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Evaluating the Effectiveness of Supply Chain Simulation Exercises
in Public Health: A Literature Review Perspective

Cranfield University
Procurement and Supply Chain Management

MSc Thesis
Academic Year: 2024 - 2025

Supervisor: Dr. Ismail Abushaikha
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This thesis is submitted in partial fulfilment of the requirements for
the degree of Master of Science

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Academic integrity declaration

I declare that:

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- the thesis submitted has not been previously submitted to this university or any other.
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Abstract

This thesis explores how full-scale simulation exercises (FSEs) contribute to the creation, transfer and retention of tacit knowledge in humanitarian operations. Drawing on a systematic literature review of 28 peer-reviewed studies, the analysis applies Knowledge Creation Theory and the SECI model to examine three levels of learning. At the individual level, tacit knowledge is developed through socialisation—informal exchanges, mentorship and shared experiences—and internalisation, where explicit procedures are embodied through practice and reflection. These processes strengthen professional competences, enhance confidence and foster adaptive expertise that endures beyond exercises. At the organisational level, FSEs serve as formal mechanisms for externalising individual insights through debriefings, codified training artefacts and evaluation practices, while knowledge-centred and trust-based cultures support informal sharing across teams. At the system level, FSEs provide collaborative platforms where diverse organisations rehearse joint responses, align practices and build collective memory. Effective knowledge and information management further enables dissemination and coordination across agencies. Overall, the findings show that FSEs are not merely training events but critical knowledge infrastructures that link individual expertise, organisational learning and inter-organisational collaboration. By demonstrating how tacit knowledge can be systematically cultivated and institutionalised, the study contributes to theory on knowledge creation and offers practical guidance for enhancing preparedness and resilience in humanitarian operations.

Keywords:

full scale simulation exercise; humanitarian operations; tacit knowledge; knowledge creation theory; organisational learning; interorganisational collaboration

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List of Abbreviations

CIPP	Context–Input–Process–Product
COVID-19	Coronavirus Disease 2019
CRM	Crew Resource Management
FSE	Full-scale simulation exercise
FSEs	Full-scale simulation exercises
FSX	Full-scale exercise
HIC(s)	High-income Country/Countries
HDX	Humanitarian Data Exchange
HKM	Humanitarian knowledge management
IASC	Inter-Agency Standing Committee
IHR	International Health Regulations
LMIC(s)	Low- and Middle-income Country/Countries
MMAT	Mixed Methods Appraisal Tool
NGO(S)	Non-governmental organisation(s)
OCHA	United Nations Office for Disaster Risk Reduction
SECI	Socialization, Externalization, Combination and Internalization
UNDRR	United Nations Office for the Coordination of Humanitarian
UNEP	United Nations Environment Programme
WHO	World Health Organization

1 Introduction

1.1 Background

In response to the increasing complexity and frequency of humanitarian emergencies, a large United Nations agency has recognised the importance of strengthening humanitarian operational readiness and supply chain agility. One notable initiative is the full-scale simulation exercise (FSE) conducted in Malawi, designed to replicate real-life emergency response conditions. During this exercise, logistics personnel, humanitarian organisations, and partner organisations engaged in a high-pressure, time-sensitive environment to rehearse and evaluate their coordination, resource allocation, and decision-making capabilities. Beyond testing procedural effectiveness, such exercises provide a powerful platform for experiential learning. They expose participants to real-world challenges, promote inter-agency collaboration, and, critically, enable the transfer of tacit knowledge (practical know-how, contextual insight, and intuition) that cannot be easily documented but is essential for effective humanitarian response. This review explores how FSEs, such as the Malawi exercise, contribute to humanitarian performance. It focuses in particular on how these exercises support tacit-knowledge acquisition and internalisation at the individual level, how such knowledge is externalised and absorbed at the organisational level, and how inter-organisational coordination is strengthened in complex emergencies.

1.2 Full-scale simulation exercises

In the field of emergency preparedness and response, simulation exercises are commonly categorised into discussion-based and operations-based activities. According to the WHO Simulation Exercise Manual (WHO, 2017), discussion-based exercises include tabletop exercises, which are facilitated discussions of emergency situations in a low-stress environment and are the only type of simulation exercise that does not require an existing response plan. Operations-based exercises include drills, which test a specific operation or function; functional exercises, which simulate and coordinate multiple functions of an organization's response plan in a time-pressured setting; and full-scale exercises

(FSX), which simulate a real event as closely as possible and are designed to evaluate the operational capability of emergency management systems under realistic, stressful conditions, requiring the mobilisation of personnel, equipment, and resources. In this study, the term full-scale simulation exercise (FSE; plural: FSEs) is adopted to highlight the simulated and multi-agency nature of such large-scale, operations-based activities, while remaining consistent with the WHO definition of full-scale exercises (FSX).

In humanitarian operations, FSEs are consistent with the WHO definition of FSX. They emphasise their simulated and multi-agency character and are recognised as highly effective training tools in complex, resource-constrained environments. A recent scoping review (Pek, Quah, Valente, Ragozzoni, & Della Corte, 2023) demonstrated that simulation within FSEs enhances learning and responsiveness at both the individual and system levels across disaster and mass-casualty scenarios. However, evidence on sustained behavioural change and tangible operational outcomes remains limited. This underscores the need for more standardised reporting, rigorous evaluation frameworks, and evidence-based practices to strengthen the translation of FSEs learning into real-world humanitarian response.

1.3 Tacit/Explicit Knowledge, Knowledge Creation Theory, and SECI Model

Knowledge can be broadly understood in two complementary forms: tacit and explicit. Tacit knowledge, first elaborated by Polanyi (1966), is personal, experiential, and context-bound. It is embedded in action, skills, and intuition, and much of it remains unarticulated because it is difficult to capture in formal language. Tacit knowledge is typically acquired through practice, observation, and social interaction, and is most effectively transferred through direct experience or apprenticeship rather than codified instructions (Polanyi, 1966; Nonaka & Takeuchi, 1995). In contrast, explicit knowledge is formalised and systematic, expressed in words, numbers, and documents, and can be more easily stored, transmitted, and shared across individuals and organisations. Importantly, the two forms are interdependent: tacit knowledge provides the

interpretive framework that gives meaning to explicit knowledge, while explicit knowledge can be internalised to enrich and expand the tacit base (Nonaka & Takeuchi, 1995).

Building on the distinction between tacit and explicit knowledge, Nonaka and Takeuchi (1995) proposed the Knowledge Creation Theory (KCT) to explain how new knowledge is generated through the continuous interaction of these two forms. Central to this theory is the SECI model, which comprises four modes of knowledge conversion: Socialisation, Externalisation, Combination, and Internalisation. This model conceptualises knowledge creation as a dynamic, spiraling process. In this model, knowledge does not remain static but is constantly converted between tacit and explicit forms. Socialisation (tacit-to-tacit) emphasizes the sharing of experiences through joint activities and observation; Externalisation (tacit-to-explicit) involves articulating implicit insights into codified concepts; Combination (explicit-to-explicit) integrates and systematises existing knowledge into new configurations; and Internalisation (explicit-to-tacit) refers to the embodiment of codified knowledge into personal routines and practices (Nonaka et al., 2000). Together, these four modes form a cycle that sustains organisational and individual learning, enabling the renewal of tacit knowledge and the creation of innovative practices.

While the SECI model incorporates four modes of knowledge conversion, this study focuses specifically on Socialisation and Internalisation, as they are most directly related to the transformation of tacit knowledge at the individual level. Socialisation (tacit-to-tacit) involves sharing experiences through direct interaction, whereas Internalisation (explicit-to-tacit) refers to the process of embodying codified knowledge into personal routines and skills. These two modes are particularly relevant for sustaining tacit knowledge and are therefore central to the thematic analysis in this research (Nonaka & Takeuchi, 1995; Nonaka et al., 2000). This dynamic is illustrated in the SECI model (**see Figure 1-1**).

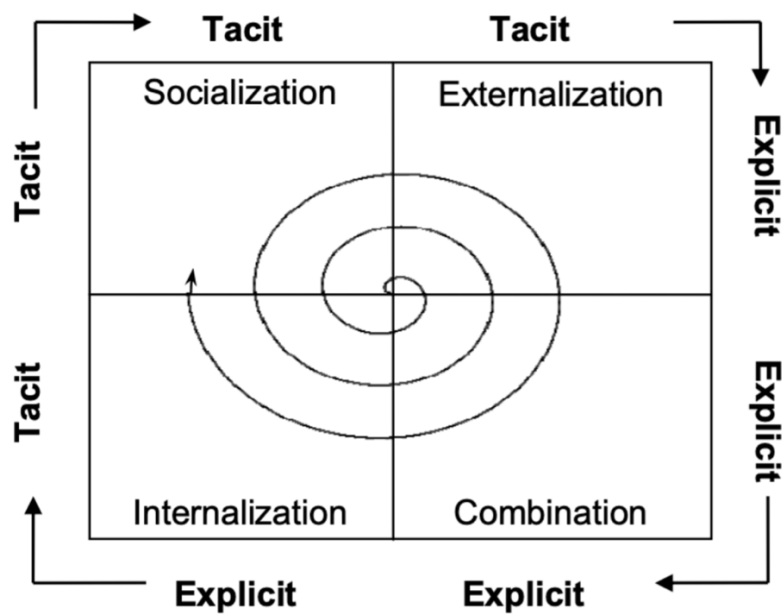


Figure 1-1: The SECI Model

(Source: Nonaka & Takeuchi, 1995)

1.4 Humanitarian knowledge management

Humanitarian knowledge management (HKM) has been defined as “the systematic process and strategy for finding, capturing, organizing, distilling and presenting data, information and knowledge for a specific purpose and to serve a specific organisation or community” (King, 2005, p. 653). This definition highlights that HKM goes beyond the handling of raw information, emphasising the importance of organising and transforming data and experiences into usable knowledge that can inform decision-making and improve operational response. In practice, however, HKM continues to face considerable challenges. Humanitarian operations are characterised by urgency, uncertainty, and the involvement of multiple actors across different organisations, which often leads to fragmented information flows and difficulties in systematically managing knowledge (Van de Walle & Comes, 2015). While large volumes of reports and data are generated during emergencies, there remains a lack of mechanisms for the standardised collection, storage, and retrieval of information, as well as weak institutionalisation of lessons learned and best practices.

1.5 Research Objectives and Research Questions

1.5.1 Research Objectives

This study aims to systematically review how FSEs contribute to humanitarian operations through the lens of the KCT, with a focus on tacit knowledge acquisition and transformation at the individual and organisational levels. In addition, the review explores how, at the system level, humanitarian stakeholders use FSEs and knowledge management practices to strengthen collaboration and enhance overall operational performance.

1.5.2 Research Questions

In line with these objectives, the study is guided by the following research questions:

RQ1: How do humanitarian operators acquire and internalise tacit knowledge through Full-scale simulation exercises?

RQ2: How do humanitarian organisations externalise and integrate individual tacit knowledge into explicit organisational knowledge?

RQ3: How do inter-organisational knowledge-management practices enhance collaboration and improve humanitarian operational effectiveness?

1.6 Justification

While KCT/SECI has been widely applied in corporate settings, its application in public and humanitarian domains remains limited. In parallel, FSEs are increasingly used for preparedness and training, yet much of the literature evaluates practical outputs rather than the knowledge-creation mechanisms that underpin their effectiveness. Positioning FSEs within a KCT lens addresses this gap by explaining how tacit knowledge is generated, shared, and embedded, thereby extending theory and informing practice.

1.7 Structure of the Dissertation

This dissertation is organised into six chapters, each building towards a comprehensive understanding of how FSEs contribute to humanitarian

knowledge management and operational effectiveness. Chapter 2 outlines the systematic literature review (SLR) methodology, including the search strategy, inclusion and exclusion criteria, and data extraction process. Chapter 3 presents the descriptive analysis of the reviewed studies, highlighting key trends and characteristics. Chapter 4 reports the thematic findings, structured around the research questions, while Chapter 5 situates these findings within the broader academic and practical context. Finally, Chapter 6 concludes the dissertation by summarising the key insights, reflecting on limitations, and offering recommendations for future research and practice.

2 Methodology

2.1 Introduction

This chapter introduces the methodological approach underpinning the study. It employs a Systematic Literature Review (SLR) to ensure a rigorous and transparent examination of the research field. An SLR is a structured method for identifying, evaluating, and synthesising existing studies to generate a comprehensive and unbiased account of current knowledge. In contrast to traditional narrative reviews, which may be selective and descriptive, SLRs are characterised by replicable protocols, explicit inclusion and exclusion criteria, and systematic procedures for data extraction and synthesis (Tranfield, Denyer, & Smart, 2003). These features are designed to minimise researcher bias while enhancing analytical clarity and reliability.

Since its introduction into management and social science research, the SLR has been widely adopted to address fragmented bodies of literature, integrate diverse evidence, and provide foundations for theory development and practical decision-making (Denyer & Tranfield, 2009). In humanitarian studies, although the volume of research has grown, systematic attempts to synthesise findings remain scarce. This gap highlights the importance of systematic reviews as a means of consolidating insights and identifying common themes and research gaps (Bruno & Haar, 2020).

Accordingly, this study applies an SLR to systematically identify, screen, and analyse literature on full-scale simulation exercises (FSEs) in humanitarian contexts, with a particular focus on their contribution to knowledge creation processes at the individual, organisational, and system levels. The remainder of this chapter outlines the review protocol, including search strategy, article identification, inclusion and exclusion criteria, quality appraisal, and the data extraction and synthesis procedures that guided the analysis.

2.2 Review Advisor

To ensure the systematic literature review was conducted with objectivity, transparency, and replicability, expert guidance was sought throughout the process. Dr. Ismail Abushaikha (subject specialist) provided advice at several key stages, including project scoping, the formulation of research objectives and questions, the development of search strings, the determination of inclusion and exclusion criteria, and the selection of appropriate sources and databases. His supervision ensured that the review process adhered to the essential characteristics of a systematic literature review.

2.3 Defining Search Terms

Based on the objectives of this study, four key terms were identified to guide the systematic literature search: FSEs, humanitarian logistics, knowledge creation Theory (KCT), and SECI model. The definitions were drawn from authoritative sources to ensure conceptual clarity and consistency throughout the review. The definitions applied in this study are summarised in **Table 2-1**.

