooling resources and harmonizing goals among independent entities [8,11].
Cooperation	The act or instance of working or acting together and cross functioning for a common purpose or benefit for empowerment among independent entities [8,11,12].
Sustainable Development Goals	The global goals adopted by the United Nations in 2015 comprise 17 calls to action and aspire to eradicate poverty, safeguard the environment, and guarantee universal well-being by the year 2030 [13].

Research specific terms

Feasibility study	A study that aims to evaluate the appropriateness of an intervention for further testing the adaptability and sustainability of conceptual ideas [14].
Complex intervention	Interventions in health or social care services at different levels characterized by the convergence of various interacting components in real-world events including quantity and diversity of interventions

Complex intervention *(continue)*	implemented, the complexity of delivering and receiving individuals' behaviors, the range of targeted groups or organizational levels affected by the intervention, the diversity and variability of outcomes, and degree of flexibility permitted [15,16].
Efficacy	A comprehensive examination of the extent to which the intervention yields the intended outcomes under idealized conditions [17].
Effectiveness	A comprehensive examination of the extent to which the intervention yields the intended outcomes in real-world settings [17].
Pragmatic paradigm	An epistemology for employing optimal methodologies for investigating real-world issues. The chosen methodologies which are particularly evident in mixed methods allow for the incorporation of diverse sources of data and knowledge to effectively address research inquiries [18].
Utilitarianism (Utilitarian theory)	A consequentialist ethical theory asserting that actions are morally right if they maximize overall happiness or pleasure and minimize suffering [19-21].

INTRODUCTION

Disasters and emergencies caused by diverse hazards have exhibited pronounced and escalating impacts on individuals and communities on a global scale [22]. The Center for Research on the Epidemiology of Disasters (CRED) has revealed a concerning trend in natural hazard impacts. Comparing the periods between 1980-1999 and 2000-2019, the number of affected individuals increased by one-third, with a nearly twofold rise in economic losses [23]. Among natural events, floods, storms, and earthquakes have steadily risen [24]. Moreover, it has been widely discussed that climate change has contributed to the heightened frequency and probability of these natural events [25-27].

In addition to natural threats, man-made incidents, including industrial accidents or terrorist attacks [28-33], and public health emergencies like pandemics contribute to this growing global concern [34,35]. Recent catastrophic events, such as the Coronavirus 2019 (COVID-19) pandemic, which resulted in over 6 million deaths worldwide [36], and the Turkey-Syria earthquake that claimed the lives of at least fifty thousand individuals [37,38], further emphasize the profound impacts of disasters on humanity. Furthermore, the protracted hybrid conflict between Russia and Ukraine, which targets critical infrastructures and densely populated areas, including hospitals, places the injured at greater risk of fatalities due to limited access to medical treatments [39,40]. Despite the increase in the frequency of catastrophic events, population growth, urbanization, and demographic aging also contribute to the heightened disaster risks and impacts by increasing exposures and vulnerabilities to such events [41,42].

Hospitals play a pivotal role in optimizing the population's health outcomes and addressing determinants of health. These determinants encompass a broader spectrum of factors, including the social and economic environment, the physical environment, and individual characteristics and behaviors [43]. Despite their routine care responsibilities, hospitals face additional challenges during disasters, including sudden surges in injuries and suffering. Nevertheless, overcrowded hospitals exhibit limited availability of beds, spaces, and staff to manage a sudden onset emergency. A surge in capacity following the instructions in a preplanned contingency plan may resolve this predicament. Such a plan instructs to stop admission of non-emergency cases, planned hospital activities, such as surgical interventions, and discharging patients capable of receiving care at home, thus preparing to receive affected and injured populations from the incident areas [44-46].

There are, however, two possible scenarios that may hinder such action. First, when hospital functionality is compromised during infectious disease outbreaks and unable to admit additional patients. For instance, during the COVID-19 pandemic, new patients could barely be accepted since the hospitals were already overwhelmed with infected patients and were a place for isolation of diagnosed cases [47,48]. Second, hospitals may be threatened directly, necessitating partial or total evacuation, such as fire outbreaks or terror attacks. Fire outbreaks are more commonly associated with the practice of partial evacuation and rarely escalate to the point of necessitating a total evacuation. In contrast, total evacuation is more frequent in scenarios such as terror attacks and armed conflicts, as observed in conflicts in Syria, and the ongoing war in several locations, e.g., the Ukrainian war, and war in Gaza [49-52].

It is, therefore, imperative for hospitals to be prepared to address internal and external threats and effectively mitigate and respond when facing emergencies, including hospital evacuation [53], which is a complex procedure defined by the United Nations Office for Disaster Risk Reduction (UNDRR) as "moving people and assets temporarily to safer places before, during, or after the occurrence of a hazardous event to protect them" [54]. Additionally, other experts have provided similar definitions of hospital evacuation, emphasizing the importance of ensuring individuals' safety [55-57].

Consequently, hospital evacuation requires extensive support from external resources [58-60].

Given the escalating internal and external threats to hospitals, the emergence of new threats creating new disasters and public health emergencies, and the fact that each hazard presents unique challenges, a comprehensive disaster preparedness framework, researched and practically integrated is crucial to ensure a timely and effective response throughout all phases of the disaster cycle [6,61]. These phases include mitigation, preparation, response, and recovery. Such a framework also needs to consider several vital factors, such as the severity and complexity of the incident, its duration, available resources and existing surge, proactivity and determination in leadership, and the need for multiagency collaboration, which in turn, also indicates a need for given and tested collaborative elements, enhancing and promoting partnership, striving after mutual goals. A collaborative tool may also be used to measure the impact of the actions and responses made [62,63].

In 2015, the UNDRR collaborated with stakeholders at various levels, from local to international, to develop the Sendai Framework for Disaster Risk Reduction [64]. This global policy framework provides countries with 15-year period guidelines to integrate DRR considerations into strategic plans, focusing on enhancing population health and well-being outcomes in alignment with the Sustainable Development Goals (SDGs) outlined by the World Health Organization (WHO) [65]. The alignment efforts emphasize the need for integrated and synergistic actions in a proactive approach to build resilience and consequently reduce vulnerabilities to hazards [66]. The framework identifies priority areas for action, including risk comprehension to strengthen risk governance and investigate risk reduction methods for practical disaster preparedness efforts. These areas pave the way for a more secure and sustainable future for communities worldwide [67].

Additionally, it is imperative to establish *coordinated, cooperative, and well-communicated* efforts among the various agencies and stakeholders involved in disaster management [8,9]. These efforts facilitate appropriate information sharing, resource mobilization, and utilization while clearly defining the roles and responsibilities of relevant parties. This *multiagency collaboration*

approach leverages the expertise of diverse organizations, enabling the creation of a more comprehensive disaster management plan and *enhancing surge capacity* for effective response and recovery from various major incidents [68,69].

SURGE CAPACITY FOR DISASTER RESPONSE

Surge capacity is a crucial concept in disaster and emergency management. It represents the ability and preparedness of a system or organization to rapidly enhance its response capabilities when faced with sudden or unforeseen events [46,70]. This measure embraces the swift mobilization of additional resources. Surge capacity comprises 4 essential elements known as the 4S: Staff, Stuff, Structure, and System. Staff includes medical and non-medical personnel who possess skills beneficial to disaster response, which may involve on-call physicians, hospital or clinic personnel, retired nurses, and community volunteers. Stuff refers to the medical and non-medical equipment and supplies related to disaster management. Such resources include personal protective equipment, ventilators, and blood pressure measurement devices. Structure primarily focuses on spaces or areas designated as command centers or medical treatment zones. Finally, the system pertains to the practical guidelines and instructions governing Staff, Stuff, and Space utilization. Maintaining an adequate surge capacity is essential for effectively and efficiently managing disasters, as it facilitates the prompt escalation of response efforts based on the event's severity [5,46,71,72].

In practical terms, the first surge capacity relies on the available onsite staff, stuff, and spaces within the organization. These resources are typically sufficient to respond to the immediate impacts of the disaster [73,74]. However, due to the dynamic nature of disasters, the events and their consequences inevitably expand, necessitating the activation of a second surge capacity [33,75,76]. This second surge relies on available personnel who may be off-duty or retired and medical devices and treatment areas that are currently unoccupied. While contingency plans incorporate comprehensive surge planning, the actual impact of disasters and emergencies often necessitates an extensive expansion that surpasses even the second surge capacity. Previous studies reported situations where the demands on

emergency medical services, emergency care utilization, and hospital capacity became overwhelming and stretched existing resources to their limits [33,76,77]. For example, during hurricanes in the United States and earthquakes in Japan, hospitals were confronted with the daunting task of evacuating patients, demanding a substantial influx of transportation resources, including transport ventilators, trained personnel, and suitable vehicles [76,78-80]. In these situations, a more flexible surge capacity, using other resources than the healthcare facilities might be beneficial [7,66,81,82].

Enhancing Surge Capacity

In recognition of the formidable challenges posed by such catastrophic events, initiatives have been made to explore and mobilize resources from various sectors beyond the traditional boundaries of healthcare organizations. These include the private sector, which comprises medical entities like private hospitals and clinics, non-medical private organizations, nongovernmental organizations such as the Red Cross, and community-based facilities [81,83-86]. The goal is to recruit and leverage the capacities and capabilities of these diverse entities, pooling resources to meet the escalating demands of disaster situations. Such surge enhancement may shift from reactivity to proactivity and emphasize the significance of the new paradigm of disaster management [7].

LEADERSHIP AND MULTIAGENCY COLLABORATIONS FOR DISASTER RESPONSE

Leadership and Collaborative Measures

The Incident Command System (ICS) has been extensively employed to communicate and deploy temporary tasks among organizations involved in disasters and emergencies [87]. The system was originally developed in response to California-wide fires in the early 1970s; the ICS encompasses hierarchical functions essential for addressing such events. These functions include the incident commander, liaison officer, safety officer, public information officer, operation section, planning section, finance and

administration section, and logistics section [87,88]. The ICS framework is illustrated in Figure 1. This system is advantageous in high-risk situations with numerous variables, as it ensures reliable performance [88].

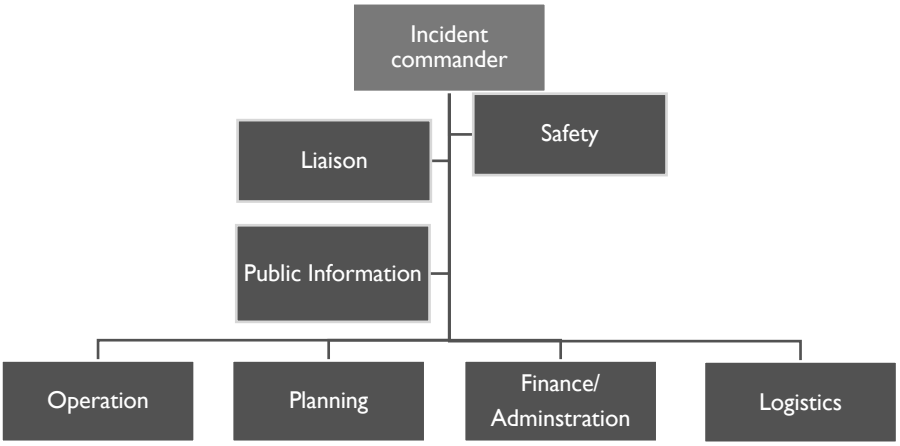

Figure 1 An Incident Command System framework. Adapted from Bigley GA and Roberts KH. Published in 2001[91].

However, comprehensive disaster management necessitates the adoption of systematic, multidimensional, interdependent decision-making and multiagency approaches [6]. The vertical structure of the ICS may pose constraints in these regards. Subsequent literature, therefore, has introduced more horizontal structures, particularly in the context of large-scale disasters [89,90]. These horizontal structures facilitate improved collaboration among multiple agencies, including community, nongovernmental, and private sectors [61,89]. These alternative structures have been recognized and incorporated into disaster response plans and training programs, such as the Major Incident Medical Management and Support (MIMMS) program, which also utilizes seven key principles, often used to facilitate the implementation of horizontal multiagency collaboration [91].

The principles comprise Command and Control, Safety, Communication, Assessment, Triage, Treatment, and Transport, referred to by the acronym CSCATTT. These principles serve as fundamental pillars for effective

response efforts. Moreover, they have been employed as measurements for evaluating capabilities across various domains [92,93].

The first 2C principles, Command and Control (C2), encompass strategic management and governance involving initiation and decision-making processes [92,94,95]. Command-and-control principles aim to facilitate and enhance the performance of individuals directing under resource constraints. It is crucial to acknowledge that while most critical decision-making should ideally be premeditated as part of a hazard vulnerability assessment and contingency plans, the exigencies of actual incidents often necessitate prompt and potentially challenging decision-making processes [96-98]. These decisions may be contingent upon those in charge's leadership styles and personal attributes, subsequently influencing the application of command-and-control principles [99]. Previous research explored leadership styles within command-and-control contexts among emergency physicians engaged in disaster scenarios and revealed a diverse spectrum of leadership styles, including active, passive, and consensus-based approaches. Notably, despite the apparent divergence in leadership styles, the overarching objectives of the responses remained consistent, primarily centered on preserving lives and efficiently managing resources [94,100].

Safety (S) within disaster management comprises a multifaceted approach involving assessment, surveillance, and monitoring [101]. The paramount objective is the safety of the dedicated personnel (Self), incident scene (Scene), and patients (Survivors), respectively, which entails continuous and rigorous safety evaluation and oversight. Significantly, in incidents involving chemical, biological, radiological, nuclear, and explosive (CBRNE) agents, a specialized safety framework is required [102,103]. This framework necessitates the presence of technical safety personnel, the deployment of specific equipment tailored to the nature of the incident, the allocation of dedicated spaces, and adherence to safety protocols. Moreover, in the digital era, where the world is rapidly advancing towards digitalization, the significance of data has grown exponentially which may pose potential threats [104]. Hence, data security has become one of the critical safeties in disaster preparedness components. This security involves comprehensive risk assessment and

continuous surveillance to identify and address vulnerabilities that could jeopardize data integrity and confidentiality [105].

Communication (C) involves internal, external, and public communication. All communication has vertical and horizontal means and components to consider, covering channels, devices, and content [106]. The channel and devices depend on available resources at the time [107]. Flexibility is essential in this regard, as the dynamic nature of disaster situations may necessitate adaptation to ensure effective communication. Equally significant is the content, which demands meticulous preparation and consideration. Key elements include clearly defined communication goals, the formulation of core messages, and the identification of target audiences [108].

Assessment (A) components in MIMMS revolve around evaluating and surveilling disaster circumstances and resource availability. The inherent dynamism of disaster events mandates a continuous and vigilant assessment process. This assessment process entails ongoing evaluation of the evolving disaster circumstances, encompassing factors such as the extent of damage, potential consequences, and resource requirements. The information gathered through assessment serves as foundational information for strategically allocating resources (4S) to meet the escalating demands of the incidents. Furthermore, the assessed information is significant in determining the necessity for additional response organizations and the recruitment of specialized expertise. The latter necessitates educational initiatives that synchronize the knowledge and abilities of volunteers and extra staff to smoothly fit in the chain of actions [109-111].

Triage (T) and Treatment (T) represent the medical aspects of MIMMS, primarily focusing on the balance between maximizing survivors and make the greatest good for most under austere circumstances. This utilitarian approach grounded in the ethical philosophy that seeks to achieve the greatest happiness for the greatest number of people has been recognized during disaster management [20,21]. Attuning to utilitarianism, the triage and treatment processes prioritize the overarching welfare of the affected population as the supreme moral objective. This ethical stance underscores the commitment to making decisions that optimize the chances of survival and well-being for most individuals affected by a disaster. Consequently, the

crisis standard of care concept has been developed [112], and is widely accepted to provide sound ethical and legal issues for the actions of medical personnel during disasters [113,114]. The crisis standard of care reconciles the challenging decisions that must be made in resource-limited crises. It serves as a critical ethical compass for healthcare providers, offering guidance on allocating resources and prioritizing care in the face of overwhelming demand [113,114].

