Disaster e-Health Scope and the Role of RFID for Healthcare Purposes

Samaneh Madanian

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To my family, and all who helped me in one way or another all throughout my life.

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Abstract

Disasters, either natural or manmade, are sudden and mostly unpredictable. They are of such enormous scale that it is necessary for societies to embark upon special planning and preparedness before disasters strike to prevent or diminish their destructive consequences. These plans aim at enhancing and facilitating response and recovery efforts. They are a part of two well-established domains: disaster management and disaster medicine.

There is intensifying research in the fields of disaster management and disaster medicine. The intention of these studies has been to find ways to enhance disaster response missions by concentrating on coordination, communication, situation awareness, and the overall decision-making process of top authorities and managers (Abkowitz, 2008). In this regard, some researchers, such as Sieben, Scott, and Palacios (2012) and Norris et al. (2015), have suggested systematic utilisation and integration of e-health technologies for healthcare purposes within the Disaster Management Cycle (DMC). This specific focus had not been addressed previously.

This research has identified an emerging field of Disaster e-Health (DEH) in the intersection of three areas: disaster management, disaster medicine, and e-health. The ultimate aim of DEH is enhancing the delivery of healthcare services and their quality in all phases of disasters through e-health technologies. Although currently various e-health technologies have been used within DMC for different purposes, their usage is ad hoc. To exploit the full potential of e-health technologies, a model is required that has not been addressed before; this model is DEH.

To better understand the potential of DEH, this research was conducted in three phases. First, a scoping review across the three above-mentioned fields that constitute DEH was undertaken. The outcome of this phase was defining the scope of DEH in which the included e-health technologies, their applications, services and futures as well as the related stakeholders were specified. Then, by finding inspiration from use-case methodology, the researcher defined a method for a systematic generation of functional scenarios within DMC. The aim of this phase was to identify the e-health technologies that could be used in these scenarios. Finally, in the third phase, the researcher tried to identify the role of RFID during the DMC. Potential uses of this technology were proposed for a number of scenarios that were generated for different disaster phases.

Finally, a Delphi method was conducted in which experts were asked to evaluate both the scope of DEH as well as the potential usefulness of RFID applications in the generated scenarios within DMC and DEH scope.

This research study contributes to the body of knowledge through defining the scope of DEH that clearly demonstrates its functionalities and potentials within DMC and for the involved stakeholders. Moreover, this research proposes a method for systematic scenario generation within DMC. A further key contribution of this study is the provision of a comprehensive investigation of RFID roles and applications within DMC.

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Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signed by: Samaneh Madanian

Date: 17 April 2018

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List of Abbreviations and Acronyms

APELL	Awareness and Preparedness for Emergencies at Local Level
APMO	Average Percent of Majority Opinions
BAN	Body Area Network
BD	Big Data
CC	Cloud Computing
CPOE	Computer Physician Order Entry
CRED	Centre for Research on the Epidemiology of Disasters
DECOI	Disaster e-Health Community of Interest
DEH	Disaster e-Health
DMC	Disaster Management Cycle
DSS	Decision Support System
DSS-DM	Decision Support System for Disaster Management
ED	Emergency Department
EHR	Electronic Healthcare Record
EKG	Electrocardiogram
EM	Emergency Medicine
EMR	Electronic Medical Record
EMS	Emergency Medical Services
FBO	Faith Based Organization
FDA	Food and Drug Administration
GIS	Geographical Information System

GPS	Global Positioning System
GSM	Global System for Mobile Communication
GPRS	General Packet Radio Services
HIS	Health Information System
ICT	Information and Communication Technology
IEMS	Integrated Emergency Management System
IoT	Internet of Things
IQD	Interquartile Deviation
IQR	Interquartile Range
ITU	International Telecommunication Union
ITV	In-Transit Visibility
JCAHO	Joint Commission on Accreditation of Healthcare Organizations
MeSH	Medical Subject Headings
MIS	Management Information System
MH	Mobile Health
MSF	Médecins Sans Frontières
NGO	Non-Profit Organization
NFC	Near Field Communication
PAHO	Pan American Health Organization
PDA	Personal Digital Assistant
PHR	Personal Health Record
RAND	**R**esearch **AN**d **D**evelopment

RFID	Radio Frequency Identification
SDO	Service Delivery and Organisation
SN	Social Network
TH	Telehealth
TTF	Task-Technology Fit
UN	United Nations
UNEP	United Nations Environment Programme
UNISDR	United Nations International Strategy for Disaster Reduction
WAN	Wide Area Network
WHO	World Health Organization
WSN	Wireless Sensor Network

CHAPTER 1

INTRODUCTION

1.1 Introduction

The current thesis investigated Disaster e-Health (DEH), a recently emerged paradigm in the intersection of the fields of disaster management, disaster medicine, and e-health. The primary goal of the research was to define its scope and then consider a systematic scenario generation idea for developing disaster scenarios for all phases of disasters. Moreover, its final goal was to explore the Radio Frequency Identification (RFID) applications and its role within DEH scope.

DEH mainly deals with utilising e-health technologies at pre- and post-disaster phases to provide effective and efficient healthcare services for citizens. However, from among available e-health technologies, this thesis chose to study the role of RFID technology for the healthcare purposes within disaster management cycles (DMC) and for DEH scope. Moreover, this research aimed to explore the implications of technology-use scenario method for DEH disaster scenario generation (functional scenario).

This chapter gives an overview of the research. Section 1.2 provides background for the research. In section 1.3, the key research concepts are identified and defined. The research motivations, aims, and objectives, as well as research questions are discussed in sections 1.4, 1.5 and 1.6. This discussion is followed by details of the study approach and research design (section 1.7), after which the significance of the study is highlighted. The chapter includes a list of papers related to this research, which were delivered at conferences and symposia (section 1.9), before concluding with an outline of the thesis structure in section 1.10.

1.2 Research Background

Disasters are destructive events threatening public health and the environment and disrupting and/or impeding normal operations. The source of disasters can be natural, such as hurricanes (Baldini, Hess, Oliveri, Seuschek, & Braun, 2011), earthquakes (Nekooei Moghadam, Saeed, Khanjani, & Arab, 2011; Tahmasebi et al., 2005), tsunamis and floods (H. J. Meyer, Chansue, & Monticelli, 2006) and bushfires (ABC News, 2009). Disasters can also be the result of human actions or mistakes (Baldini et al., 2011), for example, terrorist attacks (Arnold, 2002), fires (Piza, Steinman, Baldisserotto, Morbeck, & Silva, 2014) and civil wars (Trim, 2004). Disease epidemics, such as Ebola (CNN, 2014), sometimes have severe consequences: killing thousands of people or making them homeless, destroying health infrastructure, and disrupting public and commercial services. Ebola that has claimed over 5,500 deaths only in West Africa (CNN, 2014).

Natural disasters occurring over the past decade or so (see Althwab & Norris, 2013 and Chatfield, Wamba, & Tatano, 2010) include the 2004 Indian Ocean tsunami in which more than 288,000 people died in a dozen countries; Hurricane Katrina in the USA was responsible for over 1,800 causalities; the devastating 2010 Haiti earthquake killed more than 300,000 people; the 2011 Tōhoku earthquake and tsunami killed nearly 16,000; the 2009 Victoria bushfires, whilst resulting in less than 200 deaths, devastated over 450,000 hectares of land and destroyed more than 2,000 homes. According to Chan, Killeen, Griswold, & Lenert (2004), disasters happen almost every day around the globe. However, statistics from Centre for Research on the Epidemiology of Disasters (CRED) show that the severity, and complexity (damage to life and property) of disasters have significantly increased over recent decades (Figure 1.2). This centre has been active for almost 50 years. According to the centre database, in 2016, 341 natural disasters occurred: these caused 10,201 deaths, affected a further 199,592,192 and cost USD147,781,165,000.

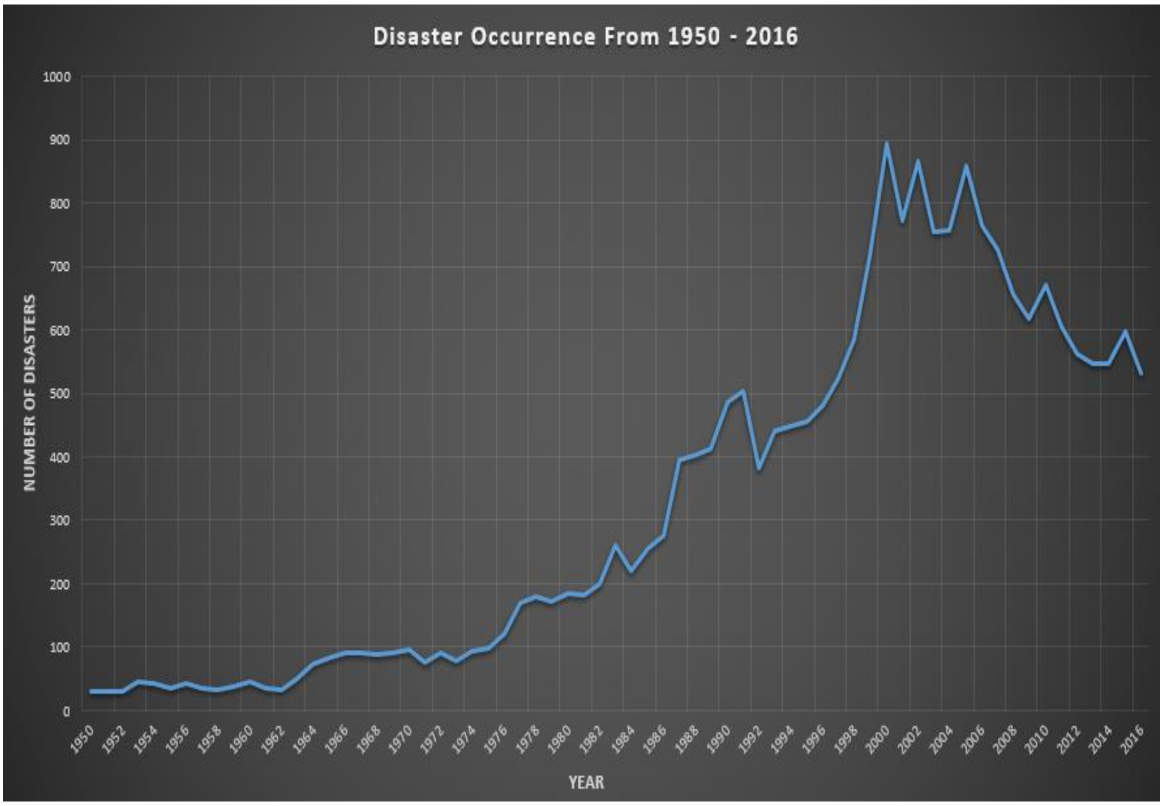

Figure 1.1 Disaster occurrence (statistics extracted from CRED , n.d.)

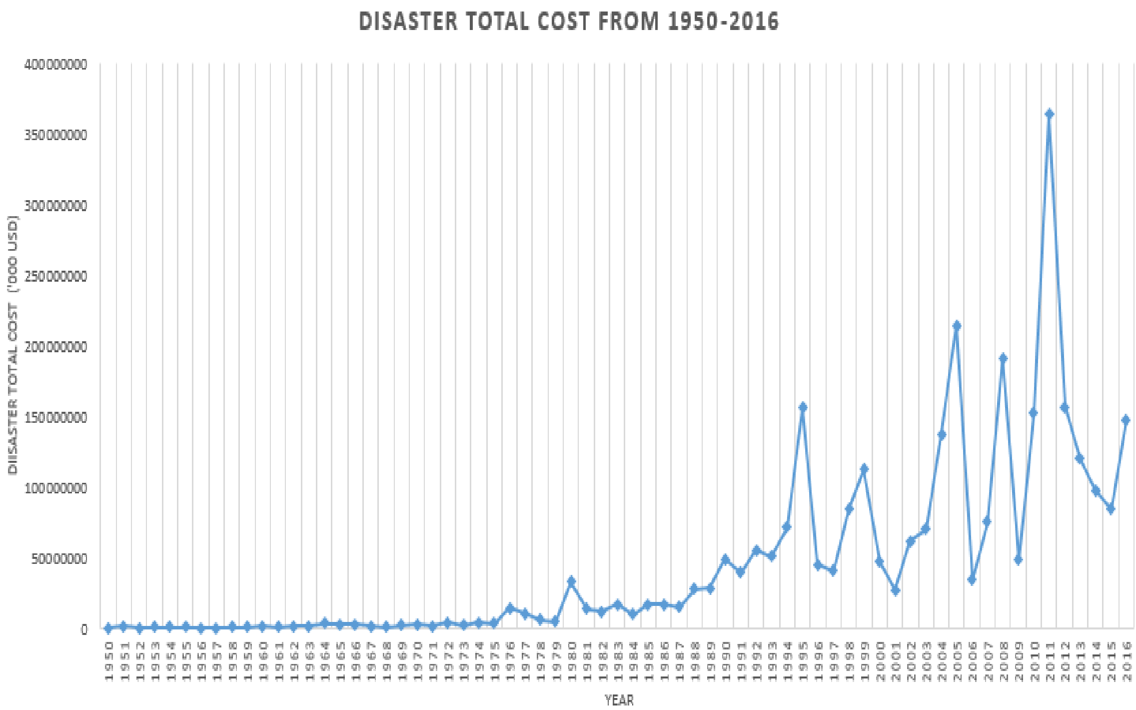

Figure 1.2 Disaster - total cost from 1950 to 2016 (statistics extracted from CRED, n.d.)

In any disaster, regardless of the cause, one of the most important and immediate considerations is responding to healthcare demands. This can begin with public health education and continue through to treating casualties for injuries and reducing the impact of their trauma immediately after the disaster. Health effects of disasters can be physical as well as psychological; full recovery, even if possible, can take several years.

This research focuses on the healthcare demands of the population at all stages of the disaster cycle. DMC encompasses four phases: mitigation, preparedness, response, and recovery (Baldini, M. Braun, E. Hess, F. Oliveri, & H. Seuschek, 2009). In this regard, the objective of the current study is to assess the role of e-health technologies in each phase of disasters and help investigate the area of DEH. DEH has been proposed by Norris et al., 2015 as able to overcome the challenges of disasters by devising a model to utilise e-health applications for improving disaster healthcare in all phases of the DMC.

1.3 Definition of Key Concepts

In the following subsections, the operational definitions for some key concepts used in this study are given.

1.3.1 Disaster

Disasters are sudden events that impose casualties and property destruction upon human societies. They disrupt services and the general course of life of the affected people in such a way that extra measures are required to deal with them as compared to normal situations. The main differentiating feature of disasters as compared to other events, such as emergencies, is that responding to them overwhelms a nation's capacity and the rescue resources that are usually available (Adler et al., 2011). Disasters differ with regard to their severity (magnitude and intensity) and can curb the administrative potentials of the involved organisations.

There is no single universally accepted definition of a disaster, however, for this research the following definition is adopted:

> A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts,

which exceed the ability of the affected community or society to cope using its own resources (United Nations, 2009, p. 9).

Regardless of disaster type and source, their consequences involve injuries to, and deaths of the affected people as well as varying degrees of damage to the area's infrastructure (C. Adler et al., 2011).

1.3.2 Disaster Management

'Disaster management' is a general term including all phases of planning for, and reacting to disasters. It is defined as "the coordination and integration of all activities necessary to build, sustain, and improve the capabilities to prepare for, respond to, recover from, or mitigate against threatened or actual disasters or emergencies, regardless of cause"(Blanchard, 2008, p. 344). Disaster management attempts to minimise the effect of disasters by various activities, including "damage assessment, reconstruction, emergency health services and the creation of supply chains to bring needed goods" (Baldini et al., 2011, p. 43).

1.3.3 Disaster Medicine

The need to provide healthcare in disasters has led to the development of 'disaster medicine specialty' defined as medical and medico-organisational actions performed in disasters (de Boer, 1995). It developed from military medicine (Rüter, 2006) for surgical responses to war casualties from the field disaster to the hospital bed (de Boer, 1995). 'Disaster medicine' can be defined as "a system of study and medical practice associated primarily with the disciplines of emergency medicine and public health" (Hogan & Burstein, 2007, p. 2). This area concentrates on disaster casualties' medical demands; however, its practitioners need to have an understanding of the main elements of disaster management: planning, mitigation, assessment, response, and recovery (Hogan & Burstein, 2007).

1.3.4 e-Health Technology

In 2003, the Service Delivery and Organisation (SDO) Programme Board of the National

Health Service in the UK identified e-health as an important area for future research (S. Anderson, Allen, Peckham, & Goodwin, 2008). In 2005, the World Health Organization (WHO) defined e-health as “the cost-effective and secure use of ICT in support of health and health-related fields, including healthcare services, health surveillance, health literature, and health education, knowledge and research" (World Health Organization, 2005, p. 121).

e-Health encompasses a variety of technologies from telemedicine and mobile health to big data, Electronic Healthcare Record (EHR), Decision Support System (DSS), the Internet of Things (IoT), and RFID. It also includes a wide range of health services like home monitoring systems, online health information websites, automated online therapy, interactive electronic health records, shared electronic records, tailored health education programmes, healthcare system portals, mobile health communication programmes, and advanced telehealth applications.

1.4 Research Motivation and Problem Statement

Disasters cause environmental destruction, human condition and life degradation, and social and economic disruption incur enormous costs to people worldwide (Madanian, Parry, & Norris, 2015). Disasters also impose a lot of pressure on medical and public health services. Based on the trend in Figure 1.1, it can be expected that in future this upward trend will continue in terms of both disaster occurrences and their effects. Consequently, susceptibility to natural and environmental disasters is tending to grow, and it is anticipated that more people will be affected by disasters in the coming years. Contributing causes include global climate change, population increase, industrialisation, the spread of communicable infectious diseases, terrorist threats, increasing urbanisation, and global conflicts (Arnold, 2002; Patricelli, Beakley, Carnevale, Tarabochia, & Von Lubitz, 2009; Subbarao et al., 2008). Furthermore, based on the current evidence (Figures 1.1 and 1.2), there is no easy way to reduce the impacts of disasters; therefore, carrying out research to find ways in which technology can help is vital (Chan et al., 2004)

In this regard, preparing plans for rescuing people and preventing life loss due to disasters is becoming one of the top priorities of any government. These plans form the disaster management and disaster medicine disciplines that, if enacted properly, can significantly lessen the harmful effects of disasters. However, both disaster management and disaster medicine operations are frequently far from perfect and have a long list of failures (Levett, 2015); having efficient disaster management is a problematic area for many countries. Moreover, disaster medicine had poor communication with disaster management, so much so that Bissell (2007, p. 20) claims "emergency management and the health sectors are natural allies that have, seemingly, only recently begun to recognise each other". According to the reviewed literature, some major factors contributing to these inefficiencies are:

- Both disaster medicine and disaster management have different roots, development, and priorities in a way that coordination and communication between them in disasters is often missing, and it leads to delayed, sub-standard, improper, or sometimes no care (Norris et al., 2015).
- Although both areas emerged to work side by side in preparing for, responding to, and recovering from disasters, they sometimes fail to share their tools and personnel and have not collaborated smoothly in preparing for and responding to mass emergencies.
- Neither disaster medicine nor disaster management uses the new range of information or modern e-health technologies (Norris et al., 2015); since the latter is used in normal healthcare, it is believed that they can offer great potential at all stages of the DMC. Nevertheless, understanding exactly 'how' this potential can be realised has remained difficult to judge (Maturana, Scott, & Palacios, 2012) because there is no model for their usage in disasters.

These issues are the reasons that necessitate more research and better reports from disasters, especially for the healthcare sector that lacks an academic evidence base (Lee, Booth, Challen, Gardois, & Goodacre, 2014). Therefore, in this study the researcher endeavoured to identify the scope of DEH for overcoming the current issues and to determine how e-health applications can be used to improve disaster healthcare in all phases of the disaster cycle. These applications include not only those used in established e-health practice, but also those recently made available by the rapid development in mobile and sensor technologies, specifically RFID (for the reasons of selecting RFID, see 3.5.1).

1.5 Research Aims and Objectives

This research dealt with the current limitations and challenges in the areas of disaster management and disaster medicine in different phases of disaster. It also set to improve understanding of the role and application of different e-health technologies, specifically RFID technology in DMCs for healthcare purposes. Furthermore, this research inspired by the use-case methodology to generate functional scenarios for different disaster management phases.

To archive the research aims, the following objectives were set for this thesis:

1- identifying the current set of challenges in disaster management and disaster medicine for each disaster phase;
2- discovering the gap within the literature with a focus on disaster management, disaster medicine and healthcare requirements and demands;
3- investigating the role of e-health technologies and RFID, in particular within DMC and DEH scope;
4- identifying the scope of DEH;
5- examining technology-use scenario application for scenario generation; and
6- extending the current body of knowledge in the areas of disaster management and disaster medicine by utilising e-health technologies through introducing the DEH paradigm.

1.6 Research Questions

To achieve the research objectives, a preliminary study and database search were carried out to find the gaps in/among the research areas. This was a part of a scoping study, as discussed in chapter 5, section 5.2.1. The outcome of the preliminary study raised the following research questions:

1- What is the scope of DEH?
2- Can we represent disaster scenarios with use-cases, for example, in the domain of DEH?
3- What technology is appropriate for these use-cases?
4- How can these use-cases support practitioners?

5- What competencies and protocols will be needed for these technology applications?

However, all the research questions, except the first one, were modified in light of a comprehensive literature review and preliminary findings from the scoping study (see Figure 5.2 for the scoping study procedure). The finalised research questions for this study are:

1- What is the scope of DEH?

2- In the identified functional scenarios which e-health technologies are appropriate to satisfy healthcare requirements within DMC and DEH scope?

3- What is the role of RFID technology in DMC and within the DEH scope?

4- Among the identified roles for RFID, in the view of the experts, which of them are the most desirable and applicable?

1.7 Study Approach and Research Design

The overall flow of the research development is illustrated in Figure 1.3. The research started with problem(s) identification. This identification was carried out through a background review by which the gaps in and among areas of investigation were identified. These gaps formed the problem statement section. Accordingly, the research questions were formulated and the research objectives were set so that they were able to fill or narrow the identified gaps by the end of this thesis. Data gathering was performed in two phases followed by the data analysis in three phases. Finally, the research findings were evaluated using the Delphi method.

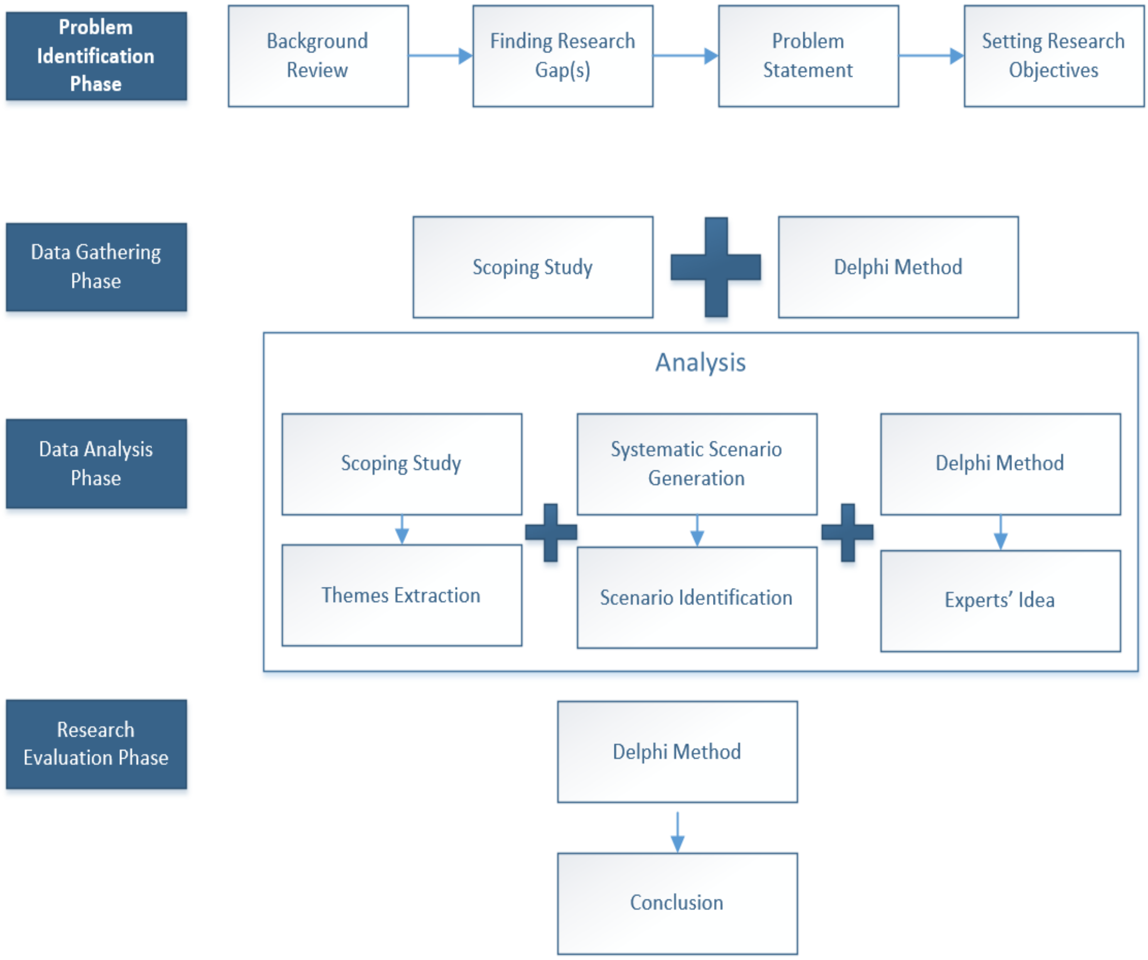

Figure 1.3 The overall research development

This research mostly followed a qualitative approach with an exploratory research design. For conducting this research, three different approaches were employed (see chapter 4 for their full explanation).

- ✓ Phase 1 - Scoping study: answering RQ 1, RQ 3 and RQ 4 (What is the scope of DEH?)
- ✓ Phase 2 - Functional scenario generation: answering RQ 2 (In the identified functional scenarios which e-health technologies are appropriate to satisfy healthcare requirements within DMC and DEH scope?)
- ✓ Phase 3 - Delphi Technique: answering RQ 3 and RQ 4 (as well as evaluating results and the overall research)

In phase 1, a scoping study was employed to define DEH scope and create a boundary for the field. Then, the extracted data from the scoping study was used for thematic analysis (Braun & Clarke, 2006) and content analysis (Mayring, 2000) to identify, analyse, and report the patterns (themes). These patterns help the researcher to analyse the data from a wide range of studies and define the DEH scope. For this phase, EndNote and Nvivo were employed for data extraction, text analysis and theme identification (see chapter 5 for more details). Then, by considering the results of thematic and content analysis and the review of the literature, the researcher identified disaster challenges in the DMC and categorised them based on the disaster phases. After that, inspired by use-case methodology, the researcher identified possible functional scenarios (see chapter 6).

For the last phase, the Delphi Method was employed in order to help us not only to gather experts' ideas and feedback on the results of the previous two stages, but also to evaluate the study findings. In this regard, based on the results of the scoping study (phase 1) and technology-use scenario (phase 2), a questionnaire was prepared. Afterwards, experts in the field (both academic and practitioners) were identified according to their prominent experience or distinguished academic achievements (publications in international conferences or scientific journals) in disaster management, disaster medicine, and/or e-health. They were then invited to participate in the study via email (see chapter 7 for more details).

1.8 Research Contribution

The importance of disaster management becomes clear after each major disaster when a country's resources are overwhelmed. Therefore, renewed interest in this field has appeared, especially after recent tragedies such as the Indian Ocean tsunami, Hurricane Katrina, the Haiti earthquake and many others. Those occurrences highlighted a real need for efficient disaster management to mitigate the pain and suffering and to alleviate the overall impact of disasters (Baldini et al., 2011). However, still many countries struggle with inadequate and ineffective disaster management (Sieben et al., 2012).

In this study, to narrow or, if possible, fill the identified gaps, Tufekci and Wallace (1998) believe it is necessary for disaster managers to employ developments in Information and Communication Technologies (ICT). This can be accomplished by considering research from recognised fields and introducing a new model that enables us to help integrate disaster management, disaster medicine, and healthcare and establish collaboration between them.

This study aims to identify ways to improve the use of IT technologies in disaster management and medicine fields. However, the applications of IT technologies are limited in the fields of disaster management and disaster medicine (Meissner, Luckenbach, Risse, Kirste, & Kirchner, 2002), yet they can offer great potential for improving efficiency and effectiveness in dealing with disasters. The underlying reason is that IT technologies currently provide such supports in people's daily life. Since e-health technologies are designed specifically for facilitating healthcare challenges in normal medicine, they may be useful within the disaster medicine discipline, which specifically deals with medical issues in disasters. It is vital, then, to "extend e-health applications to support disaster medicine" (Chronaki et al., 2008, p. 1005). It is possible that e-health also can be used in disaster situations to improve healthcare with the same results as in everyday medical care. This is because in such messy and disordered situations, new communications technologies, such as computer miniaturisation, the Internet, and advanced smart devices, may greatly enhance the emergency medical operations in disasters (Black et al., 2011).

This study aims to support a need to systematise technology usage across the boundaries of disaster management and disaster medicine with a new paradigm that applies information and e-health technologies to improve disaster health planning and response before, during and after disasters. As a result, the output of the current research will represent a model telling us what, when, and how current e-health technologies can be used in DMC, through the newly emergent DEH field. This work does not try to develop any new technologies, but to use the available e-health technologies more effectively as tools that can support disaster management and disaster medicine.

1.9 Publication List

Journal Paper

Parry, D., Madanian, S., Norris, T. (2018). Design considerations for a disaster ehealth appliance, *Journal of the International Society for Telemedicine and eHealth 6* (1), 4-1.

Conference Papers

1- Abbas, R., Norris, T., Madanian, S., & Parry, D. (2016). *Disaster e-health and interagency communication in disaster healthcare: A suggested road map.* HiNZ International Conference on Health informatics, Auckland, New Zealand.

2- Parry, D., Madanian, S., & Norris, T. (2016). *Disaster e-health - Sustainability in the extreme.* IEEE 14th Intl Conference on Dependable, Autonomic and Secure Computing, Auckland, New Zealand.

3- Madanian, S. (2016). *The use of e-health technology in healthcare environment: The role of RFID technology.* 10th International Conference on e-Commerce in Developing Countries: With Focus on e-Tourism (ECDC), Isfahan, Iran.

4- Madanian, S., Parry, D., & Norris, T. (2015). *Healthcare in disasters and the role of RFID.* 15th World Congress on Health and Biomedical Informatics (Medinfo), Brazil, Sao Paulo.

5- Norris, A. T., Martinez, S., Labaka, L., Madanian, S., Gonzalez, J. J. & Parry, D. (2015). *Disaster e-health: A new paradigm for collaborative healthcare in disasters.* 12th International Conference on Information Systems for Crisis Response and Management (ISCRAM), Norway, Kristiansand.

6- Madanian, S., & Madanian, A. S. (2015). *The role of healthcare information systems based on RFID technology in improving the delivered services in healthcare sector.* Presented as poster in IS National Conference, Tehran University, Tehran, Iran.

Symposia

7- Madanian, S. (2017). *Social media: From entertainment application to disaster management application.* 11th Annual AUT Postgraduate Research Symposium, August 18, Auckland, New Zealand. https://www.aut.ac.nz/__data/assets/pdf_file/0005/746609/Samaneh-Madanian.pdf

8- Madanian, S. (2016). *Disaster e-health scope and disaster scenario generation.* 10th Annual AUT Postgraduate Research Symposium, August 18, Auckland, New Zealand. https://dev.aut.ac.nz/being-a-student/current-postgraduates/academic-information/academic-study-support-and-resources/postgraduate-seminars-and-workshops/postgraduate-symposium/?a=673565

1.10 Thesis Structure

The structure of the thesis is in line with the research development discussed in section 1.6 so the overall structure of the thesis can be categorised into five main sections with their corresponding chapters for each research activity (Figure 1.4).

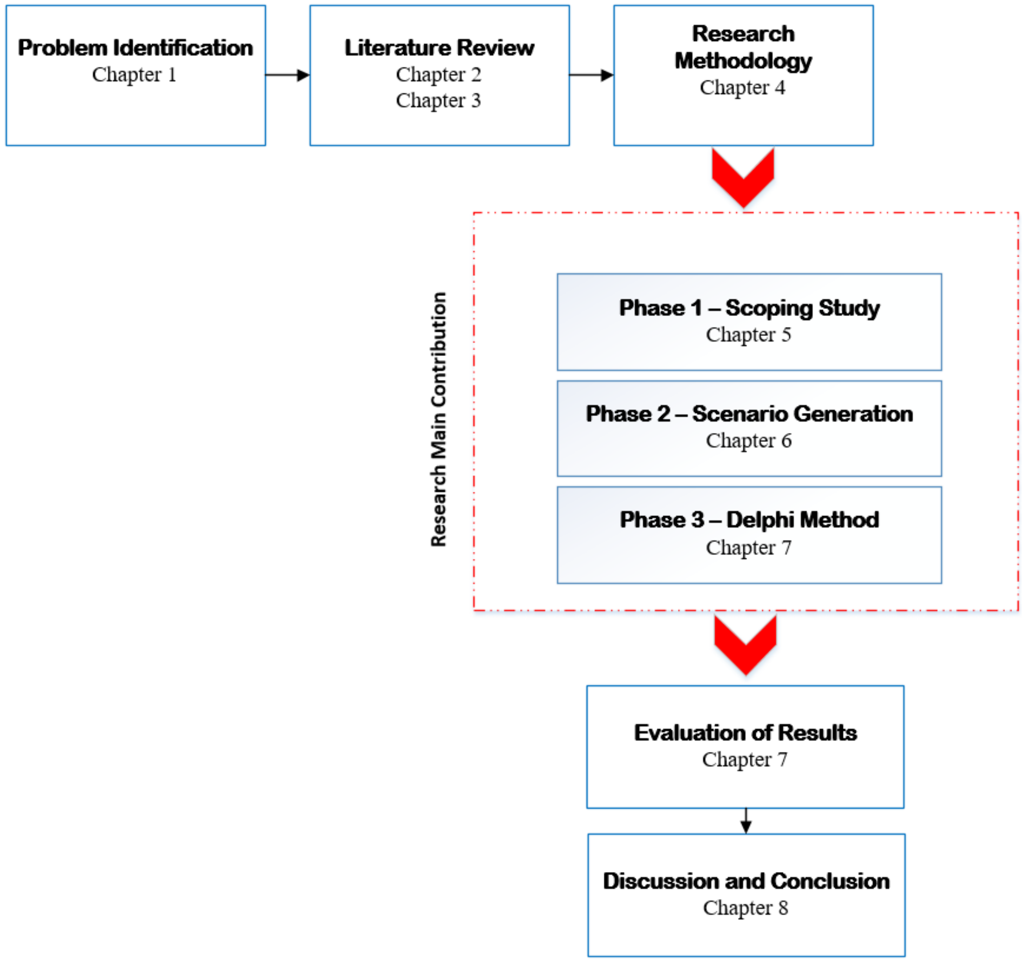

Figure 1.4 Thesis structure

For the 'Problem Identification' phase, chapter 1 herein provided an overview of the required information in different areas of disaster management, disaster medicine, e-health technologies, and DEH. It also introduced the research by way of detailing background information to the field and then explaining the key concepts underpinning the study. Then the chapter went on to discuss why there is a need to conduct research in this particular field, and, thus, what the aims and objectives are. Finally, the research questions and approach were set out.

Chapter 2 provides background information and fundamental concepts in the two fields of disaster management and disaster medicine. It also presents studies related to this field of study by considering them in relation to the research questions and objectives.

Chapter 3 reviews the e-health concept, its background and technologies. In the first section of the chapter, an overview of a number of e-health technologies and their applications within DMC is presented. The remainder of the chapter concentrates on IoT and RFID technologies, their applications for healthcare purposes and their usages for the DMC.

Chapter 4 describes the research process and design in detail together with their justifications. All the applied research methodologies in this study are also explained in this chapter. Moreover, it discusses scientific explanations for the applied data gathering and analysis methods.

Comprehensive details of the data analysis methods and their results are given in chapters 5, 6, and 7: they cover the scoping study, functional scenario generation by use-case methodology and Delphi method, respectively.

Finally, chapter 8 provides the discussion of the research findings and integrates all parts of the thesis into meaningful conclusions.

1.11 Chapter Summary

The purpose of this chapter was to introduce the aims of the current research. The chapter described research background together with definitions of the key concepts underpinning this study. This chapter also discussed the research motivations and current problems in the area that led to formulating the research questions. At the end of the chapter, the study approach and thesis structure were outlined and the researcher’s conference and symposia papers related to this study were listed.

The next chapter will provide a comprehensive discussion on the areas of disaster management and disaster medicine regard to citizens’ healthcare demands.

CHAPTER 2
DISASTER MANAGEMENT AND DISASTER MEDICINE LITERATURE REVIEW

2.1 Introduction

A literature review helps researchers to expand the knowledge about the area of investigation and to justify the proposed study as one that contributes something new to the cumulated knowledge (Paré, Trudel, Jaana, & Kitsiou, 2015).

Chapter 2 offers a comprehensive review of the international studies in the domains of disaster management and disaster medicine relevant to this research to present, rather than evaluate, the fundamental knowledge and concepts needed for the research study. The chapter begins by discussing the procedure of conducting the literature review of the two fields of disaster management and disaster medicine. It then addresses the healthcare challenges when disasters strike and during the post-disaster period. This chapter also emphasises the vital need for efficient and effective disaster management and disaster medicine systems in mitigating the consequences of disasters on citizen's health. Related studies are discussed to highlight the current limitations, barriers, and deficiencies within the disaster management and medicine disciplines.

2.2 Process for Literature Review

Research Question 1 (RQ1) focuses on disaster e-health (DEH) and on identifying its scope. As DEH is recently emerged, it has limited related literature and it is required to drill down to the areas upon which it is built. This means that to define this area and find its scope, it is necessary to consider the literature of its three main areas. Chapters 2 and 3 review DEH literature with regard to the fields of disaster management, disaster medicine and e-health.

This chapter concentrates on the disaster management and disaster medicine domains. By considering these two domains in tandem with the research questions and objectives, the following aspects were identified as needing to be addressed:

- Disaster management
- Disaster medicine
- Healthcare challenges in disaster management and disaster medicine

There are a significant number of studies that investigate different facets of each of the above aspects. Two separate review processes were followed to gather the key literature for this research. First, a broad search was undertaken through a scoping study of different electronic databases. The search framework, procedure and its comprehensive description are discussed in chapter 5). With regard to the scoping study results, those that related to the disaster management or disaster medicine fields were included in this literature review.

The second review process was more extensive and so is explained here in some detail. It was performed to investigate the current challenges and open issues in the literature related to the areas of disaster management and disaster medicine to address the two initial research objectives (discussed in chapter 1, section 1.5) as follows:

- identifying the current set of challenges faced by workers in disaster management and disaster medicine for each disaster phase; and
- discovering gaps within the literature with a focus on the disaster management, disaster medicine and healthcare requirements and demands.

As with the scoping study, this search was also conducted according to a modified framework based on the framework proposed by Templier & Paré (2015) (Figure 2.1).

In both literature review and scoping study procedures, those studies were considered that explored different disaster management frameworks, citizen healthcare requirements before, during and after disasters, and the challenges within the two disciplines of disaster management and disaster medicine that hinder improving quality healthcare for populations.

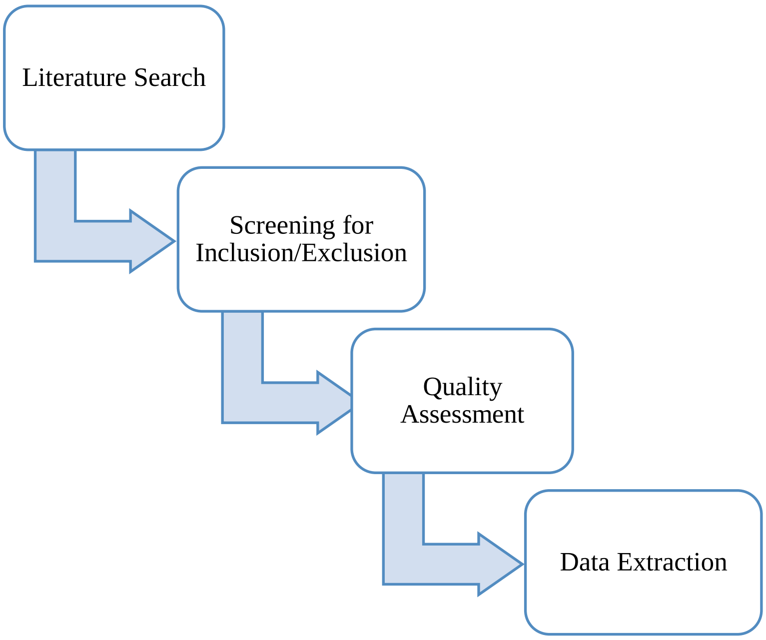

Figure 2.1 Review framework (adapted from Templier & Paré, 2015)

The literature review search was performed between June and August 2017, specifically on the following electronic databases:

- EBSCO
- ProQuest
- Google Scholar
- Scopus
- PLOS

On these databases, the search covered conference papers and journal articles, books and book chapters, as well as reports provided by Pan American Health Organization (PAHO), Centre for Research on the Epidemiology of Disasters (CRED), World Health Organization (WHO), United Nations Office for Disaster Risk Reduction (UNISDR) and Emergency Management (EM) organisations that discussed disaster management, disaster medicine, and challenges with regard to the healthcare environment and systems. Conference letters, editorial letters, conference proceedings abstracts, and company white papers were excluded. The general keyword search used to retrieve related articles included *disaster*, *disaster management*, *disaster medicine*, *e-health*, *healthcare*, *and disaster healthcare*. Then, an extensive search was performed by combining the search terms with words and phrases such as theory, framework, theoretical framework, consequences, challenges, problem, and literature review. Moreover, during the search procedures in some stages, Boolean operators such as "AND" and "OR" were utilised to narrow down the search findings. A number of these combinations were: "e-health" AND disaster; "disaster management" AND Challenges; Healthcare AND disaster.

No specific timeframe was set for the search in relation to the date of publications and only articles in English were considered and no priority was given in terms of research location. For this search process all articles regardless of their research methodology were included. This search found 104 articles in the area of disaster management or disaster medicine from which 35 duplicate articles were excluded. After abstract review and assessing the articles' full-text for eligibility, 28 articles were found to be completely relevant and considered for the full review (Figure 2.2).

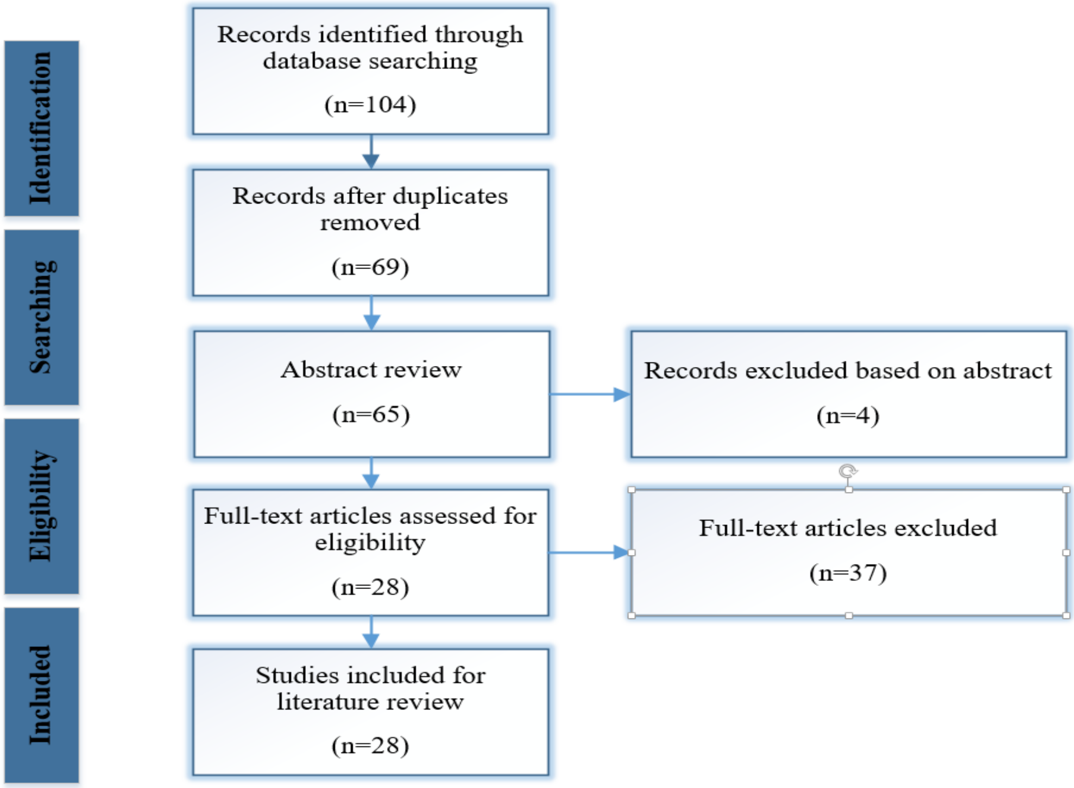

Figure 2.2 Literature review flow diagram of study selection

Besides these 28 articles, –from the scoping study search - explained in chapter 5 - the studies related to disaster management and disaster medicine backgrounds and challenges were extracted and presented in this chapter.

2.3 Disaster Management

In this regard, defining disasters and knowing how to distinguish them from related terms that are often used interchangeably - terms such as emergency, incident, and crisis - is essential. Based on the United Nations (UN) definition for disaster (see chapter 1), a concept of disaster for the purpose of this research was created and, accordingly, an understanding associated with the management of disaster was established. When any threat influences vulnerable groups of societies and forces damage, fatalities and injuries (Khan, Vasilescu, & Khan, 2008), it is considered a disaster and can be distinguished from an accident or incident if any or all of the following criteria are held true:

- it disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope using its own resources (International Federation of Red Cross and Crescent International Federation of Red Cross and Crescent Societies, n.d);
- there is insufficient capacity or measures to reduce or cope with the potential negative consequences (The United Nations Office for Disaster Risk Reduction, 2007);
- its occurrence disrupts the normal conditions of existence causing a level of suffering that exceeds the capacity of adjustment of the affected community (World Health Organization, 2002); and/or
- it overwhelms the ability of a given area or community to meet the demand for healthcare (Zibulewsky, 2001).

These points can be true for both natural and manmade disasters; however, for manmade disasters some additional criteria have been taken into consideration (Table 2.1). In this study, the criteria provided by CRED (2009) were considered.

Table 2.1

Manmade Disaster Criteria

	Criteria	Source
1	• 10 or more people reported killed. • 100 or more people reported affected. • Declaration of a state of emergency. • Call for international assistance.	The Centre for Research on the Epidemiology of Disasters (CRED, 2009)
2	• At least $1 million damage • at least 100 dead • at least 100 injured	Disaster Research Unit of University of Bradford (Baird, O'Keede, Westgate, & Wisner, 1975)
3	• 25 or more fatalities. • 125 or more injured. • 10,000 or more evacuated. • 10,000 or more deprived of water. • US$10 million or more in damage.	UNEP-APELL (cited in Shaluf, Ahmadun, & Said, 2003)

Disasters are usually an inseparable part of human life and have always afflicted civilisations. Even with the advent of new technologies, natural hazards are still making trouble in an environment of many municipalities around the world. Due to the specific characteristics of disasters, such as being sudden, unplanned and unpredictable, they create unstable and changing conditions of environments and stressful situations that negatively influence decision making. Therefore, disasters incur exceptional challenges for an emergency response system in a community, disrupting the regularly available rescue services to varying degrees according to the intensity and magnitude of the disaster (C. Adler et al., 2011; Chan et al., 2004).

Consequences of disasters can be short term or long term; social and economic consequences are the common long-term consequences while, according to PAHO (2000, p. 4), the short-term consequences can be:

- Severe injuries requiring extensive treatment
- Increased risk of communicable diseases
- Damage to health facilities

- Damage to water systems
- Food shortage
- Major population movement

Different organisations with different backgrounds are involved in relief operations and this adds to the confusion and the overall complexity to the situation. However, to mitigate the worst effects of disasters and alleviate their consequences, sufficient preparation and planning is necessary. In other words, in such circumstances, if there are preparation guidelines before disasters or a planned operational programme or procedure and standards to be followed after disasters, the adverse effects of disasters such as death and damage to properties can be reduced to a great extent. These guidelines and plans are a part of disaster management. Therefore, disaster management can be considered a series of connected operations that are interlinked closely (Patricelli et al., 2009) based on a set of effective standard measures and a number of schedule and planning procedures. As a result, its main objective is to save people's lives (Rolland, Patterson, Ward, & Dodin, 2010).