Table 2-1: Definition of Key Terms

Key Term	Definition	Source
Full-Scale Simulation Exercise (FSEs)	A type of operations-based exercise designed to simulate a real event as closely as possible, evaluating the operational capability of emergency management systems under	World Health Organization (WHO, 2017)

	realistic conditions, requiring mobilisation of personnel, equipment, and resources.	
Humanitarian Logistics	The process of planning, implementing, and controlling the efficient, cost-effective flow and storage of goods, materials, and related information, from origin to consumption, to alleviate the suffering of vulnerable people.	Kovács & Spens (2007)
Knowledge Creation Theory (KCT)	Knowledge creation theory explains the dynamic process in which tacit and explicit knowledge interact through continuous conversion, enabling organisations to generate new knowledge and support learning and innovation.	Nonaka & Takeuchi, (1995)
SECI Model	A framework describing four modes of knowledge conversion: socialisation, externalisation, combination, and internalisation, which explain how organisational knowledge is created and expanded.	Nonaka & Takeuchi, (1995)

(Source: Author, 2025)

2.4 Developing Search Strings and Database Selection

To ensure a comprehensive and systematic retrieval of relevant literature, two search strings were developed to target distinct thematic intersections. The first search string focused on studies examining the role of FSEs in humanitarian contexts. It combined terms related to training and simulation activities (including “operational exercises,” “training exercises,” “simulation exercises,” “emergency simulation,” “full-scale exercises,” and “experiential learning”) with terms describing humanitarian response and logistics (such as “humanitarian,” “humanitarian logistics,” “humanitarian supply chain,” “humanitarian operations,”

“emergency response,” “emergency logistics,” “crisis response,” “disaster response,” and “disaster relief”).

The second search string targeted literature exploring KCT and the SECI model within humanitarian settings. Here, humanitarian-related terms were combined with concepts associated with knowledge creation processes (e.g., “knowledge creation theory,” “KCT,” “tacit knowledge,” “SECI,” “knowledge management,” and “knowledge transfer”).

The searches were conducted across **ProQuest**, **EBSCO**, and **Scopus**, three major bibliographic databases selected for their complementary disciplinary coverage. **Scopus**, operated by Elsevier, is the largest abstract and citation database of peer-reviewed literature and provides extensive coverage across the social sciences, management, and disaster studies (Burnham, 2006). **ProQuest** aggregates a wide range of scholarly journals, dissertations, and reports, and is particularly strong in the social sciences and humanitarian research domains. **EBSCO** offers comprehensive access to management, organisational studies, and applied social science journals, many of which publish research relevant to knowledge management and humanitarian operations. The combination of these three databases was therefore considered appropriate to capture both disciplinary breadth and topic-specific depth. The temporal scope was set between 2000 and 2025, a range chosen to incorporate both foundational contributions and more recent developments. The complete search strings are presented in **Table 2-2**.

Table 2-2: Search String Formation

Database	Search string
ProQuest, EBSCO, Scopus	Search string 1 ("operational exercises" OR "training exercises" OR "simulation exercises" OR "emergency simulation" OR "full-scale exercises" OR "experiential learning") AND ("humanitarian" OR "humanitarian logistics" OR "humanitarian supply chain" OR "humanitarian operations")

	OR "emergency response" OR "emergency logistics" OR "crisis response" OR "disaster response" OR "disaster relief")
ProQuest, EBSCO, Scopus	Search string 2 ("humanitarian" OR "humanitarian logistics" OR "humanitarian supply chain" OR "humanitarian operations" OR "emergency response" OR "emergency logistics" OR "crisis response" OR "disaster response" OR "disaster relief") AND ("knowledge creation theory" OR "KCT" OR "tacit knowledge" OR "SECI" OR "knowledge management" OR "knowledge transfer")

(Source: Author, 2025)

2.5 Article Identification

The database searches yielded a total of 565 records retrieved through the application of the two search strings across ProQuest, EBSCO, and Scopus. To ensure academic rigour and the quality of the evidence base, the results were limited to peer-reviewed journal articles published in English, with full-text availability and complete reference lists. The temporal scope was restricted to studies published from 2000 onwards, thereby incorporating both foundational contributions and more recent developments relevant to the research objectives.

In addition to database retrieval, supplementary searches were conducted using snowballing techniques. This process involved screening the reference lists of key articles and monitoring citation alerts, which generated an additional eight records. The combined total of 571 records formed the initial corpus prior to the removal of duplicates.

2.6 Screening Process

The screening procedure was carried out in three stages. First, duplicate records were identified and removed in Microsoft Excel, resulting in 418 unique titles. Second, title and abstract screening was performed against the predefined inclusion and exclusion criteria, leading to the exclusion of 329 papers that did not meet the scope of this study. Finally, a full-text assessment of the remaining

87 articles was undertaken, during which 59 papers were excluded due to insufficient methodological detail or lack of conceptual alignment with the research focus. This resulted in a final sample of 28 studies included in the review. The overall process is visually summarised in the PRISMA flow diagrams (Figures 2-1 and 2-2). To ensure transparency and replicability, a comprehensive record of the screening and eligibility assessment, covering all 573 identified studies, was documented in Microsoft Excel. This supplementary dataset includes full bibliographic details, screening outcomes, and the reasons for exclusion at each stage. Given its length, the complete table is not embedded in the thesis but is provided separately as **Supplementary File 1 and 2** (SLR Screening Process), with a reference note in **Appendix B**. This approach aligns with established SLR methodological guidelines, ensuring both rigour and auditability.

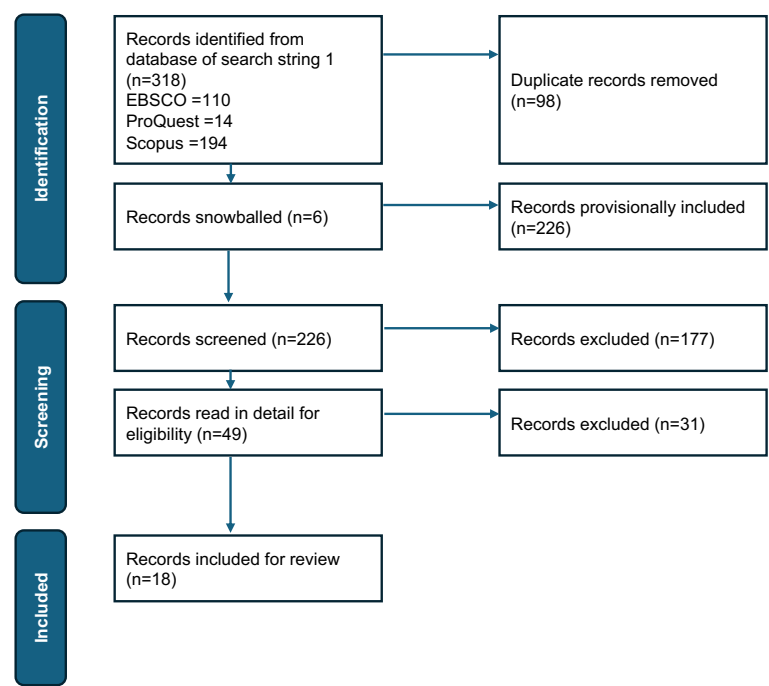


Figure 2-1: PRISMA Flow Diagram – Search String 1

(Source: Author, 2025)

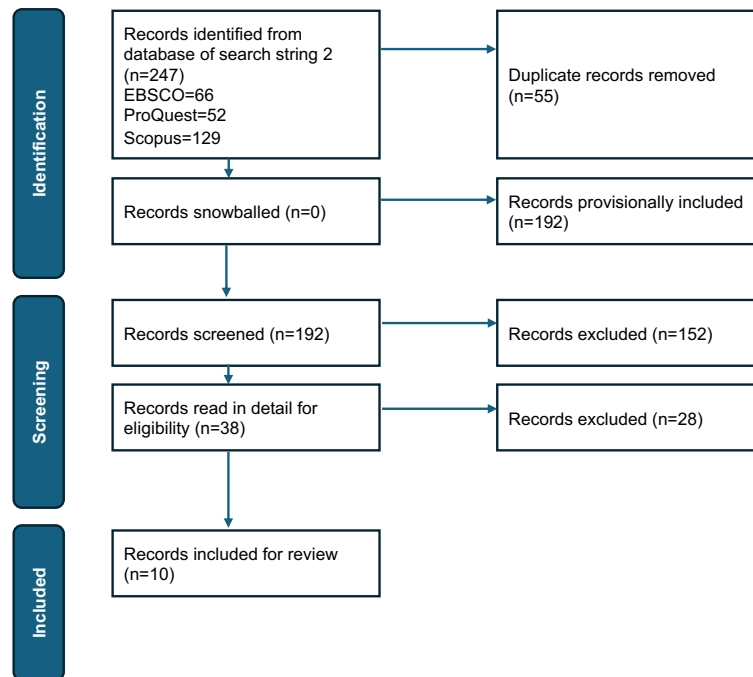


Figure 2-2: PRISMA Flow Diagram – Search String 2

(Source: Author, 2025)

2.7 Inclusion and Exclusion Criteria

2.7.1 Inclusion criteria

To ensure that the review remained rigorous and aligned with its objectives, a set of inclusion criteria was established. Restricting the scope to peer-reviewed English-language articles published between 2000 and 2025 ensured both methodological rigour and contemporary relevance. Focusing on natural hazards and conflict-related emergencies was consistent with the mainstream framing of humanitarian action (Sphere Association, 2018; UN OCHA & UNEP, 2021), while excluding studies on industrial or technological disasters that are generally managed outside humanitarian systems. Furthermore, only studies describing or

analysing FSEs involving live deployment of personnel, resources, and inter-agency coordination were retained to distinguish them from less complex formats such as tabletop or functional exercises (WHO, 2017). Finally, the emphasis on tacit knowledge, its transfer, and broader knowledge management processes ensured conceptual alignment with the theoretical lens of Knowledge Creation Theory (Nonaka & Takeuchi, 1995).

The inclusion criteria applied in this study are summarised in **Table 2-3** (see **Appendix C** for the detailed extraction forms).

Table 2-3: Inclusion Criteria for the Systematic Review

Criterion	Specification
Publication type & quality	Peer-reviewed journal articles available in full text and providing complete reference lists.
Language & timeframe	Published in English between 2000 and 2025.
Disaster context	Studies address emergencies arising from natural hazards (e.g., earthquakes, floods, storms) or conflict-related/complex emergencies (e.g., armed conflict, mass displacement), and are situated within civilian-led humanitarian response structures (UN agencies, NGOs, Red Cross/Red Crescent, local authorities).
Exercise characteristics	Describes or analyses a full-scale simulation exercise involving live deployment of personnel, resources, and inter-agency coordination in real time. Involves multiple stakeholder organisations.
Knowledge focus	Examines tacit knowledge, its transfer, or broader knowledge management processes, explicitly or through recognised frameworks such as the KCT or the SECI model.

Methodological detail	Provides data, analysis, or conceptual discussion that allows evaluation of how experiential insights are captured, externalised, shared, or institutionalised.
-----------------------	---

(Source: Author, 2025)

2.7.2 Exclusion criteria

The exclusion criteria applied in this review are presented in **Table 2-4**. These criteria ensured consistency with the study's focus on FSEs in humanitarian contexts by excluding exercise types lacking operational realism, scenarios managed outside humanitarian systems, non-civilian training activities, and studies without a clear link to knowledge creation processes. This approach helped retain only those studies directly relevant to the research aims and theoretical framework, while ensuring transparency and methodological rigour.

Table 2-4: Exclusion Criteria for the Systematic Review

Criterion	Specification
Simulation type	Excluded studies on tabletop exercises, virtual/augmented reality simulations, computer-based models, games, drills, or functional exercises, as these lack the operational realism, inter-agency mobilisation, and field deployment of FSEs
Disaster type	Excluded studies focused exclusively on industrial or technological disasters (e.g., chemical spills, nuclear accidents), as these are managed by specialised technical authorities rather than mainstream humanitarian response (Sphere Association, 2018; UN OCHA & UNEP, 2021).
Stakeholder type	Excluded military and police training exercises, as humanitarian response is defined as civilian-led, with armed forces mobilised only as a last resort (IASC,

	2008). Student/classroom simulations were also excluded as they do not involve operational actors.
Conceptual focus	Excluded studies not addressing tacit knowledge, tacit knowledge transfer, or knowledge management processes. Retained only those explicitly analysing experiential knowledge creation, aligned with KCT and the SECI model

(Source: Author, 2025)

2.8 Data Extraction Process

Following the final selection of studies, a structured data extraction process was undertaken to ensure consistency, transparency, and replicability. A customised template was developed in Microsoft Excel to capture both descriptive and methodological details of each publication. Specifically, information was systematically recorded under the following categories: (1) author(s); (2) title of the article; (3) document name; (4) journal title; (5) date of publication; (6) volume; (7) issue number; (8) page numbers; (9) paper type (qualitative, quantitative, mixed-methods, conceptual, or review); (10) geographical location; (11) context or industry; (12) sample size; (13) data collection method; (14) method of data analysis; (15) key findings related to the research questions; (16) abstract; (17) keywords; (18) organisational sector; and (19) quality appraisal score, assessed using the MMAT or marked as not applicable (N/A) for non-empirical studies.

The extracted data and quality appraisal results were recorded using a standardised Word template, with each study documented in a structured format covering descriptive, methodological, and analytical elements. This approach ensured systematic comparison across studies while maintaining transparency and replicability. The complete data extraction table is provided in **Appendix C**, which presents detailed information for each of the 28 included studies and forms the foundation for the thematic synthesis discussed in Chapter 4.

2.9 Quality Appraisal

The methodological quality of the included studies was assessed using the Mixed Methods Appraisal Tool (MMAT, version 2018), which provides a consistent framework for evaluating qualitative, quantitative, and mixed-methods research (Hong et al., 2018). Each empirical study was appraised against the relevant MMAT criteria, with responses coded as Yes (Y), No (N), Can't determine (C), or Not applicable (NA). Two initial screening questions were applied to confirm whether the research question was clearly stated and whether the collected data were adequate to address it.

For synthesis, studies were classified as high quality (4–5 criteria met), medium quality (2–3), or low quality (0–1). Non-empirical papers, such as reviews or conceptual contributions, were marked as not applicable (N/A) since the MMAT cannot be meaningfully applied to such designs.

The detailed criteria and quality appraisal scores are presented in **Appendix D** to ensure transparency and allow readers to examine individual study ratings.