The final principle in the MIMMS is Transport (T), assuming a critical role in disaster logistics management [115]. It is designed to address the transportation's details, including access, routes, and how staff, resources, and survivors are transported both to and from disaster incident sites and between treatment facilities [71]. Timely and safe transportation access is paramount. In addition, transportation management during disasters lies in the need for multiagency collaboration. Effective disaster response often necessitates various transportation options, including ground, air, and sea transportation. In many cases, these transportation resources may be available within military bases [116,117], underscoring the importance of well-structured communication, coordination, and cooperation to achieve collaboration among various agencies. Ground transportation, often facilitated by emergency vehicles and personnel, ensures rapid access to affected areas and the movement of critically injured individuals to medical facilities [118]. Air and sea transportation may be indispensable when rapid deployment and evacuation are necessary, especially in regions with challenging terrain or when dealing with large-scale disasters [31,119,120].

Multiagency Collaboration

Coherent collaboration among multiple responding organizations is fundamental in fortifying disaster response resilience [61,90,121]. Extensive research has reported the pivotal roles in bolstering disaster responses played by and collaborated among public organizations, private actors, nongovernmental organizations (NGOs), and local facilities, underscoring the imperative to strengthen these partnerships. The recruitment of these entities is contingent upon cultural, educational, social, and environmental factors [122].

Public organizations, such as fire and police departments and healthcare organizations, have been recognized as vital early responders. Historical incidents are downright reminders of the adverse consequences of inadequate collaboration among governmental agencies [123-125]. Accordingly, governance systems and collaborative policies have been methodically structured and organized. Moreover, recent crises, such as the COVID-19 pandemic, have provided tangible evidence of the efficacy of these refined systems and policies, building up to disaster response resilience through orchestrated collaboration among government officials, and rigorously testing inter-governmental collaboration efforts worldwide [126].

In addition, private actors have been duly recognized as indispensable partners [86]. The global overview on the roles of the private sector in disaster risk reduction identified 5 potential avenues of private actors including 1) direct community assistance, 2) the innovation of products for public applications, 3) collaborative ventures with other implementing entities (NGOs, governments, and international bodies), 4) the establishment of private foundations, and 5) the development of preparedness protocols [85]. The primary motivation driving private sector involvement is the preservation of business continuity. Over decades, public-private collaborations have been initiated and cultivated. As a result, private sectors have become integral components of disaster risk reduction, response, and recovery endeavors [83,127,128]. The recent Global Assessment Report on Disaster Risk Reduction (GAR) issued by the UNDRR in 2022 continued to accentuate the strengthening of such partnerships [69].

Furthermore, previous incidents have highlighted the NGOs in supporting the public and society during response and recovery phases, particularly in low to middle-income countries [122,129]. These organizations usually originate from locals, possess intimate knowledge of neighborhoods, and boast extensive experience collaborating closely with communities. They deliver services to local communities during routine circumstances and exhibit flexibility in redirecting their support to areas necessitating assistance during disasters. NGOs assume substantial responsibilities in providing surge capacity during and following incidents. Furthermore, community partnership as part of disaster risk reduction plans, response strategies, and

recovery initiatives has consistently demonstrated efficacy in strengthening interdependence and augmenting overall outcomes [130,131]. However, the capacities and capabilities of communities can exhibit significant disparities between countries, thereby necessitating the establishment of local and national directives to engage these invaluable resources systematically [81,122,129,132].

Besides community partnerships, military organizations have contributed knowledge, skills, and supplies during disaster responses [116]. Military tactical techniques have been transferred and adopted by civilian healthcare professionals, providing rapid treatments under austere circumstances [133]. Furthermore, in some countries, military-built field hospitals have frequently extended their services to meet the demand for alternative care options. In recent times, the escalating rates of wars and acts of terrorism have necessitated a more structured collaboration between civilian and military entities[39,134]. This evolving collaboration reflects a critical aspect of disaster response strategies, leveraging the expertise and resources of both sectors to ensure a more robust and coordinated approach to disaster mitigation and recovery [116,134].

HEALTHCARE INTERVENTION IMPLEMENTATION

The inadequacies in surge planning and multiagency collaborations highlight the need for more effective measures. A recent proposition put forth by the UNDRR, WHO, and CDC is the intervention of a community partnership concept [66,68,69,81]. While this proposition outlined the expansion of the surge capacities to the local community, the proposed details predominantly remained in the theoretical strategies intended for generalization across nations. However, the effective execution of these strategies necessitates a deep and comprehensive community engagement. This engagement must consider the intricate nature of interventions encompassing cultural, educational, and socioeconomic aspects [69]. Additionally, the healthcare system itself is a complex entity, marked by variations in its components and a multitude of factors, including the healthcare setting and the number of target groups or levels. These variations significantly influence the successful

implementation and the adaptability of the surge expansion interventions [17,135,136].

Given the complexity of the healthcare systems and intervention, deploying developed interventions within the healthcare system requires a comprehensive assessment of the system, the community's specific contextual factors, and early engagement of stakeholders. Prior literature has summarized the stages of implementing interventions, i.e., developing, testing, evaluating, and implementing [17]. As theories and strategies for community collaboration have been established and continue to undergo periodic review by the UNDRR, in this thesis, the development stage contributes to undertaking a more pragmatic approach within the disaster response system. The primary objective is to develop a practical and accessible framework explicitly tailored for expanding surge capacity to harness community resources effectively. Furthermore, this pragmatic framework is tested, refined, evaluated, and implemented. These stages are undertaken across a spectrum of relevant contexts and diverse scenarios, aiming to affirm the intervention's feasibility, efficacy, and effectiveness when integrated into the healthcare system.

Key Uncertainties

Challenges in Surge Expansion and Multiagency Collaboration

The collaborative surge expansion involving diverse organizations with distinct objectives and historical trajectories presents a formidable challenge within disaster management. These organizations typically operate independently, each with internal capacities and capabilities tailored to its specific missions. Understanding and aligning these internal processes and resources for collaborative surge planning necessitates considerable efforts and strategic measures [9,10]. Thus, multiagency collaboration for surge expansion and disaster response efforts remains complex [68].

Previous research further identified the difficulty in adhering to the contingency plan, particularly in staff and stuff management during actual incidents as one of the critical challenges [48,93]. Descriptive data revealed instances where staff reallocation plans were incomplete, often due to

ambiguities in role definitions or challenges faced by individuals instructed to leave patients behind [74]. Additionally, delays in reloading supplies compared to the pace of incident expansion were found to be another critical challenge [48]. These issues highlight the importance of effective surge planning and multiagency collaboration which demand the creation of comprehensive plans and execution measures. Therefore, it is essential to consider the implementation of complex interventions within healthcare services [135,137,138]. Such measures may include process evaluations to navigate the intricacies of interventions regarding surge capacity and multiagency responses during crises [66,68,139,140].

Disaster Literacy and Educational Initiatives

Çalıskan and Üner have proposed a comprehensive definition of disaster literacy, characterizing it as "the capacity of individuals to access, comprehend, evaluate, and apply disaster-related information for making informed decisions and adhering to instructions throughout their lives, with a focus on disaster mitigation, preparedness, response, recovery, and overall quality of life improvement" [141]. Research has identified a deficiency in disaster literacy, particularly in disaster preparedness, mitigation, and risk reduction, with a notable gap observed among vulnerable populations such as individuals with physical and mental impairments, children, and minority groups [142-145].

The UNDRR has emphasized the significance of evidence-based translation strategies to improve public disaster literacy. These strategies are designed to facilitate greater public access to risk assessments and relevant information, particularly in geographically specific disaster-prone areas [68]. Furthermore, individual preparedness capacity, encompassing collaboration skills and well-informed decision-making processes among policymakers and leaders, constitutes a fundamental and indispensable aspect of disaster literacy. This literacy plays a pivotal role in implementing disaster management interventions [109,144]. Disaster literacy models encompass processes that equip individuals with the knowledge and skills necessary to enhance their comprehension, critical analysis, and application throughout all

phases of the disaster cycle, including mitigation, preparation, response, and recovery [141,146]. One of the most widely adopted models for developing and evaluating training programs is Kirkpatrick's four-level evaluation model, which assesses participants' reactions, learning outcomes, behaviors, and results. These measurements are integrated within disaster literacy models and are incorporated into simulation exercises [147].

Previous studies have consistently demonstrated the essential role of simulation exercises in enhancing knowledge and skills, ultimately leading to improved learning outcomes and heightened levels of engagement [148-150]. Moreover, repeated scenario-based training has significantly enhanced disaster management proficiency [151]. Two validated exercise systems, namely the three-level collaboration (3LC) and MAss Casualty SIMulation (MACSIM), have been extensively employed in disaster literacy [152]. The 3LC exercise is a tabletop exercise that focuses on functionality and enhances organizational and structural knowledge in disaster management [100,153]. While the latter is a modular exercise based on authentic patient cards derived from real events and can enhance the learning in all managerial levels and medical aspects of individual patients (triage, treatment) [154,155].These exercises allow participants to refine their decision-making and collaboration skills across operational, tactical, and strategical levels, thus facilitating effective resource allocation in response to major incidents within dynamic scenarios [62,100,153,156]. Moreover, the common denominator for both exercises in this thesis is the use of CSCATTT, which also creates collaborative factors to engage all professionals irrespective of their professions, i.e., they enhance multiagency and interdisciplinary collaboration.

Ethical and Legal Perspectives on Disasters

Disaster circumstances often compel healthcare professionals to confront complex decision-making scenarios fraught with ethical dilemmas, thereby raising the specter of potential human rights violations [39]. To ensure the provision of optimal care to patients and to establish appropriate ethical and legal boundaries for healthcare providers, it is imperative that ethical and legal guidance be integrated into disaster management plans [114,157]. Research

into ethical quandaries during crises has underscored the significance of imbuing disaster plans with moral considerations. These moral considerations entail the development of protocols for decision support systems, crisis standard of care guidance, and comprehensive training initiatives. Such measures can potentially mitigate moral distress and safeguard the essential tenets of ethical frameworks within medical care [158,159].

The crisis standard of care guidance, introduced by the American Medical Association [112], aligns with the ethical theory of utilitarianism. According to this utilitarian theory, prioritizing the greatest happiness for the most significant number takes precedence, particularly in contexts involving patient prioritization and allocating scarce critical resources during crises [20,21]. However, the criteria for invoking the crisis standard of care remain undefined, and its global adoption has not yet materialized [113,160]. A prior study delving into multinational ethical awareness and guidance and the legal aspects of disaster management and evacuation revealed a conspicuous absence in these dimensions [161].

Contexts

As a developing nation, Thailand frequently faces disasters and has made comparatively slower strides in infrastructure development. The geographical distribution of hospitals in the country is skewed towards high-risk areas, consequently rendering them susceptible to frequent encounters with natural and man-made threats [31,162,163]. Notably, some of these hospitals contend with annual flooding incidents [31,164,165].

Thai National Healthcare System

The national healthcare system in Thailand is orchestrated by the Ministry of Public Health, serving as the central governing body, vested with the authority and responsibility for policy formulation and financial planning [166,167]. These policies and financial allocations are subsequently channeled to the District Health Services, tasked with executing healthcare services. The district health service manages primary healthcare delivery and partly

operates through a network of village health volunteers. These local individuals serve as the initial contact points between the community and the healthcare system.

Within hospital-based healthcare services, the care includes prehospital and hospital services, operating within a multi-tiered system designed to accommodate diverse healthcare needs and competencies. The foundation of this system consists of primary care hospitals, referred to as community hospitals, which typically possess bed capacities ranging from 10 to 120. These community hospitals are primarily responsible for managing chronic diseases, addressing uncomplicated health issues, and providing life-saving prehospital and emergency care services. The next tier is occupied by secondary care facilities. This tier offers more advanced prehospital care, a broader range of medical treatment options, and the capacity to accommodate patients requiring simple surgical procedures. The facilities feature bed capacities ranging from 120 to 500 [166,167].

At the summit of this healthcare pyramid lies the tertiary care level, characterized by highly skilled healthcare professionals and, foremost, medical equipment. These facilities are geared towards delivering advanced prehospital, medical, and surgical interventions of a complex nature. Lastly, university hospitals constitute the apex of healthcare provision, distinguished by their commitment to professional excellence, knowledge advancement through research, and the presence of teaching institutions [166,167].

During major events, the activation of healthcare services is contingent upon the geographical location of the events and the availability of local resources. Hospitals rely on their disaster response plans to determine the appropriate course of action in response to external threats and fire evacuations. These plans outline the procedures for activating external resources, which may come from neighboring local facilities, regional entities, national agencies, and even international organizations, depending on the severity and scope of the emergency [168,169].

Regarding health financial schemes, all Thai citizens' healthcare financing falls into 3 schemes [166,170]. These major schemes include (i) the civil servants' medical benefit scheme under the Finance Ministry, (ii) the social security scheme under the Labor Ministry, and (iii) the universal coverage scheme

under the Public Health Ministry. The universal coverage scheme serves as a safety net for all Thais not covered by the other schemes; they are directed to hospitals according to their civil registration. This scheme extends coverage to more than 72% of the population [166,170].

Previous Experiences and Responses to Major Incidents

The 2004 tsunami stands out as a significant natural hazard that struck the southwestern coastline of the country, triggered by a profound 9.0 magnitude earthquake [171]. The events resulted in the tragic loss of more than 5,000 lives, affecting both residents and foreigners while causing extensive damage to infrastructure across four provinces: Phangnga, Krabi, Phuket, and Ranong. The literature revealed the precarious state of prehospital and hospital management during this crisis. Prehospital facilities were inadequately established, primarily relying on volunteer personnel, donated equipment, and vehicles[172]. This reliance resulted in severe deficits in scene evacuation resources, leading to a "first-come-first-serve" approach to victim transportation [171,172].

Conversely, hospital management adhered to a standard major incident policy, albeit activated shortly before the arrival of the first patient [171]. Local hospital staff worked tirelessly to address the influx of cases and resource constraints, with hospital directors assuming the role of incident commanders at each facility [173]. However, comprehensive safety evaluations, surveillance mechanisms, situational assessments, and resource evaluations were absent. Communication breakdowns due to damaged tele-communications towers further exacerbated the situation [171].

Within a mere 24-hour timeframe following the incident, national and international aid poured in despite the absence of formal requests [174]. Additionally, given Thailand's robust culture of volunteering, many medical and non-medical volunteers offered their assistance, providing uncomplicated medical care, interpretation services, aid in lifting and transporting patients, and donations of food and disposable supplies. However, the sheer magnitude of the disaster placed an overwhelming burden on the healthcare system during both the immediate response and

subsequent recovery phases, leading to considerable challenges in managing injuries and relief efforts. This pivotal event catalyzed a comprehensive reevaluation of Thailand's healthcare system in the context of disaster management, prompting significant restructuring and fostering collaborations on an international scale. [28,171].

Subsequently, in 2011, weighty rains caused profound flooding in major hospitals in the central part of the country, necessitating hospital evacuation. Reports indicated a structured disaster response, notably using the ICS with the CSCATTT elements [31]. However, managerial deficiencies were concentrated on the inappropriate multiagency collaboration and inadequacy of evacuation resources, including boats, transport ventilators, and transported staff [31,84,169].

RESEARCH METHODS FOR DISASTER MANAGEMENT

Research in the field of disasters necessitates a critical examination of inherently dynamic and uncertain situations. Various research approaches, can be employed, such as epidemiologic measures, economic impact assessments, descriptive studies/surveillance, and analytic measures [140]. Given the intricate nature of disasters, research designs often require a mixed-methods approach, combining quantitative surveys and qualitative interviews. Within this context, a pragmatic paradigm, representing a common epistemological worldview, proves particularly suitable, especially in inquiries related to leadership, decision-making, and collaboration in disaster settings [18,175,176]. Additionally, in the context of research perspectives related to complex intervention implementation, considerations include efficacy, theory-based approaches, and system-focused analyses [17]. This thesis focused on exploring the implementation of a healthcare intervention (the Flexible Surge Capacity - FSC concept), deems pragmatism as a paradigm conducive to mixed-method research. This choice facilitates comprehensive data collection and analysis, addressing efficacy, theory-based considerations, and systemic perspectives within the context of healthcare intervention implementation in disaster scenarios. [177].