Disaster management has three main components: hazard, vulnerability, and capacity (Khan et al., 2008). It covers a wide range of domains and activities such as "the body of policy and administrative decisions, the operational activities, the actors and technologies that pertain to the various stages of a disaster at all levels" (Lettieri, Masella, & Radaelli, 2009, p. 117). Disaster management attempts to forecast disasters and accordingly prepare an action plan to prevent (if possible), or respond to disasters as well as to follow up activities after disasters to return to the normal situation. In this regard, disaster management objectives, as suggested by Cuny (2012), are:

(i) avoiding or mitigating loss of life and properties,
(ii) lessening the personal suffering,
(iii) enhancing recovery speed.

Since its emergence, the essence of disaster management and the related research has developed; however, in recent years, renewed interest in disaster management has appeared due to the increasing frequency of natural and manmade disasters. Many countries have given priority to the policy agenda in this field and they have started to look at their disaster management in a new perspective (Khan et al., 2008). A number of international organisations have taken the lead in this regard. In 2005, The United Nations International Strategy for Disaster Reduction and the 'Hyogo Framework for Action

2005–2015' maintain that the need for a more proactive approach to planning and preparing for disasters has been highlighted as a global priority (Lee et al., 2014). In 2015, the United Nations, at their third international conference on disaster risk reduction embraced for the first time a new framework known as 'Sendai Framework for Disaster Risk Reduction 2015-2030' (United Nations, 2015). The main objective of this framework, which is a developed version of the Hyogo Framework, is reducing substantially disaster risks, losses and damages to communities. Similarly, the World Health Organization (WHO) has asked all countries in the world to set up hospitals with a facility for disaster relief (Sutjiredjeki et al., 2009).

2.4 Disaster Management's Frameworks

Disaster management is a challenging task since disasters are dynamic events that require an immediate response, while they produce stressful situations that affect decision-making and its quality. Disasters disrupt the routine work of many organisations although requiring cooperation among them; meanwhile, inaccurate and delayed information adds to this complication. Moreover, infrastructure systems for services such as water, communication and electricity can be damaged which can be problematic. Therefore, providing information about the disaster-stricken areas is essential to dealing with disasters (Meissner et al., 2002).

Consequently, in disaster management, to prepare for, respond to and recover from disasters, a structured, clear and well defined approach - called a framework - that can address all disaster types must be followed. A disaster management framework assists societies in responding to disasters. This framework includes a complete domain of activities, programmes, and procedures related to disaster (Khan et al., 2008) which, based on the disaster life-cycle, can be classified into general stages of before, during and after a disaster (Figure 2.3).

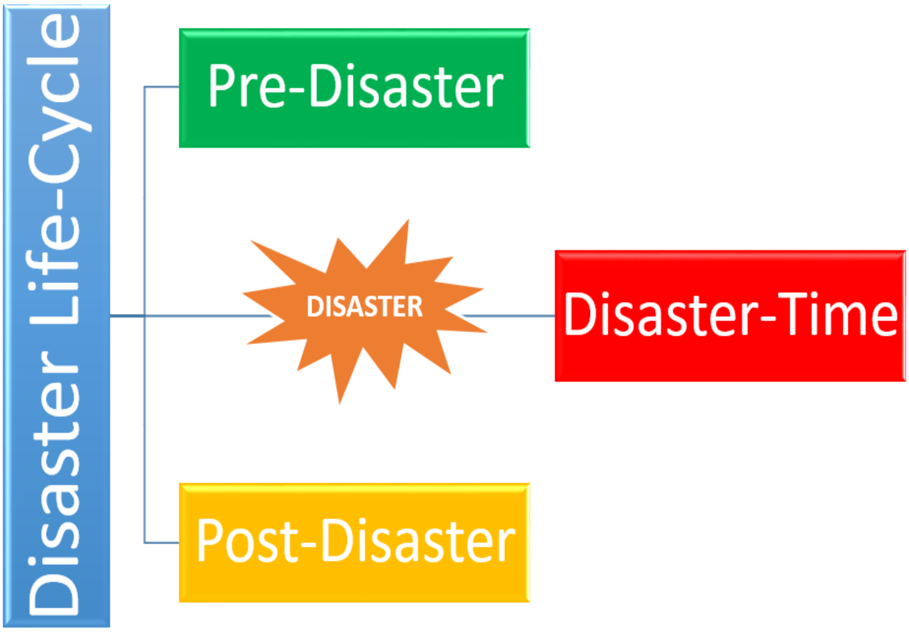

Figure 2.3 Disaster life cycle

These stages form a framework that encompasses different phases according to the activities types, purposes, and their relation to disaster. The roles of frameworks are generally decreasing disaster risk and hazard, preparing communities against disasters, responding to disasters after their occurrence and recovering the disaster situation back to normal conditions. Different organisations and studies have identified three to eight phases for disaster management framework. A number of frameworks and their phases are shown in Table 2.2.

The 4-phase framework was selected because it is one of the most generic and widely adopted models in disaster management literature (Ahmed & Sugianto, 2012; Lettieri et al., 2009). The 3-phase framework is too broad such that tasks in two of the phases can overlap while the IEMS model is too narrow and may bring complexity and confusion that, according to Sieben et al. (2012), causes limitation in the usefulness of the DMC.

Table 2.2

Disaster Management Phases

	Framework	Phases
1	IEMS model[1] (Lee et al., 2014)	Mitigation, hazard analysis, capability assessment, capability maintenance, development plans, emergency planning, response and recovery
2	3-Phase framework (Cioca & Cioca, 2010)	Prevention/warning, disaster, post-disaster
3	4-Phase framework (Baldini et al., 2009)	Mitigation, preparedness, response and recovery
4	5-Phase framework (Lin & Pathranarakul, 2006)	Prediction; warning; emergency relief; rehabilitation; and reconstruction
5	United States Office of Foreign Disaster Assistance model (cited in Cuny, 2012)	Hazard analysis, Vulnerability Analysis, mitigation and prevention, preparedness, prediction and warning, response, recovery
6	5-Phase framework (Khan et al., 2008)	Mitigation, preparedness, response/relief, rehabilitation, reconstruction
7	PPRR Framework (Zhong, Clark, Hou, Zang, & FitzGerald, 2014)	Prevention and mitigation, preparation and planning, response and relief, and recovery
8	Pearson & Mitroff (1993) framework	Signal detection, preparation/prevention, containment/damage limitation, recovery, learning

A disaster management framework has a cyclic nature that begins and ends with mitigation (Figure 2.4). Each phase has its own specific set of tasks and activities. The first two phases deal with activities that endeavour to avoid disasters and their risks, or reduce their consequences through preparing for them. Activities such as vulnerability

[1] Integrated Emergency Management System Model

analysis, disaster training and drills are examples of the activities in the pre-disaster stage. By implementing these two phases wisely and properly, there will be no, or less need to run the third and fourth phases as the disaster risks are prevented or reduced; however, their importance may be hidden and so not recognised immediately unless a major disaster occurs (PAHO, 2000).

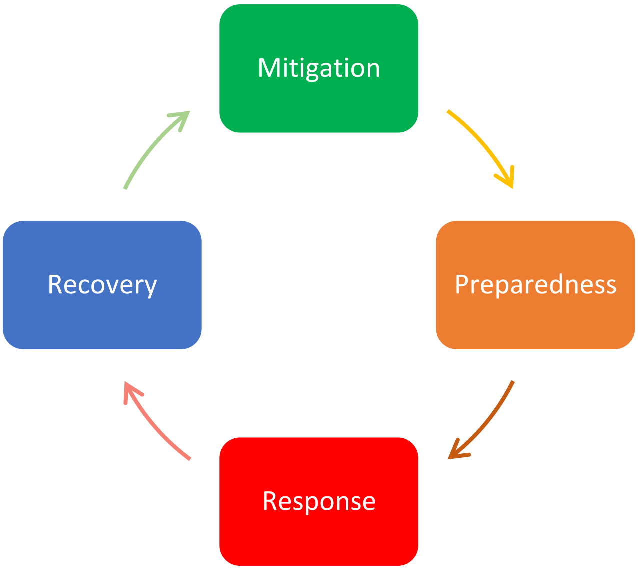

Figure 2.4 Disaster management framework

The next two phases of a disaster management framework form a post-disaster stage in which activities are associated with the disaster aftermath. The post-disaster stage includes the choices, decisions, and activities expected to minimise the effects of a disaster on human lives and infrastructure and help the situation to become normal at the earliest possible time. Furthermore, in this stage the attempt is to bring back the normal situation to the affected areas and people. Consequently, it can be said that a disaster management framework helps to diminish disaster effects, keep control of prevalent conditions and, by considering the experiences gained through endeavouring with disasters, minimise or prevent future life losses and property damages.

A detailed description for each phase in the context of this research is presented in the following sections.

2.4.1 Mitigation

Mitigation or prevention encompasses all the activities performed to identify disasters and avoid or diminish their likelihood or destructive consequences before their occurrence. This phase is mainly about "deciding what to do when a risk to the health, safety, and welfare of society has been determined to exist, and about implementing a risk reduction program" (Petak, 1985, p. 3). In mitigation, the aim is to reduce the impacts of disasters and system vulnerability through studying and assessing the risk, investigating the causes of the risk, and taking administrative measures to prevent or reduce the level of risk when it occurs. Mitigation includes long-term plans and actions to minimise the degree of risk by taking long-term risk reduction measures and decreasing the vulnerability of the community (Ahmed & Sugianto, 2009; Lettieri et al., 2009). This phase includes activities like building codes and zoning, vulnerability analyses, public education, and development of new services. Disaster mitigation is also called prevention or risk reduction (Coppola, 2015).

2.4.2 Preparedness

A preparedness phase should include activities that help people to be ready for disasters and take proper actions when they happen. In preparedness, there needs to be assurance that proper systems, plans, procedures, and resources are available and updated to assist disaster victims in coping with disasters. Developing response plans, preparing required resources for the disaster response and training citizens (from responders to general public) for post-disaster activities should be done in this phase to have an efficient and rapid response to disasters (Ahmed & Sugianto, 2007, 2009; Baldini et al., 2009; Lettieri et al., 2009). This phase, as stated by Balamir (2004) (cited in Unlu, Kapucu, & Sahin, 2010), generally encompasses technical tasks like identifying critical resources and developing among responding agencies necessary agreements. Additionally, it includes actions such as preparedness plans, emergency exercises/training, and identification of critical resources. Testing the plans and simulating exercises are the other activities that should be done in this phase as an ongoing activity on a regular basis.

The main differences between mitigation and preparedness is the emphasis of mitigation activities "on creating long-term resilience through permanent modification of physical and other circumstances which create risk and vulnerability" (Dufty, 2012, p. 41).

2.4.3 Response

Response encompasses actions that are taken during or immediately after disasters to control and manage disaster effects and bring relief to people and communities affected by disasters. Its purpose is to decrease as much as possible fatalities and other impacts on people, properties and environment (Ahmed & Sugianto, 2007; Altay & Green, 2006; Baldini et al., 2009). This phase consists of an array of emergency services following the crisis with the aim of saving human lives, providing welfare, giving aid and assistance, and preventing or reducing the spread of the crisis. The characteristics of the immediate response phase can include producing scenarios as well as either excess or incomplete data that results in high level of stress, especially when it is accompanied by time limitation in decision making. A number of important response activities are evacuation, sheltering, medical care, search and rescue, emergency relief, property protection, and damage control. However, the most crucial task within the response phase is providing healthcare services and responding to the healthcare demands of affected communities.

2.4.4 Recovery

Recovery refers to those activities carried out after disasters to provide life support systems, bring order to the disaster-stricken areas, and aid in restoring the situation back to normal and stabilising or even improving the levels of normal condition (Ahmed & Sugianto, 2007; Lettieri et al., 2009). This phase is a stabilisation phase that may last a long time (Ahmed & Sugianto, 2009; Baldini et al., 2009), enabling disaster victims to resume their normal life. The recovery phase includes “long-term activities which should be performed after disasters to help the community to regain its normal conditions and become stabilized” (Thompson, Altay, Green III, & Lapetina, 2006, p. 480). The activities in this phase include restoring, reconstructing, rehabilitating, establishing normal conditions, evaluating and assessing the programmes, and studying and evaluating the performance. In this phase, rendering financial services such as compensation and developing programmes for social and financial healing operations are common (Unlu et al., 2010).

2.5 Disaster Management and Disaster Healthcare

There are numerous difficulties in preparing for, responding to, and recovering from disasters; however, the focus of this research is on those difficulties that are related to healthcare. Citizens' healthcare requirements following a disaster can be physical, such as simple fractures, or psychological, such as post-disaster anxiety and distress. In this regard, the healthcare sector is held responsible for the most common and crucial part of disaster management. Because it can be considered one of the vital parts of disaster management, it is on the agenda of disaster management (Pourhosseini, Ardalan, & Mehrolhassani, 2015). However, healthcare has difficulties responding properly to major disasters (Maturana et al., 2012) both in developed and underdeveloped nations. Consequently, there is a need to assess and investigate the state of healthcare during and after disasters. This helps researchers to identify the specific nature and requirements of healthcare environments and, thus, take them into consideration.

Each disaster has its unique characteristics; however, most of them have similar outcomes that negatively influence human health and produce a significant number of casualties in a short time with diverse short- or long-term health related demands (Table 2.3).

Table 2.3

Disaster Health Consequences

Short-Term Health Consequences of Disasters	**Long-Term Health Consequences of Disasters**
- Social reaction - Communicable disease - Population displacement - Climatic exposure - Food and nutrition - Water supply and sanitation - Mental health - Damage to the health infrastructure	- Psychological - Functional - Quality of life impairments (Schneider et al., 2012)

(PAHO, 2000)	
- Physical and mental trauma and illness - Lack of access to life-sustaining resources and medications - Impacts from disruption of critical emergency and medical services and infrastructure (Committee on Post-Disaster Recovery of a Community's Public Health, 2015)	- Effects of trauma and chronic stress on behavioural health - Effects of physical stress - Impacts from degraded capacity of or access to health and human services - Exposure to pollutants and degradation of environmental conditions - Impacts on social determinants of health (Committee on Post-Disaster Recovery of a Community's Public Health, 2015)

Disasters can be a great challenge for a healthcare environment (Bar-El et al., 2013; Chan et al., 2004), forcing a massive pressure on the healthcare system. In healthcare the role of routine procedures is very important (de Boer, 1995), and healthcare activities are complex, and mostly interconnected, disasters may affect the procedures significantly. During disasters, however, healthcare routine procedures are disrupted, and it is necessary for healthcare systems and personnel to adjust quickly from everyday activities and routine procedures to the new condition of great uncertainty. In this chaotic situation, many decisions must be taken under uncertain conditions that may surpass healthcare resources availability and staff ability to attend to a large number of casualties in a short time.

Disasters can also cause death and injury not only through their direct effects, but also by disrupting the existing healthcare systems and by their impacts on healthcare itself. After many disasters, healthcare environments are overwhelmed not only because a considerable number of casualties need immediate healthcare, but also because, at the same time, the healthcare infrastructure and personnel, too, can be affected. In this disordered situation, the number of injured victims is proportionately much more than that of the caregivers, and medical devices and equipment, such as CTs, X-rays and MRIs, are damaged or unavailable due to power outage. Additionally, due to the disrupted existing healthcare systems and overcrowding problems, the chance of making mistakes and further adverse events occurring increases. This, in turn, affects both victims and existing patients with long-term conditions and severe illnesses that still require care and sensitive treatment.

Disasters overwhelm healthcare environments, healthcare elective functions, such as chronic disease management, and normal pattern of service delivery and resource utilisations are disrupted and even unavailable during disasters (Aitsi-Selmi & Murray, 2015; Parry, Madanian, & Norris, 2016). Therefore, the lives of hospitalised people or chronically ill individuals who need life-saving medications are in an increasingly vulnerable position. Examples for this category can include people with cancer, those who need dialysis, or even people with diabetes that need insulin. The real case example of this challenge is the termination of HIV and tuberculosis drug treatment at the time of Typhoon Haiyan (Egawa, 2015).

In this regard, the role of healthcare is critical within DMC, and there is an emphasis on the healthcare role during disaster response and recovery phases (Pourhosseini et al., 2015; Zhong et al., 2014). Healthcare is responsible for responding to casualties' healthcare demands and support recovery from disaster-related healthcare issues at different levels, as suggested by de Boer (1995):

1- at the disaster site;
2- during transportation and distribution of victims to hospitals; and
3- within hospitals.

As well as the direct healthcare-related impacts of disasters on people, sometimes disasters can cause an outbreak of epidemic illnesses that produce extra healthcare demands not only for curing the affected population, but also for preventing further spread of the illnesses. Most of the time, the disease outbreak develops within the response camp, as a result of the unavailability of clean water and food following a disaster or as a result of the disruption to critical infrastructure such as sewerage. For example, during Yolanda Typhoon in the Philippines, one of the challenges healthcare faced was that infectious diseases could not be prevented, and non-communicable diseases worsened because there was no access to water, food, shelter, and required medicine (Egawa, 2015). As another example, following the 1994 Northridge earthquake, an infectious disease called pulmonary coccidioidomycosis emerged due to the increased dust levels (Zibulewsky, 2001).

Healthcare demands following a disaster are varied, and they depend on the disaster type, location, and intensity. Efficiency and effectiveness of the healthcare activities are of prime importance, yet there is a paucity of evidence regarding the real efficiency and effectiveness of the disaster response tasks and their outcomes.

Disasters are sudden and mostly unpredictable, so when they occur, not surprisingly, the priority is saving lives and treating victims rather than gathering evidence to measure the efficiency and the effectiveness of the response. It is difficult to assess the efficiency and effectiveness of the healthcare interventions in disasters and no real statistics are available on medical errors during disasters. The characteristics of the healthcare environment during disasters and given the dynamic and highly stressful nature of disasters as summarised in Table 2.4, it can be concluded that the effectiveness and efficiency cannot be maintained even at the marginal normal situation levels; rather they tend to decrease significantly. The problem of healthcare errors is escalated as response teams are even more vulnerable to making medical mistakes.

Therefore, in healthcare, preparedness is considered a key factor for successful response, and the healthcare role and its integration in disaster mitigation and preparedness activities cannot be neglected. Through integrating healthcare into the mitigation and preparedness plan(s), healthcare can be shifted from a reactive to a proactive system.

Table 2.4

Characteristics of Healthcare During Disaster Response (adapted from Croskerry & Sinclair, 2001)

High levels of activity	High decision density	High cognitive load
High levels of diagnostics uncertainty	Inexperience of some physicians and nurses	Interruption and abbreviated care
Narrow time windows	Shift work and change	Compromised teamwork

The importance of considering the role of healthcare in disaster mitigation and preparedness plans have been brought into focus after the September 11 terrorist attack in the United States (Trzeciak & Rivers, 2003) as well as Hurricane Katrina, which completely disrupted the country’s healthcare system. It can be argued that the key element of effective response and preventing further life loss is ensuring healthcare readiness, which can be achieved by having disaster mitigation and preparedness plan(s) in the healthcare sector. Furthermore, deciding on the disaster medical supplies, their types and volume is one of the essential components of disaster preparedness (Zhong et al., 2014).

Based on the mentioned role of healthcare during pre- and post-disaster phases, healthcare and its management should be integrated into DMC to reduce the lack of healthcare in disasters since planning and preparing for disasters can make a significant difference (Hirshberg, Holcomb, & Mattox, 2001). This can be done through “systematic process, administrative, organizational, and operational decision making skills and capacities, that deals with the challenges of planning” (cited in Pourhosseini et al., 2015, p. 112).

Regarding the performance of healthcare within DMC, especially the previous disaster phases, it can be inferred that when healthcare systems and procedures in the normal workload cause medical mistakes, it cannot be expected that they work properly during disasters when, according to Table 2.4, there are several characteristics negatively affecting the healthcare environment and procedures. Moreover, all casualties cannot receive medical care in accordance with the conventional standards (Hirshberg et al., 2001).

2.6 Disaster Medicine and Disaster Healthcare

Disaster management has been shown to have shortcomings and challenges with regard to healthcare. This requires specialists who can help injured people with urgent needs (Kirsch & Hsu, 2008), and led to the introduction of a new specialisation - disaster medicine. Largely based on emergency and military medicine (de Boer, 1995), this specialisation address the demands that arise following disasters. These professionals should be a part of medical teams responsible for defining, assessing, and responding to disaster related health concerns, and effectively addressing all aspects of victim needs, from medical needs to speedy coordinating operations and preventive health services or medico-organizational actions (de Boer, 1995; Waeckerle, Lillibridge, Burkle, & Noji, 1994). They should also be able to assist with coordinated and well-planned interventions throughout the DMC (from prevention to mitigation to immediate response to rehabilitation) that are coordinated with other sectors involved in broad disaster management (Llewellyn, 1995).’

According to (James et al., 2010, p. 102), disaster medicine is:

> The study and collaborative application of sound scientific principles, practices, and standards by multiple health professions for the prevention, mitigation, management, and rehabilitation of injuries, illnesses, and other problems that affect the health, safety, and well-being of individuals and communities in disasters and public health emergencies.

Disaster medicine is a multidisciplinary domain: the overlap of three different areas of disaster management, public health, and clinical health (Figure 2.5). It may involve many other domains and professions, as Waeckerle et al., (1994) state, such as paediatrics, epidemiology, communicable diseases, nutrition, public health, emergency medicine, social mending, community care, and international health. The final aim of all involved professions is assisting the capabilities of health systems to prepare for, respond to, and recover from disasters and other emergencies (Subbarao et al., 2008).

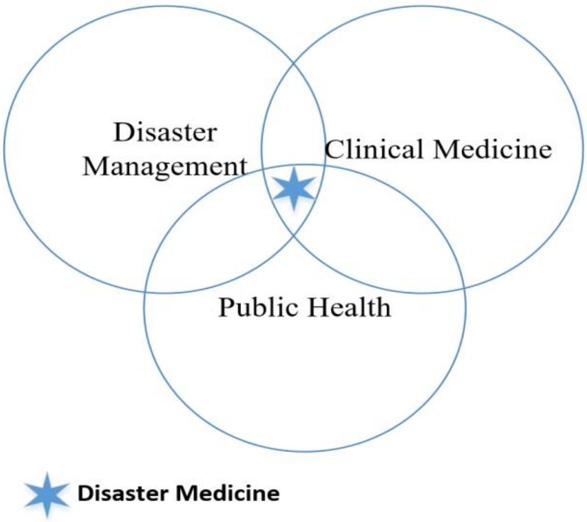

Figure 2.5 Disaster medicine elements

Disaster medicine has some major differences compared to normal medicine. It deals with delivering care to those who are injured because of the disaster, but, unlike normal medicine, its personnel, as Ciottone (2006) believes, need to join the large team of non-medical multidisciplinary responders. Therefore, familiarity with disaster management principles is important for disaster medicine providers. This is important because, in normal medicine, maximum resources are utilised and consumed by a small number of people, while in disaster medical services there is need for very large numbers of people to share the limited resources (Little, 2008).

Post-disaster conditions are different from those of normal medicine and make medical practice more difficult, conditions such as those mentioned by Civaner, Vatansever, & Pala (2017): heavy workloads, limited resources, security concerns regarding themselves, relatives, and patients, absence of firm guidance in international law and health policy and the diversity of cultural backgrounds and language barriers. Some other differences between disaster medicine and normal medicine are:

- training in situation management and decision making under pressure (International Emergency Medicine, 2011)
- providing care in a disaster situation, independent of the location (International Emergency Medicine, 2011)
- using creative and innovative approaches to solving disaster challenges (B. Chen & Parwaiz, 2011)
- applying and adopting usual medical practices in the limited situational awareness and resources conditions (James et al., 2010)
- under extreme conditions, providing care with the higher standard (James et al., 2010)
- training to act promptly and effectively in rendering medical care (Su et al., 2013)

Besides having medical knowledge, the disaster medicine personnel and medical providers are required to have competencies and be familiar with the protocols to help them put their knowledge and skills into practice in the hectic circumstances of disasters. In this regard, they need to have fundamental knowledge about disasters, and to have education and training in disaster medicine (B. Chen & Parwaiz, 2011). They also need to be trained in using their expertise and skills in disaster situations (Walsh et al., 2012) which, in turn, may result in responding effectively to disaster medical demands and serving greater numbers of people with greater amounts of goods. The overall aim of this special training for disaster medicine personnel is to enhance the efficiency of disaster response in the context of healthcare in situations when each and every second is valuable and its value is people’s lives. To this end, disaster medicine has introduced protocols, skills and competencies for clinicians and medical providers to cope with clinical conditions of disasters. Therefore, it is critically important for emergency medicine residents to receive training in disaster planning and management (Kaji & Waeckerle, 2003). If these practices are not enacted properly, the consequences can be disastrous; for example, Shamdani & Nicolai (2012) maintain that following an earthquake, the valuable time for rescue operation is estimated to be about 72 hours. Therefore, having timely actions especially for disaster-related health issues is vital, and it helps governments to prevent or at least decrease mortality, morbidity and long-lasting injuries, as well as unnecessary disaster victims' loss of life.

Due to the rising trend of disaster frequencies and intensity all over the world, there is an increasing need for disaster physicians and medical resources. Similarly, governments must be able to cope well with the health problems and medical needs of the victims (International EM, 2011; Waeckerle et al., 1994). Furthermore, the need for disaster medicine was highlighted after massive disasters and terrorist attacks, such as 9/11. Therefore, more nations emphasised having disaster medicine training in the medical schools; as early as 2003, the American Association of Colleges of Osteopathic Medicine made just such a call (Kaiser et al., 2013; Kaji & Waeckerle, 2003; Su et al., 2013). Then, the initial action for enhancing healthcare capacity for disaster response took place on October 2007 in the U.S. when President Bush signed the Homeland Security Presidential Directive (Subbarao et al., 2008). The objective of that directive was to promote creating a field that identifies the sole principles in the medicine related to disaster and public health. This was a pivotal point in the renewed interest in and publicity surrounding disaster medicine.

Disaster medicine is a broad area that tries to show a complete care within DMC although its role is quite significant, and highlighted, during disaster response when dealing with acute medical demands of disaster casualties. More importantly, disaster medicine should be used as a leading factor for preparing hospitals before the occurrence of disaster. The underlying reason is, if pre-disaster phases are implemented poorly or neglected, vulnerability of the community and thus its inability to be resilient will be more evident (Bradt et al., 2003; Djalali et al., 2014).

Disaster medicine deals with different activities in each of the phases of DMC as shown in Table 2.5.

Table 2.5

Disaster Medicine and DMC (adapted from Ochi et al., 2016; Waeckerle et al., 1994)

Disaster Phase	Disaster Medicine Related Activities
Mitigation	- Enhancing capabilities of local hospital - Preventing future disasters
Preparedness	- Anticipating potential problems - Identifying morbidity and mortality risk factors - Identifying dangerous and mortal situations
Response	- Responding to population health requirement - Determining relief needs of affected people
Recovery	- Rebuilding societies

2.7 Open Challenges in Disaster Management and Medicine Related to This Thesis

Having an effective and efficient disaster management and healthcare system is one of the important responsibilities of governments towards their citizens. This efficiency and effectiveness strongly depends on the extent to which issues are, as well as on the degree to which the required resources are available (PAHO, 2000). In this regard, disaster mitigation and preparedness (pre-disaster activities) have a vital role; however, as reported by Kaji & Waeckerle (2003, p. 867) "very few hospitals have emphasised the importance of integrated plans, and very few hospital disaster planners have actual experience."

Healthcare response after disasters is also a challenging activity. Post-event investigation of disasters (Russo, 2011), whatever their severity, shows frequent miscommunication and mismanagement that lead to poor disaster responses and delayed evacuations. All of these transfer the disaster into the healthcare environment (Hamilton, 2003). These can influence the community' health status. Therefore, it might be necessary for disaster management, especially in the healthcare sector, to be improved. Strengthening the areas of preparing, responding and recovering from disasters is essential, as the sector currently faces various failures and challenges.

These failures and challenges have motivated studies related to disaster management and medicine with a specific focus on cooperation, communication, and awareness of situations (Javed & Norris, 2012) and on the general abilities and decision-making of disaster managers (Cioca & Cioca, 2010). Many studies have been carried out and several researchers have explored and demonstrated challenges of the disaster related to the difficulty of its management with respect to healthcare (Bala, Venkatesh, Venkatraman, Bates, & Brown, 2009; Y. W. Chen et al., 2009; Lahtela, 2009; Turcu & Popa, 2009).

Callaway et al., (2012) note that when a major disaster strikes, providing adequate medical healthcare to crisis zones is difficult because of loss of infrastructure, population displacement, inter-agency coordination, variable record keeping, and unstable staffing patterns. In the same context, Khankeh et al., (2011) add the following challenges: lack of planning; inadequate organisational management of resources; and insufficient coordination in the provision of health services during disasters.

During disasters, having the sheer numbers of traumatised people, in a very short period of time, put the existing infrastructure and systems of public health under unpredictable pressure that may the escalate morbidity and mortality rate. Transferring these casualties to appropriate hospitals for timely treatment is also vitally important. If the injured cannot be relocated to suitable hospitals in time to be treated, the loss of lives would be unbearable (Y. W. Chen et al., 2009). A good example in this regard is the case of New Orleans during Hurricane Katrina where the residents could not get the appropriate medical attention they needed; the result was avoidable deaths.

At the same time, the survival rate of disasters has made the response phase in the healthcare area challenging. An extensive number of disaster injuries may overload the medical facilities due to an inconsistency between the number of patients and the resources available (Hirshberg et al., 2001). Medical personnel have to deal with hundreds of patients who arrive at the same time with almost no medical details and with severe injuries in need of immediate care. Added to this situation are shortage of medical resources, chaotic conditions and lack of time that may worsen the situation. In the Haiti earthquake, for example, WHO estimations showed that the number of immediate quake-related deaths was around 200,000 and the number of injured survivors who needed an immediate and constant healthcare response was about 300,000 (Callaway et al., 2012). In addition, as Kuo, Chung-Jung, Li, & Ming-Hui (2007) state, care operation encompasses multiple procedures, and it is difficult to plan ahead when there are different emergencies happening simultaneously in the disorder environment. Therefore, the dynamic and chaotic nature of events puts medical staff under pressure and local responders may therefore not know about the disaster situation until delayed reports arrive.

Another barrier that medical staff face is related to patients with chronic diseases. Research by James & Walsh (2011), shows that more than 109 million Americans have at least one chronic disease and many of them cannot tell you either the name or type of their disease, or the dosage of medications they take. This lack of crucial information creates significant problems when disasters strike, resources and time are limited, and caregivers are under pressure to access and collect accurate personal health information so that they can prescribe the necessary treatment and medication. The situation is even worse when medical records are lost, evacuees' have no proof of identity, and they cannot communicate their healthcare needs. All these factors increase the risk of medical errors. The research by (Bala et al., 2009) indicates that since many hospitals did not have enough medical information about the evacuees, they had to prescribe medication that, in fact, worsened the conditions of many patients. Therefore, having an effective healthcare system in addition to rapid medical response can reduce significantly disaster-related mortality (Zhong et al., 2014).

There are also some challenges reported about medical personnel in the post-disaster phases. In this regard, while different research studies indicate that having disaster knowledge and disaster medicine training are vital for medical personnel (Bradt et al., 2003; Ducharme, 2013; International EM, 2011; James et al., 2010; Kaji & Waeckerle, 2003), still during disaster response a great number of health responders have not had that training (Walsh et al., 2012). That causes the wasting of precious medical resources and, ultimately, the needs of the affected population are not addressed.

Some other crucial challenges in disasters are patient identification, medical history and real-time integration of data with physical objects (Kuo et al., 2007; Lahtela, 2009). During disasters, medical staff deal with casualties who are unconscious and unaccompanied and with children who are without their parents, none of whom can effectively communicate and explain their current medical situations and needs or their previous history (James & Walsh, 2011). Patients can also be transferred among field hospitals with little more than a short medical summary (Callaway et al., 2012). Some other healthcare challenges within DMC are presented in Table 2.6.

Table 2.6

Disaster Challenges

Disaster Challenges
There is no or limited access to the infrastructure to retrieve the patients' background (Turcu & Popa, 2009); primary challenge in responding to disasters is communication. (Chan et al., 2004; Manoj & Baker, 2007)
There are inter-organisational communication and collaboration problems (Rolland et al., 2010)
There are increased demands on the healthcare team, escalated challenges faced by managers, developed workflow bottlenecks, and decreased system capacity (Fry & Lenert, 2005).
Numerous injured people are generated in a very short time in large disasters; how to transfer these patients to appropriate hospitals in time in order to save their lives? (Y. W. Chen et al., 2009)
Hospitals do not have enough medical information about the evacuees, they have to prescribe medication that, in fact, may worsen the conditions of many patients (Bala et al., 2009). Turcu & Popa (2009) state, in emergency or disaster situations, especially when the patients are unconscious or are unaccompanied, providing patient's accurate medical history for the emergency physicians is a matter of life and death, patient health background and chronic diseases (James & Walsh, 2011), patients who continue to be transferred among field hospitals with little more than a short medical summary (Callaway et al., 2012)
There are disparate information technology systems, inefficient flow of patient medical information between organisationally and geographically distinct providers (Turcu & Popa, 2009))
There are information fragmentation, unreliable data, and inaccurate information
Because of patients' misidentification and misidentified medications (Lahtela, 2009), medicinal care can be very vulnerable to different kinds of errors, even fatal ones (Ajami & Rajabzadeh, 2013).

There are delayed information and inaccurate data regarding the true nature of the incident, needs, and ongoing response (Chan et al., 2004)
Paper triage complicates information turnover and has several limitations such as being easily marred or destroyed and having the limited space for information (Fry & Lenert, 2005; Lenert, Palmer, Chan, & Rao, 2005)
Thirty percent of time is wasted looking for and studying the information about patients (Wen et al., 2012).
Relief efforts are geared to procuring and delivering adequate supplies to the affected area in a timely manner. However, it is complicated by uncertainties in demand and social and economic consequences of inadequate or delayed supplies (Chakravarty, 2011)

The described problems suggest a significant disconnection between disaster management, disaster medicine, and healthcare due to the difficulty of obtaining and sharing vital information such as health records so that agencies can respond in a timely manner. Indeed, (Bissell, 2007, p. 20) has observed that "emergency management and the health sector are natural allies that have, seemingly, only recently begun to recognize each other". This issue first reported by Waeckerle et al. (1994), indicated that disaster physicians during response needed to interact with different organisations and agencies who have a narrow focus on response strategies. Similarly, disaster physicians have a lack of understanding of organisational hierarchy and operational activities other than medical care. Consequently, disaster personnel manage crisis events on an unreliable and ad hoc basis.

Therefore, to have an effective response, the medical team needs to have a fundamental understanding of disaster management (James et al., 2010) and of the differences between disaster and normal healthcare situations and their priorities. As a result, the medical team could cooperate and collaborate with different disciplines to safeguard population lives.

To have an effective response in the post disaster phases, there must be strong relations between different response organisations, especially the healthcare and disaster response teams in the disaster field. These systems require there to be a common understanding between them because, so far, these systems have not been able to jointly use their tools and personnel in order to prepare for huge emergencies and respond properly to them (Bissell, 2007). The fundamental reason for this is that emergency managers may not have a clear idea about the way the healthcare system responds in such situations (Bissell, 2007). In this regard, information is a key tool for delivering and managing better services, and having a faster response while maintaining quality. In other words, if disaster management and the healthcare sector have improved collaboration in real-time sharing of their information related to the situation, the overall response is most likely to improve.

On the other hand, one of the weaknesses that exists in disaster medicine and affects its efficiency is inadequate use of ICT. Many emergency medical services depend on paper-based systems while they should rely less on such systems in order to prevent information loss during large scale disasters (Case, Morrison, & Vuylsteke, 2012). It appears that responders receive the required information such as healthcare information in a hard copy or other traditional sources (Kelley, Tharian, & Shoaf, 2011). In this regard, although Waeckerle et al. (1994), in their early study, mentioned that technology could positively affect information transformation system in disaster situations, it is still the case that the use of technology in the disaster medicine area is disparate and ad hoc.

By referring to the many and varied weaknesses in this area and because of the variety of disasters with regard to their magnitude and nature, it is almost impossible to set boundaries for the related disciplines (Subbarao et al., 2008). However, there is a lack of a model representing ICT utilization and potential for facilitating the disaster management and disaster medicine activities. This model may help the fields' experts to identify clearly what ICT they can use in which disaster situation according to its characteristics and how to use it.

2.8 Summary

This chapter, explained the background study of disaster management and disaster medicine disciplines. Then, it concentrated on the healthcare challenges within DMC by providing an overview of the available research. The last part of this chapter was dedicated to the open challenges of disaster management and disaster medicine with the focus on the healthcare environments. The next chapter presents the background of e-health.

CHAPTER 3

E-HEALTH LITERATURE REVIEW

3.1 Introduction

This chapter aims to introduce the background of e-health area and one of its technologies, Radio Frequency Identification (RFID), in disasters. The role of e-health technologies in current healthcare systems together with their usage in the disaster context is discussed. Moreover, it lays out the breadth of research in the e-health domain by exploring and discussing its definition, drivers and offered opportunities. It also investigates the current role of e-health technologies in the healthcare industry as well as in disaster management cycle (DMC). The chapter identifies the gaps discussed in chapter 2 that can be addressed by e-health technologies.

Section 3.2 explains the search procedures employed to gather the related studies, and this is followed by a brief background of healthcare and IT (Section 3.3). e-Health definition and background are addressed in section 3.4; section 3.5 is an introduction to e-health technologies. This section also discusses their applications in healthcare and disasters. Sections 3.6 and 3.7 are dedicated to reviewing RFID applications in healthcare and disaster. In section 3.8, open challenges are identified, and the chapter concludes by providing how disaster e-health (DEH) can make a contribution.

3.2 Process for Literature Review

e-Health literature covers a broad area in different domains and sub-domains including healthcare, information technology and business. The underpinning concepts of e-health relevant to the research questions and objectives were identified (Figure 3.1).

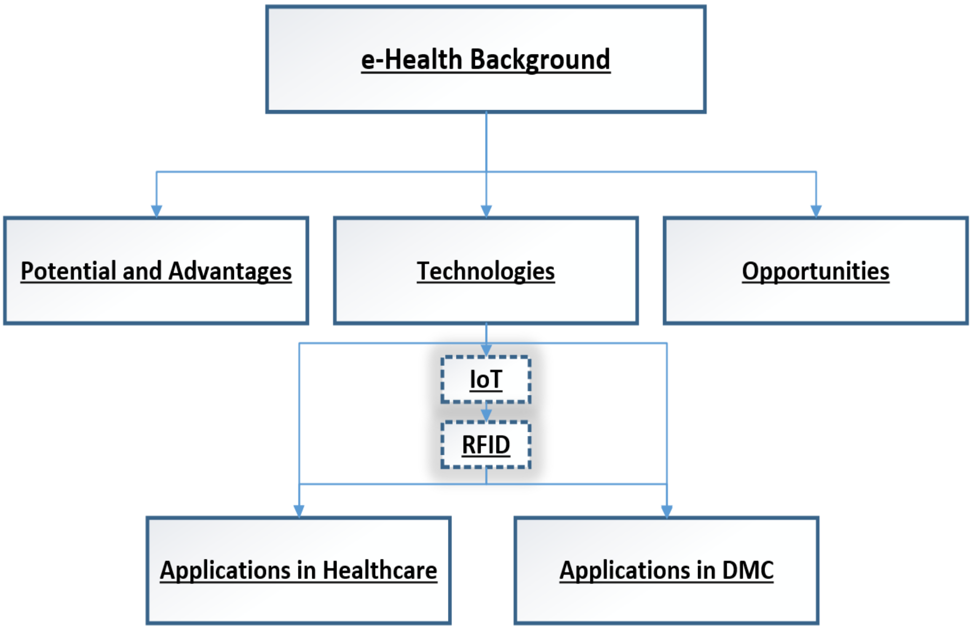

Figure 3.1 The topic areas covered in e-health literature

The areas represented in Figure 3.1 were used to guide the literature review process. This concept identification allows the researcher to highlight and synthesise the literature key findings. The relevant literature was identified for both this review and the scoping study (see chapter 5). The results addressed the following objectives:

- identifying e-health background, its potentials and advantages
- identifying the applications of e-health in healthcare
- identifying the current e-health applications in DMC
- identifying RFID roles and applications in the healthcare and disaster context.

3.3 Healthcare and IT

Healthcare has faced a number of challenges in most countries, especially in recent decades. These challenges are not area- or country-specific, and they could be found across a range of different healthcare areas, with varying levels of severity, in almost all countries. Some of the most reported challenges from diverse healthcare sectors are given in table 3.1. These challenges force high healthcare costs; medical errors that in turn impose additional costs on healthcare systems, and, most importantly, they put people's lives in danger. However, most of these errors might be prevented by employing appropriate technologies (Fuhrer & Guinard, 2006).

Since Information and Communication Technology (ICT) has already been utilised in different domains to enhance quality, efficiency, and effectiveness, it could be expected that they have the same impact on the healthcare. Therefore, ICT utilisation and integration in healthcare may increase efficiency and effectiveness of the healthcare processes, procedures, and quality of the delivered services. ICT could bring integration to the healthcare fragmented data and information and result in facilitating evidence-based practice and overcome paper-based shortcomings (Chaudhry et al., 2006). As a result, it may decrease medical errors and enhance patient safety.

Table 3.1

Reported General Healthcare Challenges

Challenges	**Reference**
Increasing healthcare cost	AbuKhousa, Mohamed, & Al-Jaroodi, 2012; Ducharme, 2013; Kayyali, Knott, & Van Kuiken, 2013; Reyes, Li, & Visich, 2012
Increasing healthcare errors	Fuhrer & Guinard, 2006; Lahtela, 2009; T. L. Wang & Chang, 2002; Yazici, 2014
Increasing ageing population	Bouet & Pujolle, 2010; M. Chen, Gonzalez, Leung, Zhang, & Li, 2010; Dohr, Modre-Opsrian, Drobics, Hayn, & Schreier, 2010; Wamba & Ngai, 2011
Concern about services quality	AbuKhousa et al., 2012; M. Chen et al., 2010; Reyes et al., 2012
Decreasing patient safety	C. Powell, 2003; Reyes et al., 2012; Trzeciak & Rivers, 2003; Wen et al., 2012
Poor operational and information management	Akiyama & Nagai, 2012; J. G. Anderson, 2007; Chaudhry, Wang, Wu, & et al., 2006; Kahn,

	Yang, & Kahn, 2010; Reyes et al., 2012; Wamba & Ngai, 2011
Lack of enough resources (human resource, medicine and equipment)	AbuKhousa et al., 2012; Kwankam, 2004; Lai, Santhiranayagam, Begg, & Palaniswami, 2011; Reyes et al., 2012; Singh & Kaur, 2010
New types of diseases due to lifestyle	AbuKhousa et al., 2012; Trzeciak & Rivers, 2003
Overcrowded healthcare facilities	Trzeciak & Rivers, 2003
Patient misidentification	Lahtela, 2009; Yao et al., 2010; Yazici, 2014
Continuity of care	S. Anderson et al., 2008

3.4 e-Health Technologies

Since the 1970s, there has been a significant move in healthcare from paper-based activities and processing toward digital- and computer-based methods; ICT tools have been utilised for health data, information and knowledge collection, storing, processing, and communication (Chaudhry et al., 2006; Nelson & Staggers, 2014). Moreover, the increase in IT usage in healthcare and other advanced technologies, such as new communications technologies, has led to the establishment of a multidisciplinary domain of e-health.

'e-Health', is a relatively new field that could be considered as an intersection of three fields: medical informatics, public health and business (Eysenbach, 2001). The first usage of this term was in 2000; in 2003 it was identified by Service Delivery and Organisation (SDO) Research Programme Board of the National Health Service in the UK as an important area for future research (S. Anderson et al., 2008; Pagliari et al., 2005).

Different researchers have defined e-health from different perspectives; a number of these definitions are set out in Table 3.2. From among them, in this study, the definition by WHO (World Health Organization, 2005, p. 121) was selected for this work.

> The cost-effective and secure use of ICT in support of health and health-related fields, including healthcare services, health surveillance, health literature, and health education, knowledge and research.

Table 3.2

e-Health Definition

Researcher	e-Health Definition
Alvarez, 2002	e-Health is a consumer-centred model of healthcare where stakeholders collaborate, utilising ICTs, including Internet technologies to manage health, arrange, deliver and account for care, and manage the healthcare system
Bliemel & Hassanein, 2004	e-Health describes the application of the internet and related technologies in the field of healthcare
Gustafson & Wyatt, 2004	Use of the internet or other electronic media to disseminate health-related information or services
Intel (cited in Eysenbach, 2001)	A concerted effort is undertaken by leaders in healthcare and hi-tech industries to fully harness the benefits available through convergence of the Internet and healthcare
Eysenbach, 2001	Referring to health services and information delivered or enhanced through the Internet and related technologies.
Mair et al., 2007	e-Health is the use of emerging information and communications technology, especially the Internet, to improve or enable health and healthcare
van Gemert-Pijnen et al., 2011	The use of electronic information and communication technology to promote health or improve healthcare
Broderick & Smaltz, 2003	e-Health is defined as the application of Internet and other related technologies in the healthcare industry to improve the access, efficiency, effectiveness, and quality of clinical and business processes utilised by healthcare organisations, practitioners, patients, and consumers to improve the health status of patients
Kwankam, 2004	e-Health is an all-encompassing term for the combined use in the health sector of ICT for clinical, educational, research and administrative purposes, both at the local site and at a distance

Pagliari et al., 2005	e-Health is about the use of information technology to facilitate patient and citizen healthcare or service delivery

As the definitions imply, e-health encapsulates two major aspects: healthcare and technologies. This covers the entire scope of digital technologies applied to health (Parry et al., 2016) used to enhance processes in healthcare for different purposes ranging from clinical and educational to administrative, at the local as well as remote places (Bliemel & Hassanein, 2004). It provides a virtually limitless set of tools and opportunities for improving users' health (Mackert, Champlin, Holton, Muñoz, & Damásio, 2014) or delivering healthcare. e-Health also includes all the delivered information and services in health enhanced by the Internet and its related technologies (Eysenbach, 2001). It can be applied not only at the level of individual patients in the context of disease treatment, but also at a wider level such as a country's population health, and not just for treatment but for prevention as well. Therefore, e-health can revolutionise not only how we plan and deliver ordinary healthcare, but also how we think about it (Norris et al., 2015).

Due to its being a broad area, e-health covers different components that fall into three categories, according to the International Telecommunication Union (2008):

- products: including devices and equipment
- services: consisting of prescription, intensive care and surgical services
- systems: covering all managerial, communication, decision support and information systems

In the wider context, e-health:

> characterises not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve healthcare locally, regionally, and worldwide by using information and communication technology (Eysenbach, 2001).

Various technologies are included in the scope of e-health. Regardless of technology types, they have the same aim of enhancing the quality of healthcare services and their accessibility for a wider community. These technologies can be divided into two categories: existing technologies, having been available for several years in recent healthcare delivery (such as EHR and DSS), and emerging technologies, finding their way and are soon to become a part of healthcare delivery (such as IoT and SN). The reason for this classification refers back to the technologies roots. Some of them are from well-established backgrounds, such as different types of information systems, while some others can be considered as emerging technologies in the healthcare domain like the 'Internet of Things', big data and cloud computing (Table 3.3).

Table 3.3

e-Health Technologies

Existing Technologies	**Emerging Technologies**
Electronic health record (EHR)	Internet of Things (IoT)
Telehealth (TH)	Social Network (SN)
Decision Support System (DSS)	Big Data (BD)
Mobile Health (MH)	Cloud Computing (CC)

The definitions of the technologies are presented in Table 3.4.

Table 3.4

Definition of the Selected e-Health Technologies

Technology	**Description**
BD	Big data can be defined by three characteristics known as three Vs: volume, velocity, and variety (Russom, 2011). In other words, these characteristics entail the increasing data size, the increasing rate of producing the data, and the increasing range of employed data formats (Ward & Barker, 2013).
CC	"A large-scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted, virtualized, dynamically-scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet" (Foster, Zhao, Raicu, & Lu, 2008, p. 1)

DSS	This is a computerised information system designed to combine information from different sources, such as data, statistics, maps, reports, artificial intelligence and expert systems, to support managers in making quality decisions (Bradt et al., 2003).
EHR	EHR is a construct that includes computerised patients' healthcare records as well as the information systems encompassing them (Black et al., 2011).
IoT	This is a new form of communication beyond simple communication between people, that is, communication between smart devices and physical objects in people's surroundings. These smart objects are able to identify, locate, and sense objects, people and their environment and connect them together (Dohr et al., 2010; Zelenkauskaite, Bessis, Sotiriadis, & Asimakopoulou, 2012a).
MH	MH refers to utilising and integrating mobile technologies, computing, and devices in the area of healthcare (Iwaya et al., 2013; Kahn et al., 2010).
SN	Social network is a web-based platform and interactive environment that allows people to create their public or semi-public profiles within the system boundaries (Boyd & Ellison, 2007). Its content can be viewed or discussed publicly, or it can be restricted to a particular community or individuals.
TH	TH incorporates and utilises information and communication technologies in healthcare domain for exchanging information and enhancing remote healthcare delivery (Singh & Kaur, 2010; van Gemert-Pijnen et al., 2011).

e-Health technologies have been adopted for a number of reasons, as stated by Broderick & Smaltz (2003):

1) It allows the provider to have more than face-to-face interaction with the patient which, in turn, helps in expanding the delivery of limited resources and expertise

2) It helps the delivery of necessary medical information through electronic media, such as the Internet, which enhances patient education and assists providers to make more knowledgeable decisions
3) It makes cooperation between different care providers easier via file sharing, electronic medical record systems, and email
4) It helps the processes to accelerate delivery and enhances the quality of services locally and remotely, within the framework of health capability and across geographic boundaries, instead of discarding the available infrastructure applications.