2.10 Summary

This chapter outlined the methodological framework underpinning the study. A SLR approach was adopted to ensure rigour, transparency, and replicability. Key search terms were defined, and two search strings were developed to capture studies at the intersection of FSEs, humanitarian logistics, and KCT. Database searches across ProQuest, EBSCO, and Scopus, supplemented by snowballing, yielded 571 records, which were systematically screened to arrive at a final sample of 28 studies. Inclusion and exclusion criteria were clearly defined to ensure conceptual alignment, while the methodological quality of included studies was appraised using the MMAT. Finally, a structured data extraction process captured the descriptive, methodological, and analytical features of each study to support subsequent synthesis.

Together, these steps provide a robust foundation for the thematic analysis presented in Chapter 3, ensuring that the findings are grounded in a transparent and replicable review process.

3 Descriptive Analysis

3.1 Introduction

This chapter systematically reviews 28 academic studies that examine the role of full-scale simulation exercises (FSEs), Knowledge Creation Theory (KCT) and knowledge management (KM) in humanitarian contexts. The review is structured along five analytical dimensions: **publication trends, journal distribution, geographic and hazard focus, KM applications, and research quality**. By tracing the evolution of research output over time, identifying disciplinary clusters, and mapping where and on what types of disasters FSEs have been studied, the chapter highlights both concentration and gaps in the literature. It also reports how KM has been incorporated, mainly in descriptive rather than theory driven ways, and summarises the methodological robustness of the empirical studies using the Mixed Methods Appraisal Tool (MMAT). Taken together, these analyses establish a transparent evidence base that informs the subsequent thematic and interpretive discussions.

3.2 Publication Trends over time

The temporal distribution of the 28 articles (**Figure 3-1**) indicates two distinct clusters. Prior to 2010, publications were scattered and rarely exceeded one per year. The first concentration appears between 2013 and 2016, when attention to disaster preparedness and knowledge management within the humanitarian sector began to expand. A second, more pronounced peak occurs between 2021 and 2023, coinciding with a series of global crises and the consolidation of institutional frameworks that placed simulation and structured learning at the centre of preparedness.

As summarised in **Table 3-1**, the 2013–2016 cluster is closely associated with disasters such as Typhoon Haiyan, the West Africa Ebola epidemic, and the Nepal earthquake. Across these events, evaluations repeatedly identified coordination gaps and underscored the need for structured training and simulation-based preparedness (Gossip et al., 2017; Hall et al., 2017; O’Keeffe et al., 2016). At the policy level, the Sendai Framework (UNDRR, 2015) and the

World Humanitarian Summit/Grand Bargain (OCHA, 2016) emphasised exercises, after-action reviews, and knowledge-management systems as integral to humanitarian reform. In parallel, the launch of the Humanitarian Data Exchange (HDX) in 2014 reinforced a data-driven approach to evaluation and scenario design, embedding knowledge management more firmly into preparedness practice.

The second cluster, between 2021 and 2023, reflects the compounded impact of the COVID-19 pandemic and the Russia–Ukraine conflict. COVID-19 placed simulation and full-scale exercises at the centre of preparedness, with studies demonstrating measurable improvements in institutional performance and protocol compliance (Reddin et al., 2021; Schumacher et al., 2022). Meanwhile, the humanitarian emergency generated by the Russia–Ukraine war prompted the first WHO-led FSX in Kyiv in 2023, focusing on multisectoral coordination of MHPSS, and research on the Poland–Ukraine border highlighted the critical role of rapid knowledge sharing and coherent KM systems in early crisis stages (WHO-Europe, 2023; Zontek & Lipianin-Zontek, 2024).

Taken together, these two publication clusters suggest that scholarly attention in this domain has been shaped not only by the occurrence of major crises but also by the progressive institutionalisation of exercises and knowledge-management mechanisms. This combination of acute shocks and evolving frameworks has created fertile ground for the observed peaks in research activity.

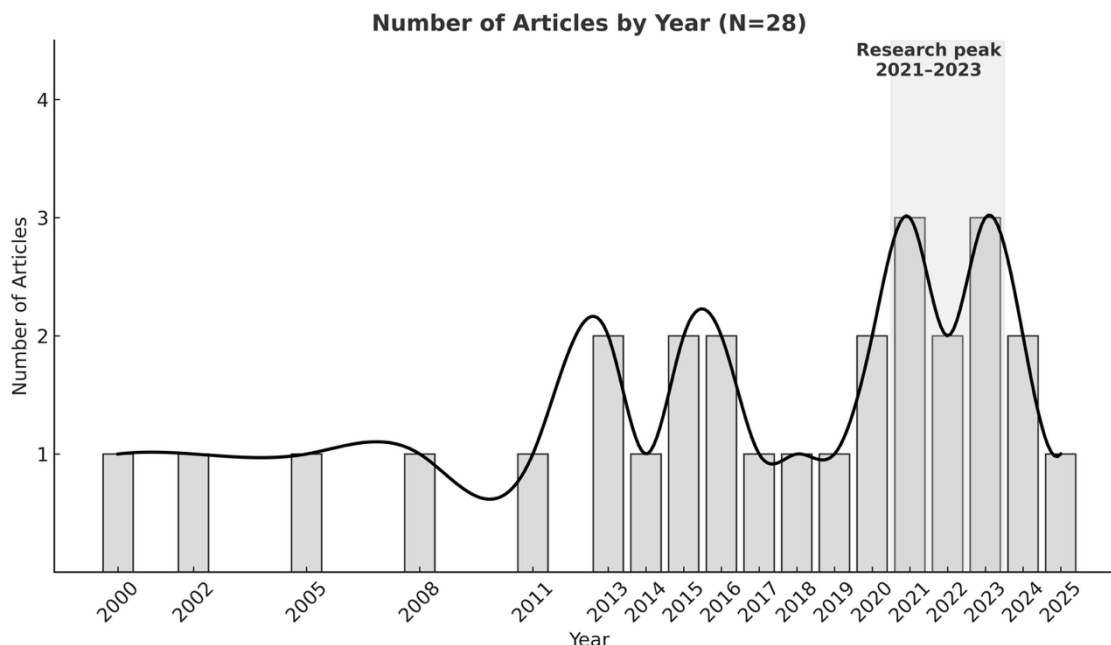


Figure 3-1: Number of Article by Year

(Source: Author, 2025)

Table 3-1: Key disasters, policy frameworks, and knowledge-management developments associated with publication clusters.

Period	Disaster/ Policy Driver	Representative Studies	Key Findings
2013-2016	Typhoon Haiyan (2013)	Gossip et al. (2017)	Stocktaking revealed that prior evaluations had not been institutionalised; highlighted need for structured training and continuous evaluation.
	Nepal Earthquake (2015)	Hall et al. (2017); Singh et al.(2023)	National and hospital-level reviews linked absence of simulation exercises to coordination failures; called for systematic

			preparedness mechanisms.
	West Africa Ebola epidemic (2014–2016)	Kratochvil et al. (2017); O’Keeffe et al. (2016)	High-fidelity simulations exposed system weaknesses, improved team performance; establishment of NETEC (2015) institutionalised simulation-based training.
	Policy frameworks (Sendai Framework; World Humanitarian Summit/Grand Bargain)	UNDRR (2015); OCHA (2016)	Mainstreamed preparedness, simulation exercises, and after-action reviews as auditable mechanisms of humanitarian reform.
	Knowledge-management infrastructure (HDX, 2014)	OCHA/HDX (2014–2024)	Enabled data-driven evaluation and exercise design; reinforced KM–SimEx ecosystem.
2021–2023	COVID-19 pandemic	Reddin et al., (2021); Schumacher et al., (2022)	Adoption of full-scale simulation exercises (FSX) and institutionalisation of simulation as core preparedness mechanisms.

	Russia–Ukraine conflict	WHO-Europe (2023); Zontek & Lipianin-Zontek (2024)	First FSX conducted in Kyiv (MHPSS focus) demonstrated interagency coordination needs; concurrent studies highlighted rapid NGO knowledge sharing and the importance of coherent KM systems.
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(Source: Author, 2025)

3.3 Distribution of Articles by Journal Title

The 28 articles reviewed are distributed across 17 journals, indicating both concentration and dispersion. As shown in **Figure 3-2**, two clear clusters emerge. The first cluster consists of disaster medicine and disaster risk journals, such as Prehospital and Disaster Medicine and the International Journal of Disaster Risk Reduction, which together account for the largest share of publications. This concentration reflects the disciplinary roots of FSEs in health and disaster governance, where simulations are primarily operationalised as preparedness tools to test surge capacity, coordination, and system readiness.

The second cluster is located in management and knowledge-oriented journals, including the Journal of Humanitarian Logistics and Supply Chain Management and the Journal of Knowledge Management. These outlets bring a more conceptual lens, linking simulation exercises to organisational learning and the conversion of tacit and explicit knowledge. Their growing presence since the mid-2010s parallels the incorporation of Knowledge Creation Theory (KCT) and related frameworks into humanitarian studies, which reframed simulation not only as an operational test but also as a process of institutional knowledge creation.

Beyond these clusters, a “long tail” of 11 journals each contributed a single article, ranging from Academic Emergency Medicine to Geosciences and Production Planning & Control. While individually marginal, these contributions highlight the cross-disciplinary character of humanitarian research. They show that simulation-

based preparedness and knowledge management are not confined to one field, but resonate across medicine, policy, education, and organisational sciences.

In summary, the distribution of journals reflects two main disciplinary anchors: disaster and medical sciences on the one hand, and management and knowledge studies on the other. At the same time, the wide dispersion across 17 journals demonstrates the breadth of humanitarian research and the ways in which different academic communities approach FSEs and knowledge management. As shown in **Table 3-2**, this pattern indicates that the literature is grounded both in applied, health-related traditions and in more conceptual, organisational frameworks. Taken together, these dimensions highlight the dual character of humanitarian preparedness research and point to the need for stronger integration across disciplinary boundaries.

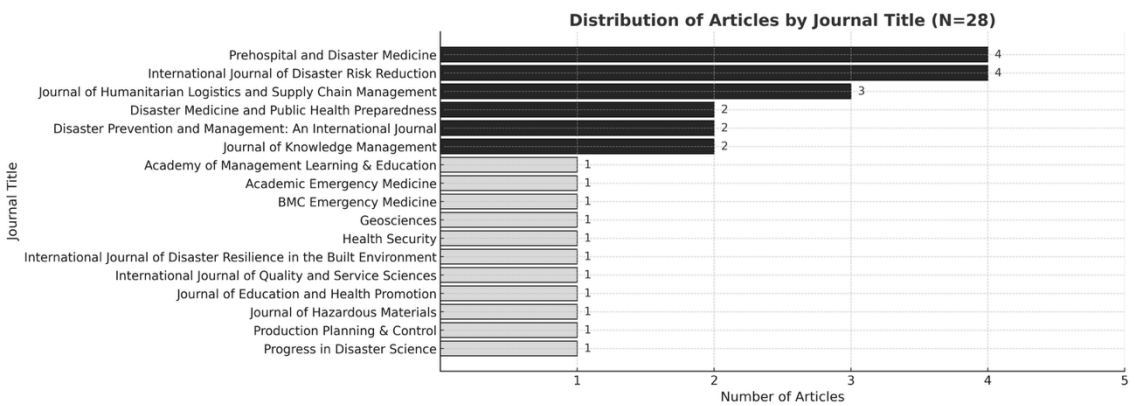


Figure 3-2: Distribution of Articles by Journal Title (N=28)

(Source: Author, 2025)

Table 3-2: Distribution of Articles by Journal Title

Cluster / Journal Type	Representative Journals	Thematic Orientation	Contribution to FSE / KM Research
Disaster medicine / risk journals	Prehospital and Disaster Medicine (4); International Journal of Disaster Risk Reduction(4); Disaster	Public health, emergency medicine,	Treat FSEs as preparedness tools to test surge capacity,

	Medicine and Public Health Preparedness (2)	disaster governance	coordination, and operational readiness.
Management / KM journals	Journal of Humanitarian Logistics and Supply Chain Management (3); Journal of Knowledge Management (2)	Supply chain coordination, organisational learning, KM	Frame simulations as mechanisms of tacit/explicit knowledge conversion and organisational resilience.
Disaster governance / policy	Disaster Prevention and Management (2); Health Security (1)	Disaster governance, health security policy	Link simulation to institutional frameworks and humanitarian reform.
Long tail (11 journals)	e.g. Academic Emergency Medicine, Geosciences, Progress in Disaster Science, Production Planning & Control	Interdisciplinary, peripheral domains	Extend FSX/KM into education, geoscience, public admin, and service sciences; show cross-cutting relevance.

(Source: Author, 2025)

3.4 Geographic and hazard distribution

The subset of ten studies that explicitly investigated full-scale simulation exercises (FSEs) presents a highly uneven geographic distribution. As shown in Figure 6, the majority were conducted in high-income settings, with the United States (n = 3), the United Kingdom (n = 2), Canada (n = 2), and Greece (n = 1)

together accounting for almost 90% of the sample. Only two studies originated from low- and middle-income countries (LMICs), namely Nigeria and Iran, underscoring a striking imbalance. According to the World Bank's classification (2023), this pattern reflects the structural barriers LMICs face in adopting and publishing FSEs: high costs, lack of specialised facilities, shortages of trained personnel, and weak institutional incentives. These constraints have been repeatedly noted in the preparedness literature as limiting the feasibility of large-scale, resource-intensive simulations in contexts most affected by disasters (Ismail et al., 2024). More broadly, this imbalance reproduces a paradox already highlighted in disaster studies: while LMICs bear the greatest disaster burdens—about 85% of events and 95% of disaster-related deaths globally, they remain under-represented in simulation-based research outputs (Roy, 2011).

Hazard typology shows a similarly uneven profile. Man-made scenarios predominate, with terrorism-related simulations accounting for one-third of the sample, followed by earthquake exercises and complex multi-hazard scenarios (22% each). The remaining cases focused on outbreak preparedness (yellow fever) and paediatric mass-casualty response. The prevalence of terrorism scenarios reflects preparedness priorities in North America and Europe, where simulation is widely institutionalised in counter-terrorism and emergency medicine training (Lewis, 2020). By contrast, hazards most pressing in LMICs, such as floods, cyclones, or epidemic outbreaks, appear far less frequently in the published simulation literature. This imbalance again highlights the resource barriers that constrain exercise design in LMICs, as well as the limited visibility of non-Western preparedness initiatives in indexed academic outlets (Ismail et al., 2024; Roy, 2011).