THE RATIONALE OF THE THESIS

Despite the existence of structured disaster response plans, there have been knowledge gaps in the execution of these plans and in the comprehensive management of resources. These gaps underscore the importance of continuous evaluation and refinement of disaster preparedness strategies. Such ongoing efforts are essential to ensure that the healthcare system can effectively respond to emergencies and address potential issues related to resource allocation and plan adherence shortcomings.

One proactive approach to addressing these challenges involves the engagement of local resources, known as FSC. This becomes especially crucial when external resource deliveries are disrupted due to infrastructure damage, or when hospitals face the necessity of evacuation, necessitating significant mobilization of staff and transportation resources. The FSC concept, as introduced by Khorram-Manesh, represents an additional resource pool derived from the local community [29]. In the related study, Glantz et al. conducted an implementation test of this concept in a region in Sweden [30]. This empirical evaluation contributes insights into the practicality of FSC and the locals' perceptions toward the concept, shedding light on its potential as a valuable component of disaster preparedness strategies.

This thesis builds upon the FSC concept and aims to assess its feasibility and applicability within the healthcare system, targeting the expansion of resources to the community and fostering multiagency collaboration during crises. Figure 4 illustrates the chronological data collection and flows. The subsequent chapters of the thesis will provide a detailed description of the implementation process, offering a comprehensive understanding of the concept execution in the Thai context.

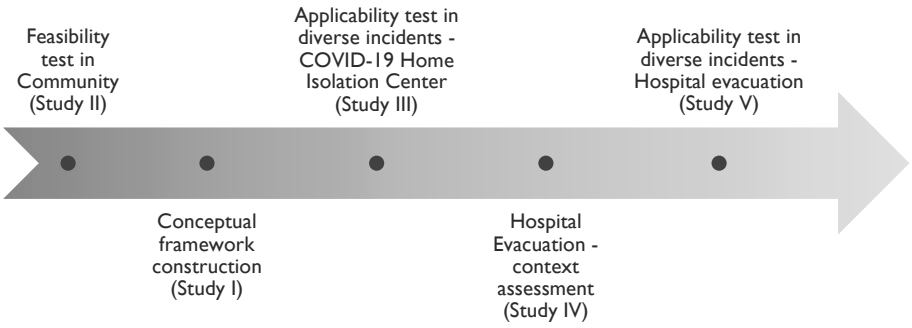

Figure 2 Data collection chart for Study I-V

Given the overlap between the COVID-19 pandemic and the timing of the doctoral study, Study II was the first study conducted online, facilitating virtual data collection. Thus, Study II serves as an appropriate initial point of exploration within the thesis, examining the adoption and feasibility of the FSC concept in Thailand.

The FSC concept was the core component of the innovation implemented in the Thai healthcare system. Figure 3 presents a logical model visualizing the implementation strategy using pragmatic research methods for disaster and public health emergencies through scenario-based simulations (the 3LC exercise) and the expected disaster preparedness outcomes.

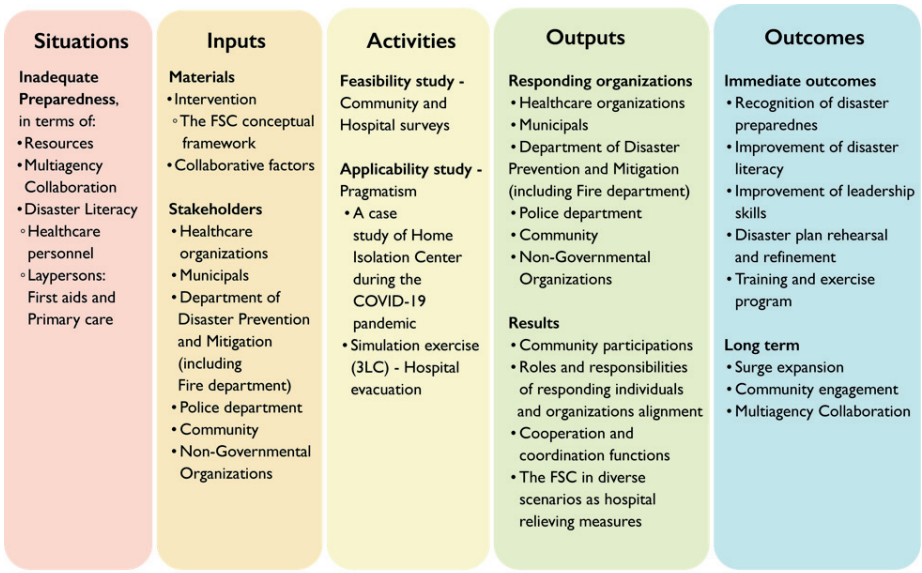

Figure 3 Logic model of FSC concept implementation. 3LC = Three Level Collaboration, and COVID-19 = Coronavirus 2019.

AIMS

This thesis examined the feasibility and applicability of a flexible concept described as "flexible surge capacity" in the management of major incidents and disasters. The studies concentrate on the essential components of a community's surge capacity and the collaborative aspects required in various infrastructures and disaster etiologies.

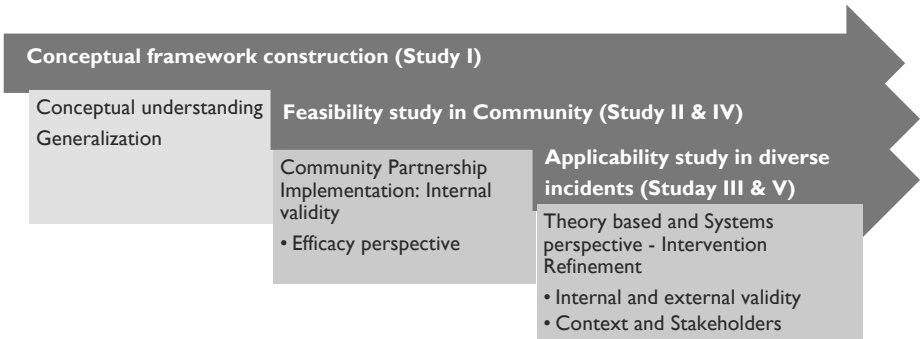

Figure 4 Coherence of the studies and aims in the thesis.

Specific aims:

I Conceptual framework construction using a review of the literature.

To develop a theoretical framework for the flexible surge capacity, inspired by existing surge capacity, complexity theory, and collaborative theoretical frameworks, and discuss its implementation and use in emergencies.

II Feasibility test using a mixed-method cross-sectional study.

To investigate the possibility of creating alternative care facilities, as part of Flexible Surge Capacity, to relieve hospitals in Bangkok, Thailand

III Applicability test using a qualitative study.

To explore the possibility of implementing the concept of flexible surge capacity to reduce the burden on hospitals by focusing on community

resources to develop home isolation centers in Bangkok, Thailand, during the COVID-19 pandemic.

IV Hospital evacuation context evaluation using a mixed-method cross-sectional study.

Besides the pandemic, hospital evacuation is another incident necessitating the "flexible surge capacity" concept. This study aimed to investigate the extent of hospital evacuation preparedness in Thailand, using the main elements of the concept.

V Applicability test using a mixed-method cross-sectional study.

To assess the effectiveness of using the 3LC exercise in developing collaboration and leadership in districts in Thailand, using the FSC concept and its collaborative tool during hospital evacuation scenarios.

METHODS

The thesis employed several research methodologies, including descriptive reviews and mixed-method cross-sectional designs, to implement complex interventions, 'Flexible Surge Capacity,' in the healthcare system during disaster response. Table 1 demonstrates the studies' methodologies overview.

Table 1 Methodologies of Study I-V

Study	I	II	III	IV	V
Designs	Descriptive review	Mixed-method cross-sectional	Qualitative prospective cross-sectional	Mixed-method cross-sectional	Mixed-method cross-sectional
Data collection	Literature review, Descriptive and conceptual	Online questionnaire, Semi-structured interview	Observation, Semi-structured interview	Online questionnaire, Semi-structured interview	Observation, Record transcription, Self-evaluation
Participants	Search engine	Alternative care facilities in Bangkok, Thailand	Operation in home isolation center and volunteers in non-governmental organizations	Representatives from hospitals (secondary care, tertiary care, and university hospitals)	Representatives from disaster responding organizations in districts of Thailand

Study	I	II	III	IV	V
Data analysis	Descriptive review	Quantitative and deductive content analysis	Deductive content analysis	Quantitative and deductive content analysis	Quantitative and deductive content analysis
Tools	N/A	Questionnaire (Adapted from Glantz V. et al. 2020)	Observation according to CSCATTT	Questionnaire (Adapted from Khorram-Manesh, A. et al. 2021)	Self-evaluation form, Observational checklist
Primary outcomes	Conceptual framework	Willingness to participate in the FSC concept and facilities' capacities and capabilities	Applicability of the FSC concept in the COVID-19 pandemic to unburden hospitals	Hospital preparedness status regarding surge capacity and collaborations	The 3LC exercise can improve the development of collaboration and leadership in hospital evacuation using the FSC concept
Ethical Approval (University Ethical Review Board)	N/A	MURA 2020/1621	MURA 2021/786	MURA 2021/573	MURA 2021/960 Ref.1299
Status	Published 2022	Published 2021	Published 2022	Published 2023	Published 2023

CONCEPTUAL AND THEORETICAL FRAMEWORK OF THE FLEXIBLE SURGE CAPACITY (FSC) (STUDY I)

The concepts and theories concerning surge capacity and disaster management were reviewed, mapped, and conceptualized to construct the flexible surge capacity (FSC) conceptual framework [178-180].

Review, Identification, and Selection of Literature

Multidisciplinary literature on surge capacity disaster characteristics, healthcare facilities' responses, and collaboration theories and concepts were extensively reviewed. Relevant literature was cultivated and categorized based on their logic and coherence to disasters and public health emergency management.

The literature review delves into an examination of surge capacity, its taxonomies, and expansion. Theoretical frameworks proposed by Hick et al. and Bonnett et al. significantly contribute to comprehending surge capacity dynamics [3-5]. The surge-generating events manifest in 2 primary forms: contained events (i.e., significant damage to infrastructure or massive local impact) and population-based (i.e., pandemic) events. The nuanced conceptualization of surge capacity is achieved through its categorization into public health, facility-based, and community-based surges (Figure 5). Additionally, the classification into conventional, contingency, and crisis capacity provides a practical demonstration for the disaster response phase (Figure 6)[3,5,45,70,74]. However, the predominantly healthcare-centric focus of these models necessitates a broader perspective on surge planning, and the efficacy of surge capacity expansion remains a challenge. Previous studies have highlighted deficiencies in surge planning efforts, leading to the inadequacy of surge expansion endeavors [31,84,173,181,182].

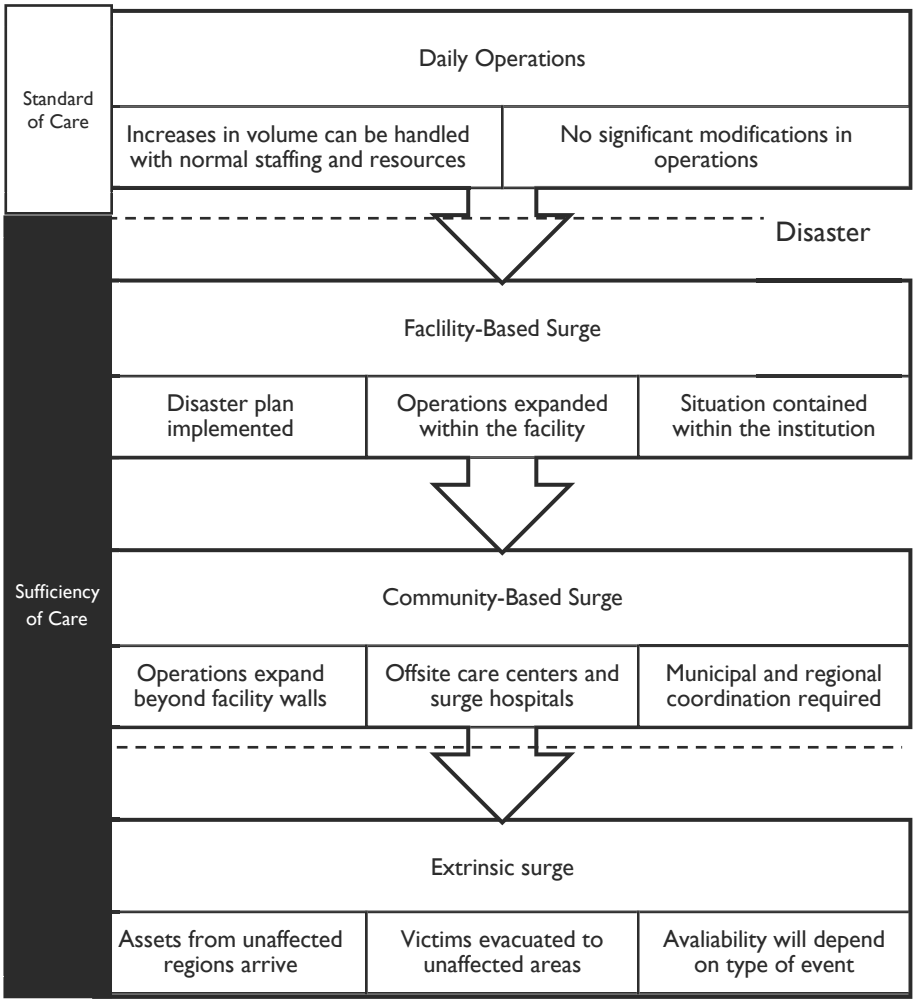

Figure 5 The progression of surge responses after disasters. Adapted from Bonnett et al. Published in 2007[3].

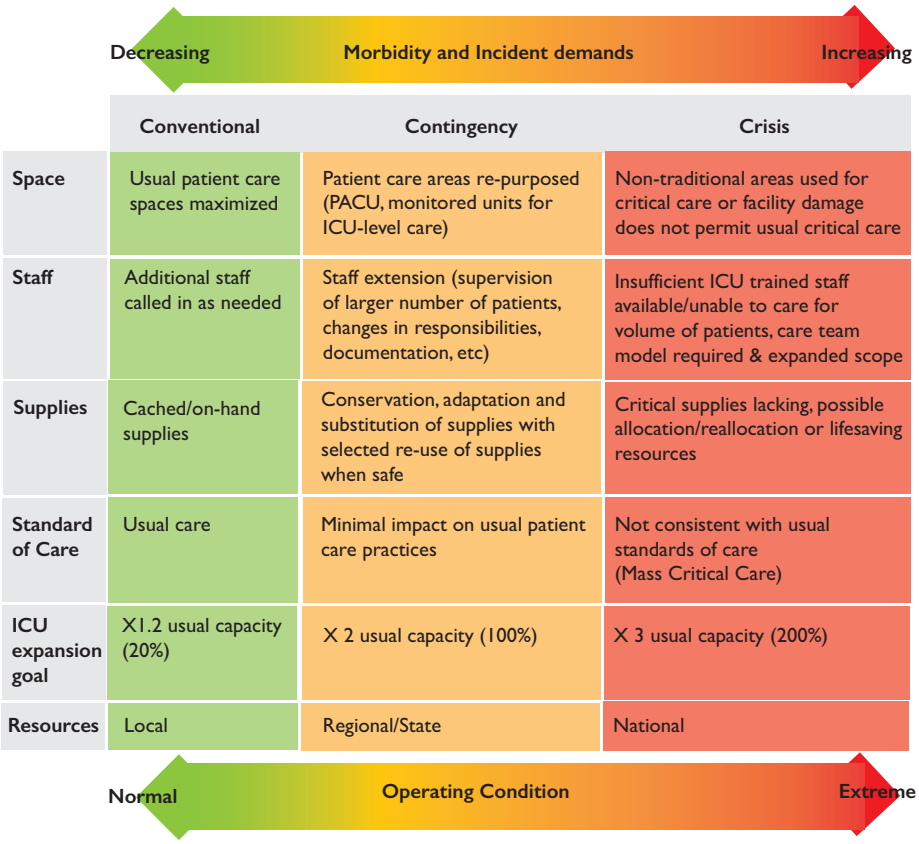

Figure 6 A surge capacity planning framework outlining the conventional, contingency, and crisis surge responses (PACU=post-anesthesia care unit). Adapted from Hick et al. and published in 2014 [74].