3.4.1 Current e-Health Technologies Usage in Healthcare

The ultimate aim of any healthcare centre is healing people and maintaining their health. However, healthcare is facing numerous challenges in pursuing its mission (see Table 3.1). ICT in general and e-health technologies, in particular, can be regarded as a solution to overcome these challenges and decrease, if not eliminate their adverse effects. These technologies could significantly enhance the efficiency of the healthcare services, clinical and non-clinical. In the clinical category, e-health technologies can support practitioners for diagnostic activities, treatment, and follow up, for example, Computer Physician Order Entry (CPOE) system or e-prescription systems. e-Health may also be used for non-clinical objectives for supporting healthcare staff in their routine and daily tasks such as administration activities; examples of such systems are medical or resource supply management and patient registration.

Kwankam (2004) suggested that e-health and its technologies help to keep pace with the rapid growth of health-related information, and to apply much of what we know to determine the health problems of people. These issues were discussed in 2005 such that the World Health Assembly accepted e-health as the means of achieving secure and cost-effective ICT use for health and its related fields. It also coerced “its Member States to consider drawing up long-term strategic plans for developing and implementing e-health services and infrastructure in their health sectors” (International Telecommunication Union, 2008, p. 5).

Given that e-health is not just a set of technological applications, its wide utilisation might lead to more health information, patient empowerment (J. Powell, 2009), an increase in the quality of data, a reduction of health errors, and the establishment of health behaviours. e-Health also is more economical for the patients because they are not forced to repeat diagnostic testing and record keeping, and it is not necessary for them to take long trips from one city to another to receive treatments (Alvarez, 2002).

From what has been discussed, it is concluded that e-health and its applications might be viewed as an economical method of delivering care. Such care involves better facilitation of meeting the healthcare requirements of the population regardless of their geographical location; thus, more people can have access to health services. These features are appreciated, especially in rural areas or less developed/underdeveloped countries where the population faces lack of medical practitioners, health specialists, and healthcare expert centres. e-Health technologies are viewed, from different perspectives, as tools with vast advantages for different stakeholders. Table 3.5, summaries major e-health stakeholders and e-health advantages for them.

Table 3.5

General Advantages of e-Health

Reference	e-Health Advantage for Patients	e-Health Advantage for Physician	e-Health Advantage for Healthcare Managers
Blaya, Fraser, & Holt, 2010	- Facilitating patient tracking through treatment initiation, monitor adherence and detect - Helping monitoring and detecting patients who might abandon care and scaling up treatment delivery and improving patient outcomes	- Reduction in medical errors and improving the productivity of the laboratory	- Ordering and managing medications, health service efficiency, forecasting medication requirements, providing accurate and timely information for strategic planning, allocating resources efficiently, and infection control
James & Walsh, 2011	- Verifying the identity of a person and providing accurate information regarding the health history and current healthcare needs of an individual		
J. Powell, 2009	- Facilitating empowerment of the patient		

S. H. Brown et al., 2007	- Presenting the user with the integrated results		- Better data organisation and integration
Bliemel & Hassanein, 2004		- Physician access to health information	- The efficiency of hospital administration activities
International Telecommunication Union, 2008		- Transferring medical images and laboratory results	- The exchange of healthcare and administrative data
Kahn et al., 2010		- Immediate access to disease reports	- The completeness and timeliness of disease surveillance
J. G. Anderson, 2007)		- Prevention of medical errors	- Healthcare costs
Singh & Kaur, 2010	- Taking care of the healthcare needs of rural population	- Assisting physicians with intelligent diagnosis systems - Enhancing collaboration of healthcare professionals	- Improving quality of healthcare and follow up services

Other areas of e-health applications are for emergency departments (ED), education, and research. In ED, e-health can be used for communicating between the emergency site and ED at the hospital and transferring patient information. This results in hospital staff being able to access the patient's medical information and field treatment. Therefore, all the information can be linked to a central database of patients' data and information (Chan, Killeen, Griswold, & Lenert, 2004).

For education and research, e-health can be used to exchange best practices or ongoing training through professional consultation or a web-based learning tool (Kahn et al., 2010). These could enhance quality standards and increase the number of skills in the healthcare domain. Moreover, e-health might improve communication between institutions (Blaya et al., 2010) so that they can share knowledge more effectively for research purposes.

Furthermore, in developing countries the positive effects of e-health utilisation, as reported by Blaya et al. (2010, p. 249), are:

- Ability to track patients through the treatment initiation process, monitor adherence, and detect those at risk to follow-up
- Tools to decrease communication times of information within and between institutions.
- Tools to label or register samples and patients.
- Ability to electronically monitor and remind patients of healthcare needs or treatment.
- Collection of clinical or research data using PDA applications.
- Reductions in errors in laboratory and medication data.

An additional list of e-health applications and their related advantages is set out in Table 3.6.

Table 3.6

e-Health Applications and Advantages

Application	Advantage
Data integration and management	Access to more data types, no date restrictions, access to up-to-date data from care at any site (S. H. Brown et al., 2007)
Computerised physician order entry systems	Reducing medical errors (Blaya et al., 2010)
Laboratory information management systems	Decreasing times for communication of results, and improving the productivity of the laboratory (Blaya et al., 2010)
Telemedicine and tele-presence applications	Reducing and/or eliminating the gap in trauma care between rural and urban areas (Latifi, Ong, Peck, Porter, & Williams, 2005)
Provider-to-provider communication	Improving patient care coordination and team management of chronic diseases (Kahn et al., 2010)
Telemedicine applications	Providing better ways to take care of the healthcare needs of the population of these areas and taking the healthcare solutions beyond geographical boundaries (Singh & Kaur, 2010)
Online training and education (for both specialist and public)	Solving the problem of scarcity of doctors or experts, raising awareness of the citizens against some deadly diseases (Singh & Kaur, 2010)
Information integration and sharing	Improving the body of epidemiological data and moving towards the overall improvement of health on a global scale (International Telecommunication Union, 2008)
Telehealth	Exchanging best practices (Kahn et al., 2010)
Pharmacy information system	Reducing the time to order medications and provide easy access to past information. (Blaya et al., 2010)

3.4.2 ICT and e-Health Technologies in Disasters

Effective management of disasters is negatively influenced by disaster unpredictability of place, time, number of injured people, and the severity and types of injuries (Latifi et al., 2005). These factors specifically affect search and rescue missions as well as providing health supports for victims.

New technologies could possibly eliminate some of these problems or diminish their impacts. Technology may be able to improve disaster management and has the potential to bring an incredible opportunity to make use of innovation to enhance disaster management (Underwood, 2010). Disaster management teams routinely use various technologies to undertake a complicated set of tasks (Garshnek & Burkle, 1999). Disaster managers may consider expanding the technology utilisation as ICT, as a technology group, has demonstrated positive effects in many fields besides healthcare, already, it is highly likely that it might be useful for catastrophic events as well.

Employing ICT developments (Tufekci & Wallace, 1998) is necessary for disaster managers so that they are able to integrate areas of disaster management and ICT with healthcare and bring collaboration among them. In the past, ICT was not widely used in disaster situations, both in disaster management and in disaster medicine, even though it could offer great potential. Embedding ICT within disaster management and medicine areas may improve efficiency and effectiveness of activities, tasks, and procedures in dealing with disasters. Additionally, ICT utilisation for facilitating disaster management may improve efficiency of response, communication integrity, and data sharing enhancement. The use of ICT to facilitate disaster management may improve the efficiency of response and interagency communication during disaster situations (Sieben et al., 2012). The reason is that in the disordered situations caused by disasters, new communications technologies, e.g., computer miniaturisation and advanced 'smart devices', can significantly enhance the emergency medical operations (Black et al., 2011). Moreover, some other applications can be supported by ICT mostly for re-establishing communication with outside-disaster sites for support purposes or within-disaster sites for managing responders.

Studying the identified challenges in disaster management and medicine (chapter 2, section 2.7), shows that many of them are related to people's health needs. Consequently, the researcher believes that by considering the direction that e-health is currently heading in healthcare, e-health technologies could be the most appropriate solution to address some of these challenges.

Considering the growth of e-health opportunities and their related capacities and services (section 3.4) parallel with their usage in today' healthcare (section 3.4.1), it is clear that e-health technologies have been designed to address challenges in normal medicine. As e-health technologies have been successful in normal healthcare and non-disaster circumstances, they may have the potential to be used in disaster situation to get the same results as in normal medicine. For example, these technologies are being used in normal medicine to enhance patient care and safety; e. g. in a community's emergency medical services (EMS), they can be used to improve incident management and informatics support either at the scene or at EDs (Chan et al., 2004)

Consequently, considering the capacities of ICT in general and e-health technologies in particular, as well as the nature of disasters and the importance of their management, e-health applications might benefit disaster situations (Sieben et al., 2012). e-Health is well suited to the disaster context, specifically to the disaster medicine discipline which mainly deals with medical issues in disasters. e-Health can also provide opportunities and innovations to answer disaster needs and public healthcare emergencies (discussed in chapter 2) more efficiently (Chan et al., 2004) and make medical-related activities more effective and efficient.

In disasters, e-health can be a tool to provide seamless support for disaster management and give proper instructions (S. H. Brown et al., 2007; Maturana et al., 2012; Singh & Kaur, 2010) to different groups of stakeholders. "These technologies have applications in terms of enhancing mass-casualty field care, provider safety, field incident command, resource management, informatics support, and regional ED and hospital care of disaster victims" (Chan et al., 2004, p. 1229). With all the advances made in e-health and digital applications, for example, the chance of delivering a portable and personalised (James & Walsh, 2011) health information system (HIS), becomes applicable to provide better responses to the emergencies regarding disasters and public health.

e-Health technologies have the potential to be used in DMC for clinical and non-clinical applications. Utilising these technologies may improve healthcare accessibility and facilitate medical care. For example, by using telemedicine and mobile health, it becomes possible to take care of the disaster injuries who are difficult to reach or send medical specialists to because of inaccessibility due to the loss of infrastructure. Furthermore, when other methods of data transmission are affected, telemedicine via satellite communication can be a suitable option. In the recovery phase, EHR could enable all patient's information and health background to be available immediately upon request, resulting in better follow-up treatments.

In the following sub-sections, the role of e-health and its technologies for each disaster phase is explored.

3.4.2.1 e-Health in Disaster Mitigation

Education and communication can play a vital role for either physicians or the public, and, accordingly, some of the e-health technologies like telemedicine and social networks could be useful. One way to raise public awareness regarding disasters and preparing for them is through social media. However, for specific groups of people such as physicians, this education can be done through more specific e-health tools like telemedicine-based clinical education. m-Health technologies can also be used. This group of e-health technologies may be considered as a commonly used tool for communication purposes.

To meet certain requirements, a number of e-health technologies can be integrated to optimise the final outcome. For example, an identified requirement of disaster mitigation is assessing a variety of national and local medical information (Chan et al., 2004), and it is believed that currently it could be most effectively addressed by cloud computing and m-health tools. The other requirements reported by Kaji & Waeckerle (2003) are integrating every hospital into the disaster plans, along with other critical components of the response effort. This requirement can also be addressed by using big data and cloud computing. Also, through integrating DSS with EHR, a number of disease preventative services may be offered.

In Table 3.7, a number of disaster mitigation requirements are laid out and, for each, an e-health technology that could facilitate the process is proposed.

Table 3.7

Selected e-Health Applications in Mitigation Phase

Disaster Phase	Disaster e-Health Scenarios
Mitigation	• **CC**: All hospitals can integrate into the disaster plans along with other critical components (Kaji & Waeckerle, 2003) • **CC**: A range of national and local medical information can be accessed (Chan et al., 2004) • **CC**: Offering a "unified patient medical record containing patient data from all patient encounters across all operators" (AbuKhousa et al., 2012, p. 625). • **DSS**: Prediction of short-term, medium-term and long-term consequences of organisation or community's activities which may be triggered by disasters, and should be assessed before implementation (Cioca & Cioca, 2010) • **IoT**: Monitoring of the environmental conditions effectively to control issues (Agrawal & Das, 2011) • **SN**: Utilising text messaging to alert target groups of health campaigns (Iwaya et al., 2013) • **SN**: Awareness presentations for educating public (White, Plotnick, Kushma, & Hiltz, 2009)

3.4.2.2 e-Health in Disaster Preparedness

Preparedness is about actions for enhancing a community's level of readiness against disasters; activities such as response planning and warning system development are the core activities of this phase. Since successful disaster response is highly dependent on the preparedness level, it is vital that healthcare organisations assess their response plan and their readiness level before any disasters strike. In order to optimise preparedness, a wide range of e-health tools such as telemedicine can be used for transferring or sharing clinical information (Garshnek & Burkle, 1999). Through using IoT technology, tracking and sharing tasks may be carried out automatically, which in turn could result in enhancing task efficiency and accuracy. Moreover, by cloud computing and big data applications, information regarding regional ED and resources availability can be tracked and shared.

Furthermore, EHR, considered as a core healthcare system, could help healthcare organisations to be better prepared for future disasters (S. H. Brown et al., 2007). EHR could benefit from using big data, cloud computing and decision support systems to overcome the challenge of matching patient loads and needs with available hospital resources, a challenge mentioned by Chan et al. (2004). Therefore, in the time of disasters, the chance of overwhelming healthcare environments by a large patient load is eliminated or decreased.

Table 3.8 presents a number of disaster preparedness requirements and the proposed e-health technologies to support them.

Table 3.8

Selected e-Health Applications in Preparedness Phase

Disaster Phase	**Disaster e-Health Scenarios**
Preparedness	• **CC**: Tracking and sharing information on regional ED availability and resources (Chan et al., 2004) • **DSS**: Controlling and forecasting, in the prevention of epidemic diseases prevention and management of floods (Cioca & Cioca, 2010) • **DSS**: Training and the evaluating command and control capability; capabilities-based planning (Thompson et al., 2006) • **DSS**: Matching patient loads and needs with available hospital resources (Chan et al., 2004) • **EHR**: Better Preparedness by having all peoples’ health background (S. H. Brown et al., 2007) • **EHR**: Integrating into existing electronic medical record (EMR) systems (Callaway et al., 2012)

	• **EHR**: Improving healthcare delivery on a daily basis and be better prepared for future disasters (S. H. Brown et al., 2007) • **MH**: Disseminating pre-disaster warnings (Fajardo & Oppus, 2010) • **SN**: Warning the general public (Petersen, Baccelli, Wählisch, Schmidt, & Schiller, 2015) • **SN**: Information dissemination and creating an emergency alert system (White et al., 2009) • **SN:** Use community engagement and informal social media to increase disaster preparedness in this difficult-to-reach population (Eisenman et al., 2009) • **TH**: Transferring and sharing clinical information (Garshnek & Burkle, 1999)

3.4.2.3 e-Health in Disaster Response

Disaster response is a time-critical phase in which any delay can be a matter of life or death. Compared to the other stages, efficiency is vital since the number of injuries is high while the available healthcare resources are scarce and finite. Several technologies can be used in this phase for different purposes. Telemedicine and mobile health have the potential to help disaster responders to provide medical specialties to reach casualties, or send trained clinical personnel (Blaya et al., 2010) to the areas lacking them. For making rapid and accurate decisions under conditions of uncertainty, DSS (Wears & Leape, 1999) can be used for decisions regarding transporting victims to the correct facility as quickly as possible (Rüter, 2006). The availability of basic medical information to health responders (James & Walsh, 2011) and continuity of their care can be provided through EHR system that helps the injured receive related and accurate care. EHR also supports portable and personalised health information systems that enhance response procedures.

Furthermore, IoT can be used to collect and share a large amount of information in real-time and make it available for decision makers for better understanding of the impact of a disaster and, thus, to react more appropriately (Petersen et al., 2015). RFID, as an IoT technology, is also useful in identifying and tracking not only disaster victims (Chan et al., 2004), but also the medical resources required to support incident management activities (Shamdani & Nicolai, 2012) and keep their records.

A selected number of e-health technologies are proposed in Table 3.9 to support disaster response activities identified by various researchers.

Table 3.9

Selected e-health Applications in Response Phase

Disaster Phase	**Disaster e-Health Scenarios**
Response	• **CC**: Providing better integration and exchange of medical records across multiple organisations and across sparse geographical areas (AbuKhousa et al., 2012) • **CC and BD:** Integrating information from disparate sources (Bradt et al., 2003) • **DSS**: Reducing the time needed to make crucial decisions regarding task assignment and resource allocation (Thompson et al., 2006) • **DSS**: Enhancing decision-making and coordinating the number of patients inbound with the number and type of hospital beds available and facilitating the work of the hospital-based providers (Bradt et al., 2003) • **DSS**: Transporting victims to the correct facility as quickly as possible (Rüter, 2006) • **DSS**: Organising medical resources and improving patient care in the disaster setting (Callaway et al., 2012) • **DSS**: Making rapid, accurate decisions under conditions of uncertainty (Wears & Leape, 1999) • **EHR**: Ensuring immediate availability of basic medical information to health responders (James & Walsh, 2011)

	• **EHR**: Accessing and collecting accurate personal health information from patients (James & Walsh, 2011) • **EHR** and **IoT**: Providing continuity of care and patient identification following a disaster (James & Walsh, 2011) • **IoT**: Identifying mobile objects (Zelenkauskaite et al., 2012a) • **IoT**: Identifying and tracking victims of disasters (Chan et al., 2004) • **IoT** and **MH**: Acquiring real-time and accurate information regarding patient needs, rescue personnel, and resources available (Chan et al., 2004) • **IoT**: Automating data entry and helping in tracking (Callaway et al., 2012; Lenert et al., 2005) • **IoT** and **MH**: Facilitating provider triage, improving provider handoffs, and tracking vulnerable populations (Callaway et al., 2012) • **IoT** and **CC**: Collecting and sharing large amounts of information in a short time (Takizawa, 2007) • **IoT**: Identifying, mobilising, dispatching, and tracking the resources required to support incident management activities (Shamdani & Nicolai, 2012) • **IoT** and **MH**: Keeping track of resources, equipment and products (Fajardo & Oppus, 2010; Shamdani & Nicolai, 2012) • **MH**: Proving SMS warning (Cioca & Cioca, 2010) • **MH**: Supporting triage in cases of large disasters (Kyriacou, Pattichis, & Pattichis, 2009) • **MH and IoT**: Monitoring health in real-time, coordinating among providers and assisting with triage (Vo, Brooks, Bourdeau, Farr, & Raimer, 2010) • **MH** and **IoT**: Storing data until connectivity is available (Oden, Militello, Ross, & Lopez, 2012) • **MH**: Receiving information about relief needs, and exchanging information about health hazards (Fajardo & Oppus, 2010)

	• **MH** and **DSS**: Allowing the prioritisation in disaster response mission (victims in more need) (Fajardo & Oppus, 2010) • **SN**: Bringing users to a helpful, user-centred Community Response Grid with local information and clear choices about what to do next (White et al., 2009) • **SN**: Requesting assistance and rescue service (Gao, Barbier, & Goolsby, 2011; White et al., 2009) • **SN**: Helping rescue teams to identify relevant areas (Petersen et al., 2015) • **TH**: Presenting solutions for the lack of trained clinical personnel, especially in rural areas (Blaya et al., 2010) • **TH**: Alleviating time and space barriers between healthcare providers and their patients (Sutjiredjeki et al., 2009) • **TH**: Providing convenient, site independent access to expert advice and patient information (Sutjiredjeki et al., 2009) • **TH**: Providing care and consultant from remotely located physicians (Vo et al., 2010) • **TH**: Enabling remote consultations and reducing patient load on local or temporary facilities (Vo et al., 2010) • **TH** and **MH:** Enabling patients and caregivers to connect for consultation, especially for routine care (Vo et al., 2010)

3.4.2.4 e-Health in Disaster Recovery

Continuous monitoring of disaster casualties and people with chronic diseases becomes possible by using IoT during the post-disaster phase. With IoT devices or sensors, vital signs can be monitored continuously. If added to the EHR, this may allow better care regardless of the geographical location of physicians and patients. Additionally, more supportive services such as tele-consultation, limited tele-diagnostic, and tele-education can be provided by mobile health or telemedicine (Sutjiredjeki et al., 2009). These services have the potential to provide better healthcare when there is a lack of specialists or experts in disaster stricken areas. In this phase, EHR could help us to improve follow-up treatment and to observe public health (S. H. Brown et al., 2007), since all citizen information and health backgrounds are available immediately upon request.

Various disaster recovery activities have been identified by a range of researchers and are shown in Table 3.10 along with proposed e-health technologies to support them.

Table 3.10

Selected e-health Applications in Recovery Phase

Disaster Phase	Disaster e-Health Scenarios
Recovery	• **EHR**: Advising and supporting patients in education and health self-management (Archer, Fevrier-Thomas, Lokker, McKibbon, & Straus, 2011) • **EHR**: Observing public health (S. H. Brown et al., 2007) • **IoT**: Monitoring remote patient and optimising care management (Agrawal & Das, 2011; Bouet & Pujolle, 2010) • **MH**: Managing, monitoring, and treating patient illnesses from a distance (Iwaya et al., 2013) • **MH**: Alerting systems for patients when it is time to take some medication (Iwaya et al., 2013) • **MH**: Making post-disaster announcements (Fajardo & Oppus, 2010) • **SN**: Identifying and locating missing children (White et al., 2009) • **TH**: Recording and reporting patient's vital signals, tele-consultation, limited tele-diagnostic, tele-education, and patient monitoring (Sutjiredjeki et al., 2009) • **TH**: Reducing disruptions in care (Vo et al., 2010) • **TH**: Alleviating time and space barriers between healthcare providers and their patients (Sutjiredjeki et al., 2009)

3.5 Internet of Things and RFID Technologies

Each e-health technology has its own strengths and weaknesses (as discussed in Appendix A). However, here the particular specialty of interest and focus is RFID as a sub-technology of IoT (see Figure 3.3 for the link between IoT and RFID). This technology selection is due to a number of reasons:

1- The scope and background of e-health technologies due to technology diversity are relatively vast, and it is almost impossible to deal with all technologies and undertake in-depth empirical research on each in this piece of research.
2- Some of the technologies and their applications are too new in the healthcare field and not enough empirical evaluation or evidence of their benefits exist.
3- Some challenges are directly healthcare related while others are indirectly related to healthcare. On the technology side, some of the technologies specifically deal with direct healthcare activities, while others can be used for direct and indirect healthcare-related tasks (e.g., logistics).

Having these reasons in mind, for the in-depth research, the IoT category and RFID as its sub-category technology were selected. For a comprehensive justification of RFID selection, the reader may refer to section 3.7.1 in which the potential of RFID and the rationales behind its selection are discussed.

IoT is a technology that enables the connection of the physical world with the online systems or digital world (Zelenkauskaite et al., 2012). The healthcare industry has recently shown a tremendous interest and potential for the usage of wireless sensors in various instances and for different purposes (Poenaru & Poenaru, 2013).

3.5.1 IoT

IoT has recently emerged and although it has been utilised in different fields, such as supply chains, wineries, agriculture, transportation and healthcare, it may take 5 to 10 years for its full market adoption (Gubbi, Buyya, Marusic, & Palaniswami, 2013). IoT is related to "Ubiquitous, Communication/Connectivity, Pervasive Computing, and Ambient Intelligence" (Dohr et al., 2010, p. 804).

According to P. Johnson (2014), IoT is a gigantic network of devices (Figure 3.2), and it is estimated that the number of devices will reach 30 billion by the year 2020. The main characteristic of IoT is that not only does it enable communication between humans and any objects (sensors, home applicants, monitoring devices, etc.) in their surroundings, but it also enables communication between those objects. The first consequence of object-human and object-object communication, as Gubbi et al. (2013) point out, is the production of large amounts of data.

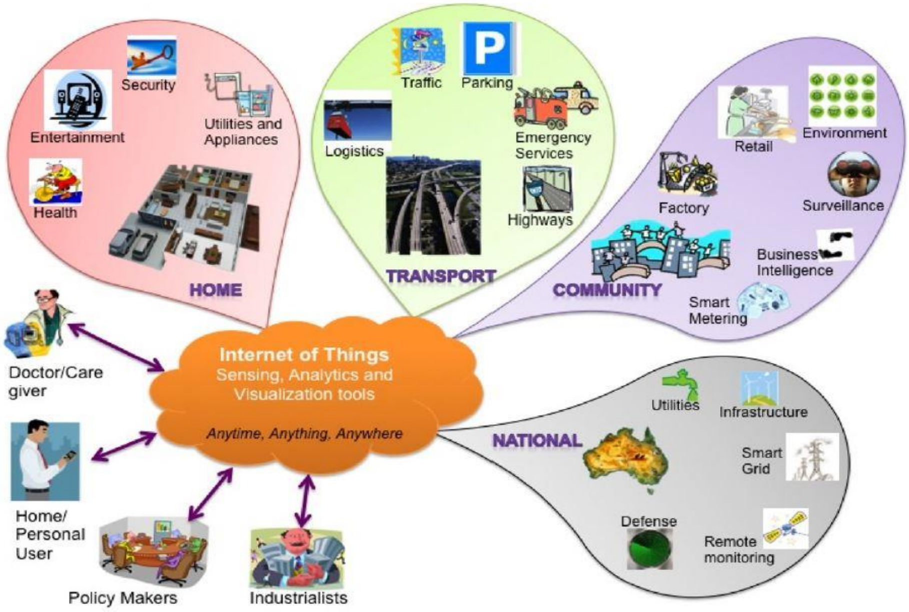

Figure 3.2 IoT (Gubbi et al., 2013)

Nowadays many applications use sensors that are capable of sending and receiving data with regard to the monitoring environment. They enable humans to sense the environment and interact with its physical objects. This interaction lets people use the valuable information provided by smart objects which gives people the power of accessing remote devices and generating the data that are fed to the sensors to help monitor the physical world remotely (Zelenkauskaite et al., 2012); this leads to the notion of having a 'smart' environment.

One of the components of IoT technology, that is, RFID, has been implemented successfully in different industries and environments and could be thought of as mature in terms of implementation and application.

Since one of the most challenging and vital tasks in disaster situations is related to healthcare, the researcher decided to investigate this matter and examine the RFID role for healthcare purposes within DMC (the relation between RFID and IoT is depicted in Figure 3.3). RFID is the selected technology for further research in this thesis due to the following reasons:

a. RFID can be the next pervasive technology in healthcare (Fuhrer & Guinard, 2006), whose applications in healthcare are expanding day by day.

b. IoT and its applications are relatively new in the healthcare concept and its full potential is not yet fully explored.

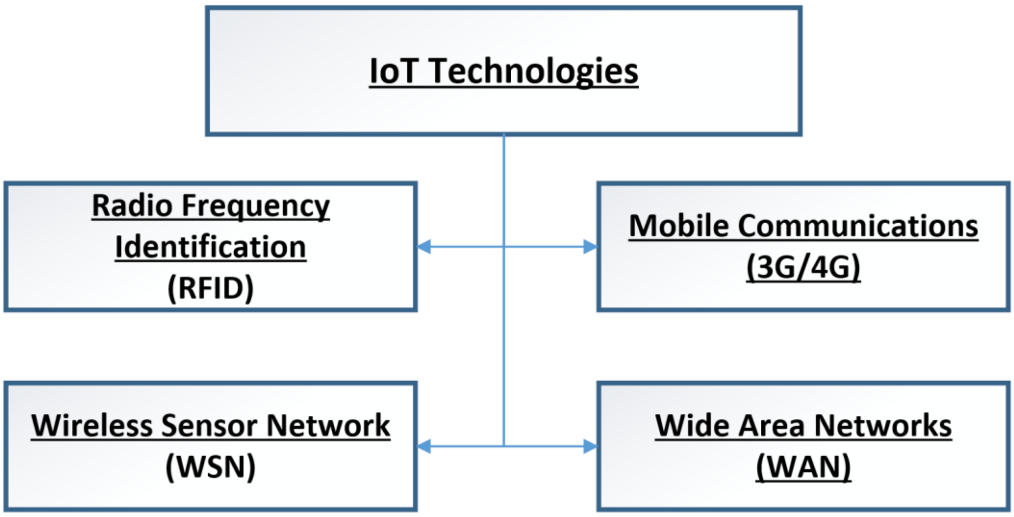

Figure 3.3 IoT technology components (adapted from Agrawal & Das, 2011)

3.5.2 RFID

RFID is not new per se, but its applications and utilisations for numerous purposes can be seen as new and innovative. Recently, the popularity of using RFID and its applications is increasing and it has attracted the attention of many industries. The number of areas in which RFID has been implemented is high, and this number is growing because feasibility of system adoption raised due to RFID technology enhancements that resulted in lower prices and more effective systems. Consequently, the overall cost of system deployment has been decreased. Importantly, dynamic rule encoding stored in tags has been introduced, and privacy protection has been achieved (M. Chen et al., 2010; Jokela et al., 2008).

RFID can connect objects wirelessly; as such, those objects can be identified and tracked, and their data can be shared with related parties and authorities (Agrawal & Das, 2011). According to the U.S. Research and Development (RAND), RFID is forecast to become one of the top 20 technologies by 2020 (Silberglitt et al., 2006), and it has been applied in numerous areas for different purposes varying from tracking and remote monitoring to real time positioning and management. A survey of 100 end users of RFID by RFID Journal found that most of them view the technology as a tool that could help them cut costs now, and improve long-term efficiencies (*End users plan to invest strategically in RFID in 2009*, 2009).

The RFID system consists of three main elements: tags, readers and middleware (Figure 3.4). RFID tags uniquely identify objects, their location, determine changes in physical data, and send these data to a corresponding transponder (Dohr et al., 2010). According to tags' energy sources used to transmit or receive information, tags are classified into three main categories: passive, active, and semi-passive. Passive tags use readers to collect energy, active tags have embedded battery, and semi-passive tags are like passive tags but additional modules could be supported through an internal battery (M. Chen et al., 2010).

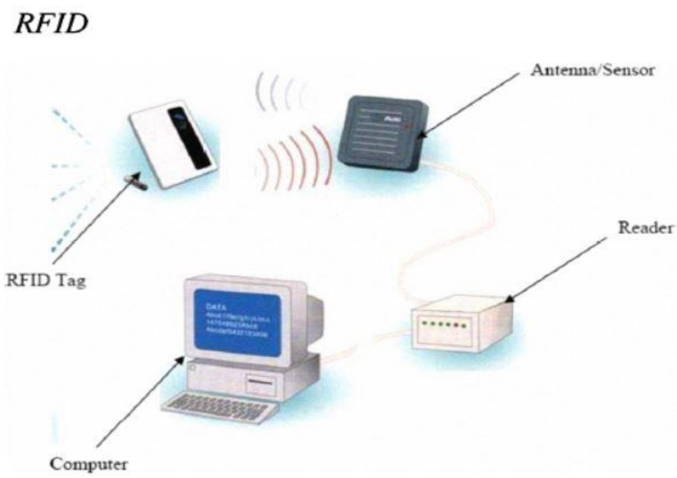

Figure 3.4 RFID system components (Y. W. Chen et al., 2009)

Previous related work by this researcher has been reported in "*The Role of Healthcare Information Systems Based on RFID Technology in Improving the Delivered Services in Healthcare Sector*" (Madanian & Madanian, 2015). Some of the sections in RFID application have previously been published.

RFID helps to use information better, faster, and more accurately than the current barcode system. Unlike GPS technologies, RFID locating systems have the capability to work within enclosed areas more accurately. Some of the RFID features that distinguish it from other auto-identification technologies and can facilitate healthcare procedures are presented in Table 3.11.

Table 3.11

RFID Advantages

• No 'line of sight' requirements	• More automated reading
• Improved read rates	• Greater data capacity
• Read/Write capabilities	• Unique identification for tags
• Data retrieved by handheld devices	• Integration with satellite or WiFi
• Contact-less communication	• No human intervention
• Two-way communication	• Higher accuracy

3.6 RFID for Healthcare Purposes

Healthcare is investigating RFID and its potential to facilitate better quality care, improve patient management, and enhance healthcare efficiency and effectiveness as well as enhance patient safety and satisfaction.

RFID is a promising tool to tackle healthcare challenges. This is because of its main capabilities, that is, automatic identification and tracking (S. W. Wang et al., 2006), as well as its characteristics and features together with an important number of its offered potential such as:

- removing data entry errors
- increasing efficiency and data accuracy
- decreasing time and cost
- reducing labour use

RFID can provide automated and precise information either from healthcare resources/equipment or from personnel and patients for a wider range of people/objects and in a shorter timeframe. RFID is also capable of addressing the requirements of the U.S. Food and Drug Administration (FDA) approach to patient safety, and enhancing communication (Kuo et al., 2007). The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) mentioned seven areas to improve patient safety, four of which can be supported by RFID (Kuo et al., 2007), namely:

(1) improving the accuracy of patient identification
(2) improving the effectiveness of communication among caregivers
(3) improving the safety of using medications
(4) eliminating wrong-site, wrong-patient, wrong- procedure surgery.

RFID utilisation in healthcare was fuelled mainly by two factors. Firstly, the FDA recommendation for the pharmaceutical and healthcare industries to adopt RFID (FDA, 2004) to combat counterfeit drugs and secure their supply chain. In this 2004 report, FDA identified several RFID applications including drug tracking and inventory management, and correct drug administration to the patients. Secondly, the rapid spread of SARS in Taiwan (Ahmed & Sugianto, 2009; S. W. Wang et al., 2006) in 2003; this has since accelerated RFID applications in clinical centres. Since that time, using RFID in healthcare has become more popular due to the speed and accuracy achievable by its implementation; this is crucial for managing healthcare sectors.

Generally, RFID in healthcare offers two major capabilities:

- real-time tracking capabilities for locating equipment, supplies, and people
- efficient and accurate access to medical data.

Based on these capabilities, RFID offers a vast range of applications in healthcare; these applications range from asset, patient, blood and specimen bags tracking to monitoring hospital wards, infection control, information retrieving, controlling drug distribution and pharmaceutical anti-counterfeiting. However, various researchers have identified RFID's main applications from different perspectives: monitoring and authorising (Bouet & Pujolle, 2010) and equipment and assess tracking (Bacheldor, 2008, 2009) the latter of which is the most adopted and widely accepted application. Many healthcare centres started RFID adoption with tracking and managing equipment (S. W. Wang et al., 2006);

however, as reported by Reyes et al. (2012), new RFID systems are focusing mostly on patient identification.

Incorporating RFID into the healthcare sector has the potential to offer a vast range of benefits. Generally, using RFID in healthcare could lead to cost saving due to business process optimisation (Fuhrer & Guinard, 2006), and to a decreasing patient mortality rate due to the removal of human errors. However, RFID benefits can be divided into different categories: visibility, efficiency, asset management, security, customer service, collaboration, and cost reduction (Reyes et al., 2012). Either directly or indirectly, these benefits result in enhancing efficiency, optimising patient safety, improving decision-making, increasing quality of caregiving and healthcare operations as well as decreasing cost, poor communication, and medical errors.

RFID deployment may help clinical industries to improve patient safety (Yao et al., 2010). This might be achieved through avoiding or reducing patient misidentification and medical errors in patient care including adverse drug effects, allergies, patient–medication mismatches and medication dosage errors (Fuhrer & Guinard, 2006; Wamba et al., 2013). Besides, RFID could reduce the inherent human errors and consequent risks by automating the communication process and delivering relevant and accurate information to responsible organisations to employ medical resources rapidly and efficiently (Madanian et al., 2015).

The optimum outcome of improving the specified areas is avoiding incorrect drug administration and other adverse events to ultimately ensure an increase in patient safety through personalised care and compliance with ‘the five R’ role. Five Rs, which are a foundation of patient safety, uses RFID to automatically ensure that the right patients receive the right drug with the right dosage at the right time and in the right way. Such a system is valuable for managing patients with chronic conditions that require complex treatment (Fuhrer & Guinard, 2006; Wamba & Ngai, 2011).

Due to the rising trend of RFID adoption in healthcare for various purposes, it seems that RFID will become a healthcare requirement (Ajami & Rajabzadeh, 2013). For example, the main reasons for RFID adoption from hospital managers’ point of view are illustrated in Figure 3.5.

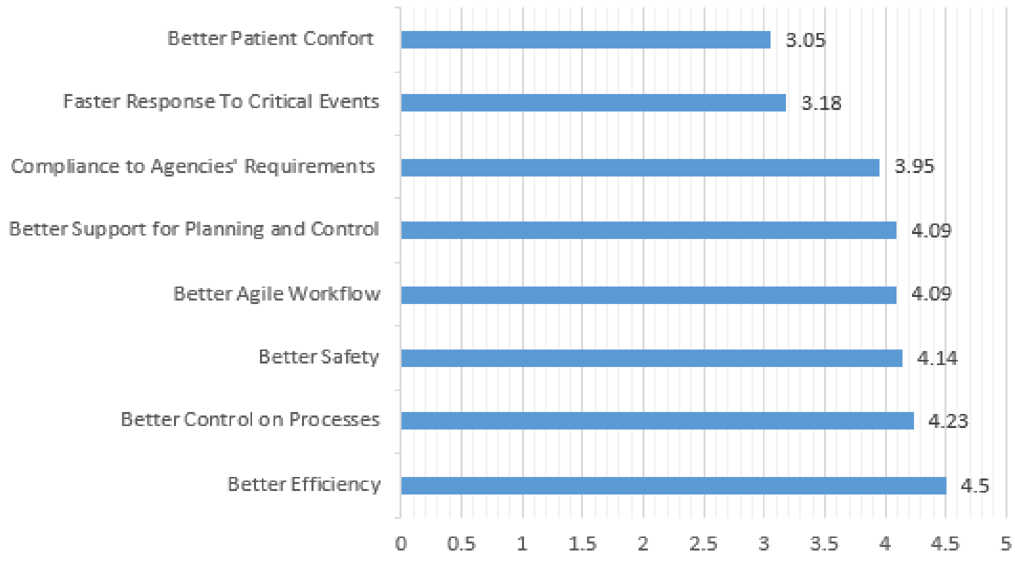

Figure 3.5 Main reasons for adopting RFID (Mogre, Gadh, & Chattopadhyay, 2009)

In Table 3.12, a number of medical centres that have utilised RFID and the purpose of their applications are provided.

Table 3.12

RFID Application in Health Centres – Extracted From Lahtela (2009) and Reyes et al. (2012)

Health Centre	Devices	RFID Application
University College Hospital Galway, Ireland	RFID handheld devices and wireless networks	RFID wristbands for identification
San Raffaele Hospital, Italy	RFID-enabled wristbands, re-writable RFID tags, wireless network	RFID for supervising blood donations and transfusions
Taiwan hospital	RFID and Location-based Medicare Service	Tracking SARS-infected patients; identifying patients and

	RFID and barcode technologies	their medications during medication administration
Harvard Medical School, USA	RFID and barcode technologies	Tracking IV pumps, equipment, ventilators, patient beds, electrocardiogram (EKG) devices and employees
Woodwards Laboratories, California, USA	RFID technology	Monitoring the hand hygiene policies in healthcare
Advocate Good Shepherd Hospital Illinois, USA	RFID enabled inventory system	Reducing annual inventory losses
Elvis Presley Memorial Trauma Unit, Tennessee, USA	RFID technology	Controlling workflow processes through the automatic capture of data on patient movements
Holy Name Hospital, New Jersey, USA	RFID technology	Fully utilising equipment that reduced equipment rental costs
Va.'s Bon Secours hospitals, Richmond, USA	RFID technology	Tagging 12,000 pieces of mobile medical equipment (e.g. wheelchairs and portable heart monitors)
Washington Hospital Centre, Washington, USA	RFID technology	Tracking the status and location of patients, staff and essential equipment
Alexandra Hospital and National University Hospital, Singapore	RFID technology	Hospital movement tracking system in Accident and Emergency Department, to track visitors, patients and staff

3.7 RFID in Disasters

The healthcare challenges presented in Table 3.1 refer to routine and daily healthcare procedures; however, these challenges can escalate during disasters when medical systems are under massive pressure, all routine procedures are disrupted, and many decisions must be taken under uncertain conditions. These obstacles (and those mentioned in chapter 2) point to the necessity of having a technology to facilitate vital information integration and sharing among disaster responders and organisations. Moreover, providing precise and timely information can highly help both disaster managers and healthcare managers to make appropriate decisions.

In this respect, based on e-health technologies literature, and considering the issues presented in Appendix A, it seems that RFID may offer a huge potential for disaster situations.

3.7.1 Why RFID in Disaster e-Health?

The reasons for narrowing down the focus of this research on IoT and RFID were highlighted in section 3.5. This section intends to support the initial justifications through a comprehensive and in-depth discussion of the RFID potentials that makes it a viable solution for disaster management challenges.

When there is high demand and pressure on the healthcare system and its resources (medical and human), the entire system may be overwhelmed. In such circumstances, several technologies can be implemented and used for each disaster phase. However, it is more desirable if a single technology can be deployed for taking care of a wider range of objectives and purposes. The reason for this selection is rooted in the high cost and complexity of implementation (Yang, Yang, & Yang, 2011); however, technologies' compatibility with each other and their integration may be an issue. e-Health tools need to be interactive, easy to use, engaging, adaptable, and accessible for a diverse range of audiences (Kreps & Neuhauser, 2010).

Adopting RFID within DMC was inspired by its current usage for normal and emergency care. Since using RFID provides efficient risk-free emergency care (Turcu & Popa, 2009), it is postulated that it could play the same role in disaster situations. Therefore, its applications could be expanded to cover disaster management and medicine.

In disaster management, the need for automation is quite significant, since disaster environments are harsh places prone to more accidents and a bottleneck in a disaster situation is automatic information handling not the lack of information or technology shortage (Ahmed & Sugianto, 2009). Therefore, automation through decreasing the direct human intervention has the potential to prevent more after-disaster incidents by automating information handling which can be achieved by employing RFID.

RFID has proved compatible with other technologies such as telecommunication, IT and robotics (Ahmed & Sugianto, 2009), and could be fully deployed in different phases of disasters because:

1- RFID applications and their benefits cover vast areas, directly or indirectly related to healthcare (its applications can include either population health and wellbeing or healthcare administrative activities);
2- it is anticipated that it can be used for the same purposes within DMC, due to its successful adoption in different areas such as supply chains and medicine (Ahmed & Sugianto, 2012);
3- RFID devices are cheap and small, which make their usage favourable for disaster monitoring compared to the other devices and technologies. While they are easy to use, they have the ability to work independently without relying too much on infrastructures such as electricity or any other pre-requisite technology (Ahmed & Sugianto, 2009; Aliyu, Chizari, & Abdullah, 2013).
4- RFID is a promising technology for disaster situations as its devices can operate in harsh environments, extreme and unsuitable working conditions, and uncontrollable climatic conditions (Ahmed & Sugianto, 2009);
5- generally, people do not tend to use those technologies that fail to correspond in any way with their daily lives or habits (van Gemert-Pijnen et al., 2011). This issue can be even more the case in disaster situations. Therefore, a technology should be used that has the least interaction with human activities and minimises human interference and intervention with the whole system.

Since RFID can reduce the complexity of disaster-related activities in DMC, different organisations have emphasised on its role for disaster management purposes (Chatfield et al., 2010):

1- 'Future Directions for IEEE Conference Business' defined RFID as one of the ten technologies that, if effectively implemented, could have a powerful effect in terms of proving highly valuable, strategically, in addressing disaster preparedness and disaster recovery.
2- The Japanese Government identified RFID applications as critical to dealing with disaster prevention and environment protection.

3.7.2 Current RFID Application in DMC

RFID, as a technological tool with unique features, is seen as a capable tool in disaster management and medicine. Through automating processes and preparing information, it can aid disaster-related activities. According to the Task-Technology Fit (TTF) model, several factors make RFID utilisations distinguishable from similar technologies, especially in the disaster management field (Ahmed & Sugianto, 2012):

1- For deployment, RFID is categorized under '*Ease of Use*' category; it means the complexity involved in the RFID utilisation and implementation, such as training requirements and technical infrastructure, is minimal.
2- *Locatability* refers to assessing the physical location of objects or people that has a high priority in disaster management activities, and is covered by RFID.
3- RFID can work seamlessly with other technologies; therefore, the *Compatibility* aspect is also covered by RFID. This factor is the leading reason for the success of RFID adoption in health.

RFID applications in disaster situations has attracted a lot of attention and set in motion a number of studies (see Table 3.13).

Table 3.13

RFID Application in DMC

Application	Purpose	Reference
Track and Trace	• Movement of assets or vulnerable citizens	Chatfield et al., 2010
	• Shipping containers	O'Connor, 2010
	• Casualties in the battlefield	Jorma, Heli, Janne, & Ville, 2013
	• Real-time patient tracking	Chan et al., 2004
	• Victims' dead body	Ahmed & Sugianto, 2009
	• Victims in a disaster situation	Ajami & Rajabzadeh, 2013; Chia, Zalzala, Zalzala, & Karimi, 2011
Information Gathering	• Searching specific shipment information	O'Connor, 2010
	• Maintaining the required details of the equipment that is deployed to the emergency scene.	Ahmed & Sugianto, 2012
	• Mobile data acquisition in the field, ambulance, and hospital	Chan et al., 2004
	• Collecting information quickly and accurately	Takizawa et al., 2007
Positioning	• Identifying the position of a victim	Daito & Tanida, 2008
	• Exact situation in the field.	Jokela et al., 2008
	• Locating patients' tent numbers for pre-operation planning	Callaway et al., 2012
	• Location when receiving emergency care	Chan et al., 2004

Monitor	• evacuees	Shamdani & Nicolai, 2012
	• The movement of tagged items from the suppliers to the emergency crisis	Baldini et al., 2011
Triage	• Using triage tags	Jorma et al., 2013
	• Online triage system for handling mass casualty	Jokela et al., 2008
Identification	• Identifying the casualties	Jorma et al., 2013
	• Recognising the patient in arranging the process of medical treatment.	Kuo et al., 2007
	• Quickly providing reliable identification to survivors	Baldini et al., 2009
Data Management	• Tags carrying the triage information (during transportation)	Jorma et al., 2013
	• Automating data transfer from one system to another	Ahmed & Sugianto, 2012
	• Transforming data for handling medical emergencies	M. Chen et al., 2010
	• Communicating triage information • Real-time information on the casualties.	Jokela et al., 2008
	• Storing basic medical information for the user • Uploading and downloading selected or incremental medical record information • Patient's personal information	Chia et al., 2011
	• Carrying data from the disaster site to hospitals	Chan et al., 2004

	• Storing and facilitating • Retrieving field care data when victims arrive at the hospital. • Supporting storage and retrieval of medical records data • Seamless tracking and transmitting information from a disaster site to the hospital emergency room and wards.	Lenert et al., 2005
	• Providing field hospital administrators with real-time census information essential for planning, resource allocation, inter-facility patient transfers, and inter-agency collaboration. • Entering patient information in real-time • Centralising repository of basic patient information • Flagging patients who require complicated post-surgical care • Using handheld device to search for patient information instantaneously generating aggregate census information for logistics, operations, and staffing requirements	Callaway et al., 2012
	• Providing accurate and trusted data	Shamdani & Nicolai, 2012
Asset Management	• Managing asset	Ahmed & Sugianto, 2012
Resource Management	• Managing resource	Ahmed & Sugianto, 2009

and Allocation	• Correctly and immediately allocating the available medical resources to the patients.	Kuo et al., 2007
	• Appropriate allocation of resources	Callaway et al., 2012
	• Managing the flow of medical supplies in the immediate aftermath of major disasters,	Shamdani & Nicolai, 2012
	• Optimally allocating medical resources and the wounded	Jokela et al., 2008
	• Allocating the available medical resources to the patients.	Kuo et al., 2007
Authentication	• Authenticating the identity of the medical personnel	Jokela et al., 2008
Medical Readiness	• Medical emergency readiness in a military medical setting.	Jokela et al., 2008
Estimation	• Estimating the near-future patient load up in the evacuation chain	Jokela et al., 2008
Warning	• Sending advance warning via the Nokia SM to the next medical facility	Jokela et al., 2008

Incorporating RFID in disaster management may help in minimising the complexity of the field and in dealing with DMC phases (Ahmed & Sugianto, 2007). Due to the ease of use of RFID and confidence in its usage (Jokela et al., 2008), it is anticipated that its deployment could help to achieve a considerable amount of benefits. By reducing human intervention and error and by providing quick and easy access to accurate and real-time information, RFID may improve post-operative care with the immediate goal of improving the quantity and quality of care and overall patient care (Ajami & Rajabzadeh, 2013; Callaway et al., 2012).