In sum, the geographic and hazard distributions reveal not only where FSEs research is concentrated, but also whose risks and preparedness priorities are most visible in scholarly debate. The dominance of high-income countries (HICs) and terrorism-focused scenarios suggests that simulation research reflects existing institutional capacities and funding landscapes more than global hazard burdens, raising questions about equity and representation in the development of evidence for humanitarian preparedness.

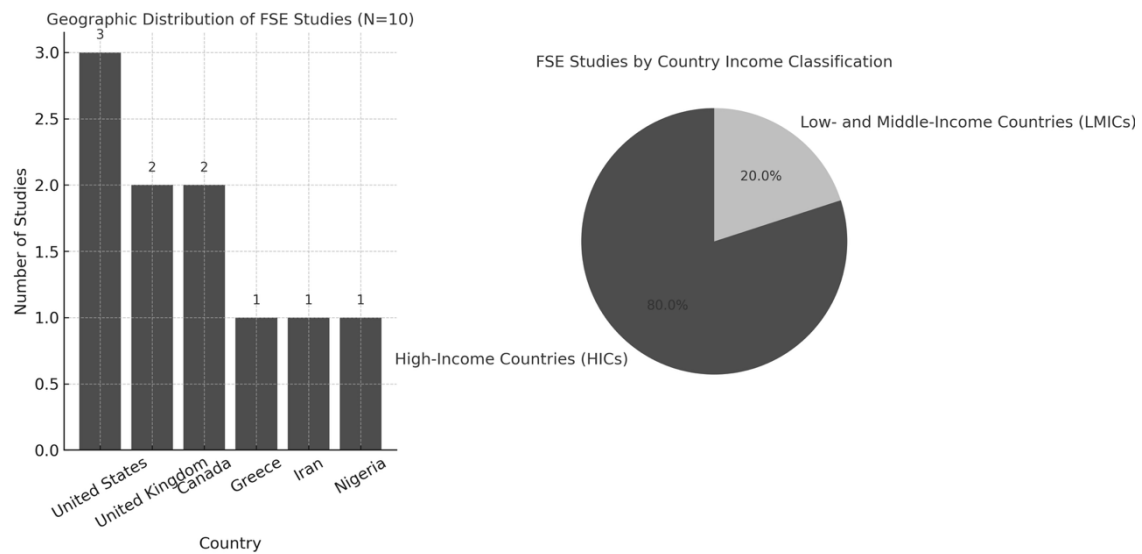


Figure 3-3: Geographic Distribution of FSE Studies by Country (left) and by Income Classification (right)

(Source: Author, 2025)

Table 3-3: Overview of Ten Studies on FSEs

Author(s), Year	Country (Income group)	Hazard type	Setting
Harris et al. (2015)	United States (HIC)	Terrorist attack (chemical release)	Regional hospitals
Burke et al. (2014)	United States (HIC)	Earthquake	Paediatric hospital preparedness
Lowe et al. (2016)	United States (HIC)	Multi-hazard (hospital evacuation)	Health care coalition
Skryabina et al. (2020)	United Kingdom (HIC)	Terrorist attack	Multi-agency, MCI response
Jafar & Fletcher (2020)	United Kingdom (HIC)	Multi-hazard (field hospital)	Emergency medical team

Bank & Khalil (2016)	Canada (HIC)	Paediatric disaster	Emergency physicians
Alexander et al. (2005)	Canada (HIC)	Terrorist attack	Emergency medicine residents
Mavroulis et al. (2025)	Greece (HIC)	Earthquake	Regional FSX (Minoas 2024)
Aliakbari et al. (2022)	Iran (LMIC)	Mass-casualty incident	Nursing staff, hospital
Okunromade et al. (2019)	Nigeria (LMIC)	Biological disaster (yellow fever)	Public health system

(Source: Author, 2025)

3.5 Knowledge Management in the Humanitarian Sector

Among the 28 studies included in this review, 12 explicitly addressed Knowledge Management (KM) in humanitarian operations. Within this subset, only three studies applied established KM theories. Specifically, Huber's **Organizational Learning Theory** was used to examine how organisations process and utilise new information; **Kolb's Experiential Learning Theory** informed evaluations of training and preparedness programmes; and Kusumastuti et al. (2021) applied the **Knowledge Creation Theory (KCT)** at the community level to explore how local actors generate and share knowledge in preparedness activities.

The remaining nine studies did not adopt formal KM frameworks. Instead, they primarily reported on descriptive or operational aspects of knowledge flows, such as after-action reviews, information management tools, and inter-agency data sharing.

Overall, the KM-related literature shows a limited but diverse engagement with theoretical perspectives, with a stronger emphasis on practice-oriented approaches than on systematic theory-driven analysis.

3.6 Quality Appraisal Overview

Of the 28 studies included in this review, 20 were empirical and were systematically assessed using the Mixed Methods Appraisal Tool (MMAT, 2018). The MMAT evaluates methodological quality across five domains: (1) clarity and appropriateness of research questions, (2) adequacy of data collection methods, (3) alignment between research design and objectives, (4) transparency and coherence of the analytical process, and (5) consistency between findings and conclusions.

The appraisal indicates a heterogeneous quality profile. Nine studies met four or five criteria and were therefore classified as high quality, typically demonstrating well-defined objectives, appropriate study designs, and detailed methodological reporting. Eight studies satisfied only two or three criteria and were rated medium quality, often due to limited methodological transparency or reliance on single data sources without triangulation. Three studies met only one or none of the criteria, resulting in a low-quality classification; these tended to lack clear research questions, comprehensive data collection strategies, or sufficient linkage between evidence and claims.

The remaining eight publications consisted of conceptual articles, systematic reviews, scoping reviews, or other forms of secondary research. As the MMAT is specifically designed for appraising empirical studies, these publications were classified as not applicable. Nonetheless, they provide important contributions by proposing conceptual frameworks, synthesising existing evidence, and offering critical reflections that guide and inform subsequent empirical research.

A summary of methodologies and quality classifications is presented in **Table 3-4**, while the complete MMAT appraisal results, including individual study scores against the five criteria, are provided in **Appendix D**.

Table 3-4: Overview of methodologies and quality ratings of included studies

Author & Year	Methodology	Quality
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Bank & Khalil (2016)	Quantitative Non-randomized	High
Skryabina et al. (2020)	Mixed-Methods	High
Harris et al. (2015)	Quantitative descriptive	Low
Burke et al. (2014)	Mixed-Methods	High
Alexander et al. (2005)	Quantitative Non-randomized	Medium
Lowe et al. (2016)	Conceptual Article	Not applicable
Jafar & Fletcher (2020)	Quantitative descriptive	High
Okunromade et al. (2019)	Quantitative descriptive	Medium
Mavroulis et al. (2025)	Qualitative Studies	Medium
Aliakbari et al. (2022)	Quantitative Non-randomized	Medium
Gralla et al. (2015)	Qualitative Studies	Low
Wagner & Thakur-Weigold (2018)	Qualitative Studies	Medium
Mahdi et al. (2023)	Systematic Review	Not applicable
Pek et al. (2023)	Scoping Review	Not applicable
Weinstein et al. (2023)	Mixed-Methods	High
Waring et al. (2024)	Secondary Research	Not applicable
Along et al. (2022)	Qualitative Studies	High
Berri & Donnelly (2021)	Qualitative Studies	High
Cozzolino et al. (2017)	Qualitative Studies	Low

Lu et al. (2013)	Conceptual Article	Not applicable
Chin et al. (2022)	Conceptual Article	Not applicable
Bölsche et al. (2013)	Quantitative descriptive	Medium
Tatham & Spens (2011)	Conceptual Article	Not applicable
Kusumastuti et al. (2021)	Mixed-Methods	High
Caballero-Anthony et al. (2021)	Qualitative Studies	Medium
Paton & Jackson (2002)	Quantitative descriptive	Medium
Armstrong & Mahmud (2008)	Quantitative Non-randomized	High
Ford & Schmidt (2000)	Conceptual Article	Not applicable

(Source: Author, 2025)

3.7 Summary

The review shows that research on humanitarian FSEs has grown in waves, with peaks around 2013–2016 and again in 2021–2023, largely in response to major crises and policy frameworks. Publications are clustered in disaster/medical journals and management-oriented outlets, but remain unevenly distributed across regions and hazard types. While KM is mentioned in several studies, systematic theoretical application is limited. The MMAT appraisal indicates that most empirical studies are of medium to high quality, though reporting gaps persist. Overall, Chapter 3 provides a consolidated overview of the field, identifies where evidence is concentrated, and points to gaps and limitations that will be explored further in Chapter 6.

4 Thematic Analysis

4.1 Introduction

This chapter presents the thematic analysis derived from the systematic review, guided by the Gioia methodology (Gioia, Corley, & Hamilton, 2013; Gioia & Chittipeddi, 1991). The purpose of this chapter is to demonstrate the process through which first-order concepts were extracted from the reviewed studies, how these concepts were grouped into second-order themes, and how these themes were further clustered into aggregate dimensions. By making the progression from data to concepts transparent, this chapter establishes the structural foundation for the subsequent discussion.

The analysis is organised around the three research questions, each of which corresponds to a different level of knowledge creation in humanitarian contexts: the individual level (RQ1), the organisational level (RQ2), and the system level (RQ3). For each research question, the first-order concepts identified in the dataset of 28 studies are presented, followed by the second-order themes that were derived through comparison and consolidation, and finally the aggregate dimensions that summarise higher-level patterns.

In line with the Gioia methodology, this chapter focuses on the descriptive and structural presentation of coding, while the interpretive implications of the themes are addressed in Chapter 5.

4.2 Thematic Analysis for RQ1 (Individual Level)

RQ1: How do humanitarian operators acquire and internalise tacit knowledge through full-scale simulation exercises?

The analysis of literature relevant to RQ1 yielded two aggregate dimensions: socialisation and internalisation. These dimensions emerged through an iterative process in which first-order concepts were grouped into second-order themes and then organised into higher-level categories.

4.2.1 Aggregate Dimension: Socialisation

The first aggregate dimension corresponds to the **socialisation** process in the SECI model. This dimension was derived by grouping a set of first-order concepts that emphasised the acquisition of tacit knowledge through informal learning and interpersonal interaction during FSEs.

In the reviewed studies, researchers frequently reported that tacit knowledge was exchanged and shared through informal conversations and other non-formal exchanges (Berri & Donnelly, 2021), as well as through peer-to-peer engagement and cross-training activities that supported coordination and adaptability within teams (Ford & Schmidt, 2000). Other contributions highlighted the role of direct interaction among colleagues in experiential settings, where learning occurred by working and reflecting together (Armstrong & Mahmud, 2008).

Through iterative comparison and abstraction, these recurring first-order ideas were consolidated into two second-order themes: (1) **informal learning** and (2) **individual interaction**. These themes were then clustered under the aggregate dimension of **socialisation**, which reflects the ways in which tacit knowledge is transferred and shared among individuals within the context of FSEs.

4.2.2 Aggregate Dimension: Internalisation

This aggregate dimension corresponds to the **internalisation** process in the SECI model. It was derived by grouping first-order descriptions that consistently portrayed how learning from FSEs is taken up into practice over time. Through iterative coding, these accounts were organised into three second-order themes: **enhanced professional competences, explicit knowledge acquisition, knowledge retention, and adaptive capability**.

Enhanced professional competences.

A first set of findings highlighted how FSEs improve both technical and non-technical skills among participants. Studies reported that exercises enhanced preparedness levels, surge capacity, teamwork, clinical competence, and problem-solving abilities (e.g., Aliakbari et al., 2022; Harris et al., 2015; Burke et

al., 2014; Lowe et al., 2016; Waring et al., 2024; Weinstein et al., 2023). These findings demonstrate that simulation-based learning extends beyond knowledge acquisition to encompass professional skills, confidence, and interprofessional collaboration.

Explicit knowledge acquisition.

Across the reviewed studies, studies reported immediate gains in knowledge following simulation-based learning. Examples include findings that exercises were useful and increased participants' knowledge, that superior knowledge acquisition was observed after simulation training, and that learning accumulated through direct experience and reflective observation (e.g., Bank & Khalil, 2016; Skryabina et al., 2020; Wagner & Thakur-Weigold, 2018). These first-order statements were grouped as a theme capturing the movement from exposure to procedures and scenarios toward concrete knowledge uptake.

Knowledge retention.

A second cluster of first-order concepts emphasised the durability of learning. Studies described training for mastery and the ability to retain and generalise knowledge for future emergencies; some reported competence retained at six months and noted direct impacts of preparedness exercises on subsequent incident responses (e.g., Gralla et al., 2015; Bank & Khalil, 2016; Skryabina et al., 2020; Weinstein et al., 2023). These recurrent observations were consolidated into a theme indicating longer-term retention of exercise-derived knowledge.

Adaptive capability.

A third set of first-order descriptions linked repeated practice to adaptive expertise in action-oriented settings. The reviewed studies noted that experiential environments foster the capacity to adjust to changing circumstances, deepen learning, and promote adaptive expertise (e.g., Armstrong & Mahmud, 2008; Gralla et al., 2015; Ford & Schmidt, 2000). These items were coded to a theme capturing the adaptive qualities that emerge as knowledge becomes embedded.

Taken together, these four second-order themes were clustered into the aggregate dimension of **internalisation**, representing how the coding process

assembled recurrent first-order accounts of competence enhancement, knowledge acquisition, retention, and adaptive embedding of knowledge within individual practice during FSEs.

4.2.3 Summary of RQ1 Analysis

The coding process for RQ1 demonstrates a clear progression from first-order concepts to second-order themes and, finally, to two aggregate dimensions. The dimension of socialisation was constructed by grouping recurrent references to informal exchanges and interpersonal interaction, while the dimension of internalisation was built from repeated descriptions of enhanced professional competences, explicit knowledge acquisition, knowledge retention, and adaptive capability. These dimensions represent the patterns consistently observed across the reviewed studies and indicate the mechanisms by which tacit knowledge is both shared and embedded at the individual level during full-scale simulation exercises. The complete data structure for RQ1 is presented in **Figure 4-1**.