To better prepare for and respond to disasters, it is crucial to comprehend the underlying theoretical perspectives. In this context, complexity theory provides a robust framework for understanding disaster events' dynamic and adaptive nature [183]. In contrast to linear models, complexity theory acknowledges the intricate interplay of factors contributing to disaster dynamics. Embracing complexity theory in surge planning facilitates a more holistic and adaptable approach to disaster preparedness [184].

Furthermore, disaster responses are contingent upon effective collaborative efforts among various stakeholders, as the impacts can extend beyond individuals to social and organizational disorders. Adopting a systematic approach encompassing multidimensional aspects and encouraging

collaboration among multiple agencies is necessary. Therefore, collaboration theories were examined to ascertain the required crucial relationships to achieve a goal [8-10,12,185]. In routine circumstances, distinct entities operate independently, employing disparate or occasionally intersecting strategies while pursuing different or convergent objectives. However, it becomes imperative to identify and discuss mutual interests and points of contact among these entities during disasters through effective communication. Figure 7 illustrates the characteristics of collaboration. Collaboration theories are essential in disaster response scenarios, where multiple entities must work together, each with its processes and goals. One notable collaboration theory, as emphasized by Patel et al., outlines pivotal factors that underpin successful collaborative endeavors [9]. These factors from Patel et al. align with the CSCATTT model, a framework harnessed in the MIMMS. The practical significance and efficacy of this CSCATTT model render it noteworthy as both a measurement and evaluation instrument [91,186].

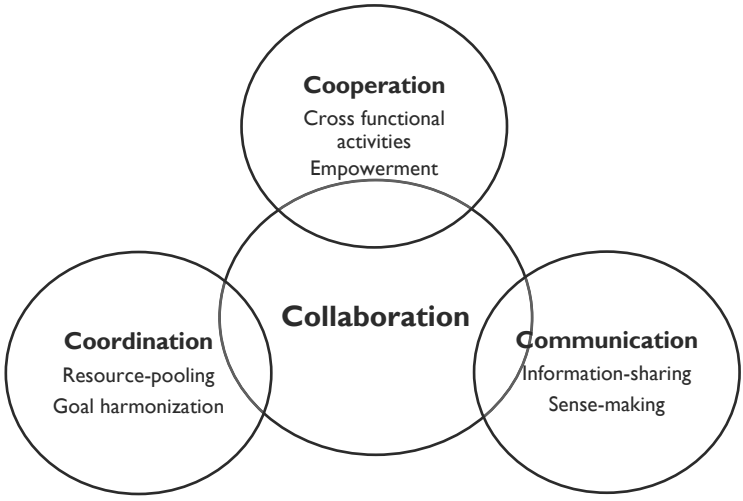

Figure 7 Collaboration characteristics[9,10,185]. Adapted from paper I

Integrating, Synthesizing, and Proposing the Conceptual Framework of the Flexible Surge Capacity (FSC)

The integration of surge capacity theoretical frameworks, complexity theory, and collaboration theory has culminated in synthesizing the FSC conceptual framework. The conceptual framework expands upon the community-based surge models previously put forth by Hick et al. and Bonnett et al., extending its purview to encompass not only the healthcare system but also local community resources [3,74]. These community resources comprise a range of both medical and non-medical facilities. Within the medical domain, these resources include primary healthcare clinics, dental clinics, veterinary clinics, and pharmacies, among others. On the non-medical front, resources include educational institutions such as schools, versatile venues like sports arenas, and lodging establishments like hotels.

Activating these local resources becomes imperative when all conventional facilities have been exhausted or cannot be accessed. Moreover, such activation becomes essential when the healthcare facilities are compromised, necessitating evacuation due to imminent threats. This integration of diverse resources underscores the adaptability and resilience inherent in the Flexible Surge Capacity Conceptual framework.

FEASIBILITY STUDY OF THE FSC CONCEPT IN COMMUNITIES AND HOSPITALS (STUDY II & IV)

Integrating the FSC concept into the healthcare system necessitates a multifaceted approach that hinges on fostering deep community engagement. To ensure its effective execution, we emphasize the need for comprehensive public education and strategic actions. Central to this strategy is the conduct of a feasibility study, which is instrumental in gauging the viability of the proposed interventions [14].

The deployment of a feasibility study involves examining various constituent elements contributing to the overall viability of the FSC concept. Previous reports proposed appropriate components, including acceptability, demand, implementation, practicality, adaptability, integration potential, expansion

possibilities, and limited-efficacy testing [14]. In this thesis, studies II and IV evaluated the acceptability, demand, practicality, adaptation, and integration through validated questionnaires. Measuring public opinions, intentions, and perceptions is imperative to explore these facets comprehensively.

Participants

Study II included all available medical and non-medical facilities in the communities in Bangkok, the capital city of Thailand. For medical facilities, public primary healthcare centers and dental clinics were sourced from the Ministry of Health. Additionally, the private and veterinary clinics operating within the private sector were identified through online search engines. Non-medical establishments, namely educational institutions, were retrieved through the Ministry of Education. Simultaneously, sports arenas and hotels were ascertained through online search engine queries.

In **Study IV**, the focus shifted to healthcare facilities of varying capacities, stratified into secondary care facilities (ranging from 120 to 500 beds), tertiary care institutions (with capacities exceeding 500 beds), and university-affiliated hospitals boasting bed capacities spanning the range of 400 to 2265. These institutions were chosen based on their capacity and capability to provide a broad spectrum of medical interventions, a critical consideration in disaster response preparedness [166,167]. The Ministry of Health was instrumental in providing the requisite names and addresses for these 143 hospitals, which constituted the focus of our investigation.

Study Tools

In both study II and study IV, data collection employed validated questionnaires sourced from previous literature [82,161]. These instruments were designed using a Nominal Group Technique as a foundational approach[187] , aimed at formulating questions that encapsulate the involvement of the FSC concept in surge planning and collaborative factors. Quantitative data acquisition was facilitated through the application of a Likert scale. While the qualitative aspect incorporated open-ended questions, allowing respondents to articulate opinions, share personal

experiences, and provide insightful perspectives. The questionnaires are available in the Appendix.

Questionnaire

In **Study II**, the questionnaire underwent a comprehensive development process guided by the expertise of three individuals with extensive experience in instrument development and an understanding of disaster and emergency management [82]. This panel of experts conducted a thorough face validation, evaluating the questionnaire based on logic, relevance, comprehension, legibility, clarity, and usability criteria. Cronbach's alpha analysis for internal consistency was 0.739. The questionnaire included hypothetical scenarios involving major incidents with multiple injured individuals and queries about the facilities' capacities and capabilities in aiding the healthcare sector's response.

In **Study IV**, the questionnaire development process diverged slightly, with three experts independently reviewing literature from 2002 to 2018, specifically focused on hospital evacuation [161]. Subsequently, content analysis was employed to derive pertinent questions that would encapsulate the complexities of hospital evacuations and their preparedness. The questions underwent face and content validity validation to ensure appropriateness and relevancy. The questionnaire comprised a spectrum of critical elements, including surge capacity, collaborative factors, ethical and legal considerations, situation assessment, and the management of vulnerable groups within the context of hospital evacuations.

A translation process was executed to ensure linguistic and semantic equivalence between the English and Thai versions of both studies' tools. Two native Thai speakers independently translated the tools into Thai, followed by a back-translation into English. The tools were then subjected to face validation and comparisons to the original English versions. Any discrepancies were addressed through discussions between the translators, and a consensus was reached regarding the accuracy and coherence of the translated versions. Furthermore, the translated tools were presented to and discussed with the original developers, further enhancing their accuracy and ensuring alignment with the intended research objectives. Once the

translation process was completed, the research details, ethical approval declarations, consent, and questionnaire were transferred to an online platform [188].

Semi-structured Interviews

The semi-structured interviews were conducted as a complementary method of data collection [189]. These interviews were structured in alignment with the content and themes of the questionnaires—however, the semi-structured format allowed for greater discussion flexibility and depth. Participants were encouraged to elaborate on their responses, allowing them to diverge from the predefined questions and introduce novel ideas and insights based on their experiences and expertise. This open-ended nature of the interviews facilitated a comprehensive understanding of the responses, contributing to the nuanced analysis of the data.

Data Collection and Processing

In **Study II**, before the distribution of questionnaires, a proactive approach was adopted to engage with the higher authorities of governmental establishments. The principal investigator, a PhD student, initiated direct communication to outline the prescribed procedures for collecting survey data. Subsequently, the pertinent governmental ministries orchestrated the dissemination of formal correspondence to various government-owned facilities, including public primary healthcare centers, schools, and sports arenas. This strategic approach to survey distribution was anticipated to enhance the responsiveness of these official entities [190]. Conversely, in the private sector, the task of disbursing official correspondence to independent entities was entrusted to Mahidol University. These letters contained a hyperlink and QR code, enabling recipients to access a repository of research particulars, ethical approval documents, and surveys hosted on the Google Form platform. The online form was available for response from November 2020 to January 2021.

In **Study IV**, all official facilities enlisted from the Ministry of Health were contacted by phone to communicate research details comprehensively.

Emphasis was placed on selecting representatives for research participation, focusing on their competencies in hospital emergency response plans and protocols. These representatives held the authority to revise the protocols and were responsible for communicating any modifications to the preparedness committee. Such representatives could be the facilities' directors, heads of security or emergency departments, or individuals occupying equivalent roles. Subsequently, formal letters were dispatched, inclusive of a hyperlink and QR code, providing access to online resources encompassing research details, ethical approval documents, consent to participation, and the questionnaire. The online form was available for response from December 2021 to April 2022.

Following the dispatch of official letters in both studies, the main investigator maintained a proactive engagement strategy, contacting all facilities via administrative emails and telephones to reinforce the importance of their research participation [188,191]. This engagement continued until the preliminary data analysis was performed, and the qualitative data reached saturation. Saturation in this context was characterized by the emergence of repetitive themes and thematic similarities within the findings, indicating that further data collection would not yield new insights [192]. At this juncture, the reminder correspondence was discontinued, with approximately 3 consequent reminders being issued [190].

All data obtained from the online platform were exported into Google Sheets and Microsoft Office Excel for initial organization and cleaning. Subsequently, the cleaned quantitative data were imported into Stata version 17 for comprehensive cleaning, organizing, and analysis preparation. Simultaneously, the qualitative data were separately prepared for deductive content analysis [192,193].

Non-Response Strategic Approaches

One of the challenges encountered in research methodology employing questionnaires is the issue of a response rate [194,195]. A review of studies focusing on survey methodology research has reported a general response rate that ranges from 22 - 68.8%. Factors influencing response rates include the survey mode, questionnaire length, content sensitivity, and language,

rather than the ethnicities and geographical locations where the research is conducted [190,196]. Studies II and IV incorporated various strategic measures, including vertical communication, advance notifications, and multiple follow-ups to augment the response rate for a predictable low success rate in online surveys.

Data Analysis

Quantitative Analysis

The quantitative data from both studies were descriptively presented in counts and proportions. In **Study IV**, the Chi-square or Fisher's exact test (the Fisher's exact test used when the expected number in each cell was below 5) was employed to assess the association between hospitals' sizes and elements in surge capacity and collaborative factors. The statistical significance level was 5% ($p < .05$).

Qualitative Analysis

The qualitative data obtained from open-ended responses and semi-structured interviews underwent a rigorous analytical process. In **Study II**, a thematic content-coding analysis was employed to examine the distribution of the surge capacity concept. This analysis aimed to identify competencies, challenges, and interests related to participation in the FSC concept. In **Study IV**, a deductive qualitative analysis inspired by Hsieh and Shannon was conducted. This analysis was grounded in the elements of surge capacity (4S) and collaboration (CSCATTT). The data were examined to uncover insights into these critical dimensions and their relations to the FSC concept. Throughout these analyses, multiple rounds of iterative readings, coding, and thematic grouping were conducted to ensure the comprehensive exploration of the qualitative data. The collaborative nature of the analysis process involved extensive discussions among the authors, culminating in a consensus regarding the findings.

APPLICABILITY STUDY AND IMPLEMENTATION IN DIVERSE INCIDENTS (STUDY III & V)

The outcomes of feasibility and evaluation studies conducted in Study II and Study IV supported the refinement of the subsequent applicability and transferability of the FSC concept in Study III and Study V. The FSC concept's applicability was examined in the context of two distinct incidents: firstly, its application in the management of the COVID-19 pandemic with the aim of alleviating the strain on hospitals (Study III); and secondly, its role in hospital evacuation scenarios, which were assessed through the 3LC exercise (Study V).

Study Design, Participants, and Data Collection

Study III: The Home Isolation Center for the COVID-19 Pandemic Management

A qualitative study design was employed to investigate the operational dynamics of a home isolation center (HIC) and its alignment with the collaborative factors (CSCATTT) and the incorporation of the FSC concept. Data for this study were collected through direct observations and interviews, focusing on the operations, and performance, perceptions, and experiences of volunteers within the HIC. This HIC was managed by a Thai non-governmental organization under the leadership of emergency physicians. Five experts in disaster and emergency management, well-versed in the study's methodology, independently observed and documented the processes taking place within the HIC. The observation guide is available in the Appendix.

In addition to direct observations, participants were purposively selected for semi-structured interviews based on their specific roles within the HIC and in alignment with the CSCATTT framework, aiming to gather additional insights and in-depth information. A total of 15 participants were chosen for these interviews, with six of them serving as team leaders within the HIC structure. The selected participants exhibited a median age of 34, with an interquartile range of 5 years. Before the commencement of the interviews,

comprehensive research details were communicated and discussed with the selected participants, underscoring the voluntary nature of their involvement. The semi-structured interviews, each lasting approximately 60 minutes, were conducted by two interviewers in a relaxed and comfortable environment, ensuring no data was inadvertently overlooked. All interviews were recorded and transcribed verbatim to ensure accuracy and thorough analysis, providing the basis for the subsequent content analysis.

Study V: The Hospital Evacuation Scenarios in the 3LC Exercise

A mixed-method cross-sectional approach was employed. The data collection encompassed both quantitative and qualitative dimensions. Quantitative data were collected through paper-based pre- and post-3LC exercise self-evaluations and observation checklists during the exercise. Qualitative data were obtained from open-ended responses in the pre- and post-self-evaluations, qualitative observation paper notes during the exercise, and video records during seminars conducted as part of the 3LC exercise.

Participants were representatives from disaster response organizations. They were selected through purposive criteria that considered their knowledge of their organizations' capacity and their roles in communicating the need for future collaboration with organizational management committees. These organizations spanned the local healthcare sector, defense sector, municipalities, and community facilities, including religious institutes, schools, clinics, and hotels. Participants were grouped into teams of 7-8 individuals to promote heterogeneity within the groups while maintaining homogeneity. This group size was chosen to encourage active sharing and meaningful discussion among participants.

The study context centered around the Chakri Naruebodindra Medical Institute, Faculty of Medicine Ramathibodi Hospital, and the surrounding districts that served as implementation areas. These areas were selected due to their strategic geographic locations and proximity to Bangkok International Airport. The districts were prone to recurrent floods and had a substantial population of over 1.4 million residents, with an equal

distribution between agricultural and industrial sectors. Four out of six districts, namely Mueang Samut Prakan, Bang Bo, Bang Phli, and Bang Sao Thong, were selected based on their suitability in terms of location, commonality of risk for national generalization, and the feasibility of collaboration among responding organizations.

Data was collected through the 3LC exercise, a well-established method for enhancing collaboration, learning, and usefulness of disaster responses by fostering self-reflection and constructive critiques in an open and secure environment. The exercise entailed 3 rounds of functional exercises in which participants responded to disaster scenarios, explicitly focusing on hospital evacuation events. It also encompassed 3 rounds of seminars where participants openly discussed their actions and responses. During the exercise, participants assumed their actual roles, actively engaging in various forms of collaboration within the context of disaster responses and utilizing the FSC concept and collaborative factors (CSCATTT).