For example, in disaster response, RFID-provided information regarding objects or people may be more accurate and reliable, available and real-time. Such data enables authorities to make quality decisions during the disaster response and coordinate more effectively the operations led by local, regional, and national organisations; as a result, faster and better joint decisions can be made (Chatfield et al., 2010). These data also help authorities to identify an optimum preparation plan to face future disasters by forecasting their capacity through precisely collected data.

RFID-captured data can be sent to high-level organisations to help them obtain a panoramic view of the disaster-affected areas. This general view could enhance medical readiness and make possible having real-time visibility of the disaster situation (Jokela et al., 2008). Furthermore, medical data thus collected can be used to track and monitor at the disaster site the conditions of hundreds, even thousands of victims on a moment-to-moment basis, over a period of hours and days to give them quality care (Lenert et al., 2005). This system, due to supporting data storage and retrieval, might facilitate retrieving disaster site data when survivors are transferred to medical centres.

RFID may be able to support a better and prompt response. Owing to the complexity of healthcare operations, high system visibility is required, and medical personnel are required to deal with different tasks at the same time in a very complex environment immediately after the disaster. For such situations, RFID may have the potential to facilitate response activities and improve their quality. RFID implementation can integrate object flow and information flow automatically, promote the information visibility (Kuo et al., 2007) among disaster responders, coordinate different organisations, and improve communication. For this purpose, different RFID applications may be useful; these applications range from patient tracking to "mobile data acquisition in the field, ambulance, and hospital to create a portable medical record" (Chan et al., 2004, p. 1232).

In a disaster medical providers must prepare reports for the controlling manager of the number of casualties, the injury types, medical needs and so on. RFID systems enable automatic data acquisition and transfer in an easy and precise way that may result in time and cost savings. This may reduce the required response time through reducing the procedural delays in disaster management activities (Ahmed & Sugianto, 2009, 2012). Therefore, the chance of saving a greater number of injuries increases since less time is spent on data gathering and transferring which could result in enhancing the disaster response and post-disaster healthcare quality. RFID can be used to check available medical supplies to help save lives in major disasters like earthquakes (Shamdani & Nicolai, 2012) by allocating correctly and immediately the required resources for injuries' treatment.

RFID can be used to track or monitor vulnerable citizens (people with chronic health conditions or disabilities, elderly, and children), evacuees, and dead bodies transferred from disaster sites to healthcare centres or other facilities during and after disasters. In this regard, real-time information about disaster survivors can be written on RFID tags to be accessible by appropriate authorities. This information can be casualties' personal information or basic medical information, such as blood type. Such data can support disaster managers and hospital managers to plan allocating resources, transferring patients among facilities, and arranging inter-agency collaboration (Callaway et al., 2012). This information might be a valuable source for a better recovery phase since it enables authorities to keep record of casualties more easily. In their studies, S. H. Brown et al. (2007) and Kuo et al. (2007) emphasised RFID as an easier and faster survivors identification method in the process of medical treatment when huge numbers of casualties are seeking treatment in disaster aftermaths. This application can provide a quick, easy, and reliable mechanism for identification and real-time tracking of injured, responders and volunteers (Baldini et al., 2009) in the disaster site. Dead body identification application was implemented in Thailand in the aftermath of the 2005 tsunami (Ahmed & Sugianto, 2009) with proven efficiency and time reduction.

RFID has also been applied to manage the supply chain of disaster materials. It provides near real-time identification, tracking, and monitoring of materials distribution from suppliers to the disaster zone. It enables humanitarian organisations and others in doing so. Several studies have shown this application to be efficient, robust, reliable, and less labour intensive (Ahmed & Sugianto, 2012; Baldini et al., 2011; Chatfield et al., 2010; Ingrassiaet al., 2012; Kuo et al., 2007).

RFID can integrate with different technologies for various applications. In the study by Aliyu et al. (2013), RFID was integrated with IoT sensors to reduce the implementation cost and energy consumption of tags while enhancing the coverage monitoring areas. In this study, IoT sensors acted as the tag (RFID) reader. In another study that was first undertaken by Jokela et al. (2008) and then enhanced by Jorma et al. (2013), RFID was integrated with Near Field Communication (NFC) and mobile phone devices to create a mobile triage (m-triage) system for carrying and communicating the triage information.

The researchers believed that this RFID-based triage system was quicker, more reliable, and could enhance the triage and, consequently, the quality of care. Also, in Haiti, RFID was used with In-Transit Visibility (ITV) network and satellite communications to track shipping containers and looking up the shipment information (O'Connor, 2010).

3.8 Open Challenges

In this chapter, the potential of e-health technologies and the rationale for their utilising in general and RFID in particular in normal medicine and in disaster situations were discussed. Maturana et al. (2012) believe that healthcare has been incapable of responding properly to major disasters. By referring to disaster damage statistics, it can be noticed that this is not an area-specific problem, and it affects both developed and underdeveloped nations alike. Although healthcare industries have benefited from e-health technologies in the normal medicine, they have demonstrated poor performance during and after disaster. A number of these benefits were mentioned in sections 3.4.1 and 3.6.

If disaster management organizations are unable to control and lead disaster management activities effectively and efficiently they may not meet the clinical needs of the disaster victims. Moreover, the unpredictable nature of most disasters and the need for making immediate and appropriate decisions have necessitated an organised approach that may benefit from e-health technologies.

e-Health technologies can be used as supportive tools to support disaster management or medicine activities. However, despite increasing use of almost all types of e-health technologies in daily medicine and in emergency care, their applications in the disaster context are still low. Although recently the implementation of some of these technologies in disasters has been increasing, their exploitation is irregular and ad-hoc; thus, it needs to be systematised and integrated to encompass disaster management and disaster medicine (Althwab & Norris, 2013). Moreover, no systematic investigation has been carried out to find out how and where might e-health application be optimal in disaster management or within DMC to address healthcare needs (Maturana et al., 2012; Sieben et al., 2012).

e-Health technologies have been applied to disaster management, primarily during the disaster response and recovery stages, but neither routinely nor throughout the DMC

(Maturana et al., 2012). The ad hoc utilisation of e-health technologies only for specific disaster phases can hinder us from putting into good use all their potential in disasters. However, it is believed that through their systematic implementation promising benefits may be achievable (Bliemel & Hassanein, 2004).

If e-health technologies are integrated with DMC, they may help in better coordinating efforts and ensuring the nation's health and well-being during disasters (James & Walsh, 2011). The potential benefits of integrating e-health include: improved response times; more effective 'first response'; reduced mortality rate; development of more rugged, reliable, and redundant technologies; and enhanced preparedness through e-learning and virtual training approaches (Sieben et al., 2012). However, the problem is that no research has been done to focus on studying the integration of e-health within DMC or systematically to examine maximising the integration of e-health within the DMC (Sieben et al., 2012).

3.9 Disaster e-Health

The use of ICT may help to improve overall disaster management, facilitate response when disaster occurs, enhance support after disaster, and keep records for improving future preparedness. Therefore, e-health technologies, as a branch of ICT that specifically deals with healthcare environments, could be integrated into disaster management and medicine and be embedded in their different phases as a responding tool to victims' health demands. This integration needs a model that is able to facilitate determining where and in what way e-health can be practised and integrated within disaster management (Sieben et al., 2012). This issue is the main objective of this research study because it has not yet been addressed.

The researcher set to demonstrate the integration of three existing disciplines of disaster management, disaster medicine and e-health (Figure 3.6) that introduce the emerged paradigm of DEH. The final goal of DEH is to overcome the challenges discussed in sections 2.7 and 3.8. DEH can be recognised as a juxtaposition of healthcare and information science. It is defined, according to Norris et al. (2015, p.2), as "the application of information and e-health technologies in a disaster situation to restore and maintain the health of individuals to their pre-disaster levels."

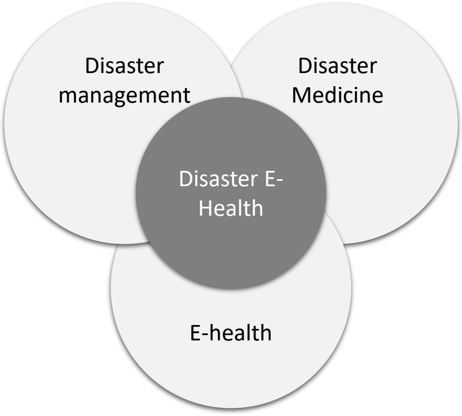

Figure 3.6 Disaster e-health and its components (Norris et al., 2015)

3.10 Chapter Summary

In this chapter, an overview of e-health, its technologies, and their applications in healthcare and DMC was provided and each aspect discussed. The literature review focused on only one technology, that is, RFID. Therefore, an extensive literature review was performed on RFID features, capabilities and applications in both healthcare and DMC. The chapter concluded by identifying open challenges in the area of e-health utilisation within DMC followed by introducing DEH as a potential solution to overcome the highlighted problems.

CHAPTER 4
RESEARCH METHODOLOGY

4.1 Introduction

This chapter explains the research development process. The objective is to familiarise readers with the applied research methods that accomplished the initial objectives described in chapter 1. The first sections of this chapter describe the adopted research approach, philosophical assumptions or paradigm, design and the related concepts together with their suitability for this study.

The next sections introduce and elaborate on the research activities to answer the research questions together with the rationale for applying these activities. In addition, the data analysis approaches for conducting the research are explained and justified. Finally, the ethical considerations related to the research study are presented.

In this research, a combination of different research activities was used to collect and analyse data (Figure 4.1). The details of these activities, their processes and tasks, are explained in the next chapters and summarised in Table 4.1.

This chapter describes:

- Overview of the research design
- Utilised research approaches and their justification
- Utilised data gathering and data analysing methods and their justification.

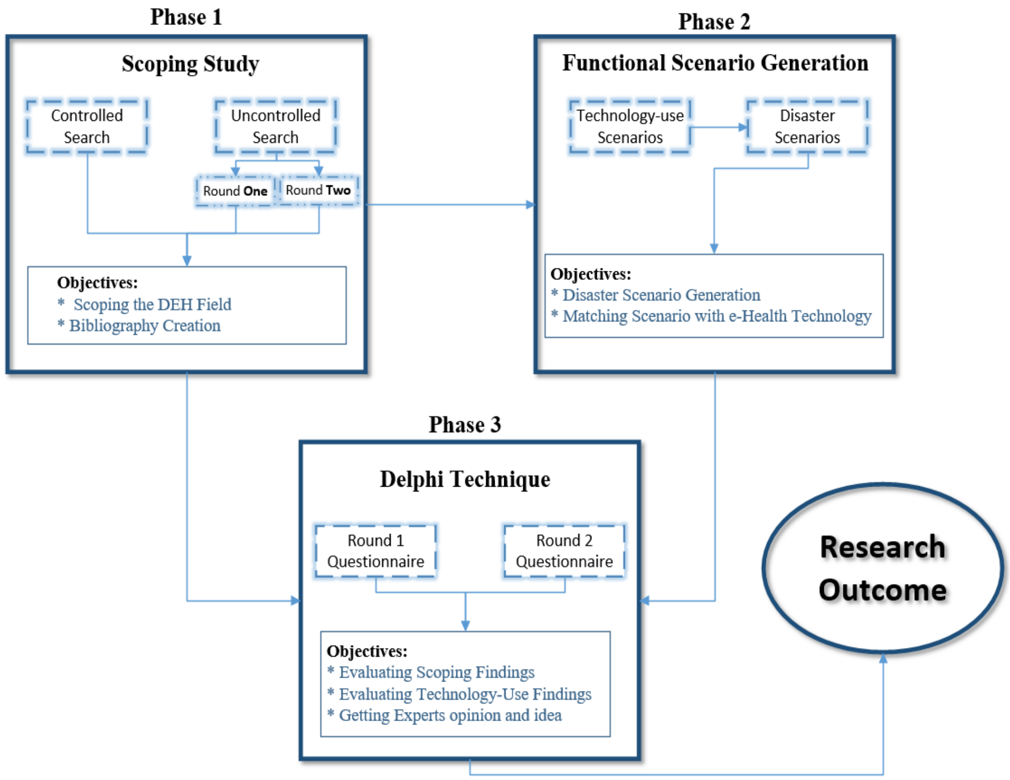

Figure 4.1 Overall framework of the research activities

Table 4.1

DEH Research Activities

Phase	Method	Purpose	Experimental Activities	Description
Phase 1	Scoping Study	- Identifying DEH scope - Bibliographic creation	1- Uncontrolled search 2- Controlled search	Chapter 5
Phase 2	Functional Scenario Generation	- Generating disaster management cycle (DMC) scenarios - Matching e-health technologies with DMC scenarios	1- Functional scenario generation 2- Technology-Use scenario creation 3- Scenario generation	Chapter 6
Phase 3	Delphi Method	- Evaluating findings - Gathering experts' ideas	- Questionnaire generation	Chapter 7

4.2 Research Approach

By considering the research problems, objectives, and questions, this research followed a mostly qualitative approach. This gives an opportunity to the researcher to gain a rich and in-depth understanding of the topic under investigation. It also "offers the greatest promise of making a difference in people's lives" (Merriam & Tisdell, 2016, p. 1).

The qualitative approach has several variations depending on the research objectives, but it mainly attempts to determine the reason for events and anticipate future comparable events. It can reveal the meaning of a phenomenon, define associated facts and features, determine relationships between events, and anticipate future events (Merriam & Tisdell, 2016). The approach is especially appropriate for the present research because:

1- Mostly non-numeric data was to be collected from the literature and analysed in context rather than by statistical methods.
2- It was important to find multiple interrelationships among a variety of research factors based on the research questions (Denscombe, 2014)
3- There is a need for a research design suitable for "studying phenomena in dynamic situations" (B. Johnson & Christensen, 2012, p. 378)

Furthermore, qualitative approach is suitable for exploratory research in which researchers concentrate on people's attitudes towards the area under study to develop an understanding of it (Creswell, 2007). This statement fits the DEH study and its objectives.

4.2.1 Research Paradigm

Research design in any fields mostly starts with some philosophical assumption or paradigm, the choice of which constitutes the intent, motivation, and expectations for the research and, consequently, affects the way knowledge is studied and interpreted. As maintained by Creswell (2007), Denzin and Lincoln (1994) and Glesne (2016), a research paradigm links to the researcher's viewpoint about the nature of reality (ontology), nature of knowledge (epistemology), and methods used in the process (methodology). Based on the combination of ontology and epistemology, various research paradigms are created that can be categorised into the following: positivism/post-positivism, constructivism, advocacy/participatory and pragmatism (Creswell, 2009).

This research followed a pragmatic paradigm. As argued by Creswell (2009, p.10), a pragmatism paradigm "as a worldview arises out of actions, situations and consequences rather than antecedent conditions". Considering the research aims and objectives and since DEH topic i) is oriented toward social sciences and ii) covers healthcare demands within DMC, achieving these objectives requires a mixed method approach. By way of explanation, one aspect of this research was identifying the scope of DEH and generating related scenarios through qualitative method. However, the other aspect of the research was quantitative as it was about identifying the role of RFID technology within DMC and DEH scope through giving ranks to the defined RFID scenarios by the research participants. Therefore, pragmatism paradigm was believed to be the most suitable approach for the mixed methods methodology. As mentioned by Creswell (2007 and 2009) and Tashakkori and Teddlie (2003), the mixed methods approach associated with the pragmatic paradigm encompasses data collection using both quantitative and qualitative to better answer the research questions.

In a pragmatic paradigm the focus is on practical aspects of the research and the emphasis is on the importance of conducting research that best addresses the research problems. In this paradigm the research problem(s) are in the central focus and all approaches that help researcher to understand the problem can be applied (Creswell, 2009). Therefore data collection and analysis methods are selected as those most likely to provide insights into the question with no philosophical loyalty to any alternative paradigm (Mackenzie & Knipe, 2006). In essence, a pragmatic paradigm is problem-centred and real-world practice oriented which matched with this research.

4.2.2 Research Process

This study followed inductive reasoning. In the qualitative inductive approach, researchers collect information to form ideas, theories and hypotheses instead of testing theories deductively as in positivist research. Qualitative researchers work towards their hypothesis from instinctive understandings and observation gathered during their time in the field. Chunks of information collected from different sources, such as documents, interviews, or observations, are collated in an orderly manner to be organised into larger topics because the researcher needs to go from the specific to general.

Normally, in a qualitative study, the results which were derived from the data inductively are in the form of "themes, categories, typologies, concepts, tentative hypotheses, and even theory about a particular aspect of practice" (Merriam & Tisdell, 2016, p. 17). Additionally, Merriam and Tisdell (2016) maintained that qualitative studies and research fields without a theory mostly follow inductive reasoning. Therefore, inductive reasoning was employed for the above reasons, as DEH is a qualitative study and there is not a single theory about it, or even if there is, it is unable to account adequately for DEH.

Based on these points, in this study, a qualitative inductive approach can help to build new theories for the DEH field since, as Saunders et al. (2012) suggest, where a naturalistic and emergent research design is used to develop a richer theoretical perspective than already exists in the literature, it is more appropriate to use inductive reasoning.

4.2.3 Research Design

Exploratory research design was chosen and employed for conducting DEH research. It is a common and suitable choice in qualitative studies with inductive reasoning (Schutt, 2015). In this design, research mostly begins with observing social interactions between phenomena under investigation and people, and researchers try to make sense of those situations. The result of the endeavours of researchers can then be a large amount of relatively unstructured information that can explain what has been found and which has the potential to take the field into a new direction.

As several researchers (Collis & Hussey, 2014; Given, 2015; Marshall & Rossman, 2011; Saunders et al., 2012; Schutt, 2015) have pointed out, exploratory studies have been used to determine what people think, how they react and why. The aim is seeking patterns and ideas or asking questions rather than testing hypotheses. Moreover, building a rich and comprehensive description of unexplored complex circumstances in the literature can be achievable. Therefore, exploratory research design entails the following purposes:

1. investigating little understood phenomena;
2. identifying important categories of meaning (themes/patterns);
3. generating hypotheses for further research.

This is especially so for the following research types in which:

(i) Very few or no earlier studies are available and not much is known about the situation under study (Collis & Hussey, 2014)
(ii) A large amount of relatively unstructured information is captured (Schutt, 2015)
(iii) An issue is examined for the first time and in-depth (Given, 2015)
(iv) An observational method is impossible or rare (Silverman, 2005).

Accordingly, the exploratory research seems a suitable research design for a DEH study The exploratory design was used as an instrument to ask open questions (Saunders et al., 2012) and clarify understanding of the phenomena under investigation as well as gain insights into the DEH scope.

4.3 Data Collection Methods

Data collection approaches tell researchers how to gather all relevant information and data to answer the predefined research questions (Myers, 2013). To conduct the current research, due to having diverse research activities, the related data were collected through two distinct data collection procedures.

For phase 1 (scoping study), data were collected from published research (secondary sources) in line with Glesne's recommendation (2016). To gather further data and evaluate the research findings, in phase 3, questionnaires were utilised through a Delphi method.

Table 4.2 presents the applied data collection method for each phase of DEH research.

Table 4.2

DEH Research Activities and Data Collection Methods

Phase	Research Activity	Data Collection	Discussion on Procedure and Findings
Phase 1	Scoping Study	Referring to published research (known as secondary sources)	Chapter 5
Phase 3	Delphi Method	Questionnaire	Chapter 7

4.3.1 Data Gathering through Published Research (Phase 1)

One of the objectives of this research was to identify the scope of DEH. Therefore, it is essential to conduct an in-depth analysis of past research or practical works in the context of e-health technologies applications within DMC.

The primary mode of data collection for this study was through referring to the published studies for analysing the relevant documents, research reports, and commentaries. This approach is often used in social sciences research (Denscombe, 2014; Schutt, 2015). In this way, more data are available from researchers all around the globe, while gathering them by the other data collection techniques can be difficult, complex, time-consuming, and in some cases almost impossible. Additionally, this method allows researchers to facilitate data collection and avoid related problems and lengthy procedures. Combining data from diverse and multiple samples and studies becomes possible in this method. Furthermore, due to the special focus of the current research – disasters – data collection through other methods, such as observation and interview, was almost impossible. Direct observation of a disaster situation is almost impossible, and interviewing all different disaster management parties and other related fields' stakeholders was impractical due to the diversity of the parties, from disaster casualties and volunteers to disaster managers and practitioners, and, above all, due to research time limitation.

Gathering qualitative data by referring to documents has a number of advantages for the purpose of this research. Firstly, documents contain information that can be used as evidence of something that can be used for revealing aspects that are not immediately apparent (Denscombe, 2014). Secondly, documents provide some records whose existence, if not permanent, does at least persist in a stable form well beyond the moment in which it was produced. All these features together with document interpretation (Myers, 2013) help researchers to provide a more comprehensive picture of the area under investigation. However, it should be noted that the important criteria of authenticity, credibility, meaning and representativeness (Myers, 2013) must be observed in document selection procedure (see chapter 5).

In this research, a further method of gathering data, the next section, was needed to make sure that this stage was done in a scientific and rigorous manner.

4.3.2 Data Gathering Through Questionnaire (Phase 3)

In phase 3 it was necessary to use the questionnaire as an instrument for validating study findings from phase 1 and phase 2 (see Figure 4.1). The questionnaire tool was used to gather further data based on the experts' opinions regarding previously generated information.

The questionnaire was believed to be an appropriate tool for this study since it has a number of strong points over and above the other methods of qualitative data collection, such as the interview or observation. Firstly, the researcher had to consider the geographical location of respondents since the required experts are found all over the world; the questionnaire is an easy, quick, and cost-effective way of approaching them to gain their viewpoints. Secondly, questionnaire distribution electronically via email was more efficient since it could be reached by several respondents simultaneously without considering their geographical locations and time differences.

Regarding the structure and content of the questionnaire, one that is simple and straightforward is recommended. This is particularly important if the intention is to distribute it electronically because should the respondents have any questions or doubts they cannot be clarified immediately (Sekaran & Bougie, 2010).

At the beginning of the questionnaire, clear instructions were provided to inform the users about the purpose of the questionnaire, how to complete it, and the ethical consideration in the data gathering stage and the data analysis stage. The questionnaire structure comprised the following sections with a brief and clear introduction at the beginning of each section to increase the familiarity of the respondents with the questions in each part:

- Respondent context information (demographic section)
- Disaster e-Health scope category
- RFID in DEH category

The questionnaire was based on five-point Likert scales. Besides, respondents were allowed, indeed encouraged to give reasons for their answers or offer additional comments in the sections provided after each question. Full details and explanations of the questionnaire structure and sections are provided in chapter 7: Delphi Method and Its Findings.

4.4 Research Approach for Reviewing Published works

Reviewing data from published works has several aims ranging from summarising to integrating data. However, the main aim of this study was to summarise the findings of the existing literature to define the scope of DEH and clarify its boundaries. It also aimed to determine the e-health technologies usage in DMC. When considering the nature of the research questions – specifically RQ 1– it is clear that answering them is not possible except by document review to extract the present empirical evidence and provide the existing body of knowledge, as well as a theoretical foundation for DEH identity.

However, it is important to take into consideration that if reviewing the secondary sources does not follow a suitable procedure or method, false and inappropriate conclusions may be drawn. Therefore, a procedure or method needs to be followed so that it can be maintained that, when all the necessary information is extracted from the published research and reports, the results are reliable enough in terms of being trustworthy and unbiased.

Since this study was classified as falling under the exploratory category, several methods for conducting the research were identified as being rooted in several research and policy domains (Grant & Booth, 2009). Although each method has its own strengths and weaknesses and no method could be considered superior to others, relevancy and rigour of the method are key.

4.4.1 Health Informatics Document Review Methods

The current research concentrated on responding to the health demands of people by using e-health technologies at the pre- and post-disaster phases. Consequently, a hybrid method was considered as the most suitable approach for both health information and information systems. Among the proposed qualitative methods for reviewing secondary sources, the most common ones for 'health information and library and information science' (Grant & Booth, 2009) and for 'information system' (Paré et al., 2015) are outlined in Table 4.3.

Table 4.3

Secondary Sources Review Methods

Review Types	For health information and library and information science	For Information system	Potential to be used for DEH Research Study
Critical review	√	√	√
Descriptive review		√	
Literature review	√		
Mapping review /systematic map	√		
Meta-analysis	√	√	Disregarded since it is a quantitative method
Mixed study review	√		
Narrative review		√	
Overview	√		
Qualitative systematic review	√	√	√
Rapid review	√		
Realist review		√	
Scoping review	√	√	√
State of the art review	√		
Systematic review	√		
Systematic search and review	√		
Systematised review	√		
Theoretical review		√	
Umbrella review	√	√	√

Table 4.4 provides the common methods and their descriptions in both areas of information system and health information that have the potential to be applied in the current research.

Table 4.4

Selected Methods for Reviewing Published Works

Method Name	Description
Critical review	This method analyses critically the extant literature on a broad topic to reveal weaknesses, contradictions, controversies, or inconsistencies (Paré et al., 2015). Its aim is to demonstrate that the investigator has extensively researched the literature and critically evaluated its quality. This method goes beyond a mere description of identified articles and includes a degree of analysis and conceptual innovation (Grant & Booth, 2009).
Qualitative systematic review	This method is appropriate for integrating or comparing the qualitative research findings and attempting to search, identify, select, appraise, and abstract data from them. It looks for 'themes' or 'constructs' that lie in or across each qualitative research (Grant & Booth, 2009; Paré et al., 2015).
Scoping review	This method is useful for mapping out a field of interest and can be used as a transparent technique to map the literature and address broad research questions on a topic (Arksey & O'Malley, 2005; Levac, Colquhoun, & O'Brien, 2010). It attempts to provide a preliminary assessment of the potential size, scope and nature of the available literature on a particular field and the extent of research evidence.
Umbrella review	It is generally referred to as the overview of reviews that accumulate and integrate relevant evidence from various reviews into one accessible and usable document. It concentrates on broad problems and/or conditions with competing interferences and underlines reviews that deal with these interventions and their results (Grant & Booth, 2009; Paré et al., 2015).

4.5 Scoping Study (Phase 1)

Among the discussed methods (Table 4.4), a rigorous scoping study was conducted due to the exploratory nature of this research and its vast scope. In this context, Colquhoun et al. (2014) propose that a scoping study can address exploratory research as a form of knowledge synthesis. Moreover, S. Anderson et al. (2008) maintain that it also acts as the initial step in areas with broad scope such that undertaking any meaningful empirical research in the first stage is difficult.

The scoping study has been conducted in a number of disciplines for different purposes, the summary of which can be found in Table 4.5.

Scoping studies are used to examine the extent, range, and nature of research activities instead of thoroughly analysing single elements of that research; they explain the main range of features of a study (Boyd et al., 2014). Valaitis et al. (2012) suggest that the main purposes of conducting scoping studies are reviewing the literature and examining their results. However, a scoping study can be used to detect research gaps in the existing literature and to offer an initial indication of the potential size and nature of the available literature on a particular topic (Arksey & O'Malley, 2005; Paré et al., 2015).

Table 4.5

Scoping Study's Purposes

Scoping Study Purposes	**Reference**
- To map the literature available in order to identify key concepts, theories and sources of evidence	Reeves et al., 2011
- Achieve a representative, but not necessarily comprehensive, sample of the distribution of an evidence base across a predefined topic area - Characterise the quality of the evidence base in terms of types of study and the specific questions or subtopics addressed by identified studies	Lee et al., 2014

- Provide an overview of the extent of the area rather than to undertake an in-depth assessment of individual studies - Rapidly map the key concepts underpinning the research area using the main sources and types of evidence available - To address topics that are too broad for a systematic review, or have not been previously reviewed comprehensively	Zhong et al., 2014
- Preliminary investigative processes that identify the range and nature of existing evidence and help in the formulation of a research question(s) and the development of research proposals - Examine the breadth of research on a particular topic - Examine the range and nature of a particular research area - Disseminate research findings or to identify gaps in the existing research literature.	Rumrill, Fitzgerald, & Merchant, 2010
- To examine the extent, range, and nature of research activity - To determine the value for undertaking a full systematic review - To summarise and disseminate research findings - To identify research gaps in the existing literature	Arksey and O'Malley, 2005
- Preliminary assessment of potential size and scope of research literature - Identify the nature and extent of research evidence (usually including ongoing research	Grant & Booth, 2009
- Clarification of working definitions and conceptual boundaries of a topic area - Outline what is already known and identify gaps in existing research - Summarise the extent, range, and nature of research activity - Summarise and disseminate research findings - Identify gaps in the existing literature (purpose four) in order to subsequently identify the key research priorities	Levac et al., 2010

- Examine what is known from existing primary studies, literature reviews and descriptive accounts - Used to disseminate research findings on particular research questions and identify gaps in research	Valaitis et al., 2012
- Identify questions and topics for future research - Review of the evidence around skill mix in secondary care - Review of the evidence on the relationship between workforce and health outcomes - Review of the evidence on the impact of local labour market factors on the organisation and delivery of health services - Identify topic areas for future research	S. Anderson et al., 2008
- Synthesise evidence that can be influential for policy and practice	Colquhoun et al., 2014
- Conduct a literature review of existing research - Highlight gaps in the existing evidence base - Engage with relevant stakeholders to identify issues of practice and policy relevance and where further evidence is needed - Recommend themes for further research	Boyd et al., 2012

There is no universally agreed definition for ‘scoping study’ (see Table 4.6). However, one of the early studies defined it as the “aim to map rapidly the key concepts underpinning a research area and the main sources and types of evidence available” (Mays, Roberts, & Popay, 2001, p. 194). For the purpose of DEH research, Levac, Colquhoun, and O’Brien’s (2010) definition was used because the initial aim of the research was to identify the breadth and depth of DEH area.

Table 4.6
Different Views on Scoping Studies

	Definition	Aim	Strength	challenge
Arksey & O'Malley, 2005	Further type of literature review and as a technique to 'map' relevant literature in the field of interest	Map rapidly the key concepts underpinning a research area and the main sources and types of evidence available'	Comprehensive and in depth coverage (breadth) of available literature	Do not assess the quality of included studies
Levac et al., 2010	'Mapping' a process of summarising a range of evidence in order to convey the breadth and depth of a field.	(1) To examine the extent, range, and nature of research activity, (2) determine the value of undertaking a full systematic review, (3) summarise and disseminate research findings, (4) identify gaps in the existing literature, (5) consider a complex problem and improve succeeding research needs	Researchers can incorporate a range of study designs in both published and grey literature, address questions beyond those related to intervention effectiveness, and generate findings that can complement the findings of clinical trials	Authors do not typically assess the quality of included studies

Colquhoun et al., 2014	Scoping reviews are a form of knowledge synthesis, which incorporates a range of study designs to comprehensively summarise and synthesise evidence with the aim of informing practice, programmes, and policy and providing direction to future research priorities	Not Mentioned	Relevant to both emerging and established fields	(1) Lack of consensus on scoping review terminology, definition, methodology, (2) reporting limits the potential of this form of synthesis, (3) difficulty sharing and retrieving information
S. Anderson et al., 2008	Contextualising knowledge in terms of identifying the current state of understanding; identifying the sorts of things we know and do not know, and then setting this within policy and practice contexts	(1) Identify questions and topics for future research, (2) identify topic areas for future research, (3) inform about what the key gaps in knowledge are	(1) Useful in identifying the services available for dispersed and vulnerable groups, (2) opportunity to map a wide range of literature, (3) have been used for a wide variety of purposes	(1) Review team needs to include a broad range of subject experts and to use a wide sweep of search terms, (2) potential bias in the perception and interpretation of a subject due to a researcher's prevailing academic discipline and research interests, (3) tight time scale prevented a more considered and comprehensive response

The scoping study is an appropriate method for emerging as well as established fields. Moreover, where an area is newly emerged and/or complex (Valaitis et al., 2012), this method may be more suitable. The initial reason, according to Levac et al. (2010), Arksey and O'Malley (2005), and Colquhoun et al. (2014), is that in emerging fields either there is a lack of evidence and shortage of randomised controlled trials, or the literature has not received enough attention and has not been reviewed thoroughly, so reviewing systematically is not possible. Furthermore, in emerging areas, there is diversity in research methodologies that makes it difficult to discover the extent of their landscape, due to the lack of evidence; therefore, in these situations the scoping study might be the best option.

The DEH area is a newly emerged field. As such, it has limited available resources and is too new to have clear boundaries and accepted content and protocols. Therefore, its extent, range, and nature must be identified. DEH is based on the existing disciplines of disaster management, disaster medicine, and e-health (Figure 4.2), and can be recognised as a juxtaposition of healthcare and information science. In the core of DEH, we deal with disasters that are mostly unforeseen in their nature, and collecting the relevant data for executing this research through other qualitative methods such as direct observation is largely impractical.

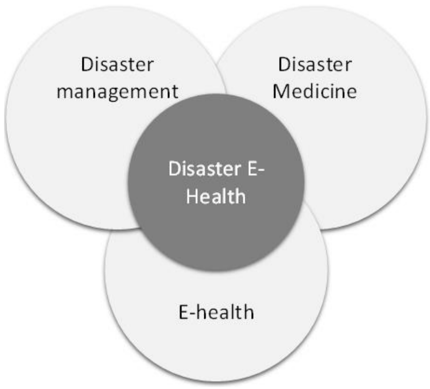

Figure 4.2 Disaster e-health and its components (Norris et al., 2015)

By highlighting the features of scoping studies and associating them with the DEH characteristics, it becomes clear that the scoping study is the most suitable tool for visualising the range of material that might be available (Arksey & O'Malley, 2005).

Scoping, moreover, can be regarded as a bridge joining the relevant works, bringing new ideas and theoretical models, and giving direction to future studies by paying attention to gaps, hidden areas, discussions, and movements (Paré et al., 2015).

4.5.1 Scoping Study Framework

A research methodology requires a conceptual framework that embodies the rationale and purpose of the study (Rumrill et al., 2010) and the methodological stages through which it proceeds. To conduct a scoping study, a methodological framework is needed which is able to provide the methodological foundation for the study. Therefore, the objective of this section is to demonstrate and explain the framework developed to conduct the scoping review.

Within the scoping study method, a major framework exists that acts as the basis for some other scoping frameworks; nevertheless, other frameworks mostly follow the stages of the main framework and only refine it by adding minor step(s) or making some enhancement in the description.

Arksey and O'Malley proposed the initial framework in 2005, and it suggests conducting the scoping review in the field of interest in five stages as below:

Stage 1 - Identifying the research question

Stage 2 - Identifying relevant studies

Stage 3 - Selecting the studies

Stage 4 - Charting the data

Stage 5 - Collating, summarising and reporting the results

In 2010, Levac et al. (2010), based on their own research experience, modified the initial framework by adding the 6th stage of 'Consultation with Stakeholders'. They have also added some clarification and enhancement to the previous stages as there was a belief that the original framework suffered from the absence of progress detail of actual work and data analysis (Khalil et al., 2016). Then, in 2014, Colquhoun et al proposed some more recommendations on clarity in defining and using reporting guidelines - 'Enhancing the QUAlity and Transparency of health Research Network' (EQUATOR) - to enhance accuracy and transparency of research studies reports. Finally, in late 2016, Khalil et al.,

(2016) refined the framework by incorporating 'Joanna Briggs Institute' (JBI) method of evidence synthesis (mostly on the 3rd stage for study selection).

The current research was based on the original framework of Arksey and O'Malley (2005); however, the proposed sixth stage by Levac et al. (2010) was also taken into consideration as a separate phase and method, that is, phase 3 and Delphi method, which is discussed in chapter 7.

4.6 Functional Scenario Generation (Phase 2)

To deploy the second phase of this research an approach inspired by use-case methodology was followed.

As an initial step in developing systems, system requirements extraction, analysis, and organisation are necessary. To do this more efficiently, methodology adoption is crucial since an iterative and interactive procedure is required, especially for large systems with a high number of users and sub-systems. By considering DEH as a system, a large number of functionalities and stakeholders (actors) can be specified. Therefore, having a structural approach was vital to define DEH requirements, functionalities, users, and their interaction with the system resulting in defining the DEH scope. In this regard, use-case methodology provided that structured form in a semi-formal approach (Gottschalk & Uslar, 2015) for the requirements of gathering and analysis.

As noted by Armijo, McDonnell and Werner (2009) and Mansurov and Zhukov (1999), use-cases are a description of a typical interaction between systems and their actors that can cover a system's behaviour and appearance as it responds to stimulus. These use-cases may demonstrate a system's functionalities in very fine detail. Furthermore, they can be used for defining the conceptual requirements of a system or for evaluating agreement with user needs during testing and assessment activities. Use-cases work around scenarios that may include different sequences of events by which the actors achieve a specific goal (function). These scenarios describe systems' functionalities and illustrate actors and system interaction (Gottschalk & Uslar, 2015). In essence, use-cases and scenarios represent system from the user's viewpoint and show what a system does and with what aim (Safdari, Farzi, Ghazisaeidi, Mirzaee, & Goodini, 2013).

Use-case methodology is mostly used in software engineering; however, in system engineering, although it is used for similar purposes, it works on a higher level to represent missions or stakeholders' goal(s) (Gottschalk & Uslar, 2015). Additionally, by following use-case methodology from a system engineering perspective, the researcher can cope with system complexity by organising development hierarchically into subsystems (Alexander & Zink, 2002). Then the detailed needs of the subsystems or the stakeholders might be extracted through systems modelling language (OMG SysML) as needs diagrams (Object Management Group, n.d.) or as agreed statements (Gottschalk & Uslar, 2016).

In this study, the actors are disaster managers and disaster medicine personnel, the system is DEH and its goal in general is trying to respond to citizens' healthcare demands before, during and after disasters. Through use-case methodology, the requirements of the users, 'disaster managers' for example, were taken into consideration and functional scenarios were generated. It needs mentioning that use-case methodology application was not continued after functional scenarios generation.

These scenarios were then used to represent the DEH functionalities or applications. Next, for each identified functional scenario, a description was provided of the requirements that must be satisfied before the technology. In this thesis, e-health technologies can be utilised to satisfy such requirements. The approach should allow disaster management and medicine experts to communicate their requirements effectively with those that are researching the application of technology in DEH. This approach is used to build ways of matching the use of technology tools (e.g. IoT) to particular disaster scenarios, e.g., discovering useful resources in a particular area (see chapter 6).

4.7 Delphi Method (Phase 3)

In phase 3 of the research, the Delphi method, which is known also as Delphi survey, study, approach and technique, was utilised. Its development dates back to the 1950s by RAND Corporation as a scientific, structured, and evaluation method. Delphi is defined as "a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem" (Linstone & Turoff, 1975, p. 3). Delphi can be used to systematically acquire, analyse, evaluate, and unify experts' opinions/ knowledge; its main objective, however, is generating expert opinion on a certain topic, theme, or problem (Steinert, 2009).

In this regard, we need to select the fields' experts and then obtain their ideas in a systematic manner and controlled opinion feedback through multiple iterations (Linstone & Turoff, 2011; Wamba & Ngai, 2013) to reach consensus among experts in a field. Delphi is suitable where the area of investigation has no or limited available historical data and/or well-established theories, but the experts possess the applicable information about the research topic; or where we deal with different research questions, under different conditions, in a great number of sectors (Bhattacharya, Petrick, Mullen, & Kvasny, 2011; Steinert, 2009; Wamba & Ngai, 2013).

Since evidence-based practices of disasters were impractical in this research, consensus methods such as Delphi can be used to provide a means of synthesising the insights of experts, as suggested by (Cross, 2005). Therefore, after finishing the DEH scoping study (phase 1) and generating functional scenarios (phase 2), Delphi was employed for assessing the findings and reaching a consensus about them among the panel of the fields' experts. For this purpose, the extracted information from the literature and generated scenarios needed to go through the Delphi method for evaluation and interpretation (Okoli & Pawlowski, 2004). Also, the Delphi method was used as the sixth stage in the scoping study framework suggested by Levac et al. (2010) for evaluating scoping study findings, as it is believed that more reliable results can be obtained through group judgments.

In phase 3, the Delphi method was used for the following reasons:

1- It "represents an inductive, data-driven approach that is often used in exploratory studies on specific topics or research questions for which no or limited empirical evidence exists" (Paré, Cameron, Poba-Nzaou, & Templier, 2013, p. 207).
2- Since the DEH area is a new and complex domain without any well-established theories or historic data, it is necessary to get feedback and knowledge from the people who know, understand, and deal with the area.
3- In this research, the international experts (either experts or participants hereafter) in the fields were consulted to assure the validity of the results (Hallowell & Gambatese, 2010), and since the experts were geographically dispersed and not just limited to the New Zealand context, the Delphi method was considered as the feasible and effective option.

4- Delphi "lends itself especially well to exploratory theory building on complex, interdisciplinary issues" (Haes & Grembergen, 2008, p. 446) and is suitable when we are concerned with complex problems. It also offers an opportunity for individuals to revise the available views (Okoli & Pawlowski, 2004).

Delphi can be conducted in multiple iterations (Figure 4.4) through which respondents submit their answers to the researcher individually and anonymously. Regarding the required number of rounds (iterations), there is no agreed number and mostly this process is repeated until a consensus is reached or a pre-defined number of rounds are conducted.

Regarding the issue of anonymity, Delphi "restricts possible bias that could arise from peer pressure or dominant individual" (Bhattacharya et al., 2011, p. 66) and thus helps to prevent negative feedback in the process of group communication (Nowack, Endrikat, & Guenther, 2011). Iteration is considered an important feature of Delphi (Bhattacharya et al., 2011), particularly if the main aim of carrying out Delphi is to reach consensus. Furthermore, multiple iterations together with opinion aggregation help us to reduce the error of individual responses as well as represent well-defined group responses.

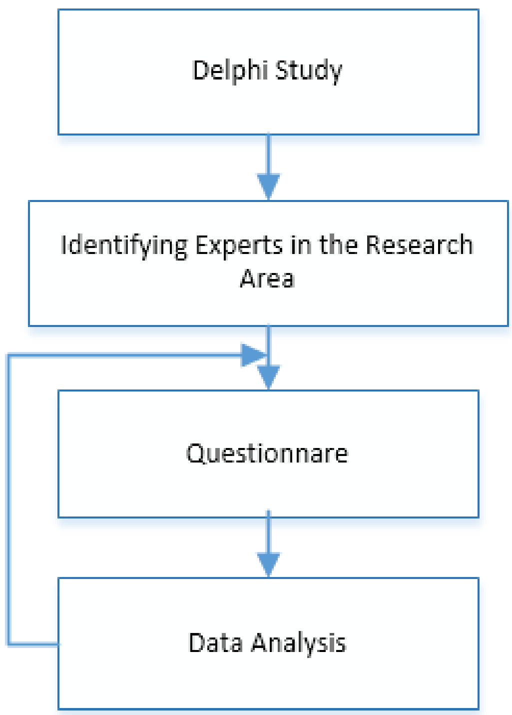

Figure 4.3 Delphi method framework

4.8 Data Analysis

Data analysis was performed in parallel with the data collection procedure. In the DEH research, it was a continuous and iterative mechanism to transform and interpret data into meaningful information. Since in this study contexts rather than numbers were important, texts' meaning and their potential relations to the research questions and objectives were taken into account. However, in phase 3 of the research, to measure the consensus among the experts, frequency distribution of the scores were calculated. Consequently, qualitative data analysis was mostly, rather than solely followed.

The result of the data collection procedure in the 'documentation and secondary sources' method was an overwhelming amount of unstructured data. Although that data had a relation with the research field, there was a need to find the hidden meanings and patterns behind them (Myers, 2013) and focus on their most important aspects based on the research questions and objectives.

There are different ways of doing data analysis in qualitative research (Glesne, 2016) and this variation is rooted in the conclusions which are expected, and also the way they are presented (Patton, 2002). For this study by referring to the research aims and objectives, thematic and qualitative content analysis were chosen, and its description and rationale are explained in the next section.

4.8.1 Thematic Analysis

Searching for themes and patterns in qualitative data, referred to as thematic analysis, is a common qualitative analysis technique. In thematic analysis, researchers try to identify, analyse and report themes or patterns within the data and find some agreement across them, and then categorise them by labels and codes (Braun & Clarke, 2006; Denscombe, 2014). There are two reasons for its selection: i) it is compatible with the chosen paradigm, and ii) it can be used in inductive analysis (Braun & Clarke, 2006), so it is a flexible and suitable tool for this study.

Within the provided data set for thematic analysis, identifying a pattern within a specific theme was the first step; consequently, themes needed to be generated prior to pattern identification. In light of Brau and Clark's (2006) suggestions, the researcher had to consider the researcher questions in order to guide the search for the most important aspects in the collected data. Moreover, since this study followed the inductive reasoning instead of trying to fit data within pre-existing themes (Braun & Clarke, 2006), looking for new themes was necessary.

Based on what has been discussed, after preparing data for analysis in the scoping study, the researcher began interpreting different aspects of the topic (informed by Boyatzis, 1998 cited in Braun & Clarke, 2006). Consequently, since the research followed inductive reasoning and there were no pre-existing literature or themes in the DEH field, the researcher tried to process and code available data and their interpretations to create themes and their description; therefore, further interpretation became possible with regard to the research topic.

4.8.2 Content Analysis

In qualitative research, to make outcomes clear for readers, sometimes there is a need to illustrate patterns or findings in numbers. In this regard, as suggested by Mayring (2000) and Myers), content analysis can be used to provide the advantages of quantitative analysis within a qualitative text interpretation and quantifying content of qualitative data. Consequently, researchers can interpret text in a simple, clear, and repeatable form.

Content analysis was the other data analysis method for the collected data in phases 1 and 3. It is defined as an approach to systematically describe the meaning of qualitative data in their context and to look for structures and patterned regularities for data comparing, contrasting, and categorising (Myers, 2013; Schreier, 2014; Silverman, 2005). This allows for analysing a large number of documents for the purpose of determining their properties such as availability of certain words, concepts, and themes (Sekaran & Bougie, 2010). Content analysis is located in the marginal border of qualitative and quantitative research and can be applied to both types of research.

In the DEH research, content analysis was used in phase 1 to capture the research trend in DMC to which e-health technologies were utilised for healthcare purposes. In addition, research trends based on different disaster types and phases were investigated and then those generated categories were compared with each other. In phase 3 of the DEH research, content analysis was adopted to extract experts' information and categorising the experts as well as categorising their responses to the questions.

By employing content analysis, researchers are able to focus on the other aspects of research relevant to research questions and codes, and analyse them in context and finally identify the existing relationships. However, in content analysis some statistical methods are often used. In this regard, content analysis creates variables for analysis by counting occurrences of particular words or themes and then tests relationships between the resulting variables (Schutt, 2015). This aspect of content analysis is useful when a researcher is looking for frequencies of words and their change in frequency over time (Myers, 2013), and thus is able to identify any available historical trends.

In this DEH research, the perspective was to qualitatively analyse the units of meaning in each message and represent them numerically to show the frequencies for each category. Consequently, for implementing a clear qualitative analysis, quantifying some aspects of DEH by frequency distribution was necessary. However, the analysis was still qualitative because "even though numerical tallies of descriptors are calculated, their role is essentially descriptive for the researcher's interpretation" (Gerbic & Stacey, 2005, p. 47). This research, as mentioned, is an exploratory study with qualitative categories that in some cases required quantitative measurements.

4.9 Ethical Consideration

This research considered the following ethical issues to be of high importance in all stages: information confidentiality, informed consent and privacy. The ethics application was submitted to AUT University's Human Ethics Committee on March 2017 using their approved format. Besides the ethics application form, other supporting documents – research questionnaire, consent form and protocol diagram – for conducting Delphi were also sent to committee. Ethics approval was granted by the Human Ethics Committee in June 2017 (Ref. 17/111 in Appendix B).

4.10 Summary

In the beginning section of this chapter, the main elements of the research that contribute to ensuring its rigour were discussed. That section contained descriptions of the applied research approach followed by the research paradigm and design together within their justifications. In the subsequent section, the data collection methods were explained for the two phases of the research. At the end of this chapter, the three main research activities (scoping study, functional scenario generation and Delphi method) that had been carried out during the research were discussed followed by data analysis methods.

The process and results of all activities will be discussed in the following chapters.