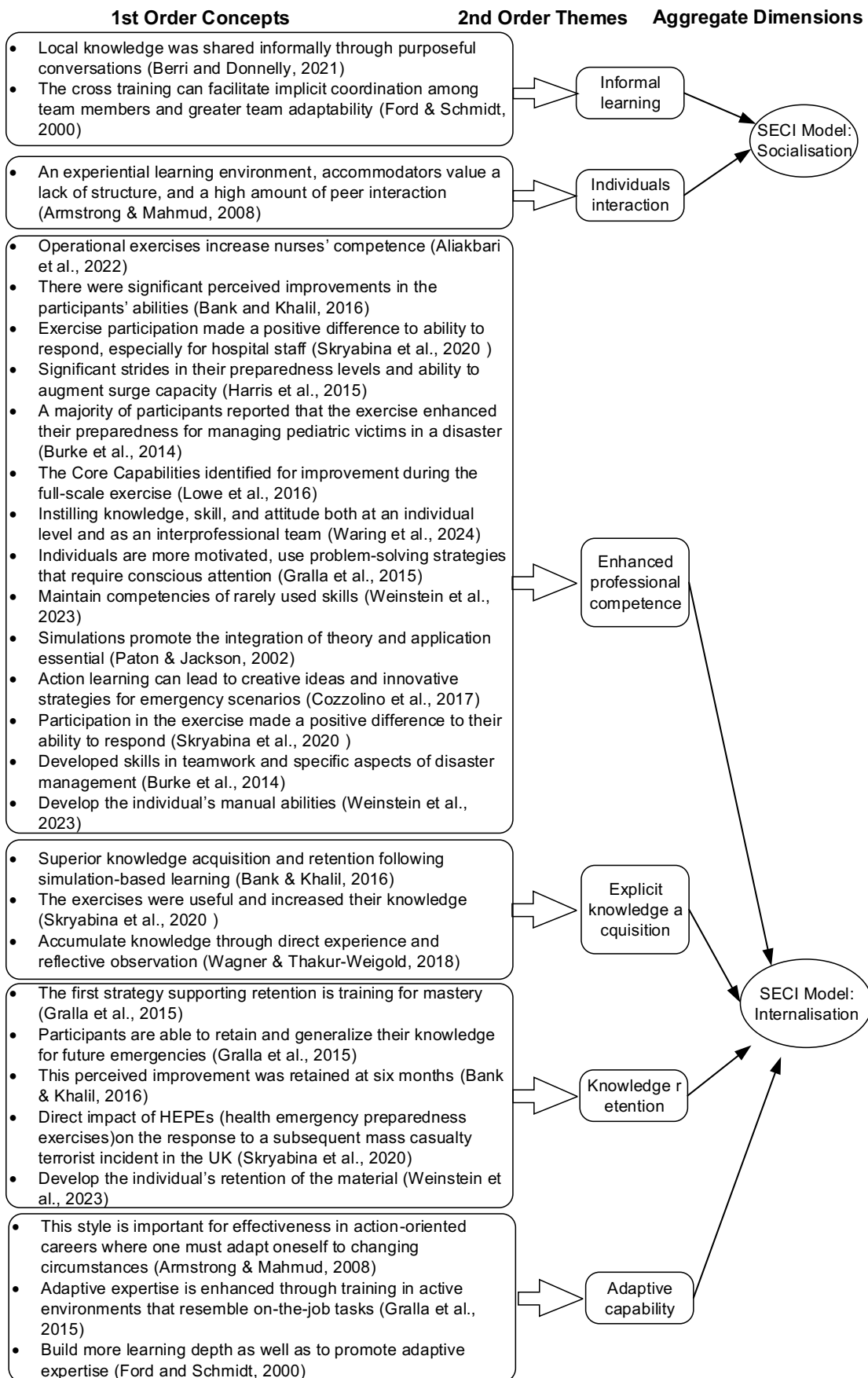


Figure 4-1: Gioia data structure for RQ1

(Source: Author, 2025)

4.3 Thematic Analysis for RQ2 (Organisational level)

RQ2: How can humanitarian organisations externalise and absorb individual tacit knowledge into explicit organisational knowledge?

The coding process for RQ2 produced four aggregate dimensions. These were derived by grouping recurring first-order concepts into second-order themes and then clustering them into higher-order categories. The four aggregate dimensions are: **simulation-based exercises, structured debriefing in simulation-based exercises, knowledge codification and training artefacts, and organisational culture and informal sharing.**

4.3.1 Aggregate Dimension 1: Simulation-based Exercises

This dimension captures how large-scale and structured simulations provide formal mechanisms for embedding tacit knowledge into organisational routines. First-order evidence showed that disaster simulations offered opportunities for participants to access and exchange tacit know-how under realistic scenarios (Kusumastuti et al., 2021). Simulations and assessment centres were also highlighted as venues where tacit expertise was surfaced and transferred across staff (Paton & Jackson, 2002). In addition, several studies emphasised the importance of standardised training and certification to ensure that knowledge generated during exercises was consistently embedded across organisations (Bölsche et al., 2013). These accounts were clustered into three second-order themes: simulation exercises, simulations and assessment centres, and standardised training, which were then grouped into the aggregate dimension of simulation-based exercises.

4.3.2 Aggregate Dimension 2: Structured Debriefing in Simulation-based Exercises

A second dimension reflects the role of structured reflection immediately after exercises. The reviewed studies reported how nightly debriefs provide feedback

and guidance, creating pauses in the exercise for reflection (Gralla et al., 2015). Debriefs were further emphasised as crucial spaces where responders reflect not only on their own actions but also on intra- and inter-agency coordination (Waring et al., 2024). Mass-casualty simulations in particular identified the debrief as an essential stage for transforming experiential insights into explicit lessons (Weinstein et al., 2023). These accounts were grouped into the second-order theme of debriefing, which was then clustered into the aggregate dimension of structured debriefing in simulation-based exercises.

4.3.3 Aggregate Dimension 3: Knowledge Codification and Training Artefacts

The third dimension concerns the translation of tacit and experiential insights into portable, reusable artefacts. Wagner and Thakur-Weigold (2018) illustrated this through the High Energy Biscuit Simulation Game, which embeds logistical knowledge into a format that can be stored, transmitted, and reused. Bölsche et al. (2013) further argued that large parts of humanitarian logistics knowledge need to be codified to ensure continuity. These recurring descriptions were consolidated under the second-order theme of knowledge codification, which was then clustered into the aggregate dimension of knowledge codification and training artefacts.

4.3.4 Aggregate Dimension 4: Organisational Culture and Informal Sharing

The fourth dimension reflects cultural and managerial conditions that sustain knowledge flows within organisations. First-order statements indicated that a knowledge-centred culture creates favourable conditions for systematic knowledge management (Caballero-Anthony et al., 2021). Other evidence highlighted that decentralised and supportive managerial styles promote spontaneous sharing and reduce barriers to open communication (Berri & Donnelly, 2021). These accounts were grouped into the themes of knowledge-centred culture and decentralisation and supportive style, which were clustered into the aggregate dimension of organisational culture and informal sharing.

4.3.5 Summary of RQ2 Analysis

The analysis of RQ2 shows that humanitarian organisations externalise and absorb tacit knowledge through a combination of structured mechanisms and cultural enablers. Simulation-based exercises provide formal platforms where tacit expertise is surfaced and aligned, while structured debriefings ensure that lessons are articulated and made explicit. Codification processes then translate these lessons into artefacts and training tools, ensuring their preservation across time and contexts. Finally, trust-based and supportive organisational cultures sustain informal exchanges, complementing formal processes and preventing knowledge loss due to staff turnover. Taken together, these dimensions highlight how organisations can transform individual tacit knowledge into institutional memory, thereby building resilient and adaptive capacities. The complete data structure for RQ2 is presented in **Figure 4-2**.

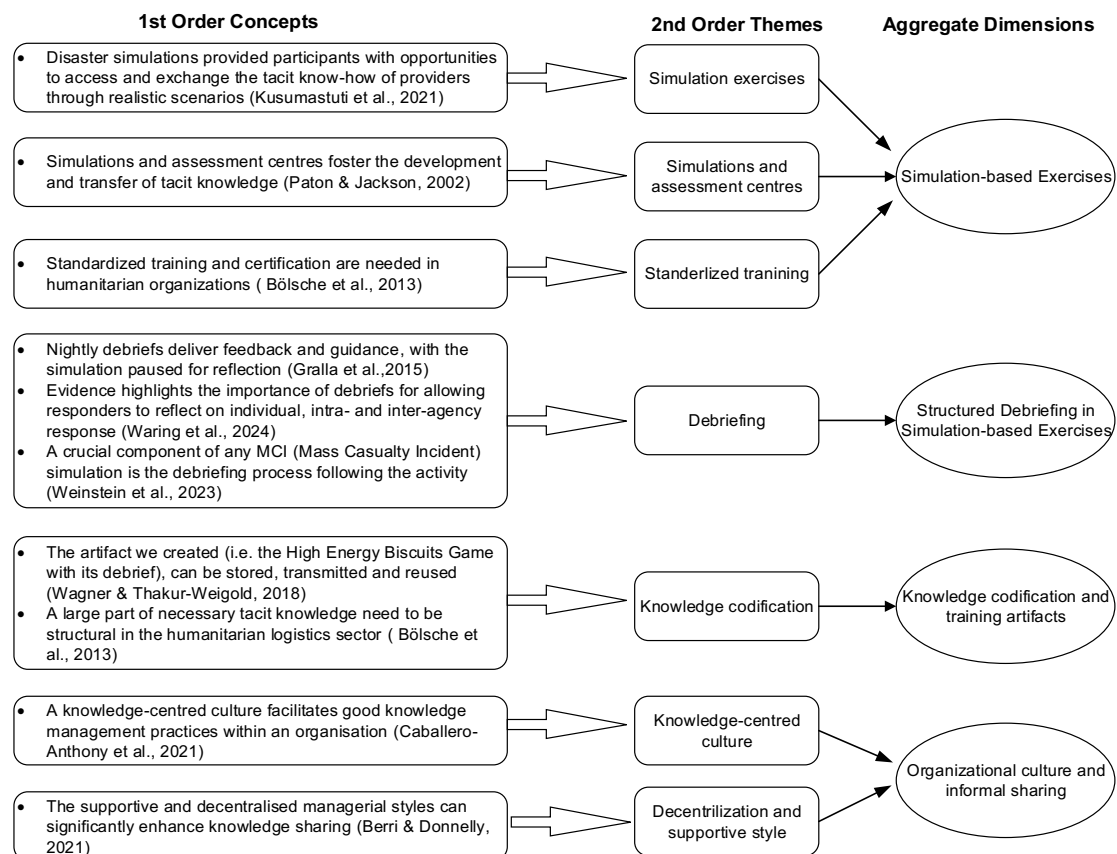


Figure 4-2: Gioia data structure for RQ2

(Source: Author, 2025)

4.4 Thematic Analysis for RQ3 (System level)

RQ3: How do inter-organisational knowledge-management practices enhance collaboration and improve humanitarian operational effectiveness?

The analysis of studies relevant to RQ3 yielded two aggregate dimensions. These were derived by iteratively grouping recurring first-order statements into second-order themes and then clustering those themes into higher-order categories. The two dimensions are collaboration enhancement through FSEs and knowledge and information management.

4.4.1 Aggregate Dimension 1: Knowledge codification and training artefacts

This dimension captures how FSEs function as system-level platforms that bring together multiple organisations and enable collaboration under realistic but controlled conditions. Across the dataset, studies described FSEs as opportunities for agencies to meet, observe each other's procedures, coordinate actions, and surface interdependencies that are hard to detect in routine settings. Evidence shows that such exercises provide shared experiences that deepen partnerships and multisector collaboration, strengthen both individual and institutional response capacities, and foster regional relationships (e.g., Mavroulis et al., 2025; Gralla et al., 2015; Okunromade et al., 2019). Reviews of pandemic and disaster preparedness further underline the necessity of FSEs to test emergency management systems in highly stressful environments and to align practices across actors (e.g., Pek et al., 2023; Mahdi et al., 2023). At the second-order level, these recurring descriptions were consolidated under the theme full-scale simulation exercises (FSE), which explains how joint scenarios act as boundary spaces where tacit knowledge begins to circulate beyond single organisations and is translated into shared, system-wide understanding.

4.4.2 Aggregate Dimension 2: Organisational culture and informal sharing

The second dimension concerns the formalisation, storage, and mobilisation of knowledge generated through FSEs so that it can be accessed across

organisational boundaries. First-order statements emphasised the need to merge and standardise stakeholder knowledge to reduce casualties and facilitate humanitarian operations, ensuring that communities and responders can understand and use information effectively (Along et al., 2022). Studies reported that knowledge sharing, translation, and absorption during and after exercises created accessible knowledge bases that consolidate collective memories for future use (Berri & Donnelly, 2021). Performance evaluation and detailed report writing were identified as mechanisms that codify field and supply-chain knowledge for subsequent operations (Lu et al., 2013). Decision effectiveness was shown to depend on the ability to quickly access and interpret diverse data under urgent and evolving conditions, with participants recognising the centrality of clear and coordinated information management during simulation activities (Paton & Jackson, 2002; Wagner & Thakur-Weigold, 2018). These accounts were organised into the following second-order themes that together constitute the dimension knowledge and information management: integrating and standardising multi-stakeholder knowledge, building and sustaining organisational knowledge bases, performance evaluation and report writing, and information management.

4.4.3 Summary of RQ3

The analysis of RQ3 shows that inter-organisational knowledge-management practices enhance humanitarian collaboration through two interconnected dimensions. First, **collaboration enhancement through FSEs** demonstrates how joint simulation exercises provide boundary spaces where diverse agencies can coordinate actions, observe each other's procedures, and build shared repertoires of practice. These exercises strengthen partnerships, foster regional relationships, and align protocols under high-pressure conditions, thereby creating system-wide preparedness. Second, **knowledge and information management** highlights the role of codification, evaluation, and standardisation in preserving and mobilising knowledge beyond individual exercises. Mechanisms such as multi-stakeholder integration, report writing, and information

management ensure that experiential insights are consolidated into collective memory and remain accessible for future responses.

Taken together, these dimensions indicate that inter-organisational knowledge management is not limited to isolated practices but reflects a cycle in which shared experiences are transformed into structured repositories of knowledge. This process enables both improved interoperability during crises and the long-term strengthening of humanitarian systems. The complete data structure for RQ3 is presented in **Figure 4-3**.