Following the scenarios, the seminar included two open-ended questions: what participants performed during the response and what could be improved based on their experiences to enhance responses in subsequent similar scenarios. The exercise was facilitated by instructors with training in the 3LC method and over five years of experience in disaster responses or active participation in annual hospital preparedness exercises. These instructors played an active role in encouraging team collaboration, with a primary focus on task execution, perspective sharing, and planning. They also kept an eye on any instances of overly polite, hesitant, or passive engagement among participants, ensuring a productive learning environment.

The scenarios used in the exercise, along with their dynamic components, were derived from high-frequency incidents in the existing literature, a 3-year accumulated data from internal hazard vulnerability assessments, the pragmatic paradigm of disaster preparedness exercises, and the complexity of the healthcare system. A nominal group technique was employed to construct these scenarios, involving four representatives from the main hospital's hazard vulnerability management committee with expertise in disaster management, each with more than five years of experience in the

field. The finalized scenarios encompassed fire, flooding, and a new emerging disease. The details of the scenarios are presented in the Appendix.

Study Tool

The study tools were based on collaborative factors (CSCATTT) and the ICS with the integration of the FSC concept. All study tools are presented in the Appendix.

Observation tools

The development of an observation tool drew upon theories and existing literature that expounded on collaborative factors in the context of emergencies and disasters [91,197-201]. Subsequently, the tool underwent an evaluation and discussion by experts specializing in emergency response and disaster management to achieve a consensus on its structure and content. The final iteration of the tool was designed into 2 parts. The first part involved recording participants' performances through a checklist, using a yes/no format and a rubric scale. The second part included free-text comment forms, which allowed the observers to offer additional qualitative insights that they deemed essential for a comprehensive evaluation.

Prior to its implementation, the observation tool was elucidated with the designated observers to ensure their thorough understanding and alignment with the evaluation process. This preparatory step aimed to enhance the tool's effectiveness and facilitate a consistent and rigorous assessment of collaborative efforts.

Self-evaluation tool

In Study V, a self-evaluation tool was employed as a key instrument to capture the perceived levels of collaboration, learning, and usefulness regarding collaborative factors and the FSC concept application. The tool featured a Likert-scale format, with responses spanning from a score of 0 representing "unknown" to a score of 5, signifying a level of proficiency where knowledge could be effectively conveyed. In addition, the tool

integrated the FSC concept manifesting through the inclusion of open-ended questions. This section was positioned to elicit participants' perspectives regarding the application of the FSC concept during hospital evacuation events. This approach sought to capture nuanced insights and experiential feedback that could shed light on the practical utility of the FSC concept within the context of hospital evacuation scenarios.

Data Analysis

Study III: Qualitative data analysis

In accordance with the conceptual framework of the FSC and its connection to collaborative factors, a deductive content analysis approach was employed [193,202]. The first step involved a comprehensive review of observational and interview notes to gain a holistic understanding of the entire dataset. Subsequently, data were scrutinized to identify meaningful units, which were subjected to condensation, abstraction, interpretation, and classification into subcategories based on their similarities and differences. The final subcategories, representing the distilled insights from the data analysis, were subjected to a comprehensive review and unanimous approval by all Thai authors involved in the study. Ultimately, the subcategories were sorted into overarching categories within the context of the FSC and collaborative elements.

Study V: Quantitative and Qualitative Data Analysis

Initially, all data were transcribed from the paper-based format into electronic records, employing Microsoft Office Excel version 16.71 for initial data processing. The data were then transferred to Stata version 17 for statistical analysis. Descriptive statistics were employed to present the data, including counts, proportions, medians, and interquartile ranges. The participants' perceptions obtained from the Likert-scale responses were analyzed using the Wilcoxon-signed rank test to compare pre- and post-self-evaluation results. Furthermore, the Likert-scale data was categorized into three levels, specifically 'poor' (scales 0 and 1), 'fair' (scales 2 and 3), and 'good' (scales 4 and 5) for an enhanced analysis. The Chi-square test or

Fischer's exact test (if the expected number in each cell was below 5) was employed to examine the proportion of poor, fair, and good ratings, assessing the differences in collaboration levels between pre- and post-exercise.

Regarding the qualitative data, a deductive content analysis approach, influenced by the work of Graneheim and Lundman, was adopted [202]. The qualitative data included participants' comments within self-evaluation forms, insights shared during seminars, observer notes, and transcripts from video recordings. These diverse qualitative data sources were compared and scrutinized through multiple readings to ensure a comprehensive understanding of the entire dataset. Meaningful units within the data were identified, highlighted, and further condensed, abstracted, and coded to facilitate the identification of recurrent themes. The coded data were subsequently categorized based on their commonalities and distinctions. To ensure the rigor and relevance of the identified themes, we engaged in reflective analysis and undertook a comprehensive review of the existing literature that pertained to these themes. Furthermore, the themes were subjected to in-depth discussions involving all authors. This collective engagement served to refine, validate, and consolidate the coded data into coherent themes, offering a nuanced understanding of collaborative elements.

ETHICAL CONSIDERATIONS

The thesis adhered to ethical guidelines and principles outlined by the Swedish Ethical Review Authority, particularly those of studies conducted in foreign countries. In broad terms, all studies strictly complied with the guidelines and instructions stipulated in sections 3-4 of the Swedish Ethic Review Act. These compliances mean the research does not involve sensitive or unlawful information concerning the study participants. The participation of individuals is voluntary, with stringent measures to safeguard against physical or mental harm. The research conduction also includes the absence of tests or samples necessitating laboratory analysis or registration in a biobank.

In addition, the research aligned with the ethical regulations and standards in Thailand, where the studies were conducted, and where the results were stored, analyzed, and evaluated following the research protocols and organizational procedures in place. Importantly, these ethical practices in Thailand consistently align with the ethical standards delineated in the World Medical Association's Declaration of Helsinki. This comprehensive commitment to ethical standards underscores the responsible and ethical conduct of research, prioritizing the rights and well-being of all participants and upholding the integrity and credibility of the studies. Before obtaining participants' informed consent, all participants were provided with a comprehensive understanding of the research details, the secure storage of their data, their rights regarding data access, and the freedom to withdraw from the study at any time and for any reason they deemed necessary.

Ethical approval for each study was sought and granted before the commencement of data collection. These approvals were obtained from the responsible ethical oversight bodies in Thailand, ensuring that the research was conducted in an ethically sound and responsible manner. The protocol codes and dates of approval are listed as follows:

- Study I: The Ethics Review Act was not applicable
- Study II: MURA2020/1621, October 5, 2020
- Study III: MURA2021/786, September 16, 2021
- Study IV: MURA2021/573, July 12, 2021
- Study V: MURA2021/960 Ref.1299, November 20, 2021

RESULTS

STUDY I

The conceptual framework of the FSC is underpinned by the adoption of the theoretical frameworks related to surge capacity, with the integration of complexity and collaboration theories. Figure 8 demonstrates the stepwise activation of the FSC conceptual frameworks. The FSC concept is designed to be activated and become operational when hospital resources are depleted, or external resources cannot be delivered due to infrastructure destruction. As a result, this concept is incorporated following the utilization of all available hospital resources, illustrating a stepwise approach in its implementation.

The FSC concept is a community-based resource utilization system comprising resources derived from medical and non-medical facilities within the local areas. The medical facilities encompass certified and authorized primary and allied healthcare centers, which include dental and veterinary clinics, physiotherapists, and pharmacies. In contrast, non-medical resources include public and private local facilities, such as schools, sports arenas, hotels, and similar establishments. The successful implementation of the FSC concept hinges on deep community involvement, which necessitates the application of measures to assess the willingness of individuals and facilities to participate and the establishment of interaction points to foster collaborative efforts.

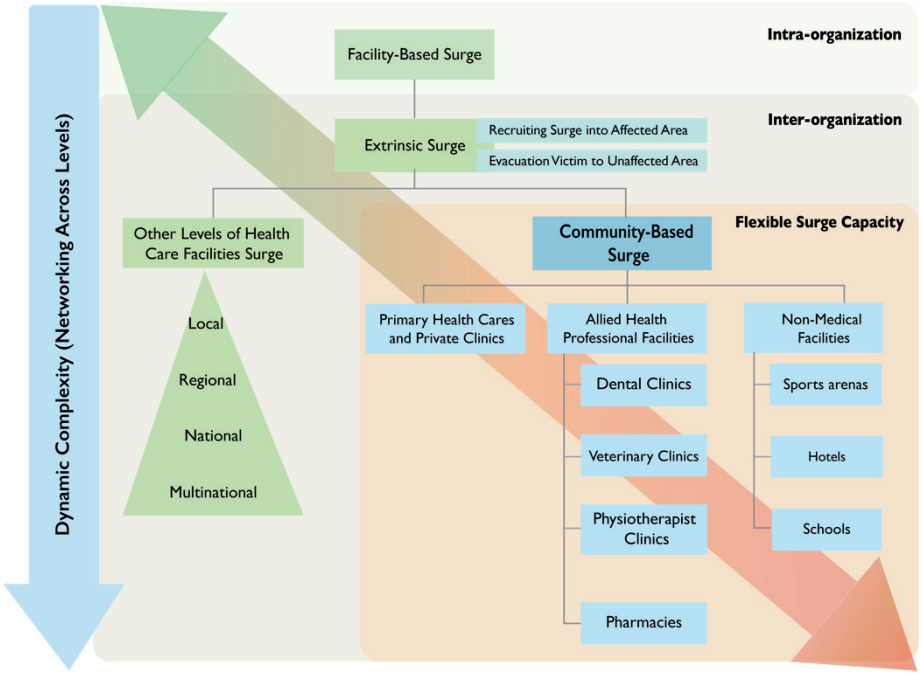

Figure 8 The Flexible Surge Capacity Conceptual Framework. Adapted from the study I

It is important to note that the activation of community resources may not always adhere to the stepwise presumption of the framework due to the dynamic and unpredictable nature of disasters. Therefore, additional measures, including intervention refinement, and feasibility and applicability tests, are imperative to ensure the effective implementation of the concept.

STUDY II

Out of 967 facilities, 228 answered the questionnaire, with the highest response rate observed among the public primary healthcare centers (PHCC), accounting for 50.7% of all PHCCs. To gain deeper insights and a more comprehensive understanding, semi-structured interviews were conducted with individuals in authoritative positions of each facility of interest, including ten primary health care centers, six private clinics, two dental clinics, two veterinary clinics, one school director, one sports facility administrator, and one hotel owner. As a part of the data processing,

smaller schools with fewer than 500 students were excluded due to their limited capacity. Consequently, the final number of included facilities and respondents stood at 739 and 162, respectively.

The capacity in the PHCCs includes doctors and nurses, with some centers having pharmacists, while private clinics typically have doctors and nurse assistants. Both types of clinics offered primary and minor emergency care and perform minor procedures. Dental clinics are staffed with dentists and dental assistants and reported to be equipped with sterile supplies. Veterinary clinics, on the other hand, have veterinarians and assistants, with some having operation rooms and sterile supplies and offered helping hands. All non-medical facilities feature small treatment rooms with nurses or nurse assistants for primary care management. The proportion of responses across these facilities is illustrated in Figure 9.

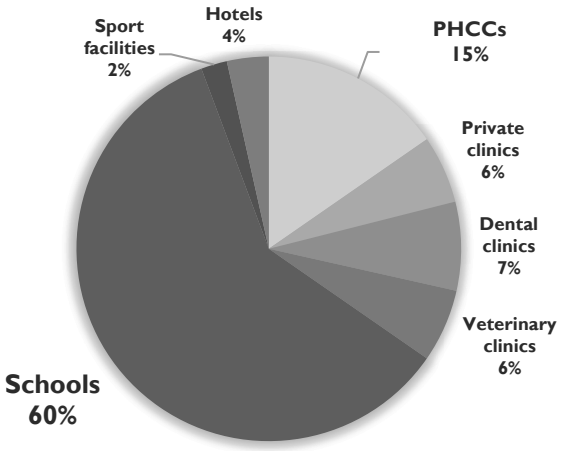

Figure 9 Response proportions

The survey and interviews revealed that a significant number of facilities expressed their willingness and demonstrated the necessary capabilities to engage in the FSC. The capabilities of these facilities are presented in Figures 10-12. However, there were exceptions, as one PHCC and two private clinics expressed that they could not help.

Additionally, several challenges were highlighted in the comments from the survey and interviews, including a lack of essential medical equipment,

limited spaces, and the need for lifesaving and emergency care educational initiatives. Some private clinics and sports arenas expressed concerns about the insufficient staff. Additionally, veterinary clinics expressed reservations about providing care to humans. Nevertheless, it is noteworthy that a majority of medical and non-medical facilities expressed a genuine willingness to enhance their emergency care and disaster management capability.