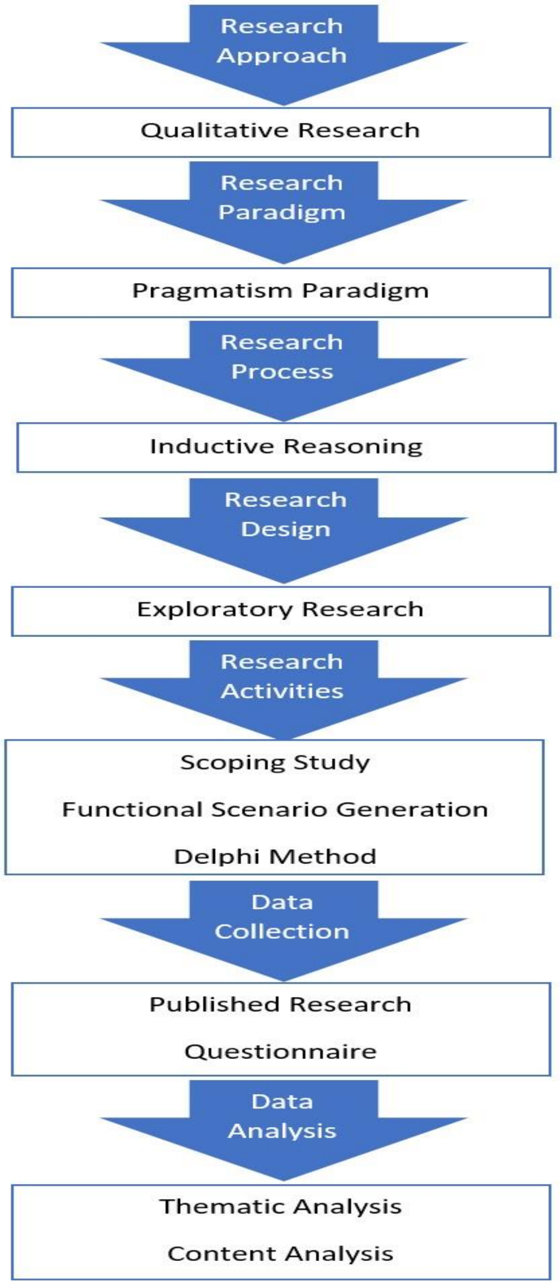

Figure 4.4 DEH design of the study

CHAPTER 5

SCOPING STUDY FRAMEWORK AND FINDINGS

5.1 Introduction

The success of DEH as a recently developed field relies upon many factors. These factors vary in different aspects and consider different requirements. Some of these factors are utilised technologies, perceived applications and features, and types of services that depend mainly on types of disasters and people involved in different activities of disaster management cycle (DMC). Accordingly, one of the main objectives of this research is to identify and define such factors that can be a part of the disaster e-health (DEH) scope. Therefore, an extensive literature review across areas of disaster management, disaster medicine, and e-health was required. To this end, in phase 1 of the research (see Figure 5.1), a very comprehensive scoping study was conducted highlighting the need for a framework to be pursued.

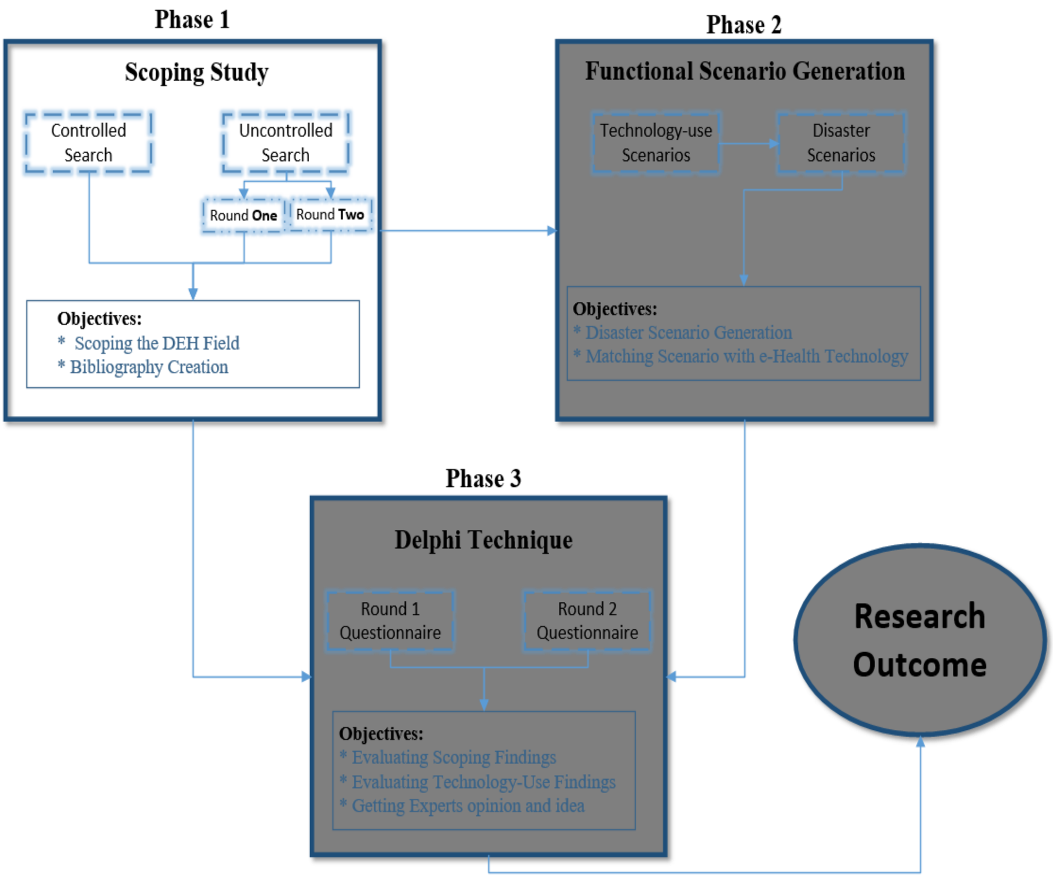

Figure 5.1 Phase 1 of the overall research activities framework

This chapter describes the customised scoping study framework and the scoping study results (Figure 5.2) in the following ways:

1- Representing the designed and followed framework for the scoping study
2- Analysing and describing the outcome and findings of the framework

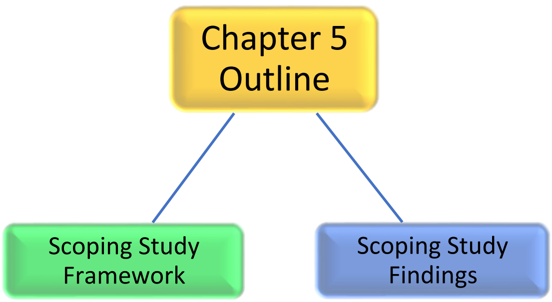

Figure 5.2 Chapter 5 outline

Section 5.2 presents details about the stages and procedures of the scoping study framework. Sections 5.3 and 5.4 show the DEH composition and emerging themes for the research and discuss the content and thematic analyses of the findings.

5.2 Scoping Study Framework for Disaster e-Health

The customised DEH scoping study framework (refer to section 4.5.1) is shown in Figure 5.3. It should be mentioned that the implementation of stage six of the framework (evaluation stage of the scoping findings), although it is considered as part of the scoping study, is done in phase 3 of the research activity framework through the Delphi method which will be explained in chapter 7.

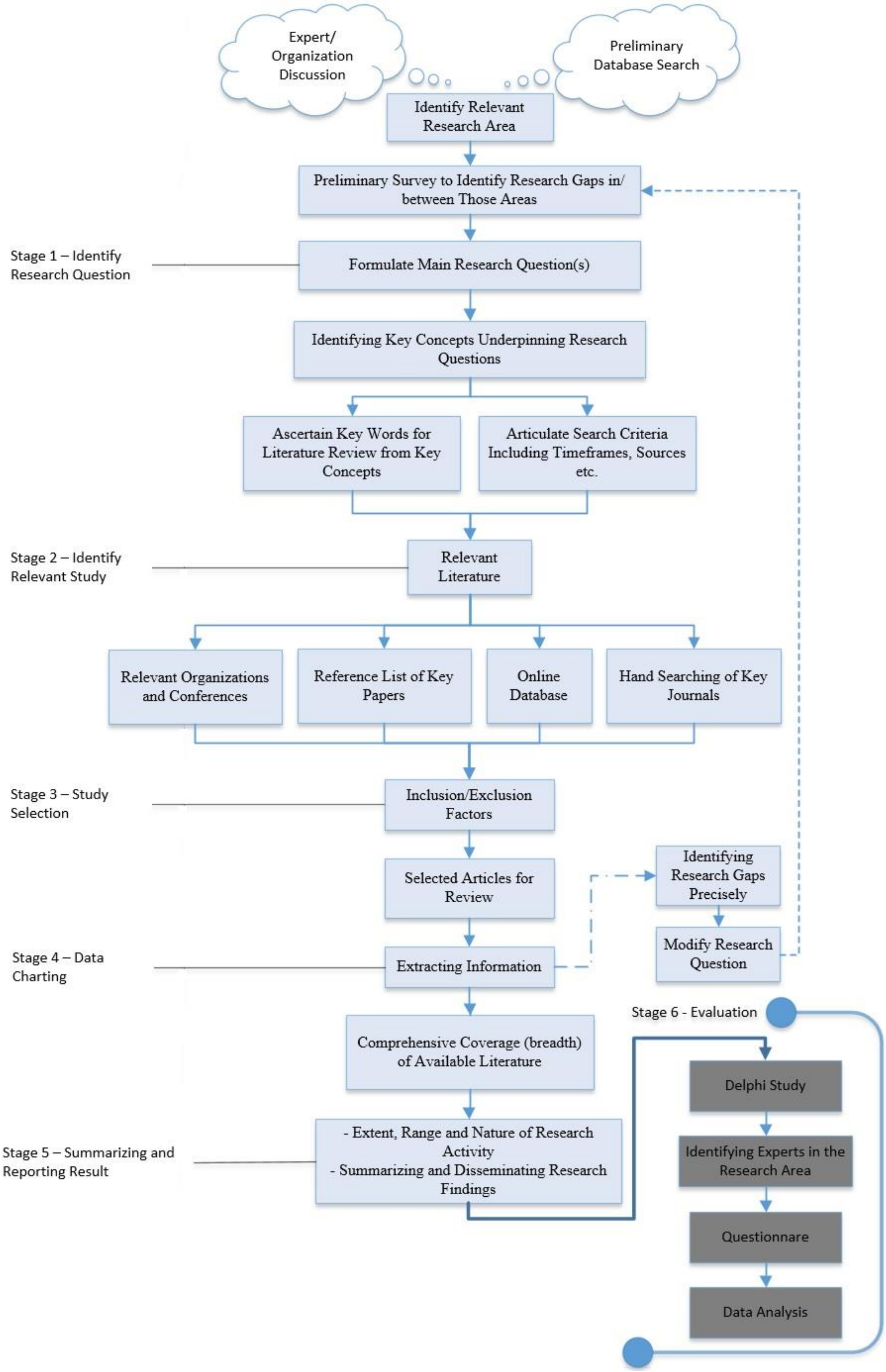

Figure 5.3 Scoping study framework for DEH

5.2.1 Stage 1 – Identifying the Research Question

The scoping study framework begins with a section dedicated to formulating research questions as the basis of the research processes and procedures. They also directly affect other stages of research and the overall research strategy and procedure. The ultimate objective of this stage is to obtain an overview of the research field and the gaps in knowledge from which the main research question(s) can be formulated. As shown in Figure 5.3, the researcher modified this stage according to the research objectives.

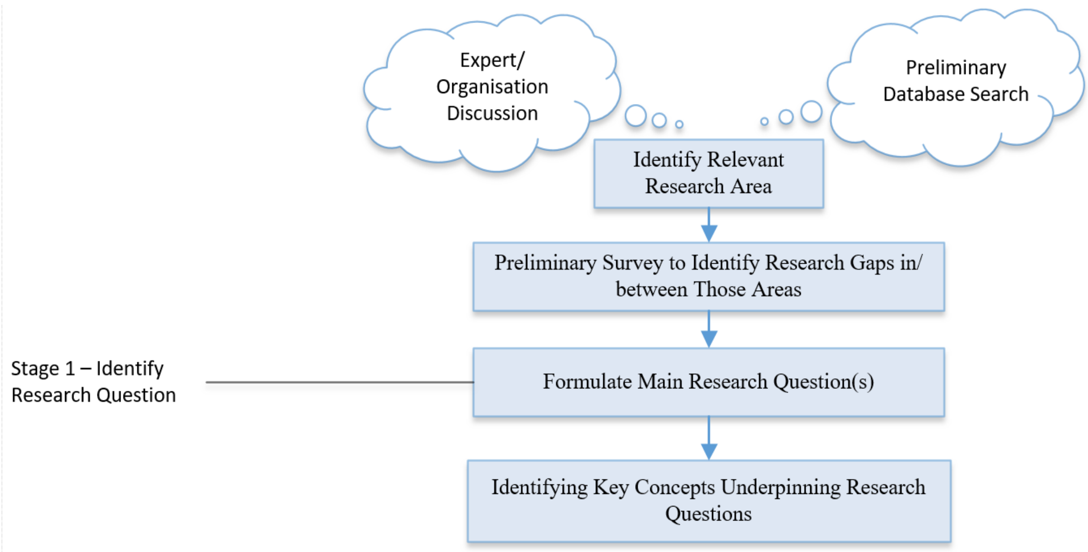

Figure 5.4 DEH scoping framework – Stage 1

Figure 5.4 shows that this process began with having 'expert/organisation discussion' and 'preliminary database search'. From this, the relevant research areas including disaster management, disaster medicine, and e-health were determined as the fields constituting DEH. In this stage, according to Valaitis et al. (2012), the first challenge is the need to clarify the definitions of the major elements (in this study, disaster management, disaster medicine, e-health and DEH). The definition of the first three concepts was mentioned in section 1.3; DEH can be defined as the following: "the application of information and communication technologies (ICTs) in a disaster situation to restore and maintain the health of individuals to their pre-disaster status"(Norris et al., 2015, p.3).

Then, by doing the preliminary database search, research gap(s) in and among the mentioned areas was (were) identified to decompose the research questions into sub-questions (as given below) that determine the key concepts and the gaps underpinning the research questions.

Considering the enhancement suggested by Levac et al. (2010), at the end of this stage there is a need to make sure that the research questions have enough clarity and consistency with the purposes of doing the scoping study; therefore, in addition to research questions, as recommended by Khalil et al. (2016) research objectives should be specified as well. The fundamental research question in this study was:

1- What is the scope of DEH?

This query was the foundation for the rest of the research questions as follow:

2- Can we represent disaster scenarios with use-cases, for example, in the domain of DEH?

3- What technology is appropriate for these use-cases?

4- How can these use-cases support practitioners?

5- What competencies and protocols will be needed for these technology applications?

The following general scoping objectives are in line with the above research questions:

1- Examining the range and nature of research activity
2- Identifying research gaps in the existing literature
3- Summarising and disseminating research findings

5.2.2 Stage 2 – Identifying Relevant Studies

A scoping study approach was utilised to extract and integrate the information from available sources to discover the scope of DEH. As shown in Figure 5.5, the following were searched:

- electronic databases and key journals in the disaster management and computer areas available through AUT library;
- reference lists of key papers;
- hand-searching of key journals and existing networks such as DECOI[2] group;

[2] Disaster e-Health Community of Interest

- relevant organisations and conferences (such as WHO organisation and ISCRAM conference).

This procedure was iterative, and all of the appropriate research papers found, regardless of their research design, methodology and quality (as suggested by Valaitis et al., 2012), were considered. This allowed us to analyse an array of resources; therefore, the review became comprehensive with regard to primary research identification (Arksey & O'Malley, 2005; Boyd et al., 2014).

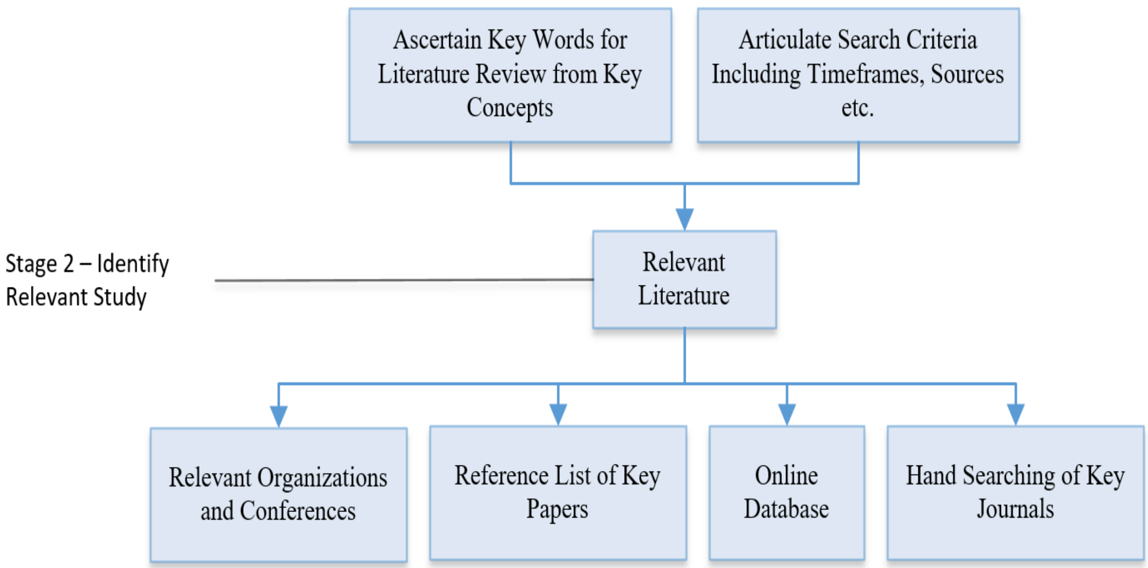

Figure 5.5 DEH scoping framework – Stage 2

In this stage, the trustworthiness was assessed and the bias was reduced through conducting the search in different databases, using various resources and international organisations' reports, all of which were identified through credible sources. All the identified materials were added to the DEH database. Then, initial inclusion/exclusion factors recognition were defined to identify the appropriate range of studies. Selection criteria such as research period, language, sources/databases and appropriate search keywords were also identified (as per Colquhoun et al., 2014) to extract all literature relevant to the topic under study. Furthermore, the relevant studies could include both quantitative and qualitative as well as non-research materials (see suggestions in Rumrill et al., 2010; Valaitis et al., 2012).

For this research, two separate procedures of uncontrolled and controlled search were followed (Figure 5.6) to find relevant publications (see sections 5.2.2.1 and 5.2.2.2, respectively, for their explanations and processes). Using both controlled and uncontrolled searches had the potential to enhance research quality while decreasing the possibility of missing studies.

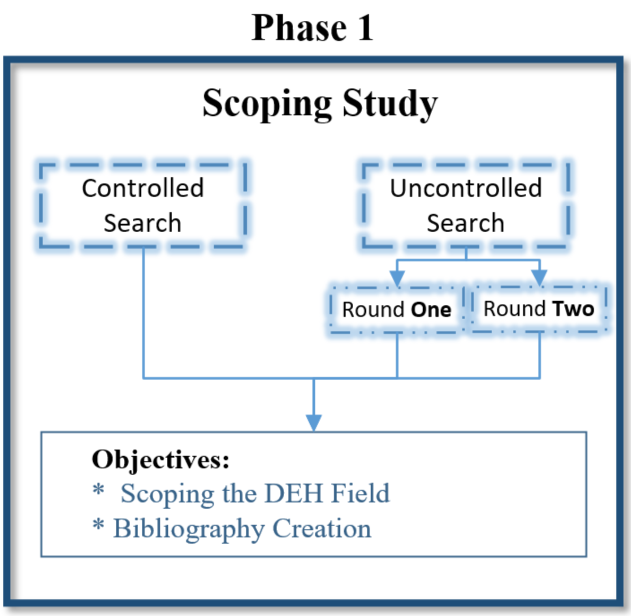

Figure 5.6 Phase 1 activities (scoping study)

Nevertheless, most of the inclusion/exclusion elements were the same for both the controlled and uncontrolled searches:

1- For both searches, only English language studies were included.
2- For the disaster management and medicine domains, articles from 1990 onward were selected since the research carried out before that date was unlikely to contain data regarding current research trends and situations.
3- For the e-health field, no specific timeframe was set - according to Pagliari et al. (2005), the first usage of the term itself dates back to 2000.
4- Articles were required to address any aspects of disaster management or disaster medicine AND e-health.
5- For e-health articles, they were included if they addressed the application of the current e-health technologies either in normal medicine or that of disaster.

Further inclusion/exclusion factors are comprehensively discussed in sections 5.2.2.1 and 5.2.2.2.

After setting the research language and timeframe, the initial screening of articles was done based on their title, and those addressing any aspects of disaster management or medicine and e-health technologies were added to the DEH research database (created in EndNote). However, those articles that did not meet the mentioned broad inclusion/exclusion factor were rejected.

5.2.2.1 Uncontrolled Search

In the uncontrolled search, the researcher used free text search terms through which she selected search keyword(s) in different fields and databases according to her knowledge and judgement rather than indexed terms. The uncontrolled search was conducted in two rounds (Figure 5.7) and included searching the available and well-known AUT University electronic databases in the areas of computer sciences (for e-health applications), disaster management and medicine. The procedure consisted of single or combined search terms/keywords– sometimes using Boolean operators, such as AND and OR - with the purpose of expanding or narrowing down the search findings. The primary goal of this search was to extract a broad range of relevant research articles in the nominated fields to help the researcher to identify the scope of the new field of DEH.

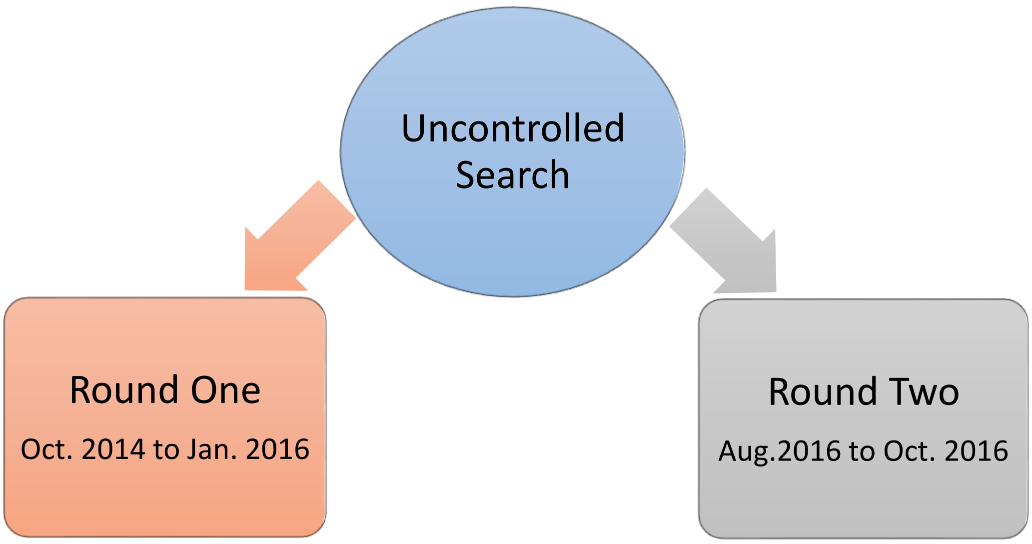

Figure 5.7 DEH uncontrolled search rounds

The first round of uncontrolled search took over a year, from October 2014 to January 2016. During this period, different keywords were used to search the following electronic databases: CINAHL Plus (via EBSCO), SocINDEX (EBSCO), Scopus, IEEEXplore, Google Scholar, Emerald, Elsevier, CINAHL, ProQuest Central, Science Direct, Springer Link, ProQuest, MEDLINE (via EBSCO), ACM Digital Library, and EBSCO.

A sample of search terms for the disaster management area is provided in Table 5.1 (refer to Appendix C for a complete list of databases and search terms). The result of this phase was a total of 2,641 related articles that were added to the DEH database in EndNote software library.

After finalising the first round of data extraction, it was realised that in a number of studies the researchers used other terms rather than "*e-health*", namely, health informatics, medical informatics and electronic health. Accordingly, another round of uncontrolled search was performed. The intention was to ensure the completeness of the scoping review regarding capturing almost all possible articles in the field, likewise in terms of expanding the breadth of research. This round was carried out Therefore, from August 2016 to October 2016.

Table 5.1

Databases and Search Terms for Disaster Management Area

Disaster Management Field			
Database	Google Scholar	**Searched Terms**	disaster management cycle, “disaster management cycle”, disaster management, “disaster management”, emergency management, “emergency management”, "disaster preparedness challenge", disaster preparedness challenge, disaster definition
	Emerald		disaster management cycle, “disaster management cycle”, disaster management, “disaster management”, emergency management, “emergency management”, "disaster mitigation", disaster definition, "mass casualty incident"
	Elsevier		disaster management cycle
	IEEE Xplore		"disaster Management cycle", disaster management, “disaster management”, "mass casualty incident"
	CINAHL		disaster management, "disaster mitigation", "disaster definition", disaster definition, "disaster management" AND challenges, "disaster management" AND failure
	ProQuest Central		"disaster mitigation"

The second round started by referring to the AUT library website and its recommended electronic databases for areas of “Disaster Management” and “Computer Science”. In those databases, a search for the previously missed keywords was performed.

The full list of databases used in this round of uncontrolled search, the covered areas and their selection rationale are provided in Table 5.2. Furthermore, in this round, a combination of three different fields of disaster management, disaster medicine and e-health was examined to discover any possible relevant studies not captured previously. The other consideration for this round was possible usage of modern technologies in disasters.

A list of all available technologies which could be used in DMC was needed, and for this purpose, a simple search for recent/innovative technologies was done in Google search engine. The name of all the databases and search terms in this round can be found in Appendix D.

Table 5.2

Uncontrolled Search Databases

	Database Name	**Cover/Search Area**	**Reason of Selection**
1	CINAHL Plus (via EBSCO)	Disaster management, disaster medicine	Recommended by AUT Library for disaster management
2	SocINDEX (via EBSCO)		
3	Scopus		
4	EBSCO		
5	ProQuest Central	Disaster management, e-health	
6	Google Scholar	Disaster management, disaster medicine, and e-health	Recommended by AUT Library for computer science field
7	IEEE Xplore	e-Health	
8	ACM Digital Library		
9	Science Direct	e-Health, disaster medicine	
10	Springer Link	Disaster medicine	
11	Elsevier	Disaster management	Within the searching procedure, several articles found useful and relevant that were published in Elsevier journals

12	MEDLINE (via EBSCO)	e-Health	Recommended by AUT Library for healthcare
13	Emerald	Disaster management, disaster medicine and e-health	As one of the aspects of the research is management, this database is recommended by AUT library for management field

At the end of both rounds of uncontrolled search, a total number of 3,956 research studies were added to the DEH database in EndNote.

5.2.2.2 Controlled Search

In controlled search, researchers have no control over keywords selection. In this method, keywords should be chosen from an existing list of keywords, and the articles are also indexed according to these keywords. Therefore, the searching process is based on the pre-defined keywords or index terms and not terms occurring in the papers' titles and abstracts; rather it is based on the keywords/indexed terms assigned to the documents.

Since not all the databases provided indexes, only two major electronic databases were searched - PubMed and IEEEXplore - both popular in their fields. While the former database is well-known in the field of healthcare, the latter has good coverage in the field of computer and IT. Besides their popularity, both databases provide subject indexing that is a crucial feature in controlled search. In this research, PubMed was mostly used for searching in the disaster management and medicine areas by focusing on healthcare-related challenges although e-health technologies applications in DMC were considered.

The controlled search started in March 2016 and was completed in May 2016, for which PubMed MeSH headings were used in the PubMed database. Medical Subject Headings or MeSH, as defined by the U.S. National Library of Medicine (1999), is a "hierarchically-organized terminology for indexing and cataloguing of biomedical information such as Medline/PubMed and other National Library of Medicine databases." Moreover, along with MeSH headings, IEEEXplore control indexing was used in IEEE database. The rationale behind these selections is discussed in the following sections.

A- PubMed Search for MeSH Headings

In the PubMed search, the same primary inclusion criteria for uncontrolled search were taken into account (such as timeframe and language). Then, the researcher screened the titles of the articles retrieved in the PubMed search. After that, those articles were considered that addressed any aspects of **disaster management** OR **disaster medicine** in relation to **healthcare and technologies**.

As a starting point, there was a need to search in the PubMed MeSH headings tree for heading associated with DEH. In the first stage, searching with the term "DEH" and its other variants like "Disaster e-health", "disaster eHealth" and "Disaster e*health" produced no results. Then, based on the DEH definition, searching for areas of "disaster management", "disaster medicine" and "e-health" in the MeSH tree was performed. The comprehensive hierarchy of the MeSH headings for the mentioned areas is available in Appendix E. The disaster medicine hierarchy is shown in figure 5.8 as an example.

"Disaster Medicine" was categorised as "Medicine" under MeSH heading (Figure 5.8) and retrieved 606 articles. It can be seen in Figure 5.9 that the number of studies in the area of "Disaster Medicine" in 2016 rose by almost eighty times compared to 2000. This study considered only those published after 1990, as mentioned earlier in 5.2.2.

Figure 5.8 PubMed MeSH searching for term "disaster medicine"

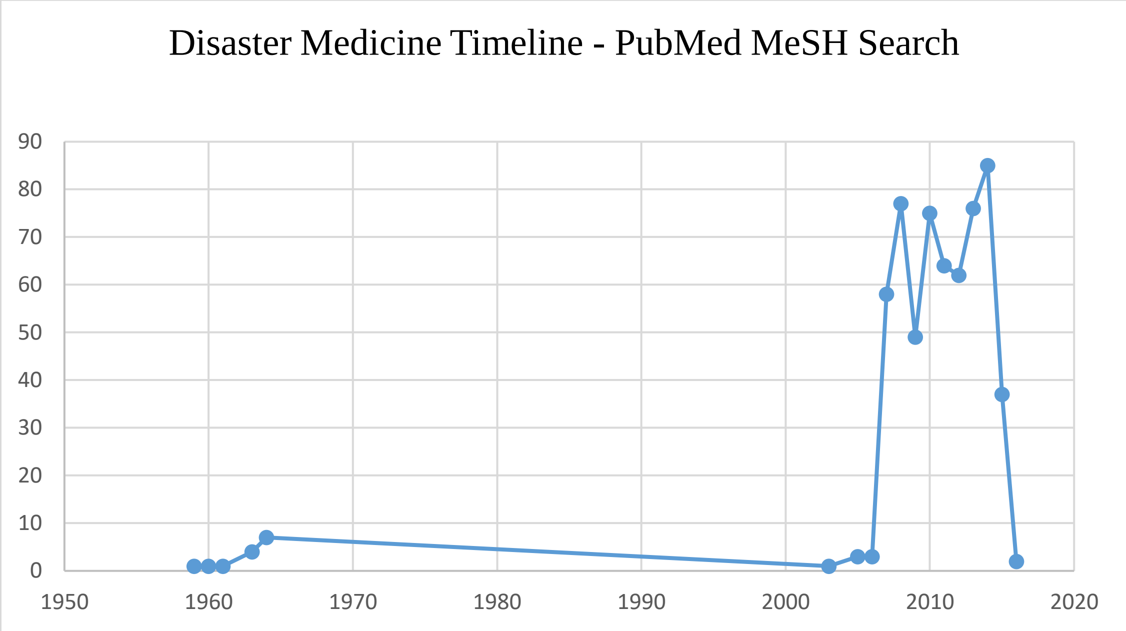

Figure 5.9 "Disaster medicine" timeline

e-Health term search in "PubMed MeSH Headings" retrieved 'Telemedicine' and 'Medical Informatics'. According to the PubMed definitions of these terms and considering the focus of this research, 'Medical Informatics' was used in the PubMed search instead of e-health because it covers a wider range of technologies as compared to 'telemedicine'.

When "**Medical Informatics**" was added to PubMed search builder, it retrieved 361,013 articles. Looking at PubMed graph, Figure 5.10, and its classification according to the number of research per year, one can see an overall upward trend. This implies increasing interest and work in this area.

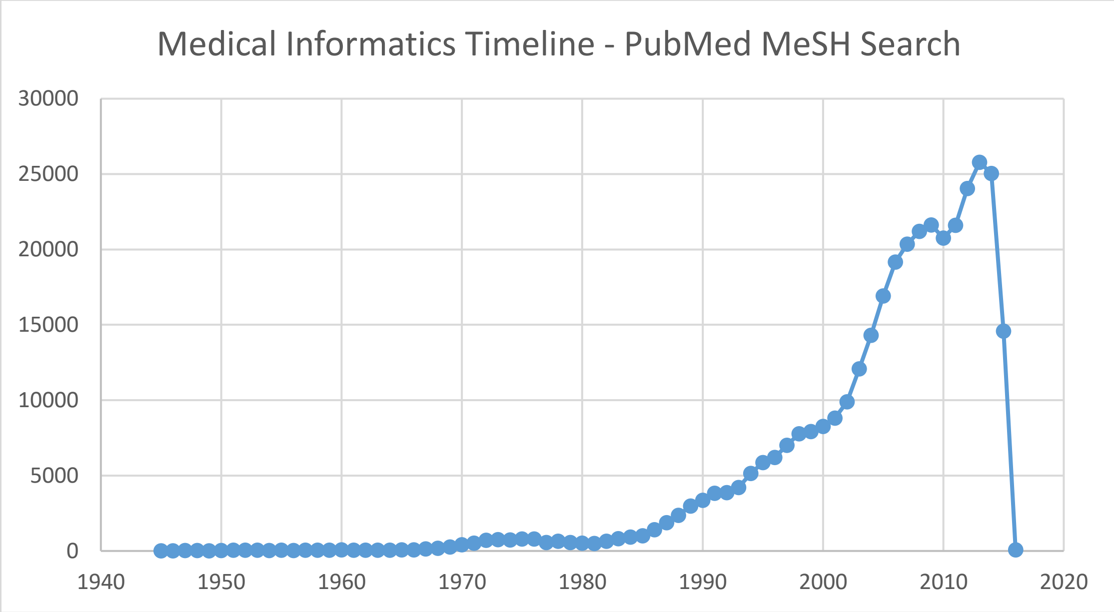

Figure 5.10 "Medical informatics" timeline

There is no MeSH heading for "Disaster Management", as a MeSH can be related to the nature of the PubMed database, which mostly covers health-related areas. However, the term "Disaster" itself was defined in this database, and thus research articles related to the disaster field could be found by using this term.

By searching **"Medical Informatics"[MeSH] AND ("disaster medicine"[MeSH Terms]",** 27 new articles were added to the DEH database. Then the process was continued by searching the combination of **("Disasters"[MeSH]) AND "Medical Informatics"[MeSH])** which captured 1,394 papers (Figure 5-11) from which 1,249 were in English, and among them those dealing with areas of disaster management and e-health or disaster medicine and e-health were chosen . The selection procedure was based on screening articles' titles only; however, were it not possible to understand the content from the title, abstract skimming was done. The following articles were excluded and were considered as irrelevant studies:

- Articles dealing with normal medicine
- Articles referring to emergency as a normal hospital and healthcare procedure rather than disaster and mass casualty situations
- Articles dealing with animals

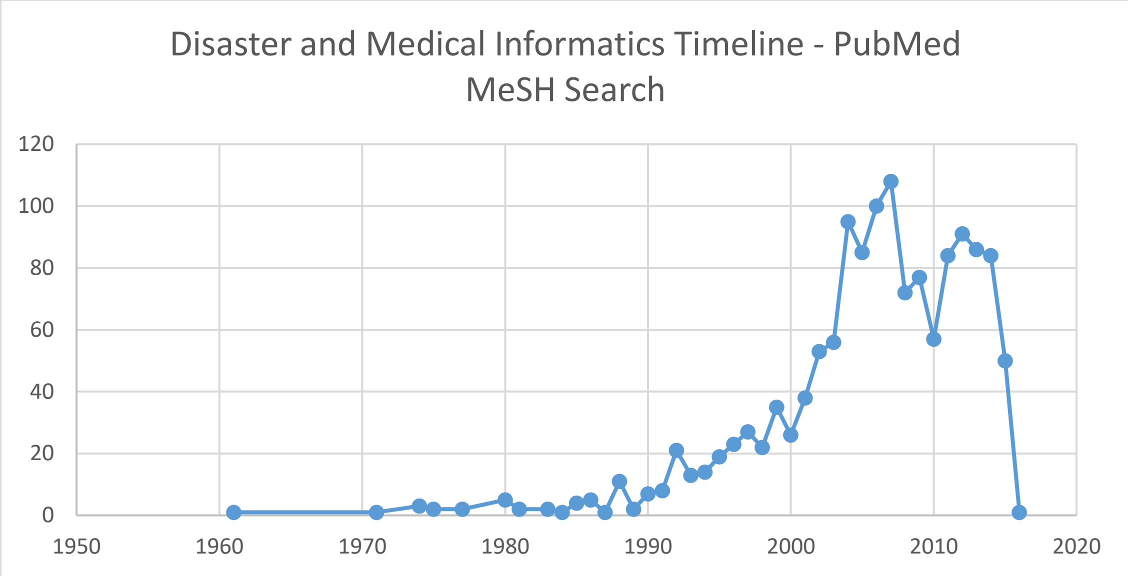

Figure 5.11 Disaster and medical informatics timeline

From the above graph, it can be seen that this area of research has attracted a lot of attention over the past two decades.

The next step involved adding the relevant papers to EndNote database and there were 775 papers in two different groups of “Medical Informatics AND Disaster” and “Medical Informatics AND Disaster Medicine”, according to the search terms (Table 5.3).

Table 5.3

Summary of Search Term Results in PubMed Database

	Search Term	**Number of Articles**
1	(“Medical Informatics"[Mesh]) AND ("disaster medicine"[MeSH])	27 articles identified
2	("Disasters"[Mesh]) AND "Medical Informatics"[Mesh])	775 articles identified

B- IEEEXplore Searching Procedure

In the first stage, in “IEEEXplore standard dictionary” a simple search was done with no specific retrieved results for the following keywords: e*health, ehealth, e-health and electronic health, medical informatics, health informatics, disaster medicine. Then, the same search was performed but in "IEEEXplore Command Search" with the MeSH terms (see Table 5.4) (http://ieeexplore.ieee.org/search/ advsearch.jsp?expression-builder)

Table 5.4

Summary of Search Terms in IEEEXplore Database

	Search Term	No of Articles
1	("MeSH Terms":ehealth AND "MeSH Terms":disaster medicine)	0
2	("MeSH Terms":e-health AND "MeSH Terms":disaster medicine)	0
3	("MeSH Terms":e-health AND "MeSH Terms":disaster management)	0
4	("MeSH Terms":ehealth AND "MeSH Terms":disaster management)	0
5	("MeSH Terms":ehealth AND "MeSH Terms":emergency management)	0
6	("MeSH Terms":e-health AND "MeSH Terms":emergency management)	0
7	("MeSH Terms":health informatics AND "MeSH Terms":emergency management)	0
8	("MeSH Terms":health informatics AND "MeSH Terms":disaster management)	0
9	"MeSH Terms":health informatics AND "MeSH Terms":disaster medicine	0
10	"MeSH Terms":Medical informatics AND "MeSH Terms":disaster medicine	1
11	("MeSH Terms":Medical informatics AND "MeSH Terms":disaster management)	0

12	("MeSH Terms":Medical informatics AND "MeSH Terms":emergency management)	0
13	"MeSH Terms":Medical informatics AND "MeSH Terms":disaster	2
14	"MeSH Terms":technology AND "MeSH Terms":disaster	2
15	("MeSH Terms":computer AND "MeSH Terms":disaster)	11
16	"MeSH Terms":mass casualty	7
17	"MeSH Terms":health AND "MeSH Terms":disaster	8
18	"MeSH Terms":electronic health AND "MeSH Terms":disaster	0

By referring to Table 5.4, it was concluded that although IEEE includes MeSH terms, very few documents were identified with these MeSH terms. As a result, finding their parallel terms in IEEE was necessary and was done according to the following steps:

- ❖ After referring to the DEH database (in EndNote), under the PubMed Groups which were created previously, searching was performed for any field in the libraries that contained "IEEE" term, to discover any IEEE articles that were captured in the PubMed searching procedure (Figure 5.12).
- ❖ In "Medical Informatics and disaster" group, 24 articles were identified together with one article in "medical informatics and disaster medicine" group.

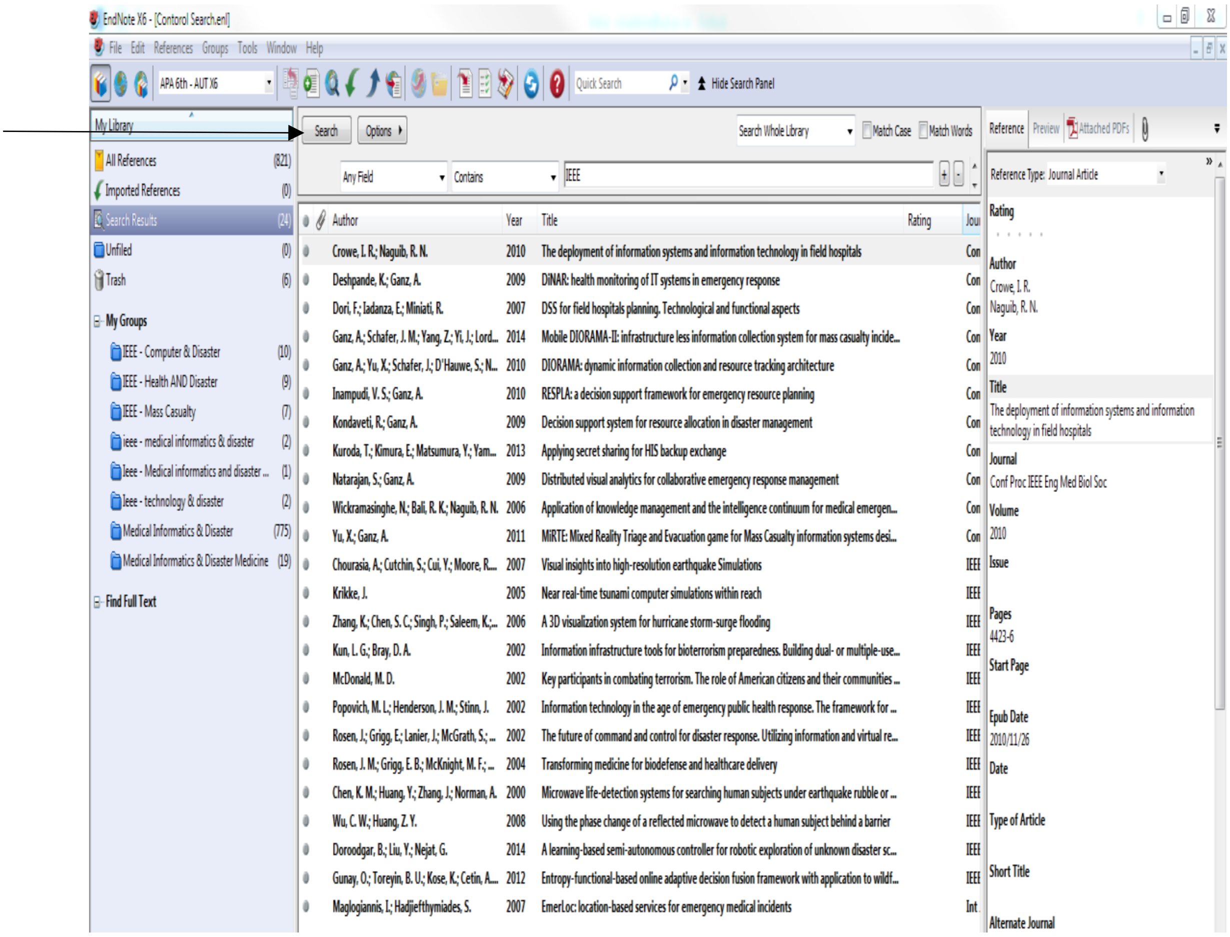

Figure 5.12 DEH database in EndNote

❖ The identified articles in step two were compared with the captured articles from IEEE database in the following EndNote groups: "IEEE - Computer & Disaster", "IEEE - Health & Disaster", "IEEE – Mass Casualty", "IEEE – medical informatics & Disaster Medicine" and "IEEE - Technology & Disaster". The results of the comparison were the following common papers in both PubMed and IEEE databases:

- Crowe, I. R. J., & Naguib, R. N. G. (2010). The deployment of information systems and information technology in field hospitals. Symposium conducted at the meeting of the 2010 Annual International Conference of the IEEE Engineering in Medicine and Biology DOI:10.1109/IEMBS.2010.5625996

- Kondaveti, R., & Ganz, A. (2009). Decision support system for resource allocation in disaster management. Symposium conducted at the meeting of the 2009 Annual International Conference of the IEEE Engineering in Medicine and Biology Society DOI:10.1109/IEMBS.2009.5332498
- Yu, X., & Ganz, A. (2011). MiRTE: Mixed Reality Triage and Evacuation game for Mass Casualty information systems design, testing and training. Symposium conducted at the meeting of the 2011 Annual International Conference of the IEEE Engineering in Medicine and Biology Society DOI:10.1109/IEMBS.2011.6092022

❖ To find out the reason that the rest of the articles did not appear in the performed different control searches in IEEE, the researcher referred to IEEEXplore database and manually searched for those articles by using article titles.

❖ By referring to articles' keywords section (see Figure 5.13), it can be seen that IEEE has different categories for keywords (Controlled Indexing, IEEE Terms, Non Controlled Indexing, MeSH Terms and sometimes Author Keyword). Through comparing the common captured articles from the PubMed and IEEE search, the following replacement keywords were identified:

- Medical Service
- Medical Informatics
- Emergency medical services
- Disaster Medicine
- Disaster

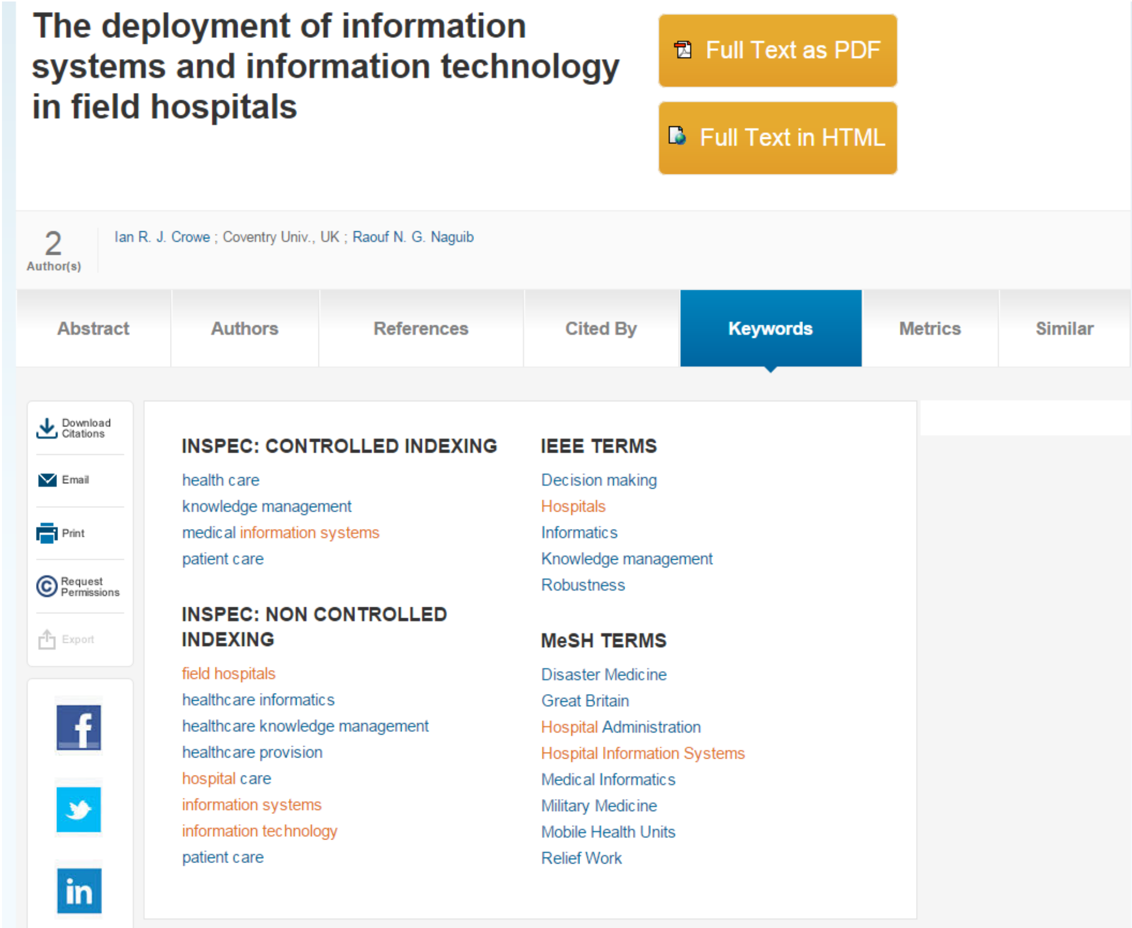

Figure 5.13 IEEE keyword categories

In IEEE keyword categories, "MeSH" was selected to have consistency with PubMed MeSH headings search; however, since MeSH category was not defined for all IEEE articles, 'Controlled Indexing' category was also considered for further search. The latter keyword category was available for all IEEE articles (unlike other categories) and, based on our sample group of 23 articles, it had the most common keywords with PubMed.