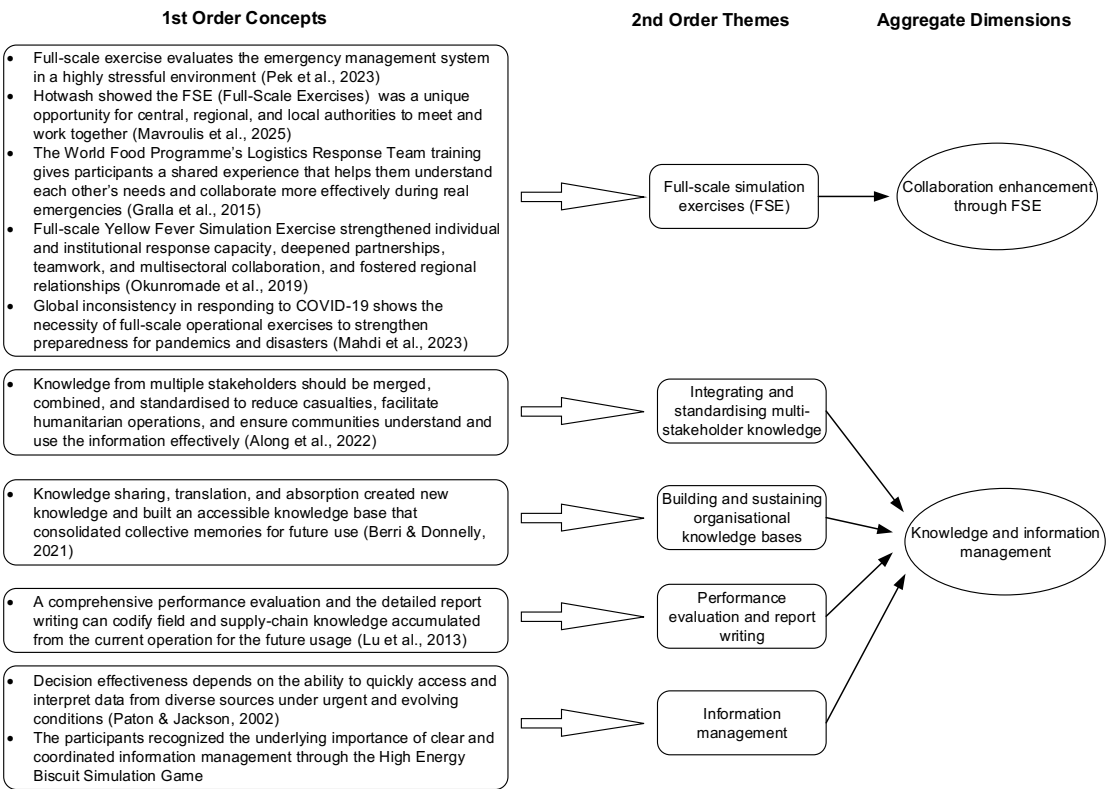


Figure 4-3: Gioia data structure for RQ3

(Source: Author, 2025)

4.5 Overall Summary of Thematic Analysis

This chapter set out, using the Gioia methodology, how first-order statements from the 28 studies were organised into second-order themes and then clustered into aggregate dimensions. Across the three research questions, a coherent cross-level picture of tacit knowledge creation in humanitarian contexts emerges.

At the individual level (RQ1), two aggregate dimensions were identified. Socialisation captures tacit-to-tacit exchange through informal interaction and peer engagement during exercises. Internalisation explains how learning is taken up into practice over time and comprises four themes: enhanced professional competence, explicit knowledge acquisition, knowledge retention, and adaptive capability.

At the organisational level (RQ2), four dimensions show how individual know-how is preserved as institutional memory. Simulation-based exercises surface and align expertise. Structured debriefing converts experience into explicit lessons. Knowledge codification and training artefacts stabilise and disseminate insights. Organisational culture and informal sharing sustain ongoing exchange alongside formal mechanisms.

At the system level (RQ3), two dimensions explain inter-organisational learning. Collaboration enhancement through full-scale exercises provides boundary spaces for alignment and joint action, while knowledge and information management integrates, codifies, and mobilises lessons across agencies.

Taken together, the analyses show a recurring pathway: exercises generate shared experience, debriefing and codification render it explicit, and cultural and information practices sustain and circulate it. Full-scale exercises operate as the common engine linking individual learning, organisational memory, and system-wide preparedness. These empirical structures provide the foundation for the interpretive discussion in Chapter 5.

The detailed coding process following the **Gioia methodology** (from first-order concepts to aggregate dimensions) is provided in **Appendix E** to ensure transparency and auditability.

5 Findings

5.1 Research Question 1

RQ1: How do humanitarian operators acquire and internalise tacit knowledge through full-scale simulation exercises?

The analysis of RQ1 shows that tacit knowledge is acquired and embedded at the individual level through two interrelated processes: **socialisation** and **internalisation**. Together, these processes explain how humanitarian responders move from interpersonal learning during exercises to the development of durable professional competences and adaptive capabilities.

5.1.1 Socialisation during simulation exercises

The findings highlight that much of the tacit knowledge circulating in humanitarian contexts is transferred through socialisation, that is, tacit-to-tacit exchange occurring in shared experiential settings. Responders gain insights not primarily through manuals or guidelines but through informal conversations, peer-to-peer engagement, and direct interpersonal interaction during exercises. Mentorship and role modelling play an important role in this process, as less experienced staff acquire subtle skills and practical judgment by observing and working alongside more experienced colleagues (Armstrong & Mahmud, 2008). Informal discussions and storytelling also emerge as crucial means of passing on intuitive expertise that cannot easily be codified (Berri & Donnelly, 2021). Furthermore, joint training scenarios allow participants to develop shared mental models, which improve coordination and enable teams to anticipate each other's actions under pressure (Ford & Schmidt, 2000). These findings underline that socialisation is not incidental but central to the value of full-scale exercises, as it is through relational and experiential exchanges that tacit knowledge circulates among individuals and becomes collectively understood.

5.1.2 Internalisation of knowledge into practice

A second process is internalisation, whereby explicit lessons from exercises are progressively translated into tacit routines. Findings show that participants not only acquire immediate knowledge gains but also embody these lessons through repetition and reflection. Simulation-based learning enhances professional competences across both technical and non-technical domains, including clinical practice, teamwork, problem-solving, and leadership (Aliakbari et al., 2022; Waring et al., 2024). It also supports explicit knowledge acquisition, with studies

reporting immediate increases in confidence and understanding following structured training scenarios (Bank & Khalil, 2016; Skryabina et al., 2020). Importantly, these lessons persist beyond the exercise setting: evidence shows that competence can be retained for several months and has been directly linked to effective performance in subsequent emergencies (Gralla et al., 2015; Weinstein et al., 2023). Repeated practice in realistic and stressful environments further cultivates adaptive capability, enabling responders to improvise and adjust to changing circumstances, a capacity often described as adaptive expertise (Ford & Schmidt, 2000; Gralla et al., 2015). Taken together, these findings demonstrate that knowledge does not remain at the surface level but becomes ingrained in responders' skills, routines, and confidence through internalisation.

5.1.3 Conclusion for RQ1

In sum, the findings for RQ1 suggest that humanitarian responders acquire tacit knowledge through the knowledge creation process of socialisation and internalisation. Socialisation enables tacit-to-tacit transfer through mentorship, interaction, and the development of shared mental models, while internalisation ensures that explicit lessons are absorbed into long-term competences and adaptive capabilities. Together, these processes show that FSEs function as engines of experiential learning, equipping responders not only with technical knowledge but also with the professional judgment and flexibility required to perform effectively in real crises.

5.2 Research Question 2

High staff turnover is a persistent challenge in humanitarian operations, often eroding institutional memory and disrupting continuity (Korff, 2015). Much of the critical expertise that supports humanitarian response remains tacit, embedded in the personal experiences of frontline staff, and therefore at risk of being lost when personnel rotate out of missions (Caballero-Anthony et al., 2021). The reviewed studies point to four main mechanisms through which organisations can address this challenge and convert individual know-how into durable organisational knowledge: simulation-based exercises, structured debriefing,

codification into training artefacts, and the cultivation of organisational cultures that support informal sharing.

5.2.1 Simulation-based exercises

Simulation-based exercises represent one of the most visible strategies for transforming tacit insights into organisational knowledge. Several studies emphasise that simulations provide an opportunity to surface and circulate practical expertise that would otherwise remain individualised. Kusumastuti et al. (2021) show that repeated disaster simulations in Lombok enabled communities to access and retain experiential knowledge, producing a shared base of competencies that supported collective responses. Paton and Jackson (2002) similarly argue that simulations reproduce the uncertainty and complexity of real crises, making decision-making processes observable and discussable. At the organisational level, embedding simulations into training frameworks reduces dependence on individual staff memory and builds a collective pool of expertise that persists over time (Bölsche et al., 2013). The implication is that exercises do more than test preparedness; they function as institutional repositories where tacit knowledge is revealed, shared, and embedded in organisational routines.

5.2.2 Structured debriefing

A second mechanism involves structured debriefs, which encourage participants to articulate their judgments and reflect on their actions. Gralla et al. (2015) highlight how daily review sessions during logistics training exercises enabled participants to externalise their learning in explicit terms. Waring et al. (2024) likewise demonstrate that the effectiveness of simulation exercises depends not only on the scenario itself but also on the systematic capture of insights during debriefing. These findings suggest that debriefs serve as a critical bridge between individual experience and organisational knowledge. By institutionalising debrief practices, humanitarian organisations ensure that tacit expertise is not lost when staff rotate but is instead preserved within the collective memory of the organisation.

5.2.3 Knowledge codification and training artefacts

A third pathway concerns the translation of tacit knowledge into codified forms that can be disseminated and reused. Wagner and Thakur-Weigold (2018) illustrate this through the design of the “High-Energy Biscuit Game,” which embeds logistical lessons into a replicable training tool. Bölsche et al. (2013) likewise argue that standardised training and certification schemes formalise individual learning into organisational routines. These practices transform lived experience into manuals, guidelines, and scenarios that remain accessible to future staff. The strength of codification lies in its ability to stabilise knowledge and make it transportable across time and context, thereby reinforcing organisational continuity and preparedness.

5.2.4 Organisational culture and information sharing

The fourth mechanism relates to organisational culture. Caballero-Anthony et al. (2021) stress that cultures oriented toward openness and trust create favourable conditions for knowledge circulation. Berri and Donnelly (2020) further show that supportive managerial practices encourage peer-to-peer exchanges, allowing knowledge to flow through informal networks. Although less formal than codification or structured debriefing, cultural conditions play a crucial role in sustaining tacit knowledge within organisations. A trust-based culture complements formal mechanisms by ensuring that expertise is continually refreshed and shared, even outside structured training environments.

5.2.5 Conclusion for RQ2

The findings for RQ2 suggest that humanitarian organisations externalise and absorb individual tacit knowledge through a combination of structured mechanisms and cultural conditions. Simulation-based exercises, structured debriefing, and codification provide formal channels for capturing and preserving experience, while organisational cultures of trust and openness sustain informal exchanges that enrich institutional learning. Together, these processes mitigate the risks associated with high staff turnover and contribute to the development of resilient and adaptive organisational capacities. These findings demonstrate that tacit knowledge, while originating in the experience of individuals, can be

institutionalised through organisational practices that convert personal insights into collective memory.

5.3 Research Question 3

Humanitarian operations typically involve multiple agencies working together under time pressure and uncertainty. The effectiveness of such operations depends not only on the capacity of individual organisations but also on the ways in which knowledge is shared, coordinated, and institutionalised across organisational boundaries. The reviewed literature highlights four recurring mechanisms that facilitate inter-organisational knowledge management: simulation-based platforms, structured debriefing, knowledge codification and dissemination, and the cultivation of trust-oriented organisational cultures. These mechanisms, identified through the coding process, illustrate how collective learning is enabled at the system level.

5.3.1 Collaboration enhancement through full-scale simulation exercises

Simulation-based exercises serve as crucial platforms where organisations rehearse interoperability and build shared understandings under realistic but controlled conditions. Unlike training that focuses on the internal development of single organisations, these exercises bring together diverse actors such as government agencies, NGOs, and community responders into common operational environments. Studies show that such scenarios allow participants to observe one another's procedures, test inter-agency coordination, and recognise interdependencies that may otherwise remain obscured (Mavroulis et al., 2025; Gralla et al., 2015; Okunromade et al., 2019).

These exercises also create opportunities for strengthening trust and partnerships across sectors. Evidence highlights that regional and local authorities use full-scale exercises to establish collaborative networks that are later activated during real emergencies (Pek et al., 2023). Lessons from the COVID-19 response underline the necessity of system-wide preparedness activities that can align protocols across multiple organisations and jurisdictions (Mahdi et al., 2023). In this sense, full-scale exercises function as boundary

spaces where tacit knowledge circulates across organisational divides and becomes integrated into a system-wide repertoire of practices.

The theoretical significance of this finding is that collaboration at the system level depends on experiential alignment rather than on formal agreements alone. Exercises provide opportunities for collective sense-making in ways that documents or plans cannot replicate. They foster adaptive capacities that are indispensable when agencies face the complexity and unpredictability of humanitarian crises.

5.3.2 Knowledge and information management

The second mechanism that supports system-level collaboration is knowledge and information management. Whereas exercises generate shared experiences, the preservation and circulation of those lessons depend on practices of codification, reporting, and standardisation. Along et al. (2022) stress the need to merge and harmonise stakeholder knowledge so that communities and responders can act on a common information base. Berri and Donnelly (2021) show that knowledge sharing and absorption during exercises create accessible repositories that consolidate institutional memory.

Performance evaluation and report writing further enable organisations to codify operational insights into formats that are portable across time and organisational boundaries (Lu et al., 2013). Decision-making effectiveness has also been shown to depend on the ability to rapidly access and interpret information under changing conditions (Paton & Jackson, 2002). Wagner and Thakur-Weigold (2018) provide a concrete example with the High Energy Biscuit Simulation Game, which embeds logistical lessons into a replicable artefact that can be used across agencies. Collectively, these practices demonstrate that system-level learning requires not only joint exercises but also deliberate mechanisms for capturing, structuring, and disseminating the resulting insights.

From a theoretical perspective, this underscores the interdependence between experiential and informational dimensions of knowledge management. Without documentation and codification, tacit knowledge risks remaining localised; without shared experiences, codified knowledge lacks relevance and legitimacy.

Effective system-level learning therefore arises from the dynamic interaction of both.