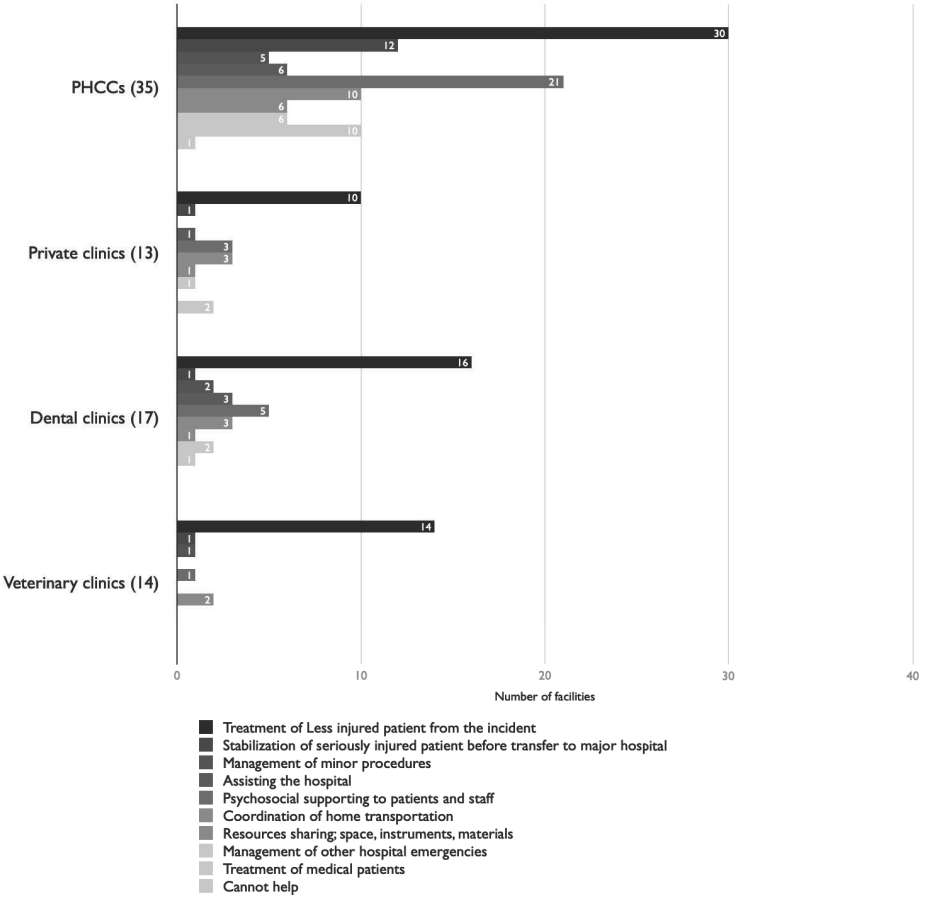

Figure 10 Medical facilities' capabilities

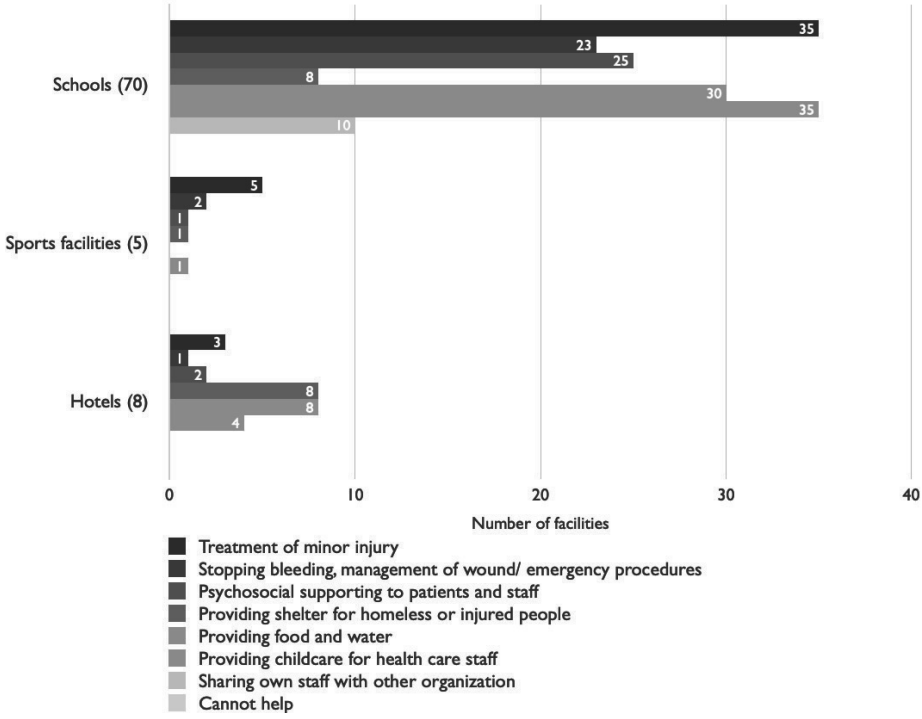

Figure 11 Non-medical facilities' capability

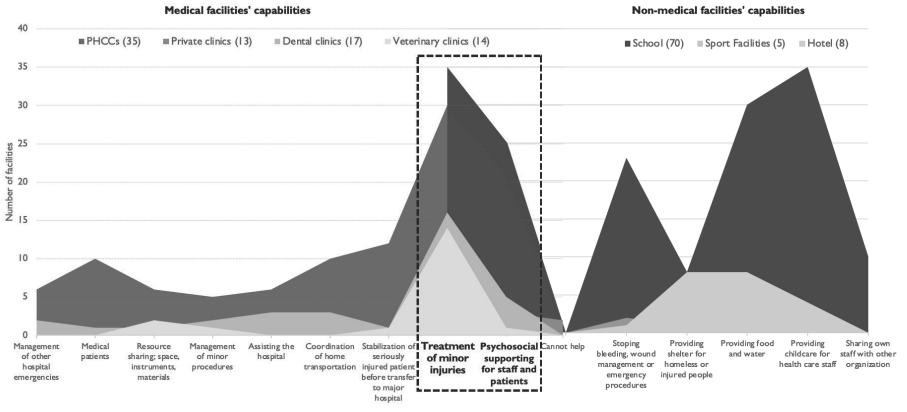

Figure 12 Capabilities of all facilities

Non-response Analysis

With various measures to enhance response rates, the responses remained constrained, falling within the range of 13.8% to 50.7% (Table 2). The facilities enlisted in the study were re-contacted to investigate the reasons for non-response. Many facilities, particularly those in the private sector, revealed that the non-response reasons were either not receiving the initial survey or reminders or being too preoccupied to respond. Nevertheless, the total number of responding actors, which amounted to 228, represented a substantial surge in capacity expansion.

Table 2 Number of responders and non-responders from facilities of interest

Facilities of interest N (%)	Primary and allied healthcare facilities				Non-medical facilities		
	PHCC	Private Clinics	Dental Clinics	Veterinary Clinics	Schools	Sports arenas	Hotels
Total	69	185	116	90	437	12	58
Overall Responders	35 (50.6)	13 (7.0)	17 (14.7)	14 (15.6)	136 (31.1)	5 (41.7)	8 (13.8)
Before reminder	18 (26.0)	13 (7.0)	16 (13.8)	14 (15.6)	77 (17.6)	1 (8.3)	3 (5.2)
After reminder	17 (24.6)	0	1 (0.9)	0	59 (13.5)	4 (33.3)	5 (8.6)
Non-responders	34 (49.3)	172 (93.0)	99 (85.3)	76 (84.4)	301 (68.9)	7 (58.3)	50 (86.2)
p-value	<0.001				0.016		

PHCC = Public primary healthcare clinics

STUDY III

The home isolation center (HIC) was successfully established and operated in alignment with the FSC concept, the ICS, and collaborative factors. The HIC facilitated the care of 5,471 patients with 275 classified as critically ill patients. Within this cohort, the daily influx of patients into the HIC exhibited a dynamic range, fluctuating between 10 to 280 cases. The operational framework of the HIC consisted of three key stages that mirrored the patient's journey within a physical hospital: registration, evaluation and treatment, and logistics.

The arrangements for the HIC were participations from medical and non-medical staff, the integration of medical devices such as pulse oximetry and temperature monitoring, and the provision of suitable local infrastructure. These recruitments were achieved through individual recruitment and an organized system to ensure robust support for the HIC. The collaboration of all resources was systematically managed, employing the principles of the ICS and collaborative factors, specifically the CSCATTT. A detail of subcategories that emerged during the operational phase of the HIC and sorted into the CSCATTT is demonstrated in Table 4.

Examples of quotations reported in Study III are as follows:

Responsibility clarification in *command-and-control* element: *"The distribution of tasks is quite informal, but at the same time, we separate tasks that strictly belong to physicians, nurses, or social workers according to the professional and legal framework."* Volunteer nurse

Health informatics, security, and privacy in *safety* element: *"The data access limitation was strictly implemented; only team leaders could authorize data access."* Non-medical volunteers

External and Internal communication in *communication* element: "Line application was applied to intra-organization, inter-organization and communicate with patients, since a majority of Thai people used the channel." Physician volunteer

Furthermore, as the operation unfolded, there was a rapid escalation in the number of COVID-19 cases, eventually reaching their peak. In response, the HIC lead team conducted a critical review of patient prioritization, leading to the reorganization of the treatment courses, patient monitoring procedures, and the delivery of essential supplies. An 8-tier triage system was formulated and promptly deployed to optimize survival chances. This adjustment addressed the evolving challenges posed by the COVID-19 outbreak and efficiently reallocated resources, ensuring that the most critical cases received the immediate attention they required.

STUDY IV

Out of the 143 hospitals initially approached, a total of 43 hospitals, each varying in capacities and resources, responded to the questionnaire. In the context of hospital evacuation preparedness, the responding hospitals revealed the presence of a hospital ICS. A significant majority, accounting for 97.6%, emphasized their capacity for autonomous responses rather than relying on central commands from provincial officials. Moreover, the study indicated that all elements within surge capacity exhibited various levels of readiness, ensuring that these hospitals could effectively deploy them when necessary. However, a small number of hospitals demonstrated a relatively lower perception of the importance of legal and ethical considerations, as well as the need for operational protocols specifically tailored for vulnerable individuals.

The findings also uncovered several noteworthy points regarding hospital evacuation literacy and training. The triage system that was planned to be used during evacuation was controversial around daily triages, and major incident triages. However, few hospitals were aware of reverse triage and its implementations. While the surveyed hospitals confirmed the existence of annual fire evacuation training, which ranged from tabletop exercises to live simulations, there was a notable absence of explicit mention of hospital evacuation training or joint training sessions with other organizations.

Nevertheless, there were varying degrees of collaboration among hospitals in different aspects. A high number of hospitals (88.4%) exhibited some

degree of inter-hospital collaboration, primarily in the context of the patient referral system. Similarly, fruitful collaborations were observed with municipal authorities and police/fire departments, particularly concerning activities related to traffic management and fire safety. In contrast, the survey revealed that collaborations with first responders and private organizations were relatively limited.

Non-response Analysis

The comparison of characteristics of response and non-response facilities is represented in Table 3. There were similarities between response and non-response participants.

Table 3 Characteristics of response, reminders, and non-response facilities

	Total Responders, N (%)	Before reminder, N (%)	After Reminder,N 1st, 2nd, 3rd*	Non-responders, N (%)	*p-value***
Geographical locations (N)					0.856
Northern (14)	5 (11.6)	1 (2.3)	0,3,1	9 (9.0)	
Northeastern (40)	11 (25.6)	6 (14.0)	4,1,0	29 (29.0)	
Eastern (14)	3 (7.0)	0	1,2,0	11 (11.0)	
Western (4)	2 (4.7)	0	1,0,1	2 (2.0)	
Middle (45)	13 (30.2)	8 (18.6)	0,4,1	32 (32.0)	
Southern (26)	9 (20.9)	4 (9.3)	1,4,0	17 (17.0)	
Total N	43 (30.1)	19 (13.3)	24 (16.8)	100 (69.9)	
Bed capacity (N)					0.008
>1000 beds (10)	3 (7.0)	1 (2.3)	0,0,2	7 (7.0)	
501-1000 beds (39)	19 (44.2)	7 (16.3)	1,10,1	20 (20.0)	
300-500 beds (56)	9 (20.9)	5 (11.6)	2,2,0	47 (47.0)	
<300 beds (38)	12 (27.9)	7 (16.3)	3,2,0	26 (26.0)	
Total N	43 (30.1)	20 (14.0)	23 (16.1)	100 (69.9)	

*Times of reminder;1st= 10th January 2022, 2nd= 20th February 2022, 3rd= 18thApril 2022
**p-value of characteristics between responders and non-responders

STUDY V

A total of 50 participants were initially recruited to engage in the 3LC exercises and research, representing a diverse range of roles and organizations, including hospitals, provincial public health agencies, police departments, provincial administrations or city municipalities, the Department of Disaster Prevention and Mitigation, and local facilities. Of these participants, 40 remained engaged throughout the study, demonstrating a significant improvement in collaboration across various areas and in the context of a hospital evacuation. However, the improvements were less pronounced in the treatment and transport elements. Moreover, the data concluded from self-evaluation and observations shed light on the participants' evolving perceptions regarding organizational collaboration. Participants demonstrated a heightened awareness of community roles within the ICS, including crucial positions such as the public information officer, medical operation roles, and logistics.

During the 3LC exercise, participants demonstrated an ability for multi-directional communication and coordination among multi-agency organizations. Additionally, participants from healthcare organizations predominantly exhibited passive or consensus-oriented leadership styles. In contrast, participants from administrative officials and the police departments took on more active leadership roles, actively guiding operational discussions and decision-making. The sub-themes that emerged within the collaborative themes during the 3LC exercise are detailed in Table 4.

Table 4 Qualitative data from direct observations (Study III and V), interviews (Study III), and self-criticism (Study V) based on collaborative elements (CSCATTT) (Adapted from Results in Study III and V)

Categories/ Themes	Study III: Sub-categories	Study V: Sub-themes/codes
Command and Control	Coordination and collaboration	The ICS was used. Important areas establishment

Categories/ Themes	Study III: Sub-categories	Study V: Sub-themes/codes
	Staff engagement	Extension of resources to the community
	Responsibility clarification	Leaders were chosen. Leadership manifestation Responsibilities were assigned and controlled by the whole group
	Sustainability	
Safety	Patient safety – Health informatics, security, and privacy	Safety officers Safety management
	Patient safety – Medication prescription and treatment reassurance	
	Personnel safety – Physical safety against the COVID-19	
	Personnel safety – personal privacy	
	Personal safety – Mental and spiritual recognition	
Communication	Intra-organizational communication - process continuity and development	Internal communication
	External communication - teleconsultation	Inter-organizational communication

Categories/ Themes	Study III: Sub-categories	Study V: Sub-themes/codes
	External communication - public communication	Public communication
Assessment	Patient registration – information purveying, information acquirement, and validation, home isolation adequacy	Own resource evaluation
	Patient operation – increase health care equity and unburden hospitals with internet connection challenges,	Surge planning Community engagement
	Critically ill patients care to increase chances of survival and unburden hospitals, the health care system devastation.	
	Patient discharge procedure	
Triage	Patient triage – optimize resources	Patient prioritization
Treatment	Current standard treatment protocols	A treatment zone was set up
Transport	Equipment and consumes acquire	Alternative means of transportation
	Delivery procedure	Patient transportation
	Timely critical patient transportation	Device transportation, particularly in critical cases
Challenges	Supplies related process. (NGO-Government Collaboration)	Command and control – organize a well-structured command post.

Categories/ Themes	Study III: Sub-categories	Study V: Sub-themes/codes
	Patient care-related process. (Teams' and communities' resilience)	Safety – develop and implement safety policy. Communication – establish standard communication channels and common information access points. Assessment – provide staff and patients' survival supplies. Transport – Develop practice guidelines for stockpiling and logistics of medical devices. Staff – provide educational initiatives. Structure – develop guidelines for community areas' utilization.

DISCUSSION

This thesis aims to examine the implementation of the FSC concept in major incidents and disaster management, with a focus on assessing to what extent (feasibility) and how (applicability) the concept contributes to enhancing resource expansion and multiagency collaboration in such scenarios. The introductory part of this thesis describes the dependency of a response to the emergency's severity and complexity, the timeframe and duration of the event, the number and availability of existing resources, such as staff, stuff, and structures, and the risks for escalation. Nevertheless, all these factors need to be orchestrated in a way that all parts of the response puzzles find their places. Therefore, guidelines and instructions are required to glue all response units and disciplines into a state of partnership, gradually formed from coordination to cooperation, into collaboration when the aims are similar, under the assumption that these units meet the feasibility requirement, that is, the knowledge and the ability of collaboration. Within the Thai context, the feasibility and successful execution of the FSC concept were observed during population-based incidents amid the COVID-19 pandemic, alleviating hospital burdens, and in contained incidents, such as hospital evacuation scenarios.

Recognition of abundant community resources has spanned decades, with various attempts, albeit largely anecdotal, to integrate these resources into the processes of disaster mitigation, preparation, response, and recovery [68,81,203-205]. Despite certain established activities, such as enlisting village volunteers in COVID-19 screening and strengthening community networks during the recovery phase [129,206,207], achieving comprehensive integration has remained equivocal. An essential facilitator for effectively utilizing community resources is early engagement, wherein communities can articulate their perspectives through collaborative efforts. However, achieving comprehensive integration has proven elusive [135,208,209]. This thesis represents a pioneering effort in this regard, employing the implementation

of healthcare science and research in disaster and public health emergencies to facilitate the implementation of the FSC concept [17,135,140].

The initial development of the FSC conceptual framework, as detailed in Study I, served as the foundation for effective communication of the concept to the public, ensuring its scalability and transferability. This framework was used as a tool to engage stakeholders in the early stages [17]. Subsequent evaluation of the concept's efficacy took the form of a feasibility study, incorporating an analysis of stakeholders' perspectives. These stakeholders involved representatives from community facilities in Study II and various levels of hospitals in Study IV.

Study II reported positive responses to FSC concept participation from the facilities of interest offering workforce (staff), medical supplies (stuff), and areas (structure) to support the disaster responses. These findings aligned with similar explorations of community engagement concepts in disaster management that demonstrated affirmative results [82,210-214]. However, challenges faced by community facilities in emergency care and disaster management knowledge were noted. A previous comprehensive review of community involvement underscored the necessity of educational initiatives at the community level to enhance engagement [142].

Regarding hospital evacuation preparedness in Study IV, hospitals reported readiness for evacuation, focusing on incident command structures, surge preparation, and staff mobilization from the plans for mass casualty incident management. Nevertheless, areas for improvement were identified, including knowledge regarding hospital evacuation, with specific attention to reverse triage and moral considerations. These findings resonated with multinational surveys in 2020, revealing deficiencies in education, training, and ethical awareness[153,161,215]. Notably, practical exercises, one of the effective educational initiatives, offer significant benefits for substantial enhancement of multiagency collaboration [153,161,215].

In subsequent studies, the implementation of the FSC concept was refined based on limitations and challenges identified during the feasibility studies. In Studies III and V, the concept's applicability was further explored and

adjusted for improved functionality during responses to the COVID-19 pandemic, a real event, and hospital evacuation scenarios. The findings underscored the high potential of community capacity and capability in engaging with incidents' responses, emphasizing collaborative elements, CSCATTT.