Accordingly, the new round of the controlled research was performed in IEEE (see Table 5.5 for its related search terms). Since IEEE is the database for technology and ICT, the keyword "disaster" was used in all search commands to narrow down the search results to disaster field only. At the end of this stage, 109 articles were added to the DEH database.

Table 5.5

New Search Terms in IEEEXplore Database

	Search Term	**Number of Articles**
1	"MeSH Terms":disaster AND "MeSH Terms":medical service	5
2	"MeSH Terms":disaster AND "MeSH Terms":emergency services	5
3	"INSPEC Controlled Terms":disaster AND "INSPEC Controlled Terms":medical informatics	0
4	"INSPEC Controlled Terms":disaster AND "INSPEC Controlled Terms":medical services	0
5	"INSPEC Controlled Terms":disaster AND "INSPEC Controlled Terms":disaster medicine	0
6	"MeSH Terms":Disaster	39 (25 relevant)
7	"MeSH Terms":disaster AND "MeSH Terms":electronic health	0
8	"MeSH Terms":disaster AND "MeSH Terms":emergency management	0
9	"MeSH Terms":disaster AND "MeSH Terms":medical information system	4
10	"MeSH Terms":disaster AND "MeSH Terms":medical informatics	2
11	("INSPEC Controlled Terms":disaster AND "INSPEC Controlled Terms":medical information system)	13
12	("INSPEC Controlled Terms":disaster medicine)	0
13	"INSPEC Controlled Terms":disaster management	0

14	"INSPEC Controlled Terms":electronic health AND "INSPEC Controlled Terms":disaster	0
15	"INSPEC Controlled Terms": emergency management AND "INSPEC Controlled Terms":disaster	299
16	"INSPEC Controlled Terms":emergency management AND "INSPEC Controlled Terms":disaster AND "INSPEC Controlled Terms":health care	3
17	"INSPEC Controlled Terms":emergency management AND "INSPEC Controlled Terms":disaster AND "INSPEC Controlled Terms":healthcare	0
18	"INSPEC Controlled Terms":emergency management AND "INSPEC Controlled Terms":disaster AND "INSPEC Controlled Terms":health	5
19	INSPEC Controlled Terms":disaster AND "INSPEC Controlled Terms":emergency medical services AND Healthcare	9
20	INSPEC Controlled Terms":disaster AND "INSPEC Controlled Terms":emergency medical services AND Healthcare	19
21	"INSPEC Controlled Terms":disaster AND "INSPEC Controlled Terms":e-health	0
22	"INSPEC Controlled Terms":disaster AND "INSPEC Controlled Terms":emergency medical services AND Health	35

5.2.3 Stage 3 – Study Selection

The outcome of stage 2 (controlled and uncontrolled) was intended to include all the potential articles related to the DEH field. These articles comprised a large number of studies that could be rated as highly relevant to less relevant and irrelevant. Therefore, a mechanism was needed to exclude the studies which were not relevant to the research questions (Arksey & O'Malley, 2005) or research objectives. This was established in stage 3 (Figure 5.14) by performing inclusion and exclusion criteria refinement (Rumrill et al., 2010). This process is similar to 'systematic review', although we rarely assess the quality of articles in scoping studies (Arksey & O'Malley, 2005) because scoping is mainly based on the article's relevancy (Valaitis et al., 2012) to the field rather than its quality. Therefore, researchers such as Levac et al. (2010) have strongly recommended that inclusion/exclusion criteria should be identified in the early phases of research.

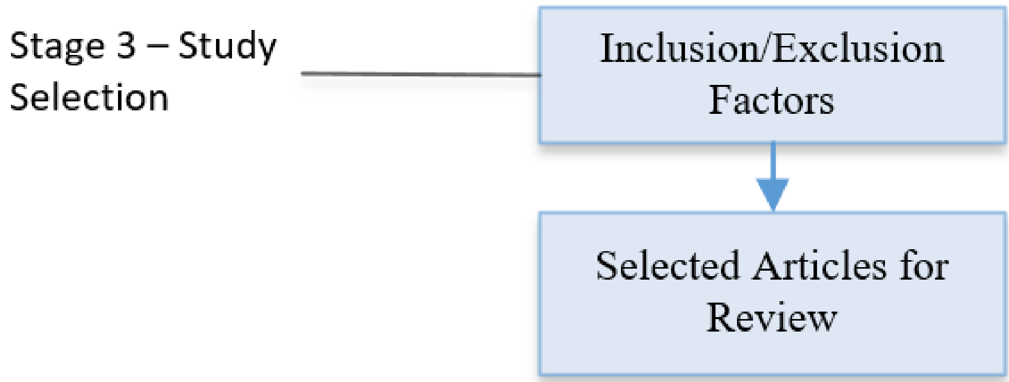

Figure 5.14 DEH scoping framework – Stage 3

After applying the inclusion/exclusion criteria to all the captured articles, in both the controlled and uncontrolled searches, the researcher selected those articles for in-depth review which were best suited to this study (according to the research questions and objectives). By applying the exclusion factors, papers for in-depth study were selected. Since two different data collection procedures were followed, for paper selection, too, two different procedures were followed based on the controlled and uncontrolled searches although the criteria were the same for both of them.

In this stage, the selected articles were checked one more time for their language and covered areas. Therefore, only the articles whose full versions were in English were selected. Moreover, articles had to be related to the areas of e-health technologies and disaster management/medicine; therefore, the papers with the following focuses were excluded: pure clinical, clinical emergencies, medical devices advancement, hazardous material releases, emergency, normal medicine, disaster recovery and risk management related to business.

5.2.3.1 Uncontrolled Search Refinement

The overall flow of study selection and exclusion criteria for the uncontrolled search is depicted in Figure 5.15.

Here, besides removing duplicate articles, those that were editors' letters or conference abstracts were also excluded. Thus, irrelevant articles were identified by referring to their abstracts or, if a decision could not be made on that basis, by skimming the whole article and deciding on its relevancy. Furthermore, articles that just covered disaster management, disaster medicine or pure technology were omitted. After implementing all the exclusion factors, a total number of 2,817 articles were identified which was still very high. Considering the research limitations, such as time, referring to each article and completing a full review, extracting its content, or even just skimming the article was relatively impractical; therefore, a mechanism was needed to help exclude a significant number of studies without affecting the quality of research.

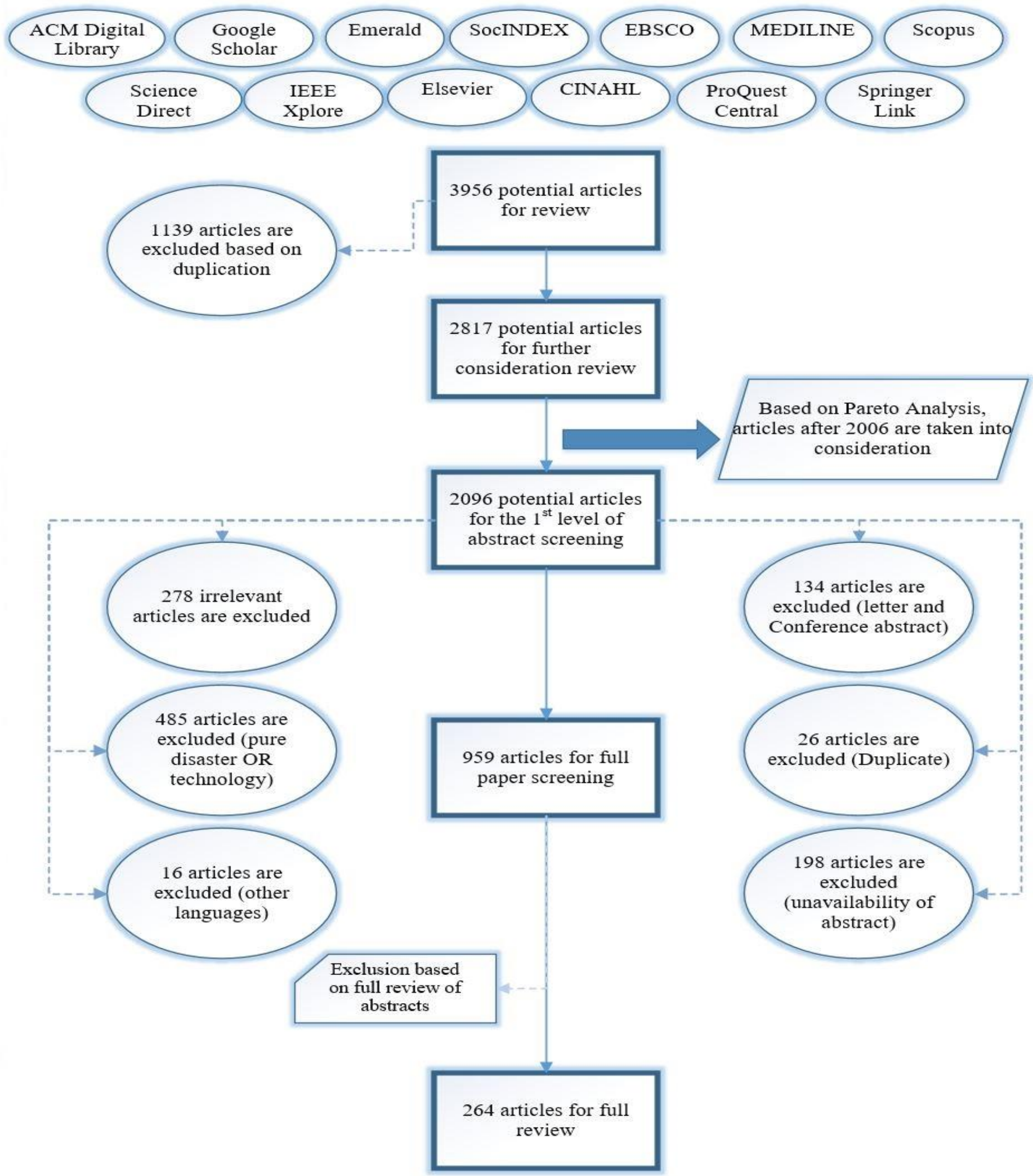

Figure 5.15 Uncontrolled search flow

Accordingly, the researcher developed an approach based on a well-established principle, Pareto Analysis, to facilitate this procedure and exclude a larger number of articles in a shorter time, and most importantly without affecting the quality of the results. Pareto Analysis is a method in the area of business and management. It is a statistical technique which is known as the 80/20 rule and is used for decision making, recognising and classifying a few tasks that have a major impact (Haughey, n.d) or identifying and prioritising problem areas (Schwalbe, 2016). This analysis is mostly used in the area of project management to help project managers detect the problem areas that cause the most quality problems within a project or system. Moreover, this technique has many applications in other areas for the purpose of quality control. The general idea of this technique is that "by doing 20% of the work you can generate 80% of the benefit of doing the entire job"(Haughey, n.d).

Consequently, this method helped this researcher, instead of dealing with all tasks (articles), to focus on those that had the most overall significant impact on the output. Pareto Analysis was performed based on the number of different technologies used in DMC for healthcare purposes in each year, called 'technology saturation'. For this purpose, the following procedure was implemented (see Table 5.6 and Figure 5.16). First, a vertical bar chart was created showing the number of different technologies in descending order on the y-axis with the first bar showing the highest count, and the years on the x-axis. Then the cumulative count percentage for each technology was calculated also in descending order based on the following formula:

$$Cumulative\ count\ percentage = \frac{Individual\ Cumulative\ Count}{Total\ Cumulative\ Count} * 100$$

After that, another y-axis was created with percentages from 100% to 0% descending in increments of 10. Next, the cumulative count percentage of each technology was plotted on the x-axis, and a curve was formed by joining the points. Finally, a line at 80% on the y-axis was drawn parallel to the x-axis. Then the line was dropped at the point of intersection with the curve on the x-axis. This point on the x-axis separates the important years on the left (vital few) from the less important years on the right (trivial many) (Haughey, n.d).

Based on the Pareto results, it could be concluded that reviewing the articles from 2006 onward and their analysis were covered to review the remaining 80%. The Pareto Analysis gives a date, which was 2006, so the studies after this date were included for review, representing a total number of 2069 articles. Next, based on the inclusion criteria explained earlier, the exclusion criteria demonstrated in Figure 5.15, and by conducting a full abstract review, 264 articles were chosen for full review.

The reason behind doing Pareto Analysis can be explained based on technology advancement. In other words, since technology revolution or improvement is so fast, the technology that is used now in comparison to its earlier versions within a ten-year period is different. Furthermore, in some cases, it can be said that there are a number of technologies that did not exist ten years ago, or technologies that were used ten years ago are non-existent today.

Table 5.6

Number of Technologies in DMC for Each Year

Utilised Technologies in DMC			
Year	**Tech Count**	**Cumulative Count**	**Cumulative Percentage**
2011	39	39	9.0
2015	38	77	17.8
2014	38	115	26.6
2013	38	153	35.3
2012	37	190	43.9
2010	37	227	52.4
2008	35	262	60.5
2009	33	295	68.1
2007	30	325	75.1
2006	26	351	81.1
2016	20	371	85.7
2005	20	391	90.3
2004	14	405	93.5
2003	13	418	96.5
2002	7	425	98.2
2001	4	429	99.1
2000	4	433	100.0

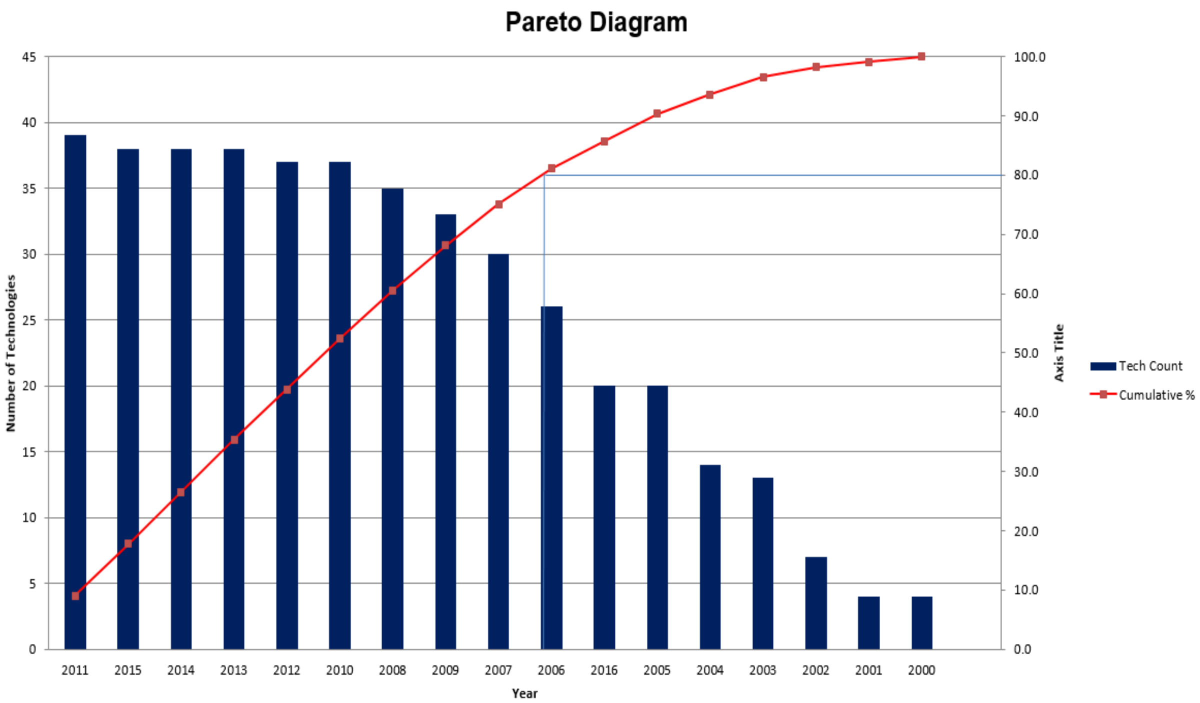

Figure 5.16 Pareto diagram

This method for paper selection is a novel approach. This approach could be useful when researchers need to deal with a high number of studies in a short period of time. Therefore, the employed procedure of performing Pareto Analysis is possibly useful for a systematic scoping review of the literature. It should be noted that the saturation criteria is subjective and depends on the nature of research studies and their objectives.

5.2.3.2 Controlled Search

In the controlled search procedure, since the researcher dealt with a smaller number of articles (925) compared to the uncontrolled search, a slightly different procedure was followed to select the relevant articles for the purpose of full review. In the first step, as with the uncontrolled search, the duplications had to be removed from the DEH database.

The next step was finding the relevant articles (those that used technology in disaster medicine or disaster management) by referring to their abstracts. The articles with the following focuses were rejected:

- dealing with normal medicine

- referring to emergency as a normal hospital and healthcare procedure rather than disaster and mass casualty
- dealing with animals rather than humans
- not in the area of healthcare
- main focus being computer-oriented like network architecture and security
- no technology being used

The last step was ranking papers according to their relevance and importance to the research questions and objectives. For this purpose, after reviewing all the articles' abstracts and skimming the contents, the researcher ranked all the articles by utilising EndNote rating system to represent and store the given ranks. In other words, all the articles were rated from five (highly relevant) to zero (irrelevant). The overall procedures of the study selection for controlled searched can be seen in Figure 5.17.

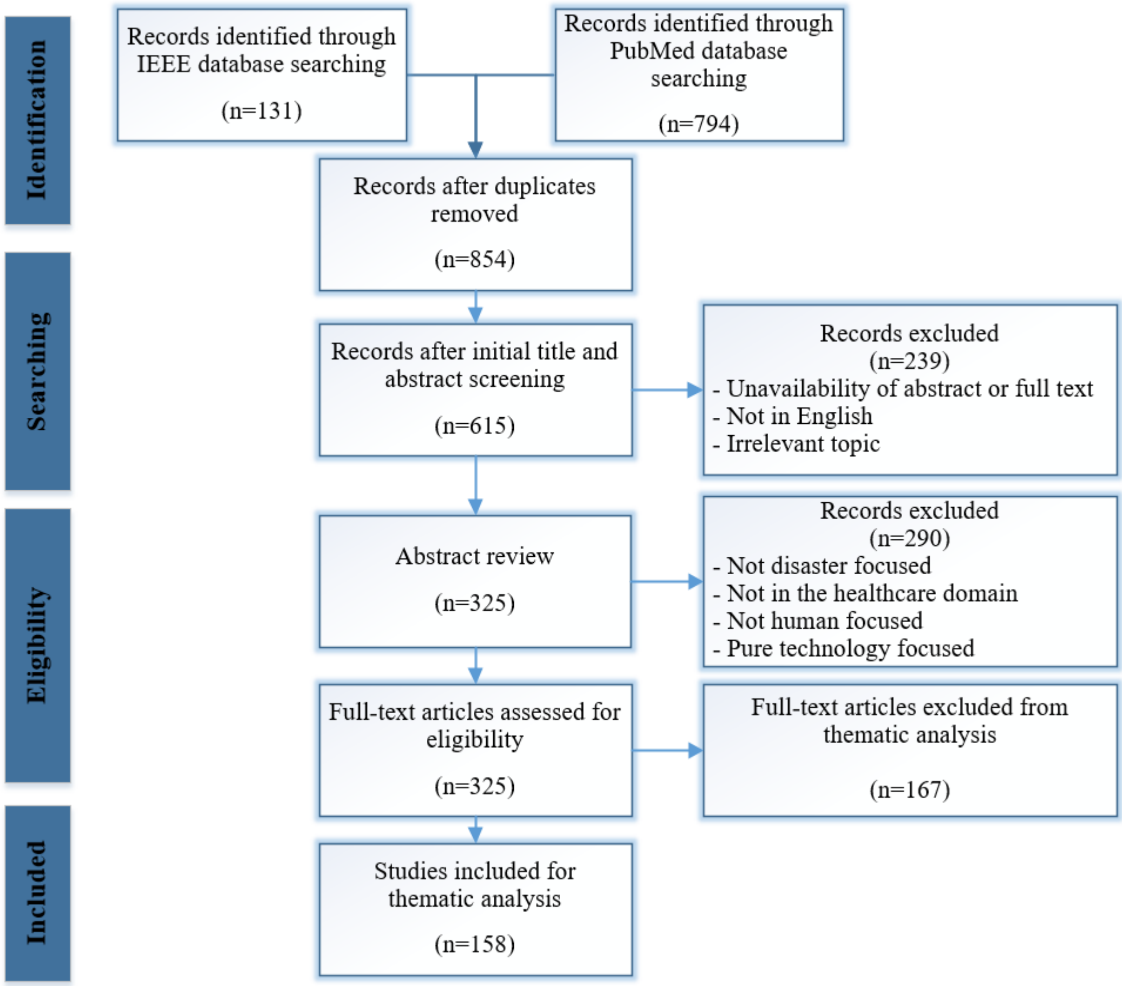

Figure 5.17 Controlled search flow

5.2.4 Stage 4 – Charting the Data

This stage involved extracting the main data from the selected studies and organising them to show their important features related to this research. As Levac et al. (2010) suggest, this stage must be iterative and consider the data charting to include and exclude the criteria that may answer the research questions. For data charting, the full text of all the selected articles were added to the DEH database in EndNote and Nvivo for qualitative analysis and for extracting data for further analysis, summarising, and drawing any conclusions. After that, the full review of the selected articles began. Then, according to charting findings, the researcher needed to consider generally all the key subjects and methods in the studies relevant to the present study (as stipulated in Rumrill et al., 2010). For this purpose, the articles were read to extract their information, and then thematic and content analyses were employed for categorising the findings in different thematic groups.

Each created theme consisted of information that concentrated on, or covered a particular aspect related to disaster management/medicine or e-health and could be used to answer the research questions. Examples include disaster management challenges for each phase, different e-health technologies that can be used in DMC and their potentials, and people who are involved in any of the mentioned disciplines. The output of this stage was the extracted information, which was categorised in different thematic groups requiring further analysis. The charts, groups and themes are presented and discussed in section 5.3.

5.2.5 Stage 5 – Collating, Summarising and Reporting the Results

The last stage of the framework was summarising the data which were obtained from the primary research review report, that is, changing the charted subjects and methods into oral explanations that could be presented to the audiences (in line with Rumrill et al., 2010). In this stage, according to the generated reports, more research gaps could be found so it would be necessary to modify or revise the research questions. This is highly important because, according to Valaitis et al. (2012), the scoping review is an iterative process; therefore, at this stage, we find out if we need to go back to stage 1 for revising formulating the research questions and reconsidering the proposed framework.

Note: in this stage, the preliminary research questions were slightly modified in light of the first information extraction (see section 1.6).

In this research, all the extracted information from previous stages was analysed descriptively (qualitatively) to find meaningful relations among each thematic group's findings or cross-sectional group's findings. Finally, the results were reported; the final results were expected to lead to the final answers for the research questions and to cover all their aspects.

The rest of this chapter is dedicated to representing the findings from stages 4 and 5 of the DEH scoping process.

5.3 DEH Emergence and its Composition

By referring to the captured articles in the controlled search, 328 relevant articles were found in which, to address healthcare demands, at least one type of e-health technology was used in either disaster management or disaster medicine. In addition, the following trend (Figure 5.18) can be identified regarding the number of studies per year in the application of e-health technologies in disaster management or medicine:

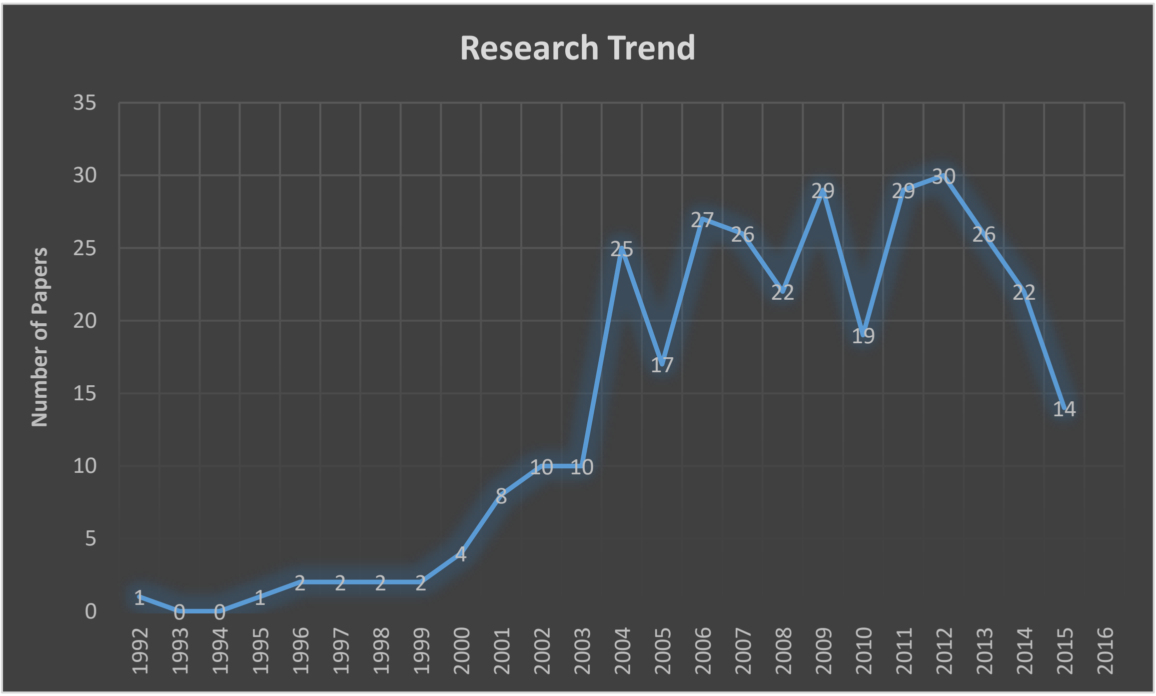

Figure 5.18 Study trend in DEH related areas (based on controlled search results)

Based on this trend, despite some small downward movements, generally a significant upward trend can be seen, specifically after 2003. The trend can be interpreted as the acceptance and popularity of e-health technologies and their applications within DMC. Regarding the 2015 dip, its roots are in the timeframe of the search procedure (mentioned in sections 5.2.2.1 and 5.2.2.2).

The next stage was examining the presence of DEH within the current PubMed MeSH headings. Since in the PubMed database no MeSH heading was found for DEH or its other terms, it was concluded that:

- DEH related articles are labelled with other existing MeSH classifications
- DEH is a new area that does not yet have its own MeSH headings
- DEH can be considered as a newly emerged field that has not yet been defined in PubMed and given a MeSH heading

In this regard, a separate procedure was followed to identify the areas constituting DEH by referring to the topic areas of the journals related to the captured articles in stage 3. Then the articles were classified based on the main theme(s) of the journal by referring to the journals' website. The extracted articles were published in a wide range of journals from different disciplines. However, the main themes were mainly about disaster management/medicine, and health informatics (Figure 5.19). Therefore, it can be said that the areas of disaster management, disaster medicine and e-health (health informatics) have articles relevant to DEH.

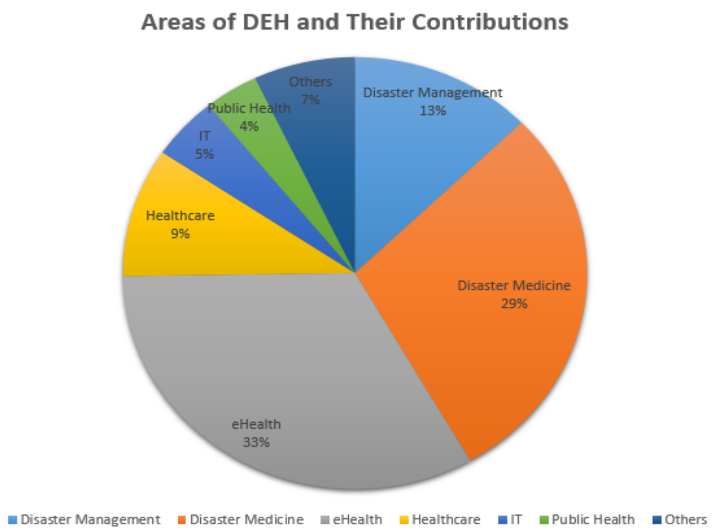

Figure 5.19 Journal areas and their contribution to the DEH

After identifying the research trend and DEH composition, the current situation of DEH had to be investigated. To do so, the combination of three fields of disaster management, disaster medicine and e-health technologies were examined. For this purpose, the researcher referred to the extracted articles from control search results. Tables 5.7 to 5.9 show only those studies that mentioned the e-health technologies usage specifically in disaster management/medicine cycle as a systematic manner. This supports the idea that e-health has not yet been completely integrated into either disaster management or disaster medicine.

Table 5.7

Disaster Management and e-Health

Disaster Management AND EHealth	Satellite-enabled eHealth applications in disaster management-experience from a readiness exercise (Chronaki et al., 2008)
Disaster Management AND e-Health	CrowdHelp: A crowdsourcing application for improving disaster management (Besaleva & Weaver, 2013)
	Application specific e-health & telemedicine systems: Implementation experience for community healthcare and systematic review of disaster publications (Soegijoko, 2011)
Disaster Management AND Electronic Health	Sahana alerting software for real-time biosurveillance in India and Sri Lanka (Waidyanatha et al., 2010)
	Satellite-enabled eHealth applications in disaster management-experience from a readiness exercise (Chronaki et al., 2008)

Table 5.8

Disaster Medicine and e-Health

Disaster Medicine AND EHealth	Satellite-enabled eHealth applications in disaster management-experience from a readiness exercise (Chronaki et al., 2008)
Disaster Medicine AND e-Health	None
Disaster Medicine AND Electronic Health	Satellite-enabled eHealth applications in disaster management-experience from a readiness exercise (Chronaki et al., 2008)
	Health information technology can make disasters seem like business as usual (Stevens & Rancourt, 2014)

Table 5.9

Disaster Medicine, Disaster Management, and e-Health

Disaster Medicine AND Disaster Management AND e-Health	Satellite-enabled eHealth applications in disaster management-experience from a readiness exercise (Chronaki et al., 2008)
Disaster Medicine AND Disaster Management AND e-Health	None
Disaster Medicine AND Disaster Management AND Electronic Health	Satellite-enabled eHealth applications in disaster management-experience from a readiness exercise (Chronaki et al., 2008)

Referring to Table 5.9, the first integration of the three areas of disaster management, disaster medicine and e-health dates back to 2008. Among 615 articles from the controlled search, only one article dealt with all three areas of DEH and no other studies were found after that search.

5.4 Thematic and Content Analysis of DEH

This research followed inductive reasoning, and for data analysis, thematic and content analyses. However, based on the inductive reasoning for data analysis, no pre-existing themes were available to be used for coding data accordingly and finding patterns within them. Instead, the themes were generated based on the research aims, objectives and questions.

Prior to data analysis commencement, a number of steps were followed, based on Braun & Clarke's (2006) suggestion, and these are outlined in sections 5.4.1 to 5.4.4.

5.4.1 Data Preparation and Organisation

The full texts of all the selected articles from stage 3 of the scoping study that were inserted into EndNote and Nvivo were checked. The intention of this step was to make sure that the full texts of all articles were available, readable and in a searchable format. Also, in EndNote, each article's 'abstract' and 'keywords' fields were checked, and if any of them was 'null', the researcher collected the related information on the Internet.

In addition, since two distinct data selection procedures were followed and each had a relatively large dataset, the researcher endeavoured to categorise the datasets in a manageable database. Subsequently, two datasets were created for controlled and uncontrolled search results in Nvivo, EndNote and Excel spreadsheet.

5.4.2 Data Coding Unit Identification

For data coding, a number of articles were read. Based on their context, different units of data from a word to a sentence and sometimes a few sentences together, were considered for coding. "Words" as data units were used to determine technology types or disaster phases in which technologies were utilised. However, for technologies applications or purposes, the whole sentence or even a few sentences together were considered because splitting a sentence into smaller units sometimes may result in losing the underlying meaning of data due to the loss of context. For example, take the sentence below:

> Decision Support System for Disaster Management (DSS-DM) is used to aid operational and strategic planning and policy making for disaster mitigation and preparedness

The unit of data for coding "technology" is "Decision Support System" as a whole because it refers to one particular technology; if the last part, that is, *'for disaster mitigation and preparedness'*, is taken away, one may mistakenly interpret that *'decision support systems'* can be used in all phases of disasters for *'operational and strategic planning and policymaking'*. Therefore, in most sections, to reduce any misinterpretation, whole sentences were considered as data coding units.

5.4.3 Generating Initial Codes and Familiarising with the Data

Prior to code generation, a number of articles were read to become familiar with the data, their meanings in context, and their depth and breadth. Then, each article's main information was entered into an Excel Spreadsheet in different categories (Figure 5.20).

Article Title	Yea	Authors	Methodology and research d	Research problem	Findings	Problem / Further resea	Usage	talk about	important result
Disaster Response in Health Care: A Design Extension for Enterprise Data Warehouse	2009	Bala, Hillol, Et. Al.		without medical records, medication + solution to provide access to the information needed during the time of such disasters	enterprise data warehouse (EDW)	before that we need rich database, need rich IT infrastructure for implementation,	Just a proposing architecture	EDW, no HC BG, US military HC system	EDW for meet the needs of strategic decision making
An Intelligent 802.11 Triage Tag For Medical Response to Disasters	2005	Leslie A. Lenert, Douglas A. Palmer, Theodore C Chan, Ramesh Rao	extensive interviews	paper triage problems, lack of real-time & poor information, communication & IS in disaster field	RFID Active tag as triage card, apply color code	Need to see the actual usage	proposing, prototype, still workimg for industrial prototype	triage in the field, some other automated triage systems with barcode and passive tags	
Disaster Mobile Health Technology: Lessons from Haiti	2012	David W. Callaway, Christopher R. Peabody, Ari Hoffman	qualitative trial of a modified version of iChart during earthquake in Haiti, tested at a large field hospital,	patients transfer with short medical summary written on their casts, interoperable patient tracking system, no patient log for operations, and no ongitudinal patient record	617 unique entries, facilitate provider triage, improve provider handoffs, and track vulnerable populations		Real Usage, Haiti disaster field tanent, 617 unique patient	Mobile health (mHealth) technology, application iChart, Triage, disaster response,	disaster response challenges and using e-health application to reduce errors
Hybrid Radio Frequency Identification System for Use in Disaster Relief as Positioning Source and Emergency Message Boards	2007	Osamu Takizawa, Akihiro Shibayama, et al.	evaluaton:field experiments and training exercises	no network connection, system for collect and disseminate information,	communication on the spot by RFID (non-contact and inexpensive,)	heavy portable reader, no victim info	evaluated in disaster prevention trainings by local communities and rescue teams	system impelementation, portable readers	
Implantation of RFID microchip in disaster victim identification (DVI)	2006	Harald J. Meyer, Nantarika Chansue, Fabio Monticelli		temporary pen marking, reidentification, large number of bodies,	RFID tags (passive and low-frequency)		Thailand tsunami	DVI, tagging bodies	
Improving Disaster Management (2010)	2010	Sarah Underwood		uneffective disaster response, less & unaccurate info from disaster field, lack of information sharing	dual-use technology, such as a mobile phone, Direct, firsthand reports, peer-to-peer incident notification system	early stage, no tele communication infra	lab - tested in 2008 earthquake in the Sichuan province of China	disaster, effects od IT on disaster management and response, UNISEF disaster app, 2 more disaster response app, UNICEF application	RapidSMS provides real-time transmission of data in a breaking emergency or in a long-standing disaster, allowing aid workers to monitor supplies and report on situations that require immediate response. monitor nutrition, water, sanitation, and supply chains

Figure 5.20 Sample view of Excel spreadsheet

At the same time, features and ideas relevant to the research questions and objectives were identified and extracted from the articles, and then were categorised into different codes. Table 5.10 illustrates some examples of article quotes and their related codes.

Table 5.10

An Example of Quotes from Articles and Matched Codes

Article's Quotes	Codes
Use of a DSS for risk identification and prevention will enable the decision-makers to turn to the best account **Flood management is made easier by the fact that floods occur in predictable locations and in most cases warning is possible** **(Cioca & Cioca, 2010)**	1- Technology usage in disasters 2- DSS technology usage in disaster mitigation 3- Provided e-health application/service 4- Disaster mitigation phase 5- Flood disaster
Require timely data in order to provide high quality recommendations **(Thompson et al., 2006)**	1- DMC challenges 2- Solution For challenge 3- Technology to solve it
Power outages and down systems, they usually take time to implement **(Johnson 2014)**	1- What are the challenges of DMC? 2- Is it possible to solve mentioned challenges by using e-health technologies? 3- What is the suitable technology?
Basic connectivity and simple text-based data communication could then remain available during the crucial gap between the time when the disaster occurs and the time when qualified manpower reach the area and set up dedicated	1- How can we provide better response during disaster? 2- What is the role of technology for providing better response?

hardware putting conventional communication infrastructure back in service. **(Petersen et al., 2015)**	3- What criteria should be considered for better response?
A well-organized disaster preparedness plan and effective community participation are crucial to mitigate the impacts of a natural disaster **To minimize the damage and the suffering the disasters might cause, it is important to maximally mobilize all human resources to cope with difficult situations** **(Pourhosseini et al., 2015)**	1- How can we provide better response during disaster? 2- What is the role of technology for providing better response? 3- What criteria should be considered for better response?
Disaster recovery and response we need integration of 1- education and training 2- communication system 3- public health surveillance **So we need IS for better coordination, ensure the health and wellbeing** **(James & Walsh, 2011)**	1- What phase of disasters? 2- What are the requirements of each disaster phase? 3- What sort of application and services do we need? 4- Is it possible to provide them by using e-health technologies?
Essential element is the proper identification of the goods and the distribution of this information to all the involved partners **(Baldini et al., 2011)**	1- Required service(s) or application(s) 2- Involved partners
The effect of having proper information on decision making before or after disaster is not something to be neglect able **(Aliyu et al., 2013)**	1- Requirements for having proper disaster management/medicine

The EndNote system was used to extract all the articles' keywords, abstracts, and journal names into the text documents. Excel spreadsheet, generated codes, and text documents from EndNote enabled the researcher to identify similar features and characteristics within the dataset. Additionally, they were viewed as data to be interpreted for hidden meanings and pattern identifications.

After gaining a preliminary insight into the gathered data, the researcher began the procedure to get the final code(s). Consequently, an iterative procedure was developed that had several iterations with the purpose of refining code meanings and definitions to be aligned with the research questions and objectives. This procedure is illustrated in Figure 5.21.

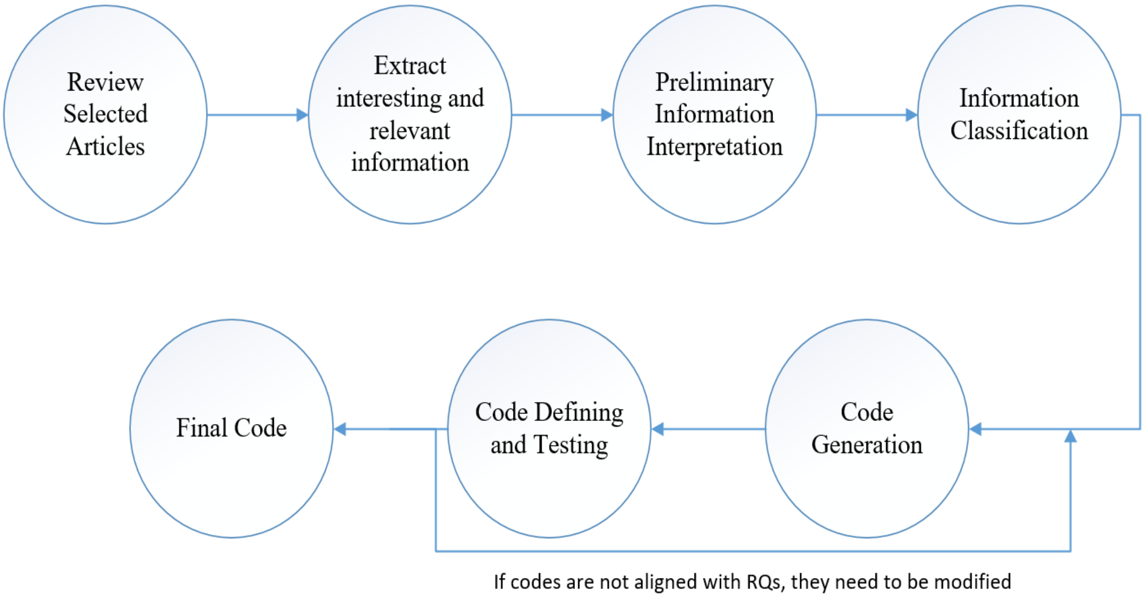

Figure 5.21 Code generation procedure

5.4.4 Searching for Themes

The aim of this stage was generating themes from codes by grouping the related codes together. Based on the inductive reasoning of the research, the generated themes needed to have strong relations with the data themselves and also to show the important aspects of the data in relation to the research question (Braun & Clarke, 2006). Accordingly, the themes were generated based on the full review of the articles from stage 3, generated codes, information from the Excel spreadsheet, and EndNote documents.

The generated themes were used to extract, highlight, and interpret the most important aspects of gathered data for answering RQ 1, that is, the scope of DEH. The generated themes and subthemes are set out in Table 5.11.

Table 5.11

DEH Main Themes and Subthemes

Themes	Sub-Themes
1. Disaster type	1.1 Natural Disasters 1.2 Manmade Disasters 1.3 Infectious Disease
2- Disaster Phase	2.1 Mitigation 2.2 Preparedness 2.3 Response 2.4 Recovery
3- Technologies	--
4- Application	--
5- Supported features	--
6- Purposes	6.1 Clinical 6.2 Non-Clinical 6.2.1 Administrative 6.2.2 Education and Training 6.2.3 Research
7- Services	--
8- Stakeholders	8.1 International 8.2 National 8.3 Local

In the following section, the results of thematic and content analysis of the extracted articles, based on the above themes, are represented to demonstrate the scope of DEH.

5.5 The Results of Thematic and Content Analysis

To define the DEH scope, there was a need to identify the elements within the boundary of DEH. With regard to e-health technologies, the scope should tell users which e-health technologies can be found within DEH boundaries, and what sort of applications and services can be provided by these technologies. Additionally, it should tell us who or which groups can use the provided services and applications and benefit from them.

The elements that constitute the themes of the study are explained in the following subsections.

To conduct the data analysis for each theme the following datasets were considered:

1- findings from full review of articles
2- the DEH database (both controlled and uncontrolled)
3- the Nvivo database (both controlled and uncontrolled)

5.5.1 Theme 1: Disaster Types in DEH

An important element that needs to be addressed within the DEH scope is disaster type. Identification of disaster type is necessary since when we talk about the DEH field, it is essential to know for which type of disaster it can be used. By referring to 'The International Disaster Database', a comprehensive list of disaster types was extracted. Based on the database, a natural disaster classification is shown in Figure 5.22. However, for manmade disasters no specific category was defined.

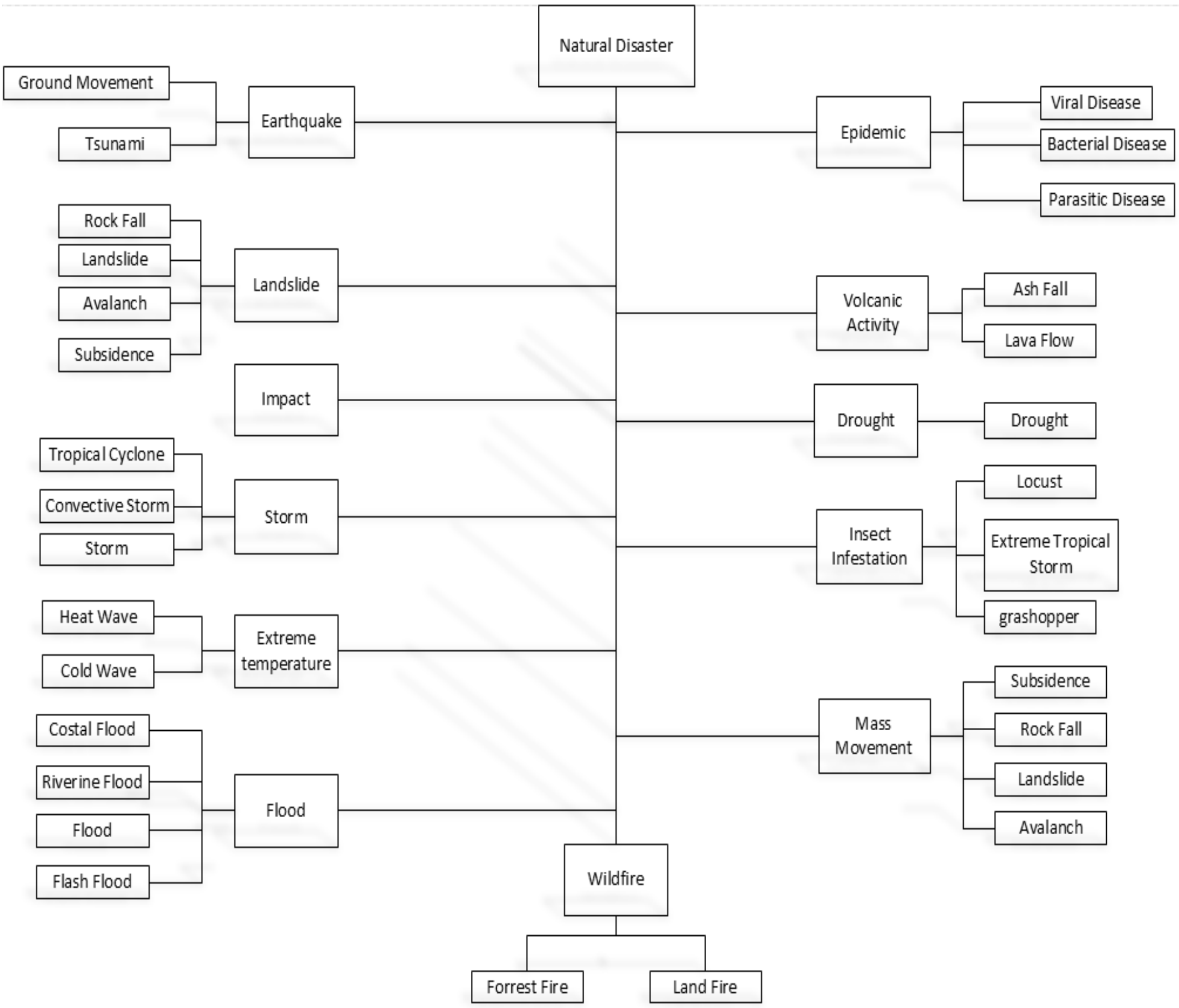

Figure 5.22 Natural disasters classification (developed from CRED)

Base on the research findings, it can be said that e-health technologies are used for different disaster types including natural, manmade, and disease/epidemics disasters (Figure 5.23). Similarly, DEH can deal with different disasters regardless of their nature. The breakdown of all disaster types, found from the scoping study, regardless of their origin is shown in Figure 5.24.