5.3.3 Conclusion for RQ3

The findings for RQ3 indicate that inter-organisational knowledge-management practices enhance humanitarian effectiveness through two mutually reinforcing processes. Full-scale simulation exercises enable multi-agency collaboration by creating shared experiential spaces that align procedures and build trust. Knowledge and information management ensures that lessons from those exercises are codified, standardised, and made accessible across organisational boundaries. Together, these mechanisms illustrate how system-wide collaboration is not simply the sum of individual organisations' capacities but the outcome of structured practices that link experience with institutional memory. While the focus here has been on theoretical and system-level significance, the practical implications for humanitarian policy, training design, and knowledge governance will be further elaborated in Chapter 6.

5.4 Chapter Summary

The findings across RQ1, RQ2, and RQ3 show that FSEs are more than isolated training interventions; they operate as infrastructures that link individual experience, organisational memory, and system-wide collaboration into a continuous cycle of knowledge creation. At the **individual level**, tacit knowledge acquisition rests on the interplay between **socialisation**, where mentoring, informal exchanges, and shared scenarios make hidden expertise visible, and **internalisation**, where repetition and reflection embed explicit lessons into durable professional competences and adaptive capacities. This dual process demonstrates that learning in FSEs is not passive absorption but an embodied and relational practice that cultivates judgement and improvisational skill under pressure.

At the **organisational level**, the findings highlight how agencies can counter the erosion of institutional memory caused by high staff turnover. Structured mechanisms such as simulation, debriefing, and codification externalise individual insights, while cultural enablers such as trust and decentralised

leadership sustain informal knowledge flows. This dual reliance shows that organisational learning cannot be reduced to documentation alone; it requires a supportive environment that legitimises and values knowledge sharing.

At the **system level**, FSEs function as boundary spaces where diverse actors—NGOs, governments, and communities—rehearse interoperability and build common repertoires of practice. Their effectiveness, however, depends on knowledge and information management: the codification, evaluation, and dissemination of lessons into artefacts and shared repositories. This combination suggests that collaboration is secured less by formal agreements than by experiential alignment during exercises and the institutionalisation of insights into system-wide memory.

Taken together, these findings challenge the view of FSEs as temporary preparedness drills. Instead, they demonstrate that FSEs are knowledge infrastructures that connect micro-level expertise, meso-level routines, and macro-level collaboration. The distinctive contribution of this review lies in showing that tacit knowledge can circulate across levels when supported by the right mix of social interaction, cultural enablers, and codification mechanisms. Reframed in this way, FSEs emerge not simply as pedagogical events but as strategic investments in humanitarian learning systems capable of sustaining resilience under uncertainty.

6 Conclusion and Implications

6.1 Overview and Answers to the Research Questions

This review set out to examine how humanitarian responders and organisations create, share, and embed tacit knowledge through FSEs. The findings, presented in Chapters 4 and 5, provide clear answers to the three research questions.

At the individual level (RQ1), FSEs enable tacit knowledge acquisition through socialisation, including informal conversations, mentoring, storytelling, and peer interaction, and its subsequent internalisation as embodied practice. In this way, FSEs help responders transform experience into adaptive expertise that endures beyond the exercise setting.

At the organisational level (RQ2), tacit knowledge is externalised and preserved when structured processes are combined with enabling cultures. Mechanisms such as FSEs, structured debriefs, and codification embed individual tacit knowledge into organisational memory, while trust-based cultures ensure that informal exchange continues despite staff turnover.

At the system level (RQ3), inter-organisational knowledge management enhances collaboration through shared platforms, joint reflection, codified artefacts, and trust. These practices improve interoperability and collective preparedness, turning fragmented experiences into system-wide learning.

Taken together, the evidence demonstrates a recurring cycle: tacit knowledge is generated in lived experience, externalised into explicit forms, disseminated across organisations, and re-embedded into practice. FSEs emerge not simply as training tools but as structured processes of knowledge creation that connect individual insights to organisational memory and system-level collaboration.

6.2 Theoretical Contributions

This review contributes to theory by applying Knowledge Creation Theory (KCT) to the humanitarian field, where its use has so far been limited and fragmented. While the SECI model has been widely discussed in management and organisational studies, few humanitarian studies have explicitly operationalised it. The analysis here makes three contributions.

First, the review demonstrates how FSEs instantiate SECI processes under humanitarian conditions. FSEs provide structured environments where tacit knowledge circulates through socialisation and becomes embedded through internalisation. This shows that exercises are not peripheral training activities but integral knowledge-creation processes, thereby extending the application of KCT into humanitarian operations.

Second, the review addresses the imbalance between explicit and tacit knowledge in existing scholarship. Most humanitarian research has emphasised formal protocols, guidelines, or codified lessons, while tacit expertise has remained under-theorised despite being central to adaptive performance. By

tracing how FSEs preserve and transmit tacit knowledge, this study strengthens theoretical understanding of how “hidden” forms of expertise shape humanitarian effectiveness.

Third, the review illustrates the relevance of KCT for volatile, high-turnover environments. Staff mobility is a defining feature of humanitarian work, often eroding institutional memory. FSEs show how the SECI processes can mitigate this challenge by embedding knowledge in collective routines and artefacts. This finding broadens the theoretical reach of KCT, demonstrating its explanatory power in contexts marked by uncertainty, scarcity, and inter-organisational complexity.

Taken together, these contributions move beyond descriptive accounts of simulation exercises to a more systematic understanding of their role in knowledge creation. They position FSEs as infrastructures that connect individual expertise, organisational learning, and system-wide collaboration.

6.3 Methodological Reflections and Limitations

From a methodological perspective, this review highlights both the opportunities and constraints of existing scholarship on FSEs in humanitarian contexts. Several limitations in the evidence base shape how the findings should be interpreted.

First, the literature remains fragmented and geographically skewed. Of the ten studies focused on FSEs, most were conducted in high-income contexts, whereas low- and middle-income countries, where humanitarian crises are often most acute, are under-represented. This imbalance reflects structural barriers such as cost, limited infrastructure, and publication bias. Consequently, the findings may over-represent experiences from resource-rich environments and reduce their transferability.

Second, there is definitional ambiguity. Although this review followed the WHO Simulation Exercise Toolbox definition, the reviewed studies use “full-scale” inconsistently, with some including table-top exercises and others restricting the term to highly resource-intensive drills. Without conceptual clarity, it is difficult to compare findings across studies or build cumulative insights.

Third, the evidence base demonstrates considerable methodological diversity and uneven quality. The dataset included quantitative non-randomised designs, mixed methods, qualitative studies, and conceptual articles. While such diversity offers multiple perspectives, many studies lack methodological rigour, and a substantial proportion rely on qualitative or conceptual approaches. Quality appraisals revealed variation across studies, with some assessed as high while others were medium or low. This unevenness constrains the strength of the conclusions and underscores the need for more systematic and high-quality empirical research.

Fourth, evaluation frameworks vary widely. Kirkpatrick's four-level model dominates, privileging individual learning outcomes while neglecting organisational and systemic dimensions. Other models (e.g., CIPP, Kaufman) are applied inconsistently. Few studies adopt longitudinal approaches, meaning that long-term retention, organisational change, or systemic collaboration effects remain under-documented.

Fifth, the measurement of tacit knowledge poses significant methodological challenges. Explicit knowledge gains can be evaluated through formal assessments, but tacit knowledge, which is embedded in judgment, intuition, and sense-making, is far more difficult to capture. Existing tools are often inadequate for detecting these subtle forms of expertise, creating an empirical gap around some of the most critical outcomes of FSEs.

Finally, the evidence base is shaped by linguistic and disciplinary biases. Restricting the review to English-language publications risks excluding insights from regions most affected by disasters. Similarly, the literature is dominated by disaster medicine, with fewer contributions from logistics, organisational studies, or management research. This disciplinary concentration narrows the perspective on FSX and their broader role in humanitarian effectiveness.

Taken together, these limitations underscore the need for greater methodological rigour, conceptual clarity, and diversity of cases. At the same time, they highlight opportunities for future research: addressing these gaps would not only

strengthen empirical robustness but also enable theory-building that more accurately reflects the realities of humanitarian operations.

6.4 Practical and Policy Implications

The findings also carry practical implications for humanitarian actors at multiple levels.

For humanitarian organisations, FSEs should be institutionalised as part of organisational knowledge management rather than treated as ad hoc training events. Embedding exercises into regular preparedness cycles, pairing them with structured debriefs, and codifying lessons into training artefacts can preserve tacit insights and reduce knowledge loss from staff turnover. Organisational cultures that value openness and trust are equally important, as they ensure that informal exchanges complement formal repositories.

For donors, investing in FSEs should be reframed as a cost-saving preparedness strategy rather than an optional training expense. Evidence shows that poor knowledge-sharing increases duplication and waste in humanitarian logistics (Van Wassenhove, 2006; Kovács & Spens, 2007). By funding exercises, certification schemes, and inter-agency platforms, donors can strengthen systemic efficiency and create durable knowledge infrastructures that improve value for money.

For governments, FSEs can be embedded into national preparedness architectures. By aligning exercises with response plans, accreditation systems, and professional development frameworks, governments can ensure coherence across agencies. Multi-jurisdiction simulations, particularly for hazards that cross borders, enhance interoperability. While high-fidelity simulations are resource-intensive, they are cost-effective compared to failures in real crises.

Alignment with global frameworks strengthens these practical implications. The Sendai Framework for Disaster Risk Reduction (2015–2030) explicitly recognises simulation as a preparedness tool. The Grand Bargain (2016) calls for joint learning and accountability. WHO's IHR Monitoring and Evaluation Framework institutionalises after-action reviews. Positioning FSX within these

frameworks allows organisations and governments to present them not as isolated events but as auditable, policy-aligned investments in resilience.

6.5 Comparative Insights from Adjacent Fields

The humanitarian sector can also learn from adjacent fields where simulation-based learning has become systematically embedded.

In healthcare, simulation is widely incorporated into training curricula, with strong evidence that repeated exposure improves clinical competence and patient safety. Reviews have shown that high-fidelity simulation leads to sustained learning gains and behavioural improvements (Issenberg et al., 2005; Lateef, 2010). These findings demonstrate how structured simulation can move beyond isolated exercises to become a core pedagogical tool.

In aviation, crew resource management (CRM) programmes, which are grounded in simulation and structured debriefing, have institutionalised tacit knowledge transfer and contributed to significant safety improvements. A substantial body of evidence demonstrates that CRM builds shared mental models, enhances coordination, and reduces human error (Helmreich & Foushee, 2010; Salas et al., 2006). The aviation sector therefore illustrates how the systematic use of simulation can drive sector-wide cultural and operational change.

Military and emergency management fields also provide instructive parallels. Stress exposure training and disaster exercises have been shown to strengthen adaptive expertise and team coordination, preparing both professionals and volunteers for unpredictable conditions (Cannon-Bowers & Salas, 1998; Perry, 2004). These examples highlight the value of combining high-fidelity simulation with structured debriefing and iterative practice.

Three cross-cutting lessons emerge. First, the importance of standardised design and evaluation frameworks: without shared metrics, simulation outcomes remain difficult to compare. Second, the institutionalisation of debriefing and codification processes, which ensure that tacit lessons are systematically captured. Third, long-term commitment from regulators and funders, which sustains continuity beyond individual projects.

By contrast, humanitarian full-scale simulation exercises often remain ad hoc, inconsistently evaluated, and underfunded. Adapting approaches from healthcare and aviation could help institutionalise FSEs in humanitarian practice, while recognising the sector's unique constraints of resource scarcity, high turnover, and multi-agency coordination.

These adjacent sectors illustrate how simulation-based learning can be institutionalised through standardised frameworks, structured debriefing, and sustained investment. For the humanitarian field, the contrast highlights the relative immaturity of FSX research and practice. This comparison not only underscores the potential of adapting lessons from healthcare and aviation but also points directly to future research needs, which are outlined in the next section.

6.6 Future Research Directions

Several avenues emerge for advancing research on FSEs and knowledge creation in humanitarian contexts.

First, there is a clear need for geographic diversification. Current research is heavily concentrated in high-income countries, while disasters disproportionately affect low- and middle-income settings. Expanding empirical work in these regions would enhance both the representativeness and practical relevance of findings (Twigg & Mosel, 2017). Community-based or modular simulations, as well as digital formats, could provide lower-cost alternatives that are more feasible in resource-constrained contexts.

Second, more work is required to establish causal links to real-world outcomes. Most studies rely on self-reported confidence or short-term knowledge gains, leaving open the question of whether FSEs translate into improved operational performance during actual disasters. Longitudinal and quasi-experimental designs could help capture whether learning persists and whether it changes behaviours in real emergencies (Dieckmann et al., 2009).

Third, there is a need for improved evaluation frameworks. Current reliance on Kirkpatrick's four-level model privileges individual outcomes while neglecting organisational or systemic impacts. Alternative or hybrid models—such as the

Context–Input–Process–Product (CIPP) framework (Stufflebeam, 2003) or Kaufman’s five levels—could provide a more holistic view. Newer methods, including behavioural observation, ethnography, and network analysis, may also be better suited to capturing tacit knowledge transfer, which is inherently difficult to measure (Polanyi, 1966; Eraut, 2000).

Fourth, stronger theoretical integration is required. Few studies in the humanitarian FSEs literature engage explicitly with Knowledge Creation Theory (Nonaka & Takeuchi, 1995), organisational learning (Argyris & Schön, 1978), or absorptive capacity frameworks (Cohen & Levinthal, 1990). Anchoring empirical work in these concepts would not only improve comparability but also support cumulative theory-building in a fragmented field.

Fifth, interdisciplinarity should be prioritised. Simulation-based training has advanced significantly in healthcare, aviation, and the military (Salas et al., 2006; Issenberg et al., 2005). Cross-sectoral research could identify which design features—such as fidelity, debriefing structures, or frequency of repetition—are transferable to humanitarian operations, and which require adaptation to contexts of resource scarcity and multi-agency coordination.

Finally, technological innovation presents both opportunities and challenges. The COVID-19 pandemic accelerated the uptake of virtual and hybrid simulation models (Lateef, 2020). Future research should examine their effectiveness relative to high-fidelity in-person simulations, particularly in terms of cost–benefit trade-offs, scalability, and knowledge retention. Comparative studies across modalities could help organisations make informed investment decisions.

Taken together, these directions point to a research agenda that is more global, rigorous, theoretically grounded, and methodologically innovative. Addressing these gaps would not only advance academic understanding but also strengthen the practical contribution of FSX to humanitarian preparedness and resilience.