In Study III, multidisciplinary stakeholders actively engaged in regular discussions addressing relevant knowledge and scientific uncertainties. These discussions contributed to educational initiatives, enhanced decision-making, and optimized healthcare deliveries[8,142,160,216,217]. The scope of these discussions extended to cover the physical, mental, and spiritual well-being of staff concerning moral considerations, alleviating moral dilemmas and distress during crises, and sustaining staff participation [114,158,218]. In the application of the FSC to the HIC, the dynamic nature of the incident intermittently gave rise to resource and financial challenges. This necessitated a re-evaluation of the relevant levels of organizational collaboration to facilitate resource expansion[129]. Moreover, the donation-dependent economy of the HIC resulted in financial insecurities, posing additional challenges to the sustainability [219]. These intricacies underscore the importance of considering the operational dynamics of incidents and the economic model when implementing the FSC concept [17,135].

In Study V, the practical 3LC exercise offered comprehensive and integrative approaches for organizations and communities. This exercise facilitated the alignment of goals and expectations, encouraging the sharing of relevant resources and establishing a more structured management system—command, control, and communication [84]. This collaborative approach aligns with the UNDRR's call for all-of-society engagement, offering a more comprehensive perspective than previous studies focusing solely on the health system or people's perspectives [68,136,206]. However, challenges arose during the exercise involved the establishment of practical collaboration guidelines and educational initiatives, consistent with findings in implementation sciences literature [209,220]. These challenges have been recognized as prime opportunities for enhancing disaster responses [66,69].

Focusing on the four vital elements of surge capacity, the findings underscore the potential surge from the community to participate in

disaster management, highlighting the concept's role in facilitating comprehensive surge expansion by leveraging community resources. In the first element, *staff*; a significant number of staff from facilities of interest (Study II) expressed their willingness to participate in the FSC concept. This finding was resonant with previous studies [82,214,221]. Consequently, in later study, when recruitment was announced, these staff volunteered to partake and stayed until the end of the responses (Study III). The engagement strategies adhered to the systematic approaches; the collaborative elements (CSCATTT) and ICS, and educational opportunities [10,87,91,142,213]. Furthermore, hospitals in Study IV and responding organizations in Study V revealed their total capacity and readiness for disaster responses.

In the second element, *stuff*, all study participants offered their medical and non-medical supplies; surprisingly, a significant amount of capacity and capability were uncovered. However, the challenges, aligning with previous lessons learned, shed light on a disproportionate balance between supply stockpiling, and demand in response to the expansion of the incident and its consequences [71,73,74,222]. These insufficiencies emphasized the need for community resource involvement and coherent collaboration.

In the third element, *structure*, most facilities exhibited some areas in their facilities to be modified to treatment zones or shelters for affected individuals and staff. Studies reported the expansion of the care areas to other facilities, such as treating minor medical complain at the primary healthcare clinic or building a field hospital at the school sports field [79,223,224]. From the survey in Study II, and 3LC exercise in Study V, allied healthcare facilities proposed their sterile room and other treatment areas, and non-medical entities offered their spaces that could be rearranged for proper responses. Additionally, hospitals responded in Study IV reported the adaptation of patient care space from adjacent facilities in the local area, especially when hospitals require evacuation and infrastructure is damaged. Finally, Study III utilized private building to stockpile necessary medical supplies and medication waiting for distribution.

In the last element, *system*, the ICS and collaborative elements, the acronym CSCATTT, played a pivotal role in systematically performing disaster

responses, providing values among disaster management society both academically, and practically [100,152,225]. These collaborative elements have found extensive applications in research on disasters and public health emergencies, educational initiatives, and the evaluation of training exercises and actual responses [62,100,146 150,226]. The elements served as integral tools within the program theories to facilitate the FSC concept implementation and to conduct research data analyses, ensuring scalability and transferability.

In previous literature, the ICS and the command-and-control elements of the CSCATTT suggest a systematic and structural approach that responding individuals and organizations designate leaders to effectively manage crises [87,88,227]. However, the FSC concept has brought about collaborative innovations in surge expansion involving entities from communities. This involvement necessitated novel measures to structure the command, control, communication, and collaboration [44]. Traditionally, responding organizations would assign leadership based on the nature of the incidents, tailoring the operational tactics, and strategies of the incident based on its types and hazards. For instance, in cases of terrorism, the police department assumes a leadership role; in fire incidents, firefighters take charge, and healthcare personnel lead the response efforts during public health emergencies. Furthermore, the leadership styles and structures often mirror each sector's leading organizations.

Several instances where leadership is assumed by law enforcement or administrative entities manifest a vertical organizational structure [228,229]. In contrast, Studies III and V demonstrated the importance of consensus-driven and horizontal leadership, especially among healthcare staff and healthcare organizations when they assumed leadership roles [58,60,98]. Moreover, these observations of healthcare leaders align with the findings derived from antecedent investigations into leadership styles during the 3LC exercise and actual disaster responses [80,100,230,231]. Nonetheless, the involvement of communities in these scenarios predominantly concentrated on operational and tactical levels, aimed at supporting surge expansion efforts. The emphasis is less pronounced at the strategic level where community leaders might be expected to lead the disaster responses [130,232]. Additionally, the findings indicated that appropriate contact points for engaging community

resources were facilitated through municipalities and public health administration [205,206].

Studies III, IV, and V also employed a deductive content analysis within the collaborative elements and revealed congruences in subcategories and sub-themes. The prominent commonalities were identified in the *command and control* focusing on management structures, *safety* including general and incident-specific safety and security procedures, *communication* addressing the content and mode of communications, and *transportation* dealing with modes, routes, and alternatives. Conversely, *assessment*, *triage*, and *treatment* elements exhibited variations attributed to incident-specific management strategies. This thesis emphasizes the importance of these collaborative elements in augmenting disaster response efforts across contexts. Nevertheless, various practical collaboration guidelines should be premediated and may be developed and achieved during training and simulation exercises.

Finally, this thesis heightened participants' awareness of their roles and responsibilities and emphasized their significance across different phases of the disaster cycle. In Studies II and IV, the feasibility assessments introduced the innovation concepts of leveraging community facilities for individuals and responding organizations. These studies not only outlined the potentialities of community engagement and resilience during disaster response but also delved into the reactions and perceptions of participants towards the FSC concept. These insights laid the groundwork for pedagogic training programs, fostering a deeper understanding of the concept [147]. In addition, the applicability studies, Studies III and V, explored participants learning outcomes, behavioral patterns, and results through a pragmatic paradigm, involving simulation exercises and responses to actual incident [100,152,225]. The findings of these studies not only substantiated the viability of the FSC concept but also underscored the efficacy of pragmatic research methods in fostering enhanced decision-making, collaboration, and learning—ultimately contributing to increased utility in disaster response efforts [140,153].

In summary, the implementation of the FSC concept yielded specific outcomes centered around the optimization of community resources,

wherein the critical functions of the concept were preserved. However, a certain degree of flexibility in the intervention was observed concerning the levels of facilities' involvement. This adaptability underscores the FSC concept's capacity to accommodate diverse operational contexts and levels of infrastructure, contributing to its versatility and applicability in disaster response and preparedness.

Limitations

Biases in Feasibility Study

Studies II and IV gathered data through online surveys, achieving 23% and 30% overall response rates, respectively. These rates increased following phone-called personal reminders. Study II's response rate rose from 5.2-26% to 7-50.6%, while Study IV improved from 13.3% to 30.1%. These figures align with average response rates in online surveys, as documented in reviews and meta-analyses [233,234]. Despite the advantages of online surveys, such as cost-effectiveness and ease of execution, they often yield low response rates, particularly among professional respondents. Various strategies have been recommended to enhance response rates, including designed execution methods, optimizing the number of survey questions, choosing an appropriate mailing time, and physical or personal repetitive reminders[190,194]. Both Studies II and IV incorporated and optimized these strategies to boost responses. However, Study II, conducted during the peak of the COVID-19 pandemic, experienced even lower response rates, whereas Study IV demonstrated improved response rates. The reason could be efforts to refine survey procedures and additional measures, such as pre-contacting participants with phone calls followed by postal mail containing the online survey.

Despite implementing response enhancement strategies, non-responses constituted the majority, introducing bias into the sample and affecting sample size and the sampling process error[235]. Investigation into non-response factors in both studies revealed similarities with previous studies, including excessive workload, survey misplacement, and improper mailing timing[236,237]. However, Study II focused on scaling up community facilities for

disaster response, not assessing sampling effect size. Thus, any number of responses positively impacted the feasibility of the FSC concept.

In contrast, Study IV aimed to explore the preparedness of hospitals for evacuation with the expectation that responses represented hospitals in Thailand; thus, non-responses are subject to selection bias. The non-response analysis in study IV demonstrated indifferences in geographical distribution between responding and non-responding hospitals, suggesting the geographic representation of the results on hospital evacuation preparedness ($p=0.856$). However, differences in the distribution of hospital sizes between responders and non-responders prevented the generalization of results to hospital preparedness in terms of bed capacities ($p=0.008$).

Apart from non-response bias, Study IV exhibited a degree of recall bias concerning knowledge and training. The survey was conducted after the peak of the COVID-19 outbreak, when numerous hospitals had deferred annual training due to social distancing policies. Consequently, the levels of knowledge and training reported were lower than pre-pandemic levels but reflected the current state of readiness[120,200]. This temporal shift in data collection highlights the importance of considering the broader context and timing when interpreting survey results, particularly in the aftermath of significant events such as a global pandemic.

Limitations in Applicability Study

While the applications of the FSC concept demonstrated success in diverse disaster settings, specifically during the COVID-19 pandemic (Study III) and hospital evacuation scenarios (Study V), it is crucial to note that the contextual elements of implementation in both studies shared similar characteristics. These included densely urbanized communities in a middle-income country where the commonality of volunteering is high [31,206]. Consequently, caution must be exercised when attempting to generalize the FSC concept to different contexts, considering variations in program theory, stakeholder engagement, and the identification of key uncertainties,

especially when cultural, educational, and social structural differences are present.

CONCLUSION

The FSC concept proved feasible in the community of a low-to-middle-income country context, where an imbalance between healthcare supply and demand is prominent during daily operations and exacerbated during crises. Moreover, the concept demonstrated its efficacy in diverse incidents, particularly when hospitals are vulnerable and necessitate cases' alleviation or evacuation. Although the concept was successfully integrated into disaster preparedness, the thesis indicated a gap in disaster literacy and inadequacy of practical guidelines, surge planning and multiagency collaboration. These inadequacies could be addressed through a collaborative platform, such as the 3LC exercise presented in Study V or various types of simulation training reported in previous studies. This collaborative approach identifies individual or organizational abilities and limitations and aims to bridge the identified gaps and enhance the community's preparedness and response capabilities. In summary, the thesis serves as a comprehensive bridge from the research of complex interventions to practices in the complex health system.

FUTURE PERSPECTIVES

The adoption of the FSC concept positively grew toward the integration of the concept into disaster preparedness at a local level. However, efforts to enhance seamless multiagency collaboration and community engagement on a larger scale remain challenging. The fundamental literacy regarding disaster and public health emergency management needs to be grounded and incorporated widely into the routine operations of multiple responding organizations. Additionally, public education initiatives should be employed to improve public awareness and understanding of disaster preparedness measures and response strategies.

Moreover, for a successful and sustained implementation of the FSC concept on a broader scale, it is imperative to involve higher authorities and governance systems. They are crucial in providing consistent policy-driven regulations and financial support to explore collaboration possibilities among diverse agencies and organizations. Establishing a regulatory framework ensures that community engagement interventions in disaster preparedness become an integral part of the broader public health agenda, thereby emphasizing the significance of collaborative efforts in mitigating the impact of disasters on communities and enhancing responses and recoveries of the communities. Lastly, future research should focus on implementing the FSC concept on a larger scale and explore innovative ways to incorporate it into existing disaster response efforts. This entails not only evaluating the effectiveness of the concept but also identifying barriers and facilitators to its widespread adoption.

ACKNOWLEDGMENT

In the journey of this doctoral thesis, I have been blessed with encouragement, guidance and support of numerous individuals, without whom this endeavor would not have been possible. With profound gratitude, I extend my heartfelt appreciation to each and every one of them.

First and foremost, I express my deepest gratitude to my esteemed main supervisor, Associate Professor **Amir Khorram-Manesh**, MD, Ph.D., whose support, insights, dedication, and mentorship have been vital in shaping the trajectory of my doctoral work. Your mentorship has shaped not only my academic pursuits but also my personal growth.

I express gratitude to Professor **Eric Carlström**, PhD, for your exceptional guidance, scholarly expertise, and support during the years.

I am immensely thankful to Assistant Professor **Lina Dahlén Holmqvist** MD, PhD, my supervisor, for your supervision and insightful feedback.

I am indebted to my all-time role model, Professor **Yuwares Sittichanbuncha**, MD, for your dedication, exceptional guidance, and support throughout my academic and personal journey. Your continued supports have been invaluable.

My gratitude extends to the esteemed members of Faculty Executive Committee (2020-2023) at Faculty of Medicine Ramathibodi Hospital, Mahidol University for recognizing the importance of the knowledge in this field and supporting my academic development.

I am thankful to my esteemed co-authors at Chakri Naruebodindra Medical Institute, Assistant Professor **Pongsakorn Atiksawedparit**, MD, PhD, and

Dhanesh Pitidhammabhorn, MD, PhD, whose collaborative efforts during the data collection enriched this thesis with diverse perspectives.

My heartfelt appreciation extends to the Let's Be Heroes foundation team, including **Lalana Kongtoranin**, MD, Assistant Professor **Ornlatcha Sivarak**, PhD, Assistant Professor **Phantakan Tansuwannarat**, MD, **Phanorn Chalermdamrichai**, MD, **Rabkwan Phattranonuthai**, MD, **Phimonrat Marlow**, DVM, **Wiyada Winyuchonjaroen**, DVM, and **Nathikarn Pongpasupa**, MD, for their dedication to our shared projects.

I am thankful to my co-authors, **Viktor Glantz**, for your contributions and collaborative initiative regarding the Flexible Surge Capacity concept.

Special recognition is extended to Ms. **Anja Andersson** for your efficient administrative support at the Institutionen för kliniska vetenskaper, Sahlgrenska akademin vid Göteborgs universitet.

I extend my gratitude to my colleagues at the Centre for Disaster Medicine at the University of Gothenburg, particularly **Yohan Robinson** M.D., Ph.D., M.B.A., and the Research Alliance in Disaster and Emergency Management (RADEM), with special thanks to Associate Professor **Krzysztof Goniewicz**, MD, Ph.D., and Associate Professor **Jarle Løwe Sørensen**, D.B.A. for their insights and collaboration.

I thank **Mohammed Sultan**, my PhD friend; my esteemed colleagues at the Department of Emergency Medicine, Faculty of Medicine Ramathibodi Hospital, Mahidol University; and the members of the Gothenburg Emergency Medicine Research Group (GEMREG), Sahlgrenska University Hospital, particularly **Samah Habbouche** and **Carl Magnusson**, for their collegiality and collaboration.

To Mr. **Tom Kanathat Chantrsiri** and Ms. **Chongkonnee Chantrsiri** of the Fire And Rescue Association (FARA), I extend my sincere gratitude for your expertise and support in Thai emergency response insights.

To my dear friends and family in Sweden, especially Mr. **Bizhan Tondkar**, Ms. **Barbro Tondkar**, and Ms. **Ruedeerat Khorram-Manesh**, your unwavering support and encouragement have been my guiding light. "Friends are family you choose," and I am blessed to have you in my life.

I express my deepest and eternal appreciation to my mother, Ms. **Pratana**. Your dedication, boundless love, encouragement, and understanding have been my source of strength, inspiration, and success.

Finally, I am grateful to my father, Mr. **Thianchai**, and my brothers, Mr. **Nattapat**, Mr. **Sirapach**, and Mr. **Sirachush**, for your boundless love, and encouragement. Your belief in my potential has been the driving force behind my accomplishments.

To all mentioned above, you have become an integral part of my academic journey, for which I am eternally grateful.