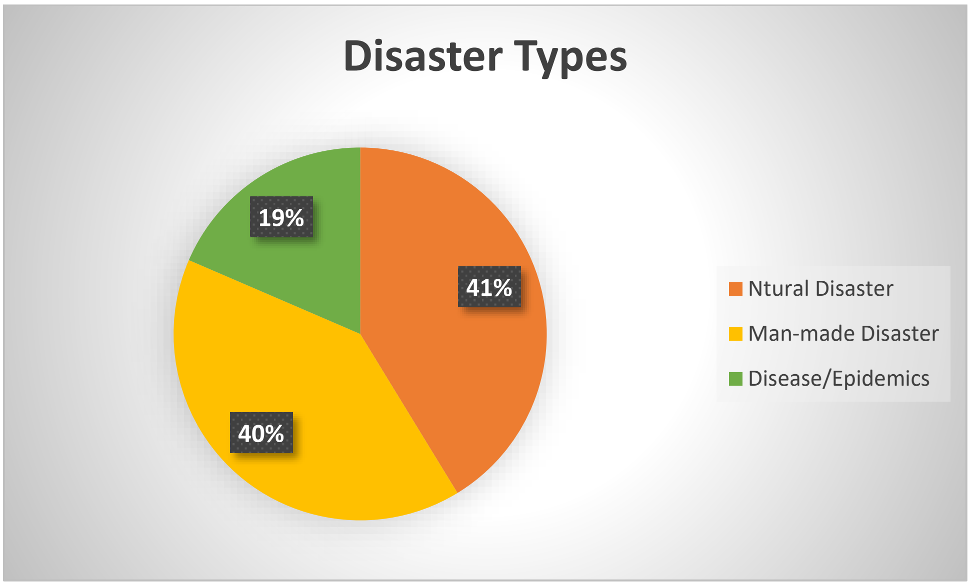

Figure 5.23 Disasters types

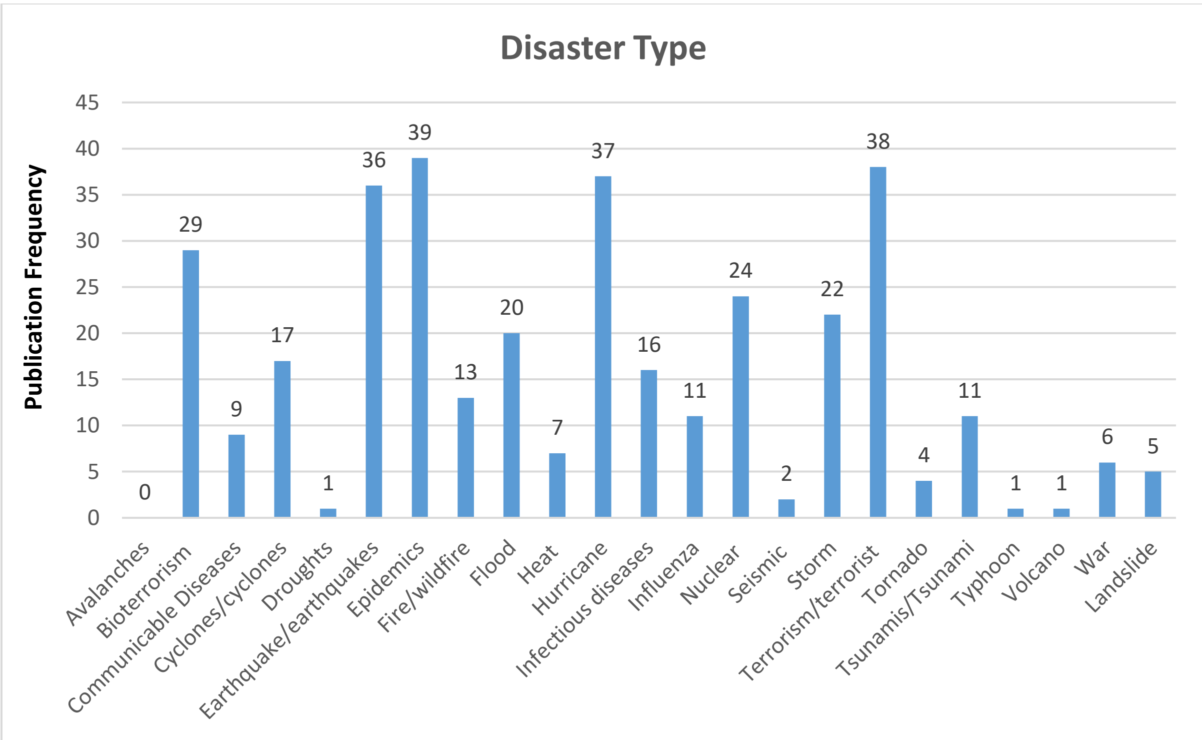

Figure 5.24 Breakdown of disasters' type

The most highlighted aspect of Figure 5.24 is diversity in the disaster types that show the use of e-health technologies in different disasters. The use of e-health in earthquakes, epidemics, hurricanes and terrorist incidents is discussed more than in other disaster contexts in the literature. It can also be interpreted that as the captured articles were more in these areas, it is probable that these areas are more researched. From another perspective, since most common disasters in the world (figure 5.25) were epidemic diseases, floods, earthquakes, and storms, it is possible that researchers focused more on those disasters; therefore, more studies have been done about them. In this regard, it might be the reason why e-health technologies applications were used higher in the mentioned disasters compared to the others.

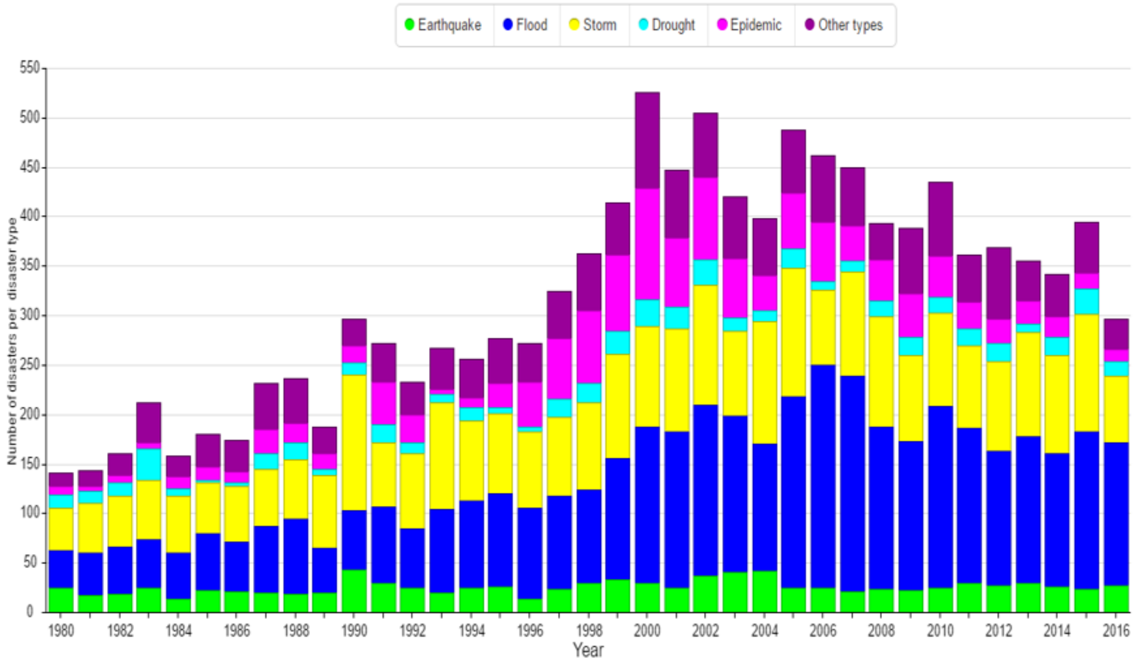

Figure 5.25 The most frequent natural disasters (adapted from http://www.emdat.be)

5.5.2 Theme 2: Disaster Phase

In this theme, the intention was to explore the disaster phases in which DEH could be used. The results are delineated in Figure 5.26; it can be seen that DEH can be applied in different disaster phases since in all phases e-health technologies were used.

With respect to e-health technologies utilisations, they had higher applications in planning and response phases in contrast with mitigation and recovery phases.

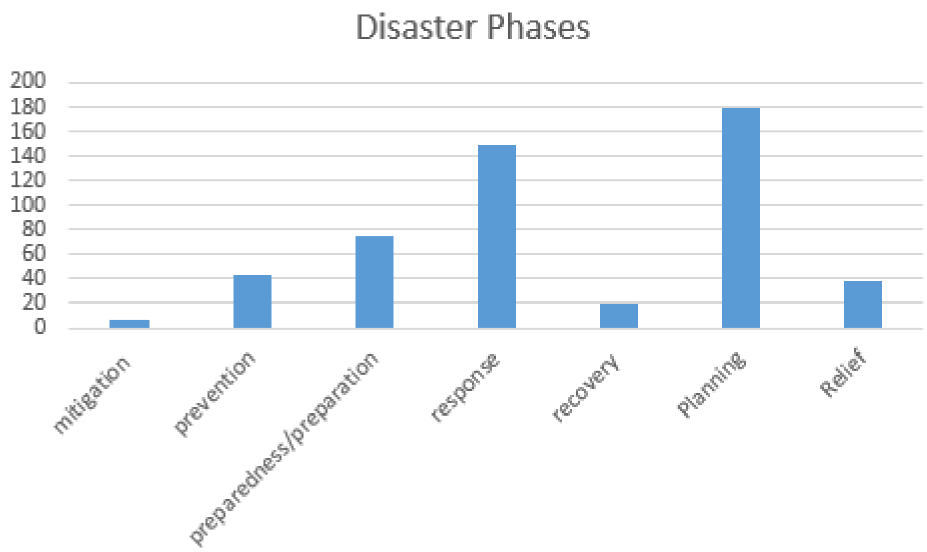

Figure 5.26 Disasters' phases breakdown

In this study, a 4-stage disaster management framework was used (as discussed in chapter 2), and to achieve consistency there was a need to categorise the findings into a 4-stage framework. Therefore, the phases with the same concepts were merged and the results can be seen in Figure 5.27.

For merging purposes, the researcher referred to the full text of articles and, based on the provided definitions, accomplished merging of the phases. As can be seen in Figure 5.27, like Figure 5.26, articles about e-health technologies usage are less common in disaster mitigation and recovery phases.

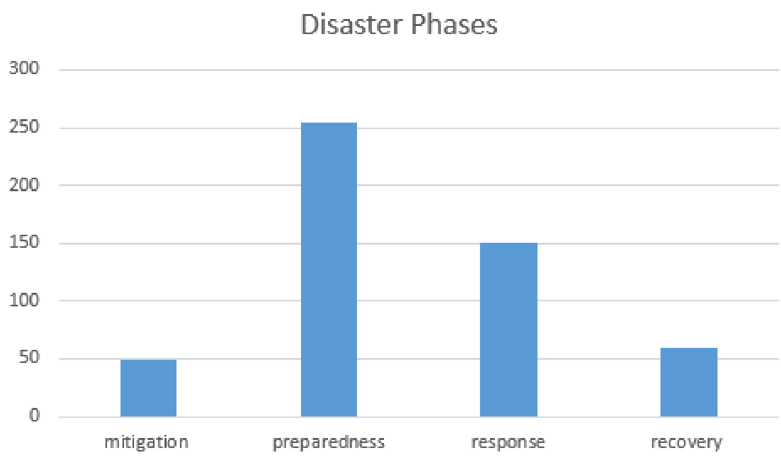

Figure 5.27 Disaster phases

5.5.3 Theme 3: Technologies within DEH

Based on the last two themes, DEH has the potential to be used in different disaster types and phases; in other words, e-health technologies can be used for different disasters and in their different phases. Now, the next question is, “which e-health technologies can be used in disasters?” Answering this question shows another aspect of the DEH scope, that is, technology.

For this theme, data analysis results was a relatively long list of different technologies from different domains. However, presenting all available technologies in DEH solely by listing their names may not be appropriate since it may cause confusion and ambiguity to readers and later on to the DEH stakeholders. To reduce this complexity, technologies were demonstrated in a hierarchical representation. Moreover, it was beneficial if the proposed model or hierarchy for the DEH e-health technologies could be based on an available internationally accepted hierarchy.

Nevertheless, from among all the searched databases in the controlled and uncontrolled procedure, only PubMed, CINAHL and EBSCO Health Databases had the taxonomy of e-health technology. However, PubMed was chosen because of its comprehensiveness and quality and equality of depth and breadth. CINAHL database has its own hierarchy in **CINAHL Headings** section with slightly different categories, and compared to PubMed, it is of higher level; and EBSCO Health Databases for subject taxonomies or thesauri refers to CINAHL Heading or PubMed MeSH heading.

Technologies in PubMed have been divided into the category of “Information Science” with “Medical Informatics” as a subcategory. In addition, there is no illustration model for the PubMed hierarchy of Information Science nor are there any for Medical Informatics. Therefore, based on the PubMed taxonomies, the researcher developed Figures 5.28 and 5.29 to show technologies hierarchy for the mentioned fields, respectively.

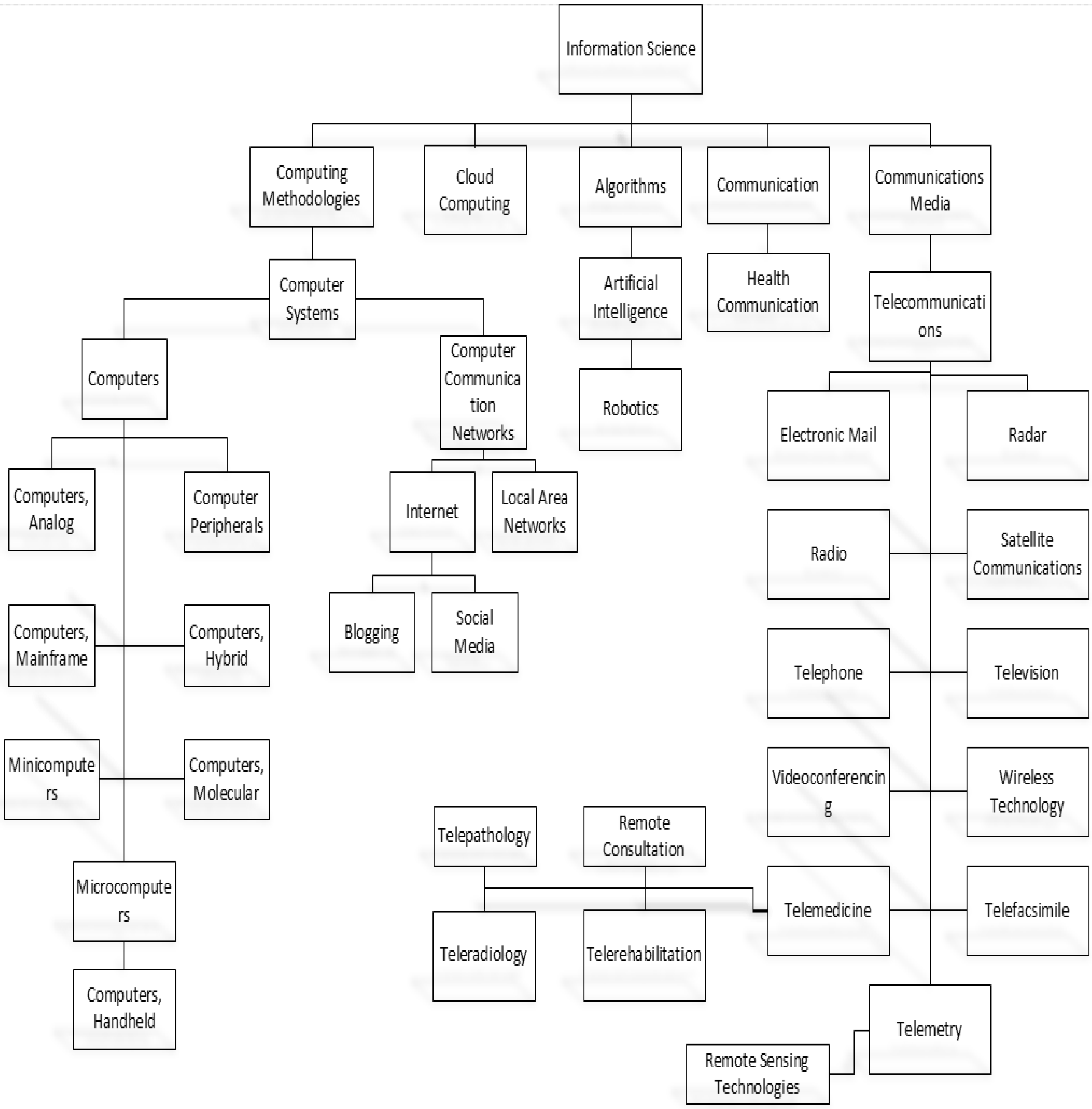

Figure 5.28 Existing PubMed hierarchy of information science

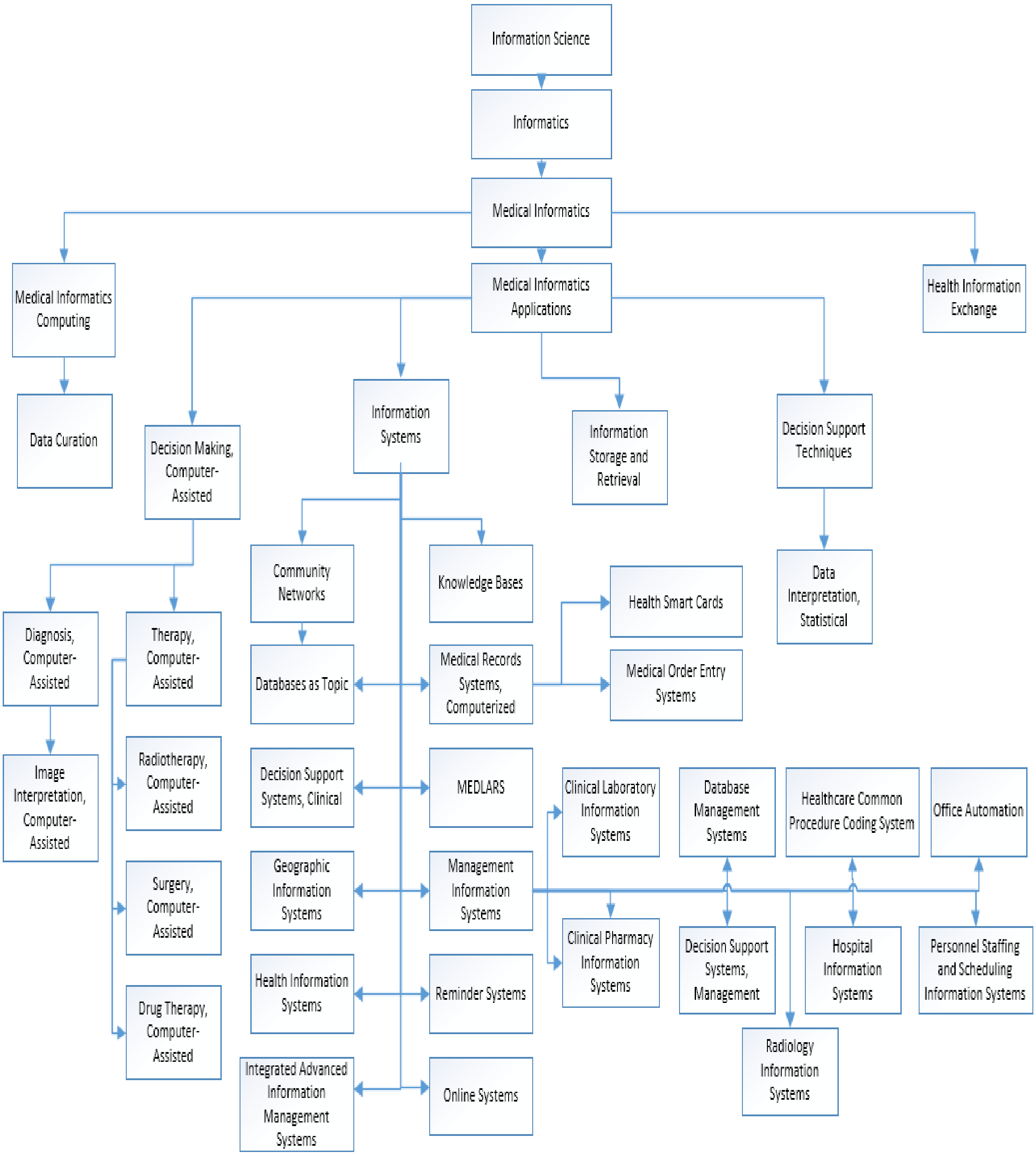

Figure 5.29 Existing PubMed hierarchy of medical informatics

Based on these classifications, the following research findings were achieved:

a) Based on the top-level PubMed technology classification and considering the search findings, high-level classification of e-health technologies within DEH scope is provided in Figure 5.30.

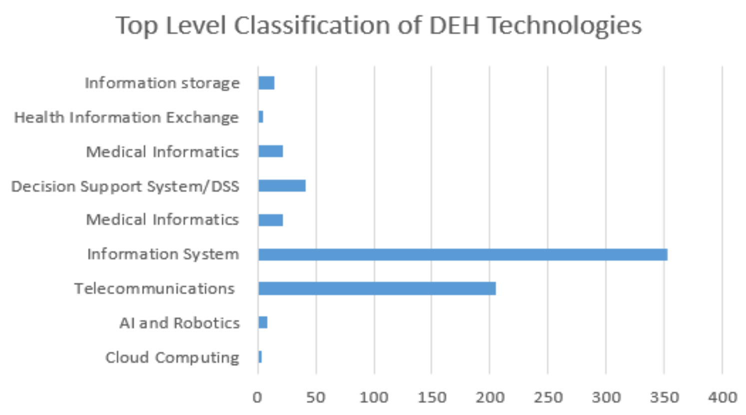

Figure 5. 30 Top level classification of DEH technologies

b) Based on the research findings, and considering PubMed classification for technologies, the low-level classification of the technologies in DEH domain is created (Figure 5.31). In this diagram, the main technologies are shaded.

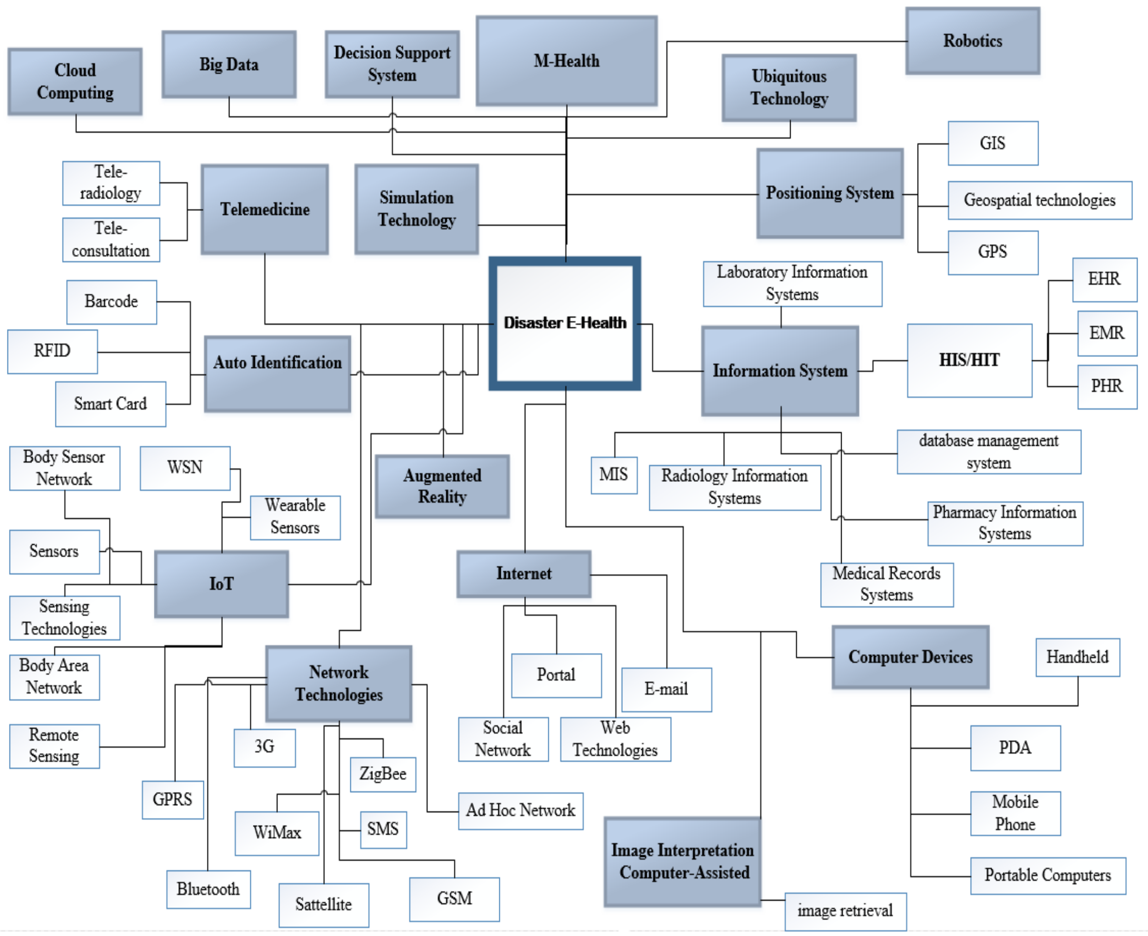

Figure 5.31 DEH technologies and their classifications

As illustrated in Figure 5.31, DEH contains a wide range of technologies from the well-established technologies such as ‘Decision Support Systems’ and ‘Telemedicine’ and ‘Information System’ to the new emergent technologies like ‘IoT’, ‘Augmented Realities’ and ‘Big Data’. There is, however, one major difference between the mentioned technologies groups: the potential of the well-established technologies in the DMC is identified to a great extent, but for the emerging technologies, this potential is not clearly identified since not many studies have been done to explore their full potential with respect to their usage in DMC.

For example, ‘Information System’ and its sub-technologies can be considered the most common technology which has been used in disaster management /medicine followed by telecommunication technologies. Two reasons might exist for those categories not having high applications for disaster situations: those technologies are in the early stages of development, or their full potential has not been clarified for their usage in DMC.

Another piece of information from Figure 5.31 reveals that some technologies, such as ‘EHR’, ‘Tele-Radiology’ and ‘Radiology Information System’, are specifically designed for healthcare environments. In contrast, there are some technologies that are not designed for healthcare environments. However, based on their positive outcome in other industries or areas, the healthcare sector has started using them for the same purposes or other clinical purposes with the intention of getting the same results as the other environments; technologies such as ‘Auto Identification’, ‘Decision Support System’ or ‘Cloud Computing’ are among these technologies.

5.5.4 Theme 4: Applications within DEH

After technology identification in the scope of DEH, it seemed necessary to discover their applications within the scope of DMC and DEH. Of course, for the DEH scope only those applications were considered that directly or indirectly dealt with healthcare areas.

Based on the data analysis, DEH applications could be classified into seven major categories of (Figure 5.32):

a. Automation
b. Identification
c. Monitoring (Tracking and Tracing)

d. Information/Data Application
e. Telemedicine
f. Managerial Application
g. Surveillance Application

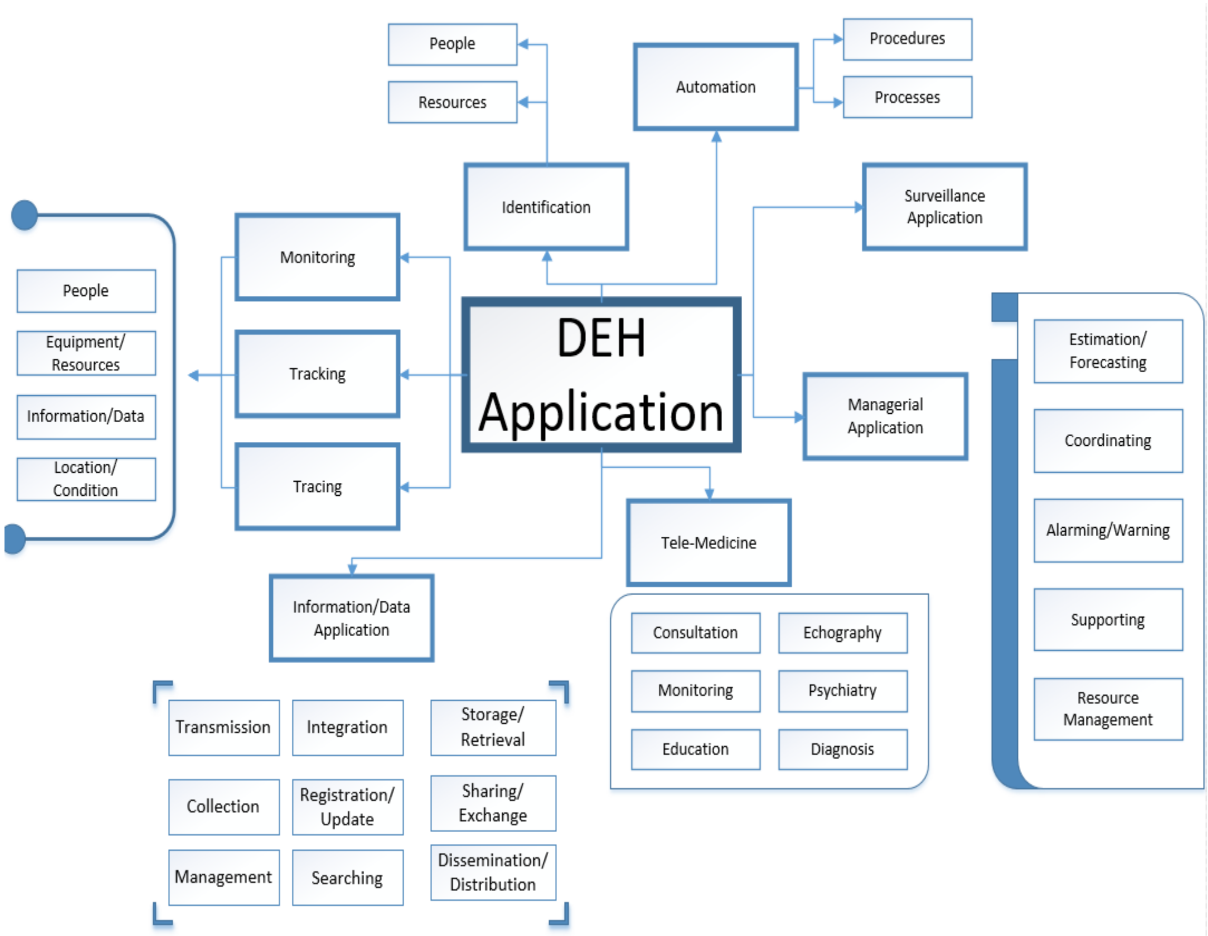

Figure 5.32 DEH applications

5.5.5 Theme 5: Features Supported by DEH

All the technologies and their applications were used to provide some features within DMC and the DEH scope to facilitate disaster preparation, response or recovery. Table 5.12 presents the list of the most important features provided by e-health technologies found in the research results.

Table 5.12

Supported Features by DEH

Feature Name	**Feature Name**	**Feature Name**
Availability	Relevancy	Collaboration
Effectiveness	Robustness	Coordination
Control	Awareness	Protection
Integration	Immediacy	Sustainability
Safety	Quality	Completeness
Monitor	Web-base	Accessibility
Readiness	Interoperability	Online
Mortality	Applicability	Real-time
Efficiency	Continuity	Computerisation
Security	Optimisation	Usability
Accuracy	Reliability	Confidentiality
Consistency	Recognition	Cooperation
Track	Scalability	Responsibility
Identification	Localisation	Accountability
Telemetry	Morbidity	Automation

5.5.6 Theme 6: DEH Purposes

The identified technologies and their applications within the DEH scope were serving different purposes that could be divided into two main clusters: 'Clinical' and 'Non-Clinical' (Figure 5.33).

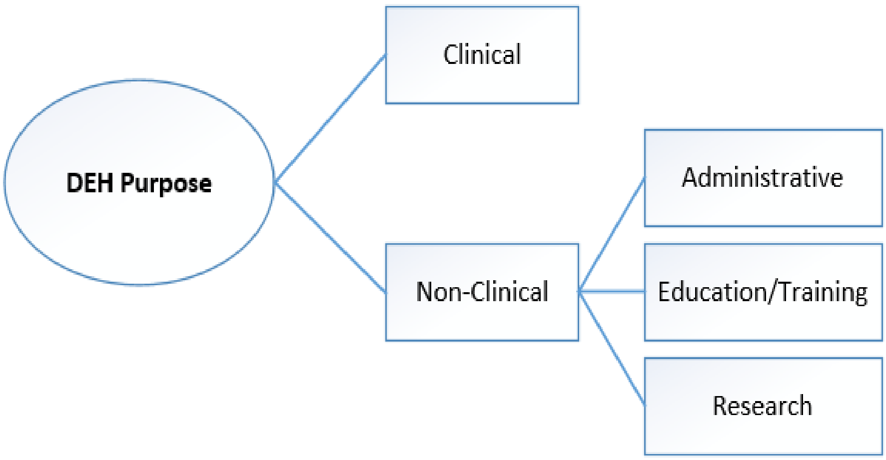

Figure 5.33 DEH purpose

a. **Clinical purposes:** all the activities/tasks, the objectives of which are rooted in providing or expanding healthcare services for the population
b. **Administrative purposes:** all the activities/tasks, the objectives of which directly or indirectly facilitate providing or expanding healthcare services for the wider population and can cover healthcare administrative procedures form admitting patients to discharging them, or making patient information transfer possible.
c. **Education/Training Purposes:** covers activities where the main purpose is to train and prepare citizens or special groups like responders for different disaster phases.
d. **Research Purposes:** those cases where the aims directly or indirectly are related to investigation and research that intend to improve either efficiency or effectiveness of the DMC activities.

Based on these definitions for the DEH purposes, a number of activities for each group of disaster phases are shown in Table 5.13.

Table 5.13

DEH Activities Examples with Regard to DEH Purposes

Purpose	Disaster Phase	Sample of Activity
Clinical	**Mitigation**	Medical planning
	Preparedness	Transferring and sharing of medical information
	Response	Remote triaging of injured patients before arriving at hospitals
	Recovery	Helping injured patients to recover at home
Administrative	**Mitigation**	Preparing humanitarian aid programme
	Preparedness	Disseminating pre-disaster warnings
	Response	Providing automation to help responders on documentation during disaster response
	Recovery	Identifying and locating missing children
Education/Training	**Mitigation**	Educating people on the foundational elements of preparedness
	Preparedness	Training the practitioner on disaster skills
	Response	Providing continuous medical education for practitioners without enough experience
	Recovery	Providing tele-education supports and services
Research	**Mitigation**	Studying the previous disasters and research on probability of their occurrence and their consequences
	Preparedness	Carrying research on required competencies for the response time
	Response	--
	Recovery	Conducting studies to identify long-term impacts of disasters on people's health

5.5.7 Theme 7: Services within DEH

Based on the different parties and their needs and demands in each phase of disaster, also considering the DEH supported technologies and applications, DEH is able to provide diverse services for a variety of parties during DMC. Thus, from a high level view, it can be categorised into three categories: operational, tactical and strategical levels (Figure 5.34)

Figure 5.34 DEH service level

1. **Operational Level Services:** The function of this group of services is to support or control operations against rules and standards and encompass day-by-day decisions. Although, diversity in these sorts of services create islands of automation, they make operations more efficient. A large number of services in DMC and DEH can be categorised under this level, such as, rapid victim identification, victim tracking, damage assessment, and critical resource distribution.
2. **Tactical Level Services:** The purpose of this range of services is supporting management and providing interconnection among different parties or organisations through diverse information management tools. These services take care of medium term planning and are used in creating procedures. Under this level

of service are categorised decision support systems as well as capacity assessment databases, health information exchange, and appropriate allocation of resources.

3. **Strategical Level Services:** The purpose of these level services is to support the system as a whole, and their output is mostly policies and overall structural decisions either among an organisation's functions or among other organisations. For this group of services, information-planning tools are used, and integrated infrastructure and global compatibility are essential. Above all, few services are available for this stage not only in DEH but also in disaster management/ medicine. These services cover long-term, complex and non-routine planning in DMC and DEH, such as planning for vulnerable population needs and safety, long-term care, or cloud-based coordination.

According to these classification and explanation, we can have these services for each disaster phase within the DEH scope. Some examples are presented in Table 5.14.

Table 5.14

DEH Service Level Examples

Service Level	**Disaster Phase**	**Service Name**
Strategic	**Mitigation**	- Enhancing patient education and empowerment - Analyse out-of-hospital emergency medical services
	Preparedness	- Preparing back-up communications systems - Education and training of health workers
	Response	- Monitor, aggregate, and analyse social media data - Cloud-base coordination
	Recovery	- Long-term care - Injured people information
Tactical	**Mitigation**	- Information integration - Medical record sharing within and across institutions
	Preparedness	- Resource database - DSSs for bioterrorism preparedness

	Response	- Dynamic information collection - Coordinating the distribution of the available medical resources
	Recovery	- Supply chain management - Integrate the delivery of care after disasters
Operational	**Mitigation**	- Organise medical resources - Analyse daily operations in emergency departments
	Preparedness	- Remote sensing - Response plans that rely on local hospitals
	Response	- Situational awareness - Electronic triage tag
	Recovery	- Psychiatrist video conferencing - Evaluation and identification of psychological problems

5.5.8 Theme 8: DEH Stakeholders

Based on the research findings, the following stakeholders level shown in Figure 5.35 were recognised.

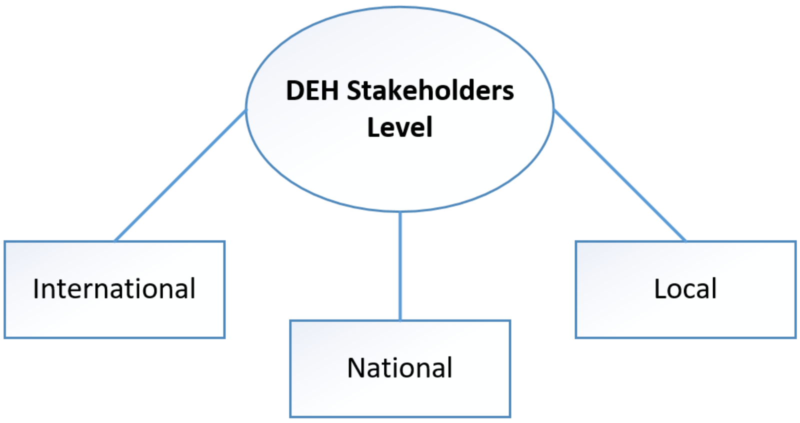

Figure 5.35 DEH stakeholders' level

The 'international' level refers to the international organisations that work in any areas that directly or indirectly can have a role in any disaster phases regardless of their nature, and their branches and supports cover almost all countries Examples of such organisations include WHO, Red Cross and Red Crescent. In contrast, the 'national' level organisations exist, and their rules are applied within the boundaries of each country and could vary from country to country. At the bottom of the hierarchy, 'local' organisations are located in the country at the sub-national level; they work under national/governmental organisations and follow their rules. These organisations are responsible for the needs and demands of specific regions or areas; they are not supposed to make any rules, are just executors of the governmental rules and need to report to the national organisations. Police and fire bureaus and the regional healthcare environments are considered at this level. Based on their level, we can set out the following categories and subcategories in terms of different parties (Figure 5.36).

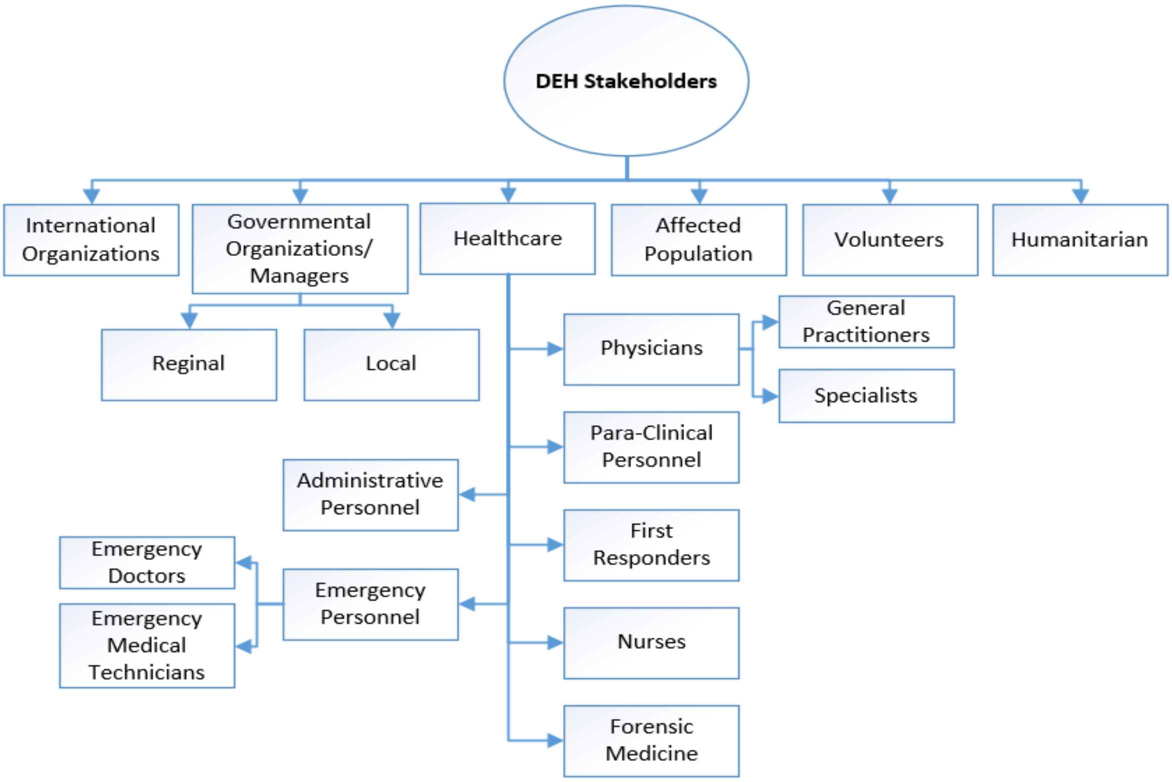

Figure 5.36 DEH stakeholders

5.6 Summary

This chapter presented the implemented scoping study framework for the DEH research, and comprehensively explained its steps and procedures. Moreover, arguments in support of all the searching procedures together with inclusion/exclusion criteria for study selection were advanced. The last section of the chapter presented the finding of the thematic and content analysis. Therefore, to this end, RQ 1 has been answered. The proposed scope consists of the following main elements of the DEH domain (see Table 5-11):

- disaster types and phases on which DEH can be utilised
- e-health technologies, their applications, and features
- types of services offered by DEH and their purposes
- DEH stakeholders

The latter part of the chapter provided expansion of the above themes based upon scoping study findings. However, the last stage of the scoping framework, evaluation of the scoping results using the Delphi method, remains and that will be covered in Chapter 7.

CHAPTER 6

DEH GOALS AND FUNCTIONAL SCENARIOS

6.1 Introduction

This chapter discusses phase 2 of the research (see Figure 6.1) and its findings. The overall objective of this phase was generating meaningful scenarios for each phase of disasters where e-health technologies within the scope of DEH might be utilised. These scenarios were described using an e-health approach and show a particular application of one or a number of e-health technologies.

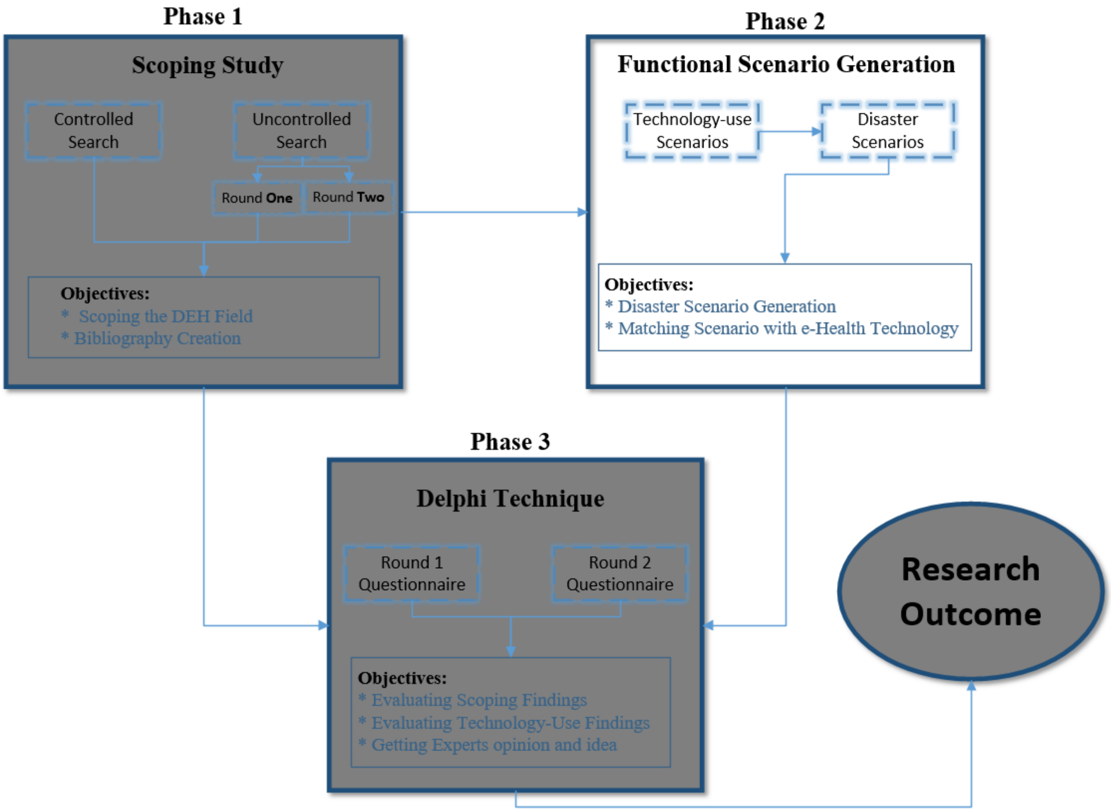

Figure 6.1 Phase 2 of the overall research activities framework

As discussed in chapter 4 section 4.6, this phase of the research is inspired by use-case methodology; however, it was continued up to the functional scenario stage while the rest of the details, such as creating use-cases for the functional scenarios, were ignored.

Use-case methodology is generally accepted in software engineering; however, for system engineering it is still controversial (Alexander & Zink, 2002). In software engineering use-case methodology is used as an outline for the system design and represents, in considerable detail, the steps of interaction(s) between the user and software to do a task in a structured story-like manner (Safdari et al., 2013; Teehan & Keating, 2010). However, in system engineering, use-cases are employed in the earliest stage of system development to define the system functionalities within the scope of the system (Heussen, Uslar, & Tornelli, 2015; Regnell, Andersson, & Bergstrand, 1996).

The ultimate aim of applying use-case methodology was to identify the first level of DEH subsystems (functions) for their future development. In this regard, a scientific and standard way of generating disaster-related scenarios was explained to support practitioners with e-health technologies in each disaster phase regardless of disaster type. For this purpose, it was necessary to define certain functional scenarios or applications. These functional scenarios can be developed through use-case methodology. It should be noted that, in this research, this methodology refers to a system engineering perspective that deals with systems at a higher level as compared to software engineering and defines missions or stakeholder goals (Gottschalk & Uslar, 2015). In this study, since functional scenarios demonstrated system objectives or applications, they were referred to as goals to determine the DEH goals and applications

The first section of this chapter (section 6.2) deals with the explanations of the modified use-case methodology that is proposed in the DEH research together with the definition of its elements. Then, in section 6.3, the defined DEH goals and proposed scenarios are discussed within the disaster management cycle (DMC). Furthermore, the explanation of goals identification for each disaster phase is discussed.

6.2 DEH Functional Scenario Generation

DEH can be considered as a complex system that makes it difficult to create a consistent and comprehensive list of all applications of e-health technologies for the diverse healthcare demands. Additionally, e-health technologies utilisations within DMC, proposed and covered by DEH, can potentially lead to an increasing number of applications that overwhelm the concept. Therefore, there is a need for a suitable system engineering to identify, successfully, all DEH functionalities within its scope.

In this regard, use-case methodology was utilised to describe the system's objectives and to outline the scope of the problems required to be solved (Alexander & Zink, 2002). Furthermore, this methodology provides a common understanding regarding DEH systems and subsystems, their objectives, and the problems they can address and probably resolve. Functional scenarios, followed by identified goals, give a description of a procedural process model for creating and formulating solutions (Gottschalk, Uslar, & Delfs, 2017) for e-health with regard to healthcare challenges within DMC and DEH scope.

DEH as a system has various stakeholders as its actors and, due to a variety of technologies and their related applications, a large number of functionalities can be expected. Since all these technologies and their applications cover broad areas, the behaviour of such a system is complicated and can be analysed at many different levels and from different perspectives. Therefore, use-case methodology application was expected to describe system (DEH) functionalities and manage its complexity through developing a hierarchical and organised set of scenarios defining the purposes of the system (Alexander & Zink, 2002). Furthermore, since DEH has certain missions and objectives that its stakeholders intend to achieve, the relations between objectives and stakeholders could also be illustrated through this methodology. Therefore, as recommended by Heussen et al. (2015), use-case methodology can be implemented by domain experts to describe the main functions of the system. In this regard, the generic high-level use-cases (up to functional scenario stage) were implemented to describe the most important purposes of DEH. This category serves as a foundation for determining finer services for further development.

Consequently, the researcher used the use-case approach to represent the interaction between DEH and its actors through defining various functional scenarios. Accordingly, based on the use-case methodology, it was possible to generate different scenarios for further development of the DEH area. Due to the broad scope of DEH, to have a clear structure and systematic way of generating functional scenarios as well as "connecting and validating the user requirements in a repeated, controlled, and rising manner" (Safdari et al., 2013, p. 3), the following categorisation was performed based on the research by Poenaru and Poenaru (2013). This classification contributes to a path to any potential applications of the e-health technologies by specifying the demonstrated categories that are illustrated in Figure 6.2.

Figure 6.2 Proposed path to generate scenario

6.2.1 Sector Identification

As the first step, the sector needs to be identified; it refers to the general domain that can potentially benefit from DEH and its e-health applications. The identified sector requires more in-depth analysis to identify its demands and challenges and, accordingly, extract its requirements. These requirements together with their properties should be considered in goals identification. In this study, healthcare was the selected sector because the focus of DEH is healthcare and its ultimate aim is to improve the quality of the given healthcare services before, during, and after disasters. In addition, almost everything within the DEH scope, from e-health technology to its applications and features, deals with citizens' healthcare needs and demands in different phases of disasters.