6.7 Final Reflection

This review has examined how full-scale simulation exercises contribute to humanitarian effectiveness by advancing processes of knowledge creation. Viewed through the lens of Knowledge Creation Theory, FSEs emerge not only as training events but also as infrastructures for preserving tacit expertise, embedding organisational memory, and fostering inter-organisational collaboration.

At the same time, the analysis reveals persistent gaps. Tacit knowledge remains under-theorised, low- and middle-income countries are under-represented, and evaluation practices are inconsistent. These limitations mirror broader humanitarian challenges of fragmentation, resource disparities, and uneven representation in global knowledge production.

Ultimately, humanitarian effectiveness depends on the capacity to learn, adapt, and collaborate under uncertainty. FSEs provide rare opportunities to rehearse these capacities, transforming individual experiences into institutional memory and collective resilience. The task ahead is to ensure that such exercises are systematically implemented, equitably distributed, and rigorously studied. Doing so would not only enhance preparedness for crises but also strengthen the humanitarian system's ability to evolve as a learning system in its own right.

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8 Appendices

Appendix A Ethical Approval Letter



21 May 2025

Dear Ms Liu ,

Reference: CURES/25262/2025

Project ID: 28766

Title: Evaluating the Effectiveness of Supply Chain Simulation Exercises in Public Health: A Literature Review Perspective

Thank you for your application to the Cranfield University Research Ethics System (CURES).

We are pleased to inform you your CURES application, reference CURES/25262/2025 has been reviewed. You may now proceed with the research activities you have sought approval for.

If you have any queries, please contact CURES Support.

We wish you every success with your project.

Regards,

CURES Team

Appendix B Systematic Literature Review Screening Process

This appendix provides an overview of the screening and eligibility assessment conducted as part of the systematic literature review. A total of 573 studies were initially identified and screened in multiple stages. Detailed records were maintained in Microsoft Excel to ensure transparency and replicability.

The complete datasets are provided separately as supplementary files:

- **SLR Screening Process for Search String 1**
- **SLR Screening Process for Search String 2**

These supplementary materials serve as a comprehensive audit trail, documenting how studies were identified, screened, included, or excluded in line with established SLR methodological guidelines.

Appendix C Data Extraction Forms

The complete data extraction forms for the 28 articles included in this review are provided separately in the supporting file titled **28 Articles Data Extraction Form**. This supplementary file contains the screening records and extracted information that formed the basis for the analysis presented in this thesis.

Appendix D Quality Appraisal Scores and Study Methodologies

Author Name and Pub Date	All Studies		Qualitative Studies					Quantitative Non-randomized					Quantitative descriptive					Mixed-Methods					Quality
	S1	S2	1.1	1.2	1.3	1.4	1.5	3.1	3.2	3.3	3.4	3.5	4.1	4.2	4.3	4.4	4.5	5.1	5.2	5.3	5.4	5.5	
Bank and Khalil (2016)	Y	Y						Y	Y	Y	Y	C											High
Skryabina et al. (2020)	Y	Y																Y	Y	Y	C	Y	High
Harris et al. (2015)	Y	Y											C	C	N	Y	N						Low
Burke et al. (2014)	Y	Y																Y	N	Y	Y	C	High
Alexander et al. (2005)	Y	Y						Y	C	Y	Y	N											Medium
Lowe et al. (2016)																							Not applicable
Jafar and Fletcher (2020)	Y	Y											C	Y	Y	Y	Y						High
Okunromade et al. (2019)	Y	Y											Y	C	Y	C	Y						Medium
Mavroulis et al. (2025)	Y	Y	Y	C	C	Y	N																Medium
Aliakbari et al. (2022)	Y	Y						Y	C	Y	Y	N											Medium
Gralla et al. (2015)	Y	Y	Y	C	C	C	N																Low
Wagner and Thakur-Weigold (2018)	Y	Y	Y	C	C	Y	N																Medium
Mahdi et al. (2023)																							Not applicable
Pek et al. (2023)																							Not applicable
Weinstein et al. (2023)	Y	Y																Y	Y	Y	Y	Y	High
Waring et al. (2024)	Y	Y																					Not applicable
Along et al. (2022)			Y	Y	Y	Y	C																High
Berri and Donnelly (2021)	Y	Y	Y	Y	Y	Y	C																High
Cozzolino et al. (2017)	Y	Y	Y	C	C	C	N																Low
Lu et al. (2013)																							Not applicable
Chin et al. (2022)																							Not applicable
Bölsche et al. (2013)	Y	Y											C	N	Y	Y	Y						Medium
Tatham and Spens (2011)																							Not applicable
Kusumastuti et al. (2021)	Y	Y																Y	Y	Y	Y	Y	High
Caballero-Anthony et al. (2021)	Y	Y	Y	Y	C	C	Y																Medium
Paton and Jackson (2002)	Y	Y											C	C	Y	Y	Y						Medium
Armstrong and Mahmud (2008)	Y	Y						Y	Y	C	Y	Y											High
Ford and Schmidt (2000)																							Not applicable

Figure 8-1: Quality Appraisal of Included Studies

Author Name and Pub Date	Methodology	Quality
Bank and Khalil (2016)	Quantitative Non-randomized	High
Skryabina et al. (2020)	Mixed-Methods	High
Harris et al. (2015)	Quantitative descriptive	Low
Burke et al. (2014)	Mixed-Methods	High
Alexander et al. (2005)	Quantitative Non-randomized	Medium
Lowe et al. (2016)	Conceptual Article	Not applicable
Jafar and Fletcher (2020)	Quantitative descriptive	High
Okunromade et al. (2019)	Quantitative descriptive	Medium
Mavroulis et al. (2025)	Qualitative Studies	Medium
Aliakbari et al. (2022)	Quantitative Non-randomized	Medium
Gralla et al. (2015)	Qualitative Studies	Low
Wagner and Thakur-Weigold (2018)	Qualitative Studies	Medium
Mahdi et al. (2023)	Systematic Review	Not applicable
Pek et al. (2023)	Scoping Review	Not applicable
Weinstein et al. (2023)	Mixed-Methods	High
Waring et al. (2024)	Secondary Research	Not applicable
Along et al. (2022)	Qualitative Studies	High
Berri and Donnelly (2021)	Qualitative Studies	High
Cozzolino et al. (2017)	Qualitative Studies	Low
Lu et al. (2013)	Conceptual Article	Not applicable
Chin et al. (2022)	Conceptual Article	Not applicable
Bölsche et al. (2013)	Quantitative descriptive	Medium
Tatham and Spens (2011)	Conceptual Article	Not applicable
Kusumastuti et al. (2021)	Mixed-Methods	High
Caballero-Anthony et al. (2021)	Qualitative Studies	Medium
Paton and Jackson (2002)	Quantitative descriptive	Medium
Armstrong and Mahmud (2008)	Quantitative Non-randomized	High
Ford and Schmidt (2000)	Conceptual Article	Not applicable

Figure 8-2: Summary of Study Methodology Types and Quality Ratings

Appendix E Gioia Method Coding Structures

1st Order Concepts	2nd Order Themes	Aggregate Dimensions
Local knowledge was shared informally through purposeful conversations (Berri and Donnelly, 2021)	Informal learning	SECI Model: Socialisation
The cross training can facilitate implicit coordination among team members and greater team adaptability (Ford & Schmidt, 2000)	Informal learning	
An experiential learning environment, accommodations value a lack of structure, and a high amount of peer interaction (Armstrong & Mahmud, 2008)	Individuals interaction	
Operational exercises increase nurses' competence (Alakbari et al., 2022)	Enhanced professional competence	SECI Model: Internalisation
There were significant perceived improvements in the participants' abilities (Bank and Khalil, 2016)	Enhanced professional competence	
Exercise participation made a positive difference to ability to respond, especially for hospital staff (Skryabina et al., 2020)	Enhanced professional competence	
Significant strides in their preparedness levels and ability to augment surge capacity (Harris et al., 2015)	Enhanced professional competence	
A majority of participants reported that the exercise enhanced their preparedness for managing pediatric victims in a disaster (Burke et al., 2014)	Enhanced professional competence	
The Core Capabilities identified for improvement during the full-scale exercise (Lowe et al., 2016)	Enhanced professional competence	
Instilling knowledge, skill, and attitude both at an individual level and as an interprofessional team (Waring et al., 2024)	Enhanced professional competence	
Individuals are more motivated, use problem-solving strategies that require conscious attention (Gralla et al., 2015)	Enhanced professional competence	
Maintain competencies of rarely used skills (Weinstein et al., 2023)	Enhanced professional competence	
Simulations promote the integration of theory and application essential (Paton & Jackson, 2002)	Enhanced professional competence	
Action learning can lead to creative ideas and innovative strategies for emergency scenarios (Cuzzolino et al., 2017)	Enhanced professional competence	
Participation in the exercise made a positive difference to their ability to respond (Skryabina et al., 2020)	Enhanced professional competence	
Developed skills in teamwork and specific aspects of disaster management (Burke et al., 2014)	Enhanced professional competence	
Develop the individual's manual abilities (Weinstein et al., 2023)	Enhanced professional competence	
Superior knowledge acquisition and retention following simulation-based learning (Bank & Khalil, 2016)	Explicit knowledge acquisition	
The exercises were useful and increased their knowledge (Skryabina et al., 2020)	Explicit knowledge acquisition	
Accumulate knowledge through direct experience and reflective observation (Wagner & Thakur-Weigold, 2018)	Explicit knowledge acquisition	
The first strategy supporting retention is training for mastery (Gralla et al., 2015)	Knowledge retention	
Participants are able to retain and generalize their knowledge for future emergencies (Gralla et al., 2015)	Knowledge retention	
This perceived improvement was retained at six months (Bank & Khalil, 2016)	Knowledge retention	
Direct impact of HEPEs (health emergency preparedness exercises) on the response to a subsequent mass casualty terrorist incident in the UK (Skryabina et al., 2020)	Knowledge retention	
Develop the individual's retention of the material (Weinstein et al., 2023)	Knowledge retention	
This style is important for effectiveness in action-oriented careers where one must adapt oneself to changing circumstances (Armstrong & Mahmud, 2008)	Adaptive capability	
Adaptive expertise is enhanced through training in active environments that resemble on-the-job tasks (Gralla et al., 2015)	Adaptive capability	
Build more learning depth as well as to promote adaptive expertise (Ford and Schmidt, 2000)	Adaptive capability	

Figure 8-3: Gioia Method Coding Structure for RQ1

1st Order Concepts	2nd Order Themes	Aggregate Dimensions
Disaster simulations provided participants with opportunities to access and exchange the tacit know-how of providers through realistic scenarios (Kusumastuti et al., 2021)	Simulation exercises	Simulation-based Exercises
Simulations and assessment centres foster the development and transfer of tacit knowledge (Paton & Jackson, 2002)	Simulations and assessment centres	
Standardized training and certification are needed in humanitarian organizations (Bolsche et al., 2013)	standardized training	
Nightly debriefs deliver feedback and guidance, with the simulation paused for reflection (Gralla et al., 2015)	Debriefing	Structured Debriefing in Simulation-based Exercises
Evidence highlights the importance of debriefs for allowing responders to reflect on individual, intra- and inter-agency response (Waring et al., 2024)	Debriefing	
A crucial component of any MCI (Mass Casualty Incident) simulation is the debriefing process following the activity (Weinstein et al., 2023)	Debriefing	
The artifact we created (i.e. the High Energy Biscuits Game with its debrief), can be stored, transmitted and reused (Wagner & Thakur-Weigold, 2018)	Knowledge codification	Knowledge codification and training artifacts
A large part of necessary tacit knowledge need to be structural in the humanitarian logistics sector (Bolsche et al., 2013)	knowledge codification	
A knowledge-centred culture facilitates good knowledge management practices within an organisation (Caballero-Anthony et al., 2021)	Knowledge-centred culture	Organizational culture and informal sharing
The supportive and decentralised managerial styles can significantly enhance knowledge sharing (Berri & Donnelly, 2021)	Decentralization and supportive style	

Figure 8-4: Gioia Method Coding Structure for RQ2

1st Order Concepts	2nd Order Themes	Aggregate Dimensions
Full-scale exercise evaluates the emergency management system in a highly stressful environment (Pek et al., 2023)	Full-scale simulation exercises (FSE)	Collaboration enhancement through FSE
Hotwash showed the FSE (Full-Scale Exercises) was a unique opportunity for central, regional, and local authorities to meet and work together (Mavroulis et al., 2025)	Full-scale simulation exercises (FSE)	
the World Food Programme's Logistics Response Team training gives participants a shared experience that helps them understand each other's needs and collaborate more effectively during real emergencies (Gralla et al., 2019)	Full-scale simulation exercises (FSE)	
Full-scale Yellow Fever Simulation Exercise strengthened individual and institutional response capacity, deepened partnerships, teamwork, and multisectoral collaboration, and fostered regional relationships (Okunromade et al., 2019)	Full-scale simulation exercises (FSE)	
Global inconsistency in responding to COVID-19 shows the necessity of full-scale operational exercises to strengthen preparedness for pandemics and disasters (Mahdi et al., 2023)	Full-scale simulation exercises (FSE)	
Knowledge from multiple stakeholders should be merged, combined, and standardised to reduce casualties, facilitate humanitarian operations, and ensure communities understand and use the information effectively (Along et al., 2022)	Integrating and standardising multi-stakeholder knowledge	Knowledge and information management
Knowledge sharing, translation, and absorption created new knowledge and built an accessible knowledge base that consolidated collective memories for future use (Berri & Donnelly, 2021)	Building and sustaining organisational knowledge bases	
A comprehensive performance evaluation and the detailed report writing can codify field and supply-chain knowledge accumulated from the current operation for the future usage (Lu et al., 2013)	Performance evaluation and report writing	
Decision effectiveness depends on the ability to quickly access and interpret data from diverse sources under urgent and evolving conditions (Paton & Jackson, 2002)	Information management	
The participants recognized the underlying importance of clear and coordinated information management through the High Energy Biscuit Simulation Game	Information management	
Findings showed that involving multi-agency representatives in exercise planning and response improves collaboration skills and understanding of each other's roles, responsibilities, and plans	Strengthening inter-agency collaboration	
Sharing tacit knowledge between organizations from different industries requires collaboration based on close relationships	collaboration	
The warning signs of emerging humanitarian crises in the context of GPHE highlight the critical need to strengthen cross-cultural understanding in order to advance humanitarian knowledge	cross-cultural understanding	
	codification	

Figure 8-5: Gioia Method Coding Structure for RQ3