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APPENDIX

STUDY II

Information Sheet, Questionnaire and interview guide

(English Translation for review only, from Study II's supplementary files)

Flexible Surge Capacity Questionnaire: In the case of a disaster or an emergency situation, it is extremely critical to utilize the available resources. Moreover, the demand for healthcare services at this critical time is tremendous, and the cooperation between those working in healthcare services and other related organizations is certainly crucial. In order to cooperate effectively, mutual understanding and respect are necessary. The objective of this questionnaire is to find measures to enhance cooperation among the related parties. The respondents are requested to participate on a voluntary basis, and no names of respondents or organizations will be revealed. The questionnaire comprises short questions and will not take a lot of time to respond to. This research study is a part of a PhD. Thesis that is done as a collaboration between Mahidol University and The University of Gothenburg, Sweden.

Scenario: In the situation that many people are injured and urgently need help, the need for resources may exceed the capacity of the nearby hospitals, leading to cooperation between related organizations and healthcare systems. It is essential for all involved to have knowledge in planning and execution. The researcher aims to understand the ability to cooperate among the health personnel from various fields in specific situations. Please read the given situation and choose the answers that your organization has the potential to carry out.

Situation: There is an accident near your workplace. In total, thereare 120 people injured, out of which 40 are severely injured and need urgent help from a big hospital that can perform operations and has anIntensive Care Unit. Another 40 people are moderately injured from inhaling smoke, and it is necessary to monitor their breathing as they may need to be intubated within 2–3 h. Some of these patients may have burns or bone fractures. The last 40 people are slightly injured and canbe treated at the hospital or other medical units.

1. Primary Care Unit

At the time of the incident, if your organization were staffed normally,what help would your organization be able to provide?

- Be able to provide care for the slightly injured patients
- Be able to provide primary care for the severely injured patients to stabilize them before transferring them to a largerhospital
- Be able to provide care for emergency patients not involved inthe accident to alleviate the congestion in the emergency roomat the hospital
- Has medical personnel to collaborate with the hospital strengthening the efforts to help the injured.
- Provide resources: area, medical equipment and devices
- Perform minor surgery, stitches, or casings for uncomplicatedfractures.
- Provide care for patients
- Provide psychological care for the injured and the team
- Coordinate the transport of the injured patients back to theirhomes
- Cannot provide any help
- Others, please specify

Things necessary for public health service organizations to be able to provide assistance

- Medical equipment and devices
  - Has sufficient medical equipment and devices to assist inspecial situations
  - Lack medical equipment and devices to enhance the ability toprovide assistance

- Medical equipment and devices needed to enhance the ability to provide assistance include……

- Local Supplies
  - Has adequate supplies to provide assistance in emergency situations
  - Lack supplies to enhance the ability to provide assistance Supplies needed to enhance the ability to provide assistance include…….
- Personnel
  - Knowledge or resources that the personnel need to enhance their ability to provide care for the injured……
- Supplies of competence

Do you have adequate skills that you would like to have in order to provide assistance in a major accident, when the need for assistance is greater than the available resources?

a. Certainly
b. Yes, but I need additional training
c. No but I can provide assistance if someone provides guidance in ……
d. Others
e. Please provide additional opinion

2. *Dental Clinic/Veterinary Clinic*

At the time of the incident, if your organization were staffed normally, what help would your organization be able to provide?

- Be able to provide care for the slightly injured patients
- Be able to provide primary care for the severely injured patients to stabilize them before transferring them to a larger hospital
- Be able to provide care for emergency patients not involved in the accident to alleviate the congestion in the emergency room at the hospital
- Has medical personnel to collaborate with the hospital strengthening the efforts to help the injured.
- Provide resources: area, medical equipment and devices
- Perform minor surgery, stitches, or casings for uncomplicated fractures.
- Provide care for patients
- Provide psychological care for the injured and the team

- Coordinate the transport of the injured patients back to their homes
- Cannot provide any help
- Others. Please specify ……

Things necessary for public health service organizations to be able to provide assistance

- Equipment and devices
  - Has sufficient medical equipment and devices to assist in special situations
  - Lack medical equipment and devices to enhance the ability to provide assistance
  - Medical equipment and de vices needed to enhance the ability to provide assistance include……
- Local Supplies
  - Has adequate supplies to provide assistance in emergency situations
  - Lack supplies to enhance the ability to provide assistance Supplies needed to enhance the ability to provide assistance include……
- Supplies of competence

Do you have adequate skills that you would like to have in order to provide assistance in a major accident, when the need for assistance is greater than the available resources?

a. Certainly
b. Yes, but I need additional training
c. No but I can provide assistance if someone provides guidance in ……
d. Others
e. Please provide additional opinion ……

3. Schools/Sports Clubs or Hotels

What assistance can you provide for the injured in the case of urgency?

- Can stop bleeding, repair wounds, perform resuscitation and other emergency procedures
- Can provide care for the slightly injured
- Can provide psychological care for patients, who experienced shocks

- Can provide accommodation for the homeless or the injured
- Can provide water and food for those in need
- Can provide care for the children in the case that their adult relatives need to help others
- Can send staff to help other organizations
- Cannot provide assistance
- Others. Please specify……

Do you have adequate skills to provide assistance that you would like to in a major accident?

a. Yes, certainly
b. Yes, but I would like to learn more. Suggestion……
c. No, but I can provide assistance if I learn relevant skills. Suggestion……
d. Others……

Necessary items for your organization to be able to provide assistance

- Equipment and devices
  - My organization has adequate equipment and devices to provide assistance in emergency situations
  - My organization lack equipment and devices to enhance the ability provide assistance
  - In order to enhance ability to provide assistance, the following equipment and devices are required: ……
- Local Supplies
  - My organization has adequate facilities to provide assistance in emergency situations
  - My organization lack supplies to enhance the ability to provide assistance
  - In order to enhance the ability to provide assistance, the following supplies are required:
- Supplies of competence

You have the skills necessary for working in a situation, when a lot of care needs to be provided

a. Yes, certainly.

b. Yes, but I need additional training in ……

c. No, but I can if someone provides advice and training in ……

d. Others

e. Please provide other opinions……

STUDY III

Observation and interview concepts on the CSCATTT

Command and Control

- How is the home isolation center led?
- How do leaders command and deploy tasks?
- How are the roles and responsibilities appointed to leaders, middle-level managers, and operation levels?
- How are intra- and inter-organizations collaborated?

Safety

- How are safety operations managed and controlled?
- How is safety monitored?

Communication

- How are internal, external, and public communications arranged?
- Which are the channels used?
- What are the contents communicated?
- How are all communication channels maintained?

Assessment

- What is the patient's journey through the center?
- What additional resources are needed, and how are they acquired?
- How are resources (staff, stuff, and structure) monitored and evaluated?

Triage and Treatment

- How are patients prioritized?
- Are patients treated according to their priorities?
- Are the treatment resources (medical equipment and medication) allocated to where they are needed?
- Are the patients re-triaged and treated according to their changes?
- What are the treatments prescribed?
- How are the patients monitored and followed up?

Transport

- What kind of transportation resources are available?
- How are transportation resources acquired and used?
- How are patients transferred to the hospitals?
- How do the transportation of patients, healthcare personnel, and medical equipment cooperate with the local emergency medical services?
- Do the home isolation center surge for alternative transportation means?

STUDY IV

Hospital evacuation questionnaire

(from Study IV's supplementary file)

Hospital evacuation is necessary due to different causes. The most common cause of hospital evacuation, mentioned by many, is fire, and most hospitals have, therefore a fire evacuation plan and yearly exercises. Based on such strategy and in most fire incidents, patients are evacuated to a safe place within or outside the hospital, and transport to other hospitals is rarely needed.

In recent years, threats to hospitals have increased due to both natural and human-made incidents. The new threats demand new plans, which may include other aspects of evacuation such as ethical priority-setting, internal and external logistics, and different organizations' roles. Additionally, different countries may have diverse legal frameworks.

This project aims to explore Thai hospitals' current evacuation readiness and preparation regarding surge capacity and collaboration, using the concept of FSC and its collaborative tool.

How do you deal with the following topics in your country?

1. Incident Command System? Most countries have some command system.
    a. Do you have any system, and how does it work?
    b. Do you have a central command or hospitals work independently?
    c. Plans for surge capacity (Staff, Stuff, Structure, System).
    d. How do you deal with private hospitals?
2. Collaboration, coordination, and communication with other organizations?
    a. In which levels, strategic, tactical, or operational?
    b. Private organizations?
3. Ethical perspectives of a hospital evacuation.
    a. Awareness of difficult medical decision-making. Leaving sick patient behind or not prioritizing them first.
    b. How aware are staff and the public?
    c. Do you have any guidelines?
4. Legal perspectives of hospital evacuation
    a. Defining legal responsibilities. Do you have any guidelines?
    b. Police tasks before, during, and after hospital evacuation
    c. Rescue teams/firefighters' tasks before, during, and after hospital evacuation
    d. Functions of other organizations such as the Red Cross, etc.
5. Internal logistic plans
    a. Staff resources?
    b. Stuff resources?
6. External logistic plans
    a. Do you have centrally dispatched ambulances or hospital-based dispatch?

b. Do you have other vehicles in reserve?

c. Staff resources?

d. How do you plan for moving stuff such as ventilators?

e. Have you identified which hospitals receive your patients?

f. Do you send medication and other therapeutic resources with the patients to the receiving hospitals and for how long?

7. Do you have any procedures for evacuation of vulnerable groups?

   a. Deaf

   b. Blinds

   c. Elderly

   d. Children

   e. Pregnant women

   f. Overweight individuals

   g. etc.

8. Do you have any plans for the removal of critically sick patients, e.g., ICU patients, patients under surgery, and patients treated for cancer?

9. Triage rules during an evacuation. The concept of reverse triage?

10. Training and exercises. If any, how many times/year?

11. Is there any topic missing that you would like to include?

STUDY V

(from Study V's supplementary files)

The self-evaluation form

General information

Age_____

Genders ☐ Male ☐ Female

Affiliation

☐ Provincial Public Health Organization

☐ Hospitals

☐ Provincial Administration

☐ District Administration

☐ Department of Disaster Prevention and Mitigation

☐ Community Please specify __ (School, Sports arena, Religious institutes, Head of Community)

☐ Police Department

☐ Military

☐ Rescuer/First responder/ Non-government organization

☐ Others, Please specify _____

Specific Information. Please rate your knowledge and understanding in the areas as follow:

	Well literacy and can convey the knowledge (5)	Understand and well practice (4)	Average Understand and practice (3)	Understand but not fluently practice (2)	Know but cannot practice (1)	Never heard of the topic (0)
Command and Control						
Safety						
Communication						
Assessment						
Triage						
Treatment						
Transportation						

Do you think the following organizations associate with disaster response or not? And how?

Police Departments……	Provincial Administrations……	Hotels……
Fire Departments……	Schools……	Sports arenas……
Primary Healthcare clinics……	Veterinary clinics…….	Others……
Private clinics……	Dental clinics…….	

The Observational Checklist

Team:_____ *Start time: _____*	***Y/N***	***Who? /What?***	***Remarks***
		COMMAND AND CONTROL	
Select leader/leadership.			
If there is no official selection, please state who act as leaders			
Select other groups members' tasks and responsibilities			
Distribute the tasks			
Use incident command system			
Recognize the need for collaboration with other organizations			
Make consensus			
Resolving the case or each action			
Outline and establish a multicausalty area including control lines, treatment areas, morgue, transportationareas and vehicle stage areas			
		SAFETY	
Identify safety officer			

Team:_____ *Start time: _____*	***Y/N***	***Who? /What?***	***Remarks***
Identify security team			
Set safety zoning			
Control safety area (fire/chemical/infectious)			
Establish the area for decontamination			
Monitor safety			
Recognize what is worth to preserve			
Recognize personnel protection			
COMMUNICATION			
Establish internal communication route			
Establish inter-agency communication route			
Establish medical record communication (type and route)			
Establish backup/alternative system			
Establish communication protocols/processes			
Appoint spokesmen (public/media communication)			
Maintain communication in all means			
ASSESSMENT			
Determine 'METHANE'			
Map structural location (person in charge/access to each zone/function)			
Maintain assessment/re-assess			

Team:_____ *Start time: _____*	***Y/N***	***Who? /What?***	***Remarks***
Surge planning			
Prioritize mutual resources			
TRIAGE			
Appoint triage leader			
Prioritize affected population			
Treat patients accordingly			
Consider re-triage			
TREATMENT			
Appoint medical treatment leader			
Medical decision-making			
Set up of treatment zone			
TRANSPORTATION			
Appoint transportation unit leader			
Decision on transport first patient			
Recognize the need for moving devices			
Realize the need for safety/protective measures/devices			
Move the patients to the ambulance transportarea			
Load the patients			
Surge for alternative transportmeans			

Incident Command System Evaluation

	5	4	3	2	1	REMARKS
COMMAND	Clear orders and information needed with optimally professional utilized	Clear leader order but not optimal professional utilized	Selection of leader but no clear role	Present of leader but no selection	No lead person	
CONTROL	All follow All multicausality areas have been organized 1. Gold/silver/bronze or Hot/warm/cold 2. control lines 3. treatment areas 4. morgue 5. transportation areas 6. vehicle stage areas	Most people follow At least 4 out of 6 areas were organized	Some people follow Only 2-3 out of 6 areas were organized.	Scarce people follow Only 1 out of 6 areas were organized.	Not at all Nothing was organized/appointed	
SAFETY	Safety officer present with strategies and management plan	Safety officer present with	Safety officer present but no	Safety was considered	Not mention	

	5	4	3	2	1	REMARKS
		strategies but no visible plan	strategies or plan	Or personal protection was used		
COMMUNICATION INTERNALLY	Team member receive information needed and performed correct tasks	Team member receive information needed	Team member receive information needed No public communication	Internal or external communication were mentioned	No communication was established	
COMMUNICATION EXTERNALLY	Interagency communication was recognized and collaborated Public communication was found	Interagency communication was recognized but independently operated Public communication was mentioned	Interagency communication and public communication were mentioned	Interagency communication or public communication were mentioned	No communication was established	
ASSESSMENT	Scene was thoroughly assessed (METHANE)	Most of the component were considered	Some of the components were	Some of the components were mentioned	No assessment	

	5	4	3	2	1	REMARKS
TRIAGE	All patient was correctly triage	Most of patient was correctly triage	Some of patient was correctly triage	Triage was mentioned	No triage	
TREATMENT	Treatment area was established, and all patient was treated at the area	Treatment area was established, and most patient was treated at the area	Treatment area was established, and come patient was treated at the area	Treatment area was mentioned, or all patient was treated at hospital	No treatment area	
TRANSPORT	Transportation modes were surge, optimally utilized, and transport area was organized	Transportation modes were surge with some organized	Transportation was utilized but not organized	Transportation modes were mentioned	No organized transportation mode	

The 3LC exercise scenarios

Scenario 1 flooding with water contamination

- After a long period of rainfall, a major hospital is flooded, and the water is 1 meter in height. The oxygen tanks and storage are in the basement, which is fully covered by water. There are 10 critical care patients in the ICU, 50 admitted patients in the regular ward, 200 patients in the outpatient departments, and 300 working staff.
- 10 mins later, the safety officer inform the hospital safety team that the water in the supplied tanks is all contaminated with heavy metal and cannot be used. HCG decides to evacuate the whole hospital.

Scenario 2 Pandemic

- 30 travelers diagnosed with a newly emerging virus are transported directly from the airport to your hospital's emergency department with respiratory distress condition and need admission. Missing the information, no PPE was used and around 30 emergency department staff, who managed these patients or were in the area, are suspected to have been exposed to the virus. (The ED needs to close for service)
- 5 mins later, all patients are admitted to the in-patient department.
- 10 mins later, you get the information from the provincial public health office that 2 other hospitals have been exposed and contaminated with this newly emerging virus disease. There is a shortage of emergency department staff, PPE, ventilators, and negative pressure rooms.

Scenario 3 Fire and oxygen explosion

- The inpatient department is on fire. 5 people are injured. The fire is spreading very fast to the three nearest wards. There are 200 patients currently admitted to the hospital and 300 working staff.
- 5 mins later, the fire spreads to the whole floor and extends to other floors.
- 10 mins later, the oxygen tank at the critical care unit explodes. A total evacuation is needed.

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