6.2.2 Segment Identification

Each sector includes closely related elements called segments, each of which covers specific sets of unique characteristics and properties. In this research, for the purpose of segment identification in the healthcare sector in DEH study, there was a need to refer to the situations in which healthcare was studied – the disaster situation. The focus of this research was the healthcare demands of populations different in nature, service and application in different phases of disaster. Thus, the segment classification needed to be based on DMC to accommodate these demands with regard to the specific characteristics of each disaster phase. Accordingly, segment in DEH can be divided into 'Mitigation', 'Preparedness', 'Response' and 'Recovery' due to the following reasons:

1- Besides healthcare, the other focus of DEH is disaster
2- DEH scope covers applications and services related to healthcare but in the disaster context
3- The segment classification, if based on DMC, allows researchers and/or stakeholders to extract related concepts, technologies, applications and services based on the disaster phases and their specific characteristics and requirements
4- Disaster phases have a significant effect on the selection or development of appropriate technologies for different applications and services based on their unique features

6.2.3 Group Identification

Each segment, based on its properties, can further be divided into several groups. These groups can be used to describe a potential usage of the system (Laplante & Laplante, 2015). In this regard, each group addresses or covers a common point(s) or specific part(s) of the system. By referring to the system engineering concept, these groups can be built based on the system interactions with other systems or users to provide a common solution for the set of problems with the same root cause.

For defining groups in this study, the researcher referred to the articles extracted from both controlled and uncontrolled searches and, after carrying out the full review, took the following steps:

- extracting all the disaster challenges that directly or indirectly related to healthcare within DMC;
- classifying the identified challenges based on the disaster phases;
- finding and grouping together the challenges with the same root cause in each disaster phase;
- naming each group based on the solution that could address the challenge.

An example for group creation is provided that shows how 'Training and Exercise' group is created within disaster preparedness phase. For this group, the researcher referred to the identified disaster management challenges in preparedness phase and extracted and categorized into one category those challenges that most likely had the same root cause. A sample of such category is provided in Table 6.1. As it can be seen in this table, the main cause of these challenges is lack of education, training or exercise to prepare people for disasters. Consequently, these challenges are grouped together and formed 'Education and Exercise' group.

Table 6.1

Disaster Management Challenges Related to Education and Exercise

Disaster Challenge	Reference
Ongoing training and drills for staff	Van Essen, 2012
Lack of expertise and training to provide the proper assistance relief	Pourhosseini, Ardalan, & Mehrolhassani, 2015
Lack of preparedness to harness volunteers	Al-Shaqsi et al., 2013
Necessary background to contribute, further training and additional disaster skills are required for the practitioner	Waeckerle, Lillibridge, Burkle, & Noji, 1994
Lack of expertise	Trim, 2004
Only a minority of the U.S. general population (30% – 40%) are disaster prepared	Eisenman et al., 2009
Failed to prepare emergency and health care providers adequately	Levett, 2015
Emergency training in disaster first-aid, rescue, and the use of specialized supplies	Zhong, Clark, Hou, Zang, & FitzGerald, 2014
Staff may lack the training to use their skills properly	Boyd et al., 2014
Lacking in supply chain expertise and technology	Baldini, Hess, Oliveri, Seuschek, & Braun, 2011
Lack of adequately trained personnel	Latifi, et. al., 2005
Lack critical knowledge and experience with disasters Lack of definitional uniformity across professions with respect to education, training, and best practices	Walsh et al., 2012
Development of specialized medical and rescue skills immediately available at the local level	Schultz, Koenig, & Noji, 1996

6.2.4 DEH Goal Identification

In general, the ultimate goal of DEH is to improve the quality of the delivered healthcare services while enhancing their efficiency and effectiveness before, during, and after disasters. Consequently, by referring to the identified groups' classification and their requirements for thorough analysis, those requirements with the same nature were categorised under specific categories to define DEH goals.

These goals are those that either system or its stakeholders try to achieve and are primarily set for specifying systems. The objective of each goal is to determine at least the first level of subsystems and the links among them making possible designing the subsystems on a secure basis. Therefore, each goal addresses specific requirements of the group and outlines the scope of the problem to be solved (Alexander & Zink, 2002). As an example, considering 'Training and Exercise' group, mentioned in the previous section, we can have the categories defined in Table 6.2.

Table 6. 2

Groups Related to Education and Exercise

	Disaster Challenges and Their Categories	**Goal Name**
1	Lack of expertise and training to provide the proper assistance relief (Pourhosseini, Ardalan, & Mehrolhassani, 2015) Failed to prepare emergency and health care providers adequately (Levett, 2015) Emergency training in disaster first-aid, rescue, and the use of specialized supplies (Zhong, Clark, Hou, Zang, & Fitzgerald, 2014) Development of specialized medical and rescue skills immediately available at the local level (Schultz, Koenig, & Noji, 1996)	**Specialised Medical Rescue**
2	Lack of definitional uniformity across professions with respect to education, training, and best practices (Walsh et al., 2012)	**Disaster Knowledge and Education**

	Lack of critical knowledge and experience with disasters (Walsh et al., 2012) Necessary background to contribute, further training and additional disaster skills are required for the practitioner (Waeckerle, Lillibridge, Burkle, & Noji, 1994) Only a minority of the U.S. general population (30%–40%) are disaster prepared (Eisenman et al., 2009)	
3	Lack of preparedness to harness volunteers (Al-Shaqsi et al., 2013) Lacking in supply chain expertise and technology (Baldini, Hess, Oliveri, Seuschek, & Braun, 2011) Lack of expertise (Trim, 2004)	**Expertise**
4	Ongoing training and drills for staff (Van Essen, 2012) Staff may lack the training to use their skills properly (Boyd et al., 2014) Lack of adequately trained personnel (Latifi, et. al, 2005)	**On-going Training and Drills**

6.2.5 Scenario Identification

The identified goals are organised collections of scenarios, and for each identified goal, several scenarios could be defined. Each scenario is covering very specific application by considering certain conditions or restrictions. They can also be used to demonstrate the system's actors and components interaction (Gottschalk & Uslar, 2015) in a single attempt. In this study, the generated scenarios were used to propose or identify the most suitable e-health technology for that particular scenario, based on the previously identified classifications, the task, its actor, its aim and task requirements.

6.3 DEH Goals and Scenarios

Based on the discussed classification, Figure 6.3 illustrates the overall way of generating goals and their related scenarios for the DEH research. Due to the high number of goals and scenarios that can be defined for the DEH, it concentrates only on groups, goals, and a few scenarios for each goal. However, it should be noted that there are a few identified groups or goals that may relate to multiple segments due to their nature and segment requirements. Logistics is a prime example in this regard since logistics planning is a key component of mitigation, as well as preparedness planning, and response.

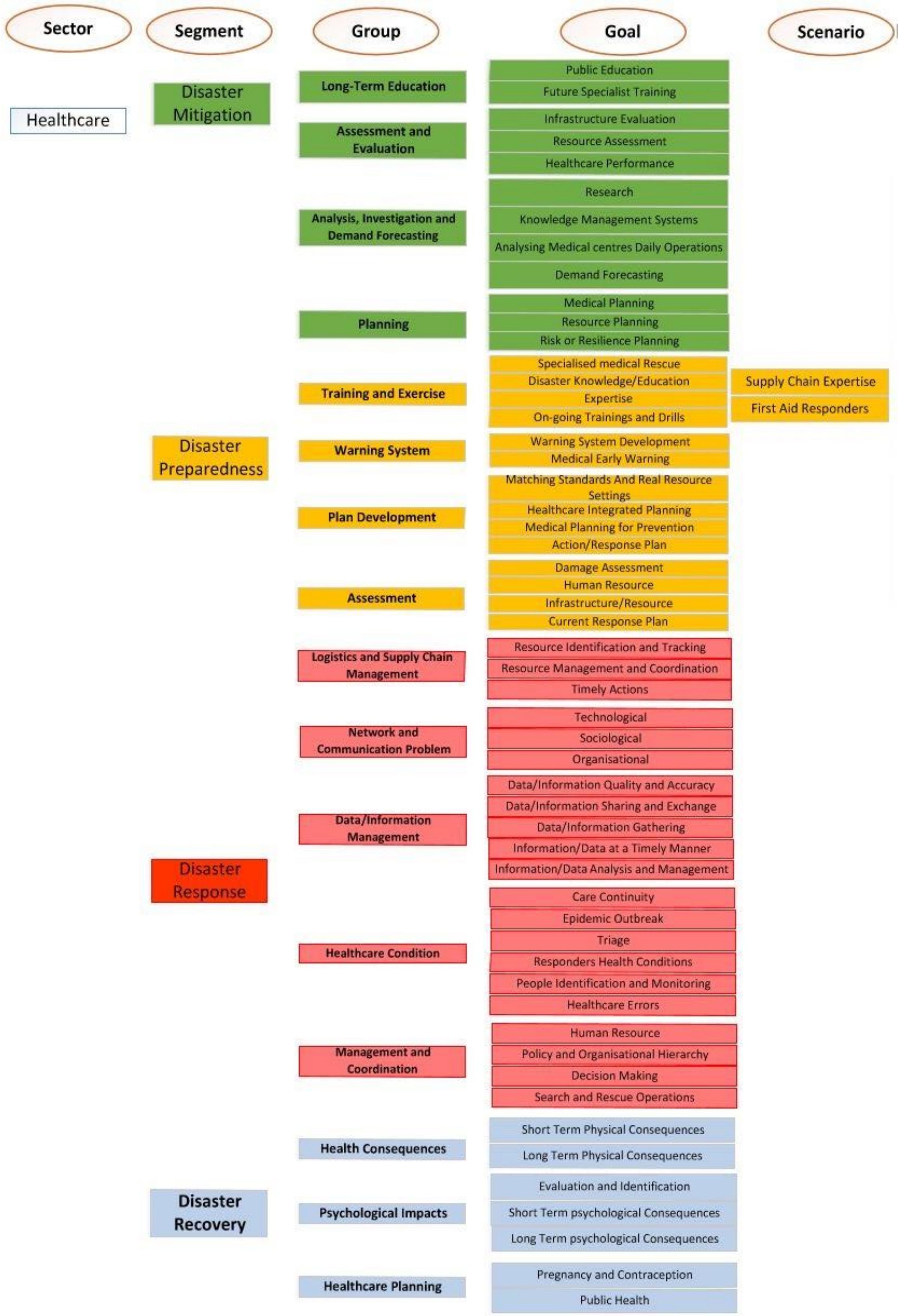

Figure 6.3 The overall functional scenario structure for DEH

6.3.1 Disaster Mitigation Goals

Based on the definition of the mitigation phase, the common aim for all groups in the disaster mitigation segment is to predict and, where possible, prevent disasters from happening or reduce their negative consequences especially for the vulnerable population and sectors as much as possible. The identified groups for the mitigation segment are presented in Figure 6.4.

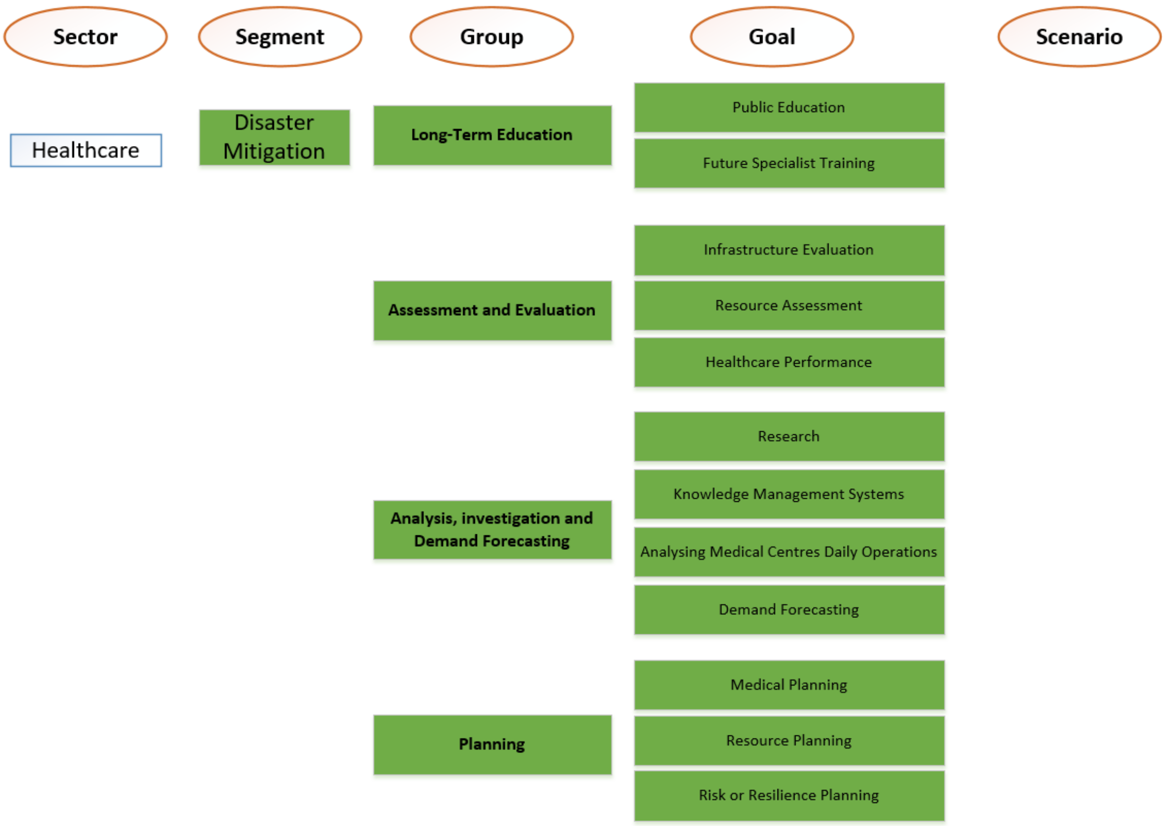

Figure 6.4 DEH Goals for disaster mitigation

The definition for each group is given below.

1- **Long-term education:** One of the mitigation tasks is to educate the public, train communities and prepare citizens for facing future disasters with the aim of improving the resilience of citizens. This group, therefore, covers all cases related to public education as a long-term plan, or long-term educational programmes. It involves training a new generation of disaster responders and practitioners to be able to face special challenges made by disasters during the response phase. It also includes training the forces to achieve competencies in using recent technologies in disaster management or medicine. Therefore, for this group, two goals can be identified:

- Public education
- Future specialists training

Some of the proposed scenarios for these goals are depicted in Table 6.3.

Table 6.3

Sample of Scenarios for Long-term Education Group

Goal	**Scenario**	**Proposed e-Health Technology**	**Reference**
Public Education	Developing public health messages as a fundamental step in disaster preparation	Social network	Reer Jr. & Ngo, 2012
		m-Health	Wukich, 2016
	Educating citizens through awareness presentations	Social network and m-health	Reer Jr. & Ngo, 2012; White et al., 2009
Future Specialists Training	International exchange of experience of disaster healthcare response, specialised medical and rescue skills, and the use of specialised supplies	Cloud computing	Chan et al., 2004
		Social network	White et al., 2009

2- **Assessment and evaluation:** Another important task of the mitigation phase is assessing the current systems, procedures, and infrastructure with the intention of identifying their deficiencies and limitations. The ultimate purpose of the activities in this group is to see whether the current systems are reliable enough or have the capacity and capability to deal with future disasters risks. These activities can minimise the risk of future disasters through proper assessment of the current situation. In addition, evaluating the damage based on the past vulnerability helps the authorities to establish suitable mitigation criteria. This category, therefore, refers to any plans or procedures for the purpose of assessing and evaluating the current situations, plans, or systems to identify any potential risks or deficiencies that may affect population health or lives in any future disaster. The identified goals for this group include:

- Infrastructure evaluation
- Resource assessment
- Healthcare performance

Table 6.4 illustrates a number of scenarios proposed for each goal.

Table 6.4

Sample of Scenarios for Assessment and Evaluation Group

Goal	Scenario	Proposed e-Health Technology	Reference
Infrastructure Evaluation	Evaluating the current disaster-resilient infrastructure	Simulation exercise in the form of a "smart card"	Sinha, 2012
	Evaluating the current healthcare infrastructure	Cloud computing and m-health	Hoang & Chen, 2010
	Accessing a variety of national and local medical informatics	Cloud computing and m-health	Chan et al., 2004
Resource Assessment	Accessing a variety of national and local medical resources	Cloud Computing m-health	Chan et al., 2004

	Assessing the current situation and plans of humanitarian aid programme	Decision support systems	Cioca & Cioca, 2010
		m-Health	Kyriacou et al., 2009
Healthcare Performance	Assessing the current healthcare situation by considering essential preparedness in relation to disaster vulnerability analysis	Simulation	Franc-Law, Bullard, & Della Corte, 2008
		Decision support systems	Cioca & Cioca, 2010
	Evaluating health performance during drills	Virtual reality	Liang & Xue, 2004

3- **Analysis, investigation and demand forecasting:** This group includes tasks for analysing the current situation of different sectors of the society with the aim of identifying their vulnerability to future disasters. Then, based on the current information and referring to the past data, it tries to predict and estimate future needs to be prepared for any potential disasters. Therefore, an important goal of this group could be identifying all the undertaken studies that investigated the current situation and comparing the situation with the past disasters' trend and results affecting the area to determine the hidden risks. Another goal can be developing information system for knowledge management, analysing the daily operations of the healthcare centres, and preparing a plan to anticipate healthcare demands of population when they face a disaster.

The following goals can be defined for this group:

- Research
- Knowledge management
- Analysing medical centres daily operations
- Demand forecasting

Table 6.5 presents these goals and the related scenarios.

Table 6.5

Sample of Scenarios for Analysis, Investigation and Demand Forecasting Group

Goal	Scenario	Proposed e-Health Technology	Reference
Research	Getting better preparation for future disasters through research capacity and expertise to carry out research on disasters and their health consequences	Decision support system	Black et al., 2011
		Information systems	Rüter, 2006
	Researching the past disasters and health consequences and probability of their reoccurrence in future	Big data	Kuehn, 2015
Knowledge Management System	Building knowledge management systems to improve disaster response performance constantly	Space-enabled knowledge products (satellite)	Srivastava, 2009
	Developing an information system to integrate local, regional, and federal resources into the disaster plan	RFID	Ajami & Rajabzadeh, 2013; Bouet & Pujolle, 2010; Kuo et al., 2007
		Geographical information system and RFID	Y. J. Chen, 2012
Analysing Medical Centres	Analysing daily operations in emergency department	IoT and Information System	Powers & Phipps, 2006
		Simulation (discrete-event simulation)	Hirshberg et al., 2001

Daily Operations	Analysing out-of-hospital emergency medical services	Cloud computing and m-health	Chan et al., 2004
Demand Forecasting	Forecasting needs of the affected population	Social Network and big data	Kuehn, 2015
	Identifying vulnerable population	m-Health	Callaway et al., 2012
		Geographical information system	Curtis, Curtis, & Upperman, 2012

4- **Planning:** This is another important task in disaster mitigation since it could lead to reducing citizen vulnerability when facing disasters in the future. All activities should be organised with the aim of developing realistic solutions for disaster preparedness and response at different local, national and international levels. The following goals are determined for this group, and Table 6.4 shows them together with their related scenarios in Table 6.6.

- Medical planning
- Resource planning
- Risk or resilience planning

Table 6.6

Sample of Scenarios for Planning Group

Goal	Scenario	Proposed e-Health Technology	Reference
Medical Planning	Medical planning on supplies and equipment at local level	Cloud computing and decision support system	AbuKhousa et al., 2012; Thompson et al., 2006
	Planning for specialised medical and rescue personnel	Big data and cloud computing	Kaji & Waeckerle, 2003

	Integrating every hospital into the disaster plans, along with other critical components of the response effort	Big data and cloud computing	Kaji & Waeckerle, 2003
Resource Planning	Planning at a local level and updating the resource planning (*resource re-allocation*)	Information system and RFID	Baldini et al., 2009
		m-Health and communication technologies	Meissner et al., 2002
	Advanced planning for volunteers in order to harness their full potential	Decision support system	Popovich, Henderson, & Stinn, 2002
		Information system and database	Schultz & Stratton, 2007; Troy, Carson, Vanderbeek, & Hutton, 2008
Risk or Resilience Planning	Building disaster-resilient communities through social capital formation	Social network	Dufty, 2012
	Planning evacuation routes and shelters by considering risk estimation and mapping	Geographical information system	Goodchild, 2006
		Decision support system	Cioca & Cioca, 2010

6.3.2 Disaster Preparedness Goals

The overall aim of the groups under this segment is to be prepared for disasters and reduce their impact and be able to respond effectively to different disaster types. Based on the extracted challenges of different disasters in the preparedness phase, effective preparedness can involve the following groups (Figure 6.5):

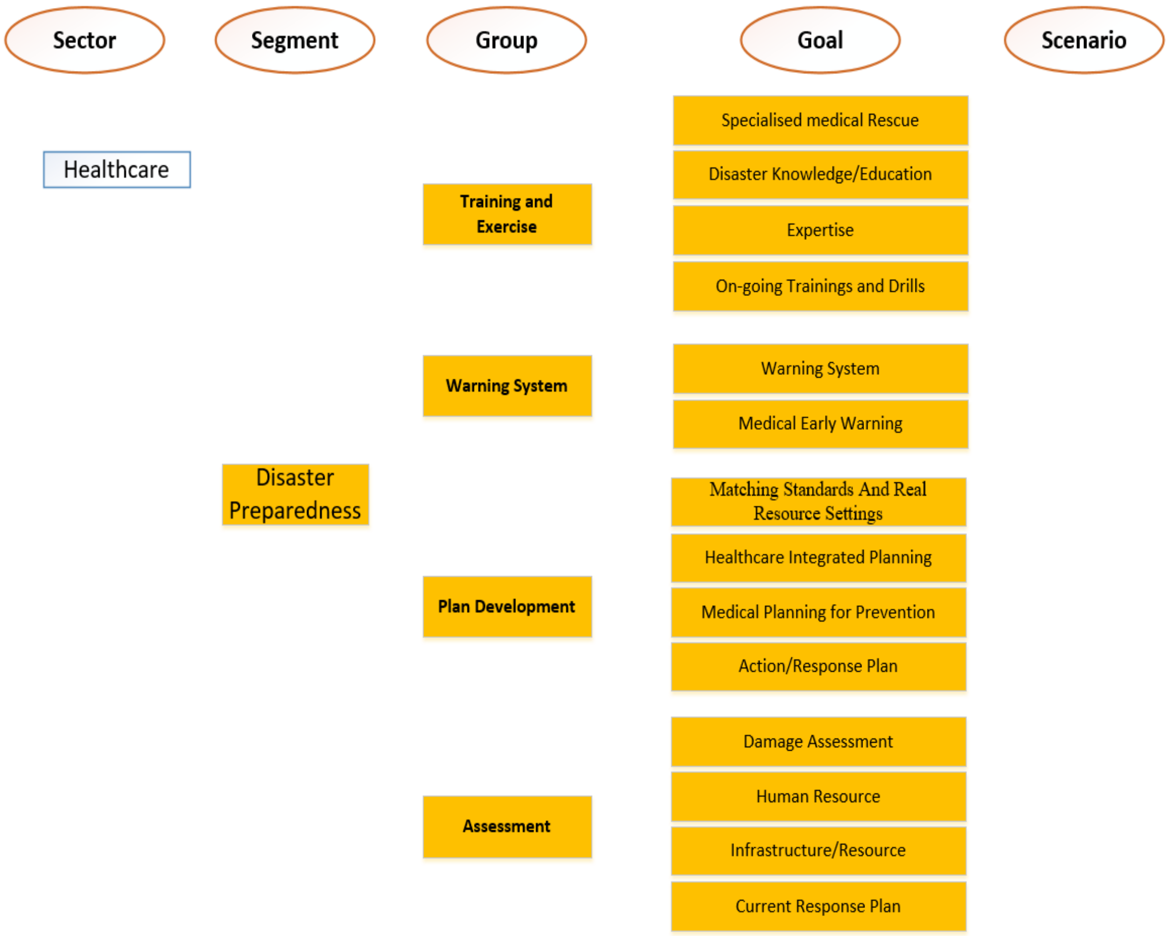

Figure 6.5 DEH goals for disaster preparedness

1- **Training and exercise:** This group consists of the educational activities with the purpose of training specialists or training individuals at different levels to be prepared for disasters and, consequently, reduce a disaster's impact. The overall aim of the goals under this group is to improve personnel skills and competencies; therefore, they will be able to work in stressful situations, and use technologies and the related equipment more effectively to improve providing proper assistance in time of disasters. Moreover, since DEH has several parties from various fields, ongoing training and drill is a way to establish integration among them. This group's goals can be divided into the following:

   - Specialised medical rescue
   - Disaster knowledge/education
   - Expertise
   - Ongoing trainings and drills

The proposed scenarios for this group of goals are illustrated in Table 6.7.

Table 6.7

Sample of scenarios for Training and Exercise Group

Goal	Scenario	Proposed e-Health Technology	Reference
Specialised Medical Rescue	Developing specialised medical and rescue skills and competencies	Telehealth	Ajami & Lamoochi, 2014
	Providing emergency room personnel with competencies to deal with major traumas	Telehealth	Latifi et al., 2005
Disaster Knowledge/ Education	Simulating context-aware exercises and training programmes to increase personnel disaster knowledge	Positioning technology and simulation; telehealth; m-Health; social network	Althwab & Norris, 2013; Maglogiannis & Hadjiefthymiades, 2007
	Educating critical knowledge to gain experience needed to effectively perform under stressful disaster conditions	Decision support system, telehealth	Blaya et al., 2010
Expertise	Getting familiar with roles and tasks, such as supply chain related activities, required to be done in disaster situation	Cloud computing; management information system	Chan et al., 2004; Lin et al., 2012

	Special training for first aid responders	Virtual reality and simulation system	Zhu, Zhao, Wang, & Zhang, 2010
Ongoing Training and Drills	Ongoing training and drills for staff at local hospital	Simulation (tablet exercises)	Bradt et al., 2003
	Mock disaster drills for regional hospital staff	Computer simulations and tablet exercises (Games)	Hirshberg et al., 2001

2- **Warning system:** this group includes tasks used to develop or prepare a warning system to be used prior to disasters with the aim of providing timely and suitable alerts or warnings for citizens to protect themselves. The following goals are determined for this group; Table 6.8 presents them with their related scenarios.

- Warning system development
- Early medical warning

Table 6.8

Sample of Scenarios for Warning System Group

Goal	Scenario	Proposed e-Health Technology	Reference
Warning System	Developing an emergency alert system for disaster warning (flood and tsunami)	Social network	White et al., 2009
		Space-enabled knowledge products (satellite)	Srivastava, 2009
	Warning the general public	Social network	Petersen et al., 2015
	Developing warning system for epidemiology disasters	Social network	Popovich et al., 2002; White et al., 2009

		Information system and decision support system	Popovich et al., 2002
Early Medical Warning	Transferring and sharing of clinical information to identify epidemic outbreaks	Big data and cloud computing	Chan et al., 2004
	Disseminating pre-disaster warnings	m-Health	Fajardo & Oppus, 2010
	Monitoring over the counter drug consumption to detect any potential epidemics	Big data and cloud computing	Chan et al., 2004
	Visualising the simulated evolution of the epidemic	Geographical information system	Chronaki et al., 2007

3- **Plan development:** The activities of this group encompass goals that try to examine the availability and practicability of response planning at the time of disasters. They are for ensuring that the preparedness plans are realistic and the current resources match with the preparedness plan standards. However, the plans should have enough flexibility to cope with unpredicted situations during the disaster response. This group's goals are:

- Matching standards and real resource settings
- Healthcare integrated planning
- Medical planning for prevention
- Action/response plan

These goals and the generated scenarios are displayed in Table 6.9.

Table 6.9

Sample of Scenarios for Plan Development Group

Goal	Scenario	Proposed e-Health Technology	Reference
Matching Standards and Real Resource Settings	Matching inventory level of drugs in pharmaceutical companies with population	Internet of things (RFID)	O'Connor, 2010
	Identifying chronic care and acute illnesses and injuries medications and matching the level of their inventory with population size	Big data, cloud computing and decision support system	Archer et al., 2011; Chan et al., 2004
		RFID and decision support system	Blaya et al., 2010; Wamba & Ngai, 2011
Healthcare Integrated Planning	Tracking and sharing information on regional ED availability and resources and integrated planning of hospital and community based healthcare facilities	Big data and cloud computing	Chan et al., 2004
		RFID	Ajami & Rajabzadeh, 2013; Bouet & Pujolle, 2010
	Integrating healthcare centres into existing electronic medical record systems	Electronic healthcare records	Callaway et al., 2012

Medical Planning for Prevention	Specifying cultural, ethnic, religious, and linguistic issues and having an appropriate plan accordingly	m-Health	Aggarwal, 2012
	Transferring and sharing of clinical information to identify any healthcare issues and providing a plan in response to that	Telehealth	Garshnek & Burkle, 1999
Action/Response Plan	Matching patient loads and needs with available hospital resources	Internet of things (RFID)	Shamdani & Nicolai, 2012
	Developing plans for evacuation in local healthcare centres	Geographic information systems	Bradt et al., 2003

4- **Assessment:** This group covers tasks and activities used to measure the current state of the response plan and strategies, as well as the competence of the involved parties in disaster management and medicine. This group's goals are to identify the strengths and weaknesses of the current system and response plan. In addition, there is a need to develop guidelines and assessment procedures for healthcare centres to make sure that enough resources are available prior to, and at the time of the disaster. The following goals can be defined for this group. See Table 6.10 for the goals and their scenarios.

- Damage assessment
- Human resource
- Infrastructure/Resource
- Current response plan

Table 6.10

Sample of Scenarios for Assessment Group

Goal	Scenario	Proposed e-Health Technology	Reference
Damage Assessment	Assessing disaster impact for the disaster prone areas	Remote sensing, GIS and satellite communications	Srivastava, 2009
	Financial assessment of future disaster losses	Databases and decision support system	Thompson et al., 2006
Human Resource	Planning on trained personnel with necessary background to contribute in disaster situation	Decision support system	Blaya et al., 2010
	Planning and identifying assistance relief	Information system (database) and decision making tools	Turner, Reeder, & Wallace, 2013
	Identifying available and future needed competences (Capabilities-based planning)	Decision support system	Thompson et al., 2006
Infrastructure /Resource	National plans for accessing electronic health records	Information system (database)	Drabek, 2012
		Decision support system	Thompson et al., 2006
Current Response Plan	Assessing the current response plan of local hospitals and disaster response teams	Simulations and decision support system	T. S. Meyer et al., 2012

	Assessing the applicability of response plan for resource acquisition and allocation	Decision support system	Thompson et al., 2006
	Assessing the community response plan in terms of the ability to manage the upcoming risks	Social network	Dufty, 2012

6.3.3 Disaster Response Goals

Like the other two previous phases, almost all the disaster response challenges fall into the following groups (Figure 6.6):

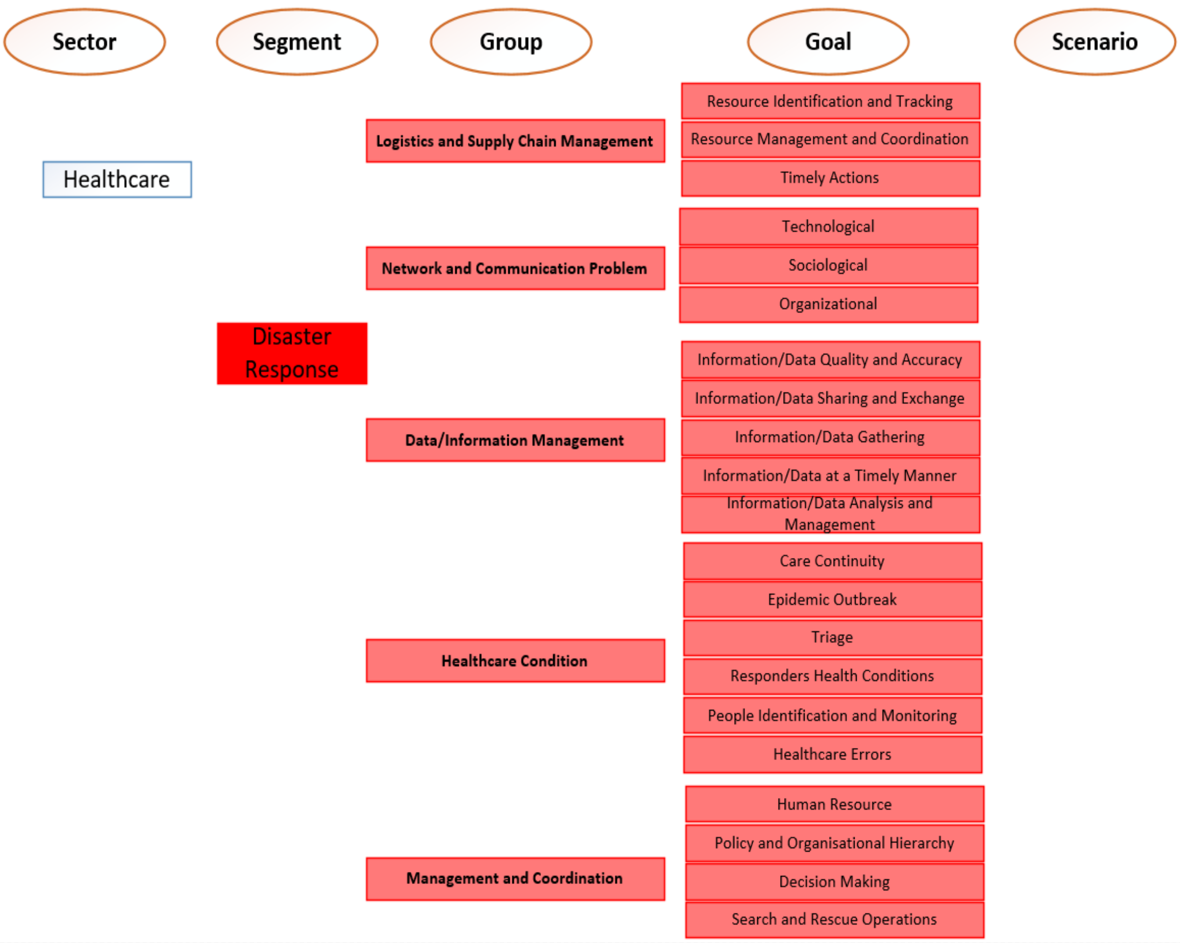

Figure 6.6 DEH Goals for disaster response

1- **Logistics and supply chain management:** This category refers to challenges of logistics, supply chain and its management. It includes those cases that have a direct connection with providing, distributing, identifying, and tracking healthcare resources and equipment during the response time. The following goals can be determined for this group:

- Resource identification and tracking
- Resource management and coordination
- Timely actions

To achieve these goals, the following scenarios are generated (see Table 6.11).

Table 6.11

Sample of Scenarios for Logistics and Supply Chain Management Group

Goal	Scenario	Proposed e-Health Technology	Reference
Resource Identification and Tracking	Keep track of the origin of the goods along each step of their delivery to the affected area	Internet of things (RFID) and m-health	Fajardo & Oppus, 2010; Shamdani & Nicolai, 2012
	Identifying, mobilising, dispatching, and tracking the resources required to support incident management activities	Internet of things (RFID)	Shamdani & Nicolai, 2012
Resource Management and Coordination	Managing and coordinating medical supplies and equipment at the disaster site	Internet of things (RFID)	Ozguven & Ozbay, 2013
		m-Health	Callaway et al., 2012

	Identifying idle resources for better management and coordinating disaster response activities	m-Health and communication technologies	Meissner et al., 2002
Timely Actions	Identifying the nearest route and stockpile at disaster affected areas	Geographical information system, decision support system, and telecommunication network	Gubara, Amasha, Ahmed, & El Ghazali, 2014
		RFID/Bluetooth	Gandhi, Ganz, & Mullett, 2010
	Identifying and bringing needed supplies to disaster areas and the affected people in the shortest possible time	m-Health and wireless mobile technology	Fajardo & Oppus, 2010
		RFID, geographical information system, smartphone, and decision support system	Kung, Wu, Chen, & Lan, 2008
	Electronically documenting medication delivery required in medical chain	Internet of things and m-health	Rüter, 2006
	Medical timely decision making	Electronic healthcare record	S. H. Brown et al., 2007

2- **Network and communication:** Communication plays a vital role in the disaster response. All the tasks related to the networks and communication among responders or organisations are categorised under this group. The classification of the goals for this group is performed based on the research by Manoj and Baker (2007), and they are as follows:

- Technological
- Sociological
- Organisational

Table 6.12 depicts these goals together with their related scenarios.

Table 6.12

Sample of Scenarios for Network and Communication Group

Goal	Scenario	Proposed e-Health Technology	Reference
Technological	Helping systems to automatically prioritise data traffic to ensure critical communications taking precedence	Internet of things	Johnson 2014
	Preventing time-consuming (re)establishment of communication networks which needs manual installation of new hardware	Internet of things	Petersen et al., 2015
	During those first critical minutes and hours right after a disaster happens when communication systems are needed most	Internet of things	Johnson, 2014
Sociological	Reducing the mobile phone networks overload problem	Social network	Underwood, 2010
	Rapidly changing the condition of disaster affected areas that necessitate having periodic information updates	Social network	Petersen et al., 2015; Underwood, 2010

Organisational	Inefficient coordination among first-responders due to lack of communication	Internet of things	Johnson 2014
	Rapidly deploying temporary organisational network	Wireless networks and satellite	Chan et al., 2004; Chronaki et al., 2008

3- **Data/information management:** All activities dealing with data or information management with different and challenging roots, other than communication, belong to this group. The related goals are:

- Information/data accuracy and quality
- Information/data sharing and exchange
- Information/data gathering
- Information/data at a timely manner
- Information/data analysis and management

These goals and their scenarios are provided in Table 6.13.

Table 6.13

Sample of Scenarios for Data/Information Management

Goal	Scenario	Proposed e-Health Technology	Reference
Information/Data Accuracy and Quality	Providing accurate information on the number of casualties and the required resources at the disaster site	Internet of things (RFID) and m-health	Callaway et al., 2012
	Providing accurate information on the available medical resources at each	Internet of things (RFID) and m-health	Callaway et al., 2012

	healthcare centre and disaster site		
Information/Data Sharing and Exchange	Exchanging information among first responders and government authorities to take appropriate actions	Mobile telecommunications, the Internet, Internet of things and social networks	Jaeger et al., 2007; Petersen et al., 2015;
	Information sharing among healthcare centres on the number of available empty beds to admit disaster casualties	The Internet	Troy et al., 2008
		RFID	Lahtela, 2009
		Cloud computing	AbuKhousa et al., 2012
Information/data gathering/integration	Automatically collecting (near) real-time information of patient needs, rescue personnel, and available resources	Internet of things	Johnson 2014
	Being able to collect information without Internet connectivity (Storing data until connectivity is available)	Internet of things and m-health	R. V. N. Oden et al., 2012
	Integrating information from disparate sources	Decision support system	Bradt et al., 2003
Information/Data at a Timely Manner	Providing crucial real-time data about disaster areas necessary to help decision-makers to better	Internet of things	Petersen et al., 2015

	understand the impact of a disaster and to react more appropriately		
	Preparing immediate information on ambulance availability and location	RFID	Chatfield et al., 2010
		Global positioning system	Chan et al., 2004
Information/Data Analysis and Management	Analysing the number of patients inbound with the number and type of hospital beds available	Decision support system	Rüter, 2006
	Making rapid, accurate decisions under conditions of uncertainty based on the information from disaster sites	RFID, hospital information system, electronic health records and decision support systems	Ajami & Rajabzadeh, 2013
		RFID	M. Chen et al., 2010

4- **Healthcare condition:** This category addresses the cases which include all challenges related to the health of disaster victims and responders as well as people with before disaster chronic or non-chronic diseases who require their vital and non-vital signs to be monitored constantly, and to react quickly in case of any emergencies or disasters. It can start with identifying and transferring the person to the healthcare centre and continues through to the last stage of discharge. This group's goals are as below

- Care continuity
- Epidemic outbreak

- Triage
- Responders' health conditions
- People identification and monitoring
- Healthcare errors

Some of the proposed scenarios can be found in Table 6.14.

Table 6.14

Sample of Scenarios for Healthcare Condition Group

Goal	Scenario	Proposed e-Health Technology	Reference
Care Continuity	Ensuring immediate availability of basic medical information to health responders	Electronic healthcare record	James & Walsh, 2011
	Avoiding disruption of the care for people with cancer	Electronic healthcare record	James & Walsh, 2011
	Rapid health assessment	Electronic healthcare record and m-health	Chronaki et al., 2008
Epidemic Outbreak	Exchanging information about health hazard	m-Health	Fajardo & Oppus, 2010
	Early identifying of epidemiological crisis in a camp of displaced refugees	Geographical information system and RFID	Y. J. Chen, 2012
	Monitoring critical resources and visualising the simulated evolution of the epidemic	Geographical information system	Chronaki et al., 2007

Triage	Remote triaging the injured patients before arrival at hospital	Telehealth	Vo et al., 2010
	Eliminating over triage of disasters casualties	m-Health and RFID	Jokela et al., 2008; Jorma et al., 2013
	Providing care and consultation from remotely located physicians	Decision support system and telehealth	Blaya et al., 2010
		Telehealth	Sutjiredjeki et al., 2009
Responders Health Conditions	Monitoring disaster responders' health conditions	m-Health and Internet of things	Agrawal & Das, 2011; Callaway et al., 2012
	Advising responders in the disaster sites on potential hazards based on the received information from disaster sites	Web-based network dashboard	Chan et al., 2004
		Internet of things	Zelenkauskaite, Bessis, Sotiriadis, & Asimakopoulou, 2012
People Identification and Monitoring	Identifying and tracking disasters victims	RFID	Reyes et al., 2012
	Tele-monitoring patients via wearable sensors	Internet of things	Aliyu et al., 2013
Healthcare Errors	Avoiding error and inaccuracy as well as destruction	RFID	Reyes et al., 2012; S. W. Wang et al., 2006

	Accessing immediate information on ambulance availability and location	RFID	Chatfield et al., 2010; Y. J. Chen, 2012
	Assessing unfamiliar and ill evacuees without knowing their healthcare background	Electronic healthcare record	James & Walsh, 2011

5- **Management and coordination:** All the related cases of management and coordination aspects of activities either on organisational bases or between/among organisations and the responding teams are categorised in this group. This group includes the following goals:

- Human resources
- Policy and organisational hierarchy
- Decision making
- Search and rescue operations

The scenarios for these goals are available in Table 6.15.

Table 6.15

Sample of Scenarios for Management and Coordination Group

Goal	**Scenario**	**Proposed e-Health Technology**	**Reference**
Human Resources	Acquiring real-time data about rescue personnel needs	Internet of things and m-health	Chan et al., 2004
	Solving coordination problem of rescue and relief team	m-Health	Fajardo & Oppus, 2010; R. V. M. Oden, L. G.; Ross, K. G.; Lopez, C. E., 2012

		RFID and web-based geographic information systems	Badpa, Yavar, Shakiba, & Singh, 2013
		Satellite technology	International Telecommunication Union, 2008; Xiong et al., 2012
Policy and Organisational Hierarchy	Providing interoperability at organisational and procedural levels among the partners	Cloud computing	International Telecommunication Union, 2008
		Satellite communication	Chronaki et al., 2007
	Lacking a common vocabulary among response organisations and between citizens and organisations	Telehealth	International Telecommunication Union, 2008
	Having inter-organisational communication and collaboration	Social network	Hossain & Kuti, 2010
	Provide task forces from several independent organisations	Communication and information system; decision support system	Meissner et al., 2002
Decision Making	Providing optimum route along different geographical locations	m-Health	Fajardo & Oppus, 2010
	Making rapid and accurate decisions	Decision support system	Bradt et al., 2003

	under conditions of uncertainty		
Search and Rescue Operations	Helping rescue teams identify relevant areas	Social network	Petersen et al., 2015
	Communicating with other rescue teams and government officials	satellite-WiFi network	Chronaki et al., 2008
	Evacuating patients to less congested medical facilities	Decision support system	Adini, Aharonson-Daniel, & Israeli, 2015

6.3.4 Disaster Recovery Goals

The aim of disaster recovery is to provide support and services and to minimise the time needed for affected people to return to their normal or near normal life conditions. Consequently, recovery activities can be either short-term starting immediately after disaster response and involving the reestablishment of basic services (Ahmed & Sugianto, 2009), or long-term activities that can sometimes take up to several years.

The identified goals under this group are shown in Figure 6.7.

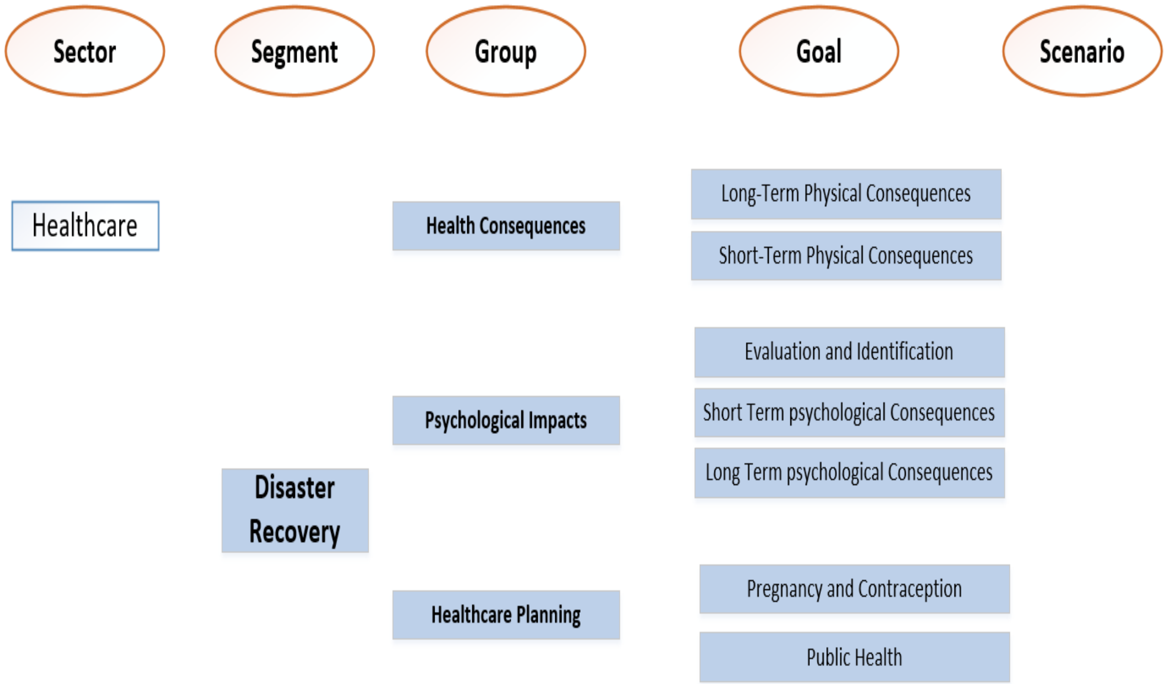

Figure 6.7 DEH goals for disaster recovery

1- **Health consequences:** One of the most common impacts of disasters on affected populations is healthcare problems that can be primary or chronic. Therefore, this group addresses one aspect of disaster impacts on the affected population's physical well-being and can be divided into two goals:
   - Long-term physical consequences
   - Short-term physical consequences

The proposed scenarios for these goals are shown in Table 6.16.

Table 6.16

Sample of Scenarios for Health Consequences Group

Goal	Scenario	Proposed e-Health Technology	Reference
Long-term Physical Consequences	Monitoring patient health and optimising care management	Internet of things	Bouet & Pujolle, 2010
	Groups for mobilising healthcare support when and where needed	m-Health	Sutjiredjeki et al., 2009
Short-term Physical Consequences	Alleviating time and space barriers between healthcare providers and their patients	m-Health	Sutjiredjeki et al., 2009
		Telehealth	Vo et al., 2010
	Recording and reporting patient vital signs, tele-consultation, limited tele-diagnostic, tele-education and patient monitoring	m-Health	Sutjiredjeki et al., 2009
		Internet of things	Aliyu et al., 2013

2- **Psychological impacts:** Due to the vast psychological impacts that citizens experience after almost all disaster types, one of the DEH goals is dedicated to this matter. All cases that deal with the mental health consequences of disasters, needs of affected population and healing procedures are categorised under this group. The scenarios for the below goals are set out in Table 6.17.

- Evaluation and identification
- Short-term psychological impact
- Long-term psychological impact

Table 6.17

Sample of Scenarios for Psychological Impacts Group

Goal	Scenario	Proposed e-Health Technology	Reference
Evaluation and Identification	Providing mood evaluation service to the disaster-affected citizen	m-Health	Aggarwal, 2012
	Measuring mental stress and sleep quality	Internet of things and body area network (BAN)	Kuroda & Tochikubo, 2012
Short-term Psychological Impact	Supporting mentally-stress patients	Electronic medical record	van der Velden, Yzermans, Kleber, & Gersons, 2007
		Web-base applications	Price, Gros, McCauley, Gros, & Ruggiero, 2012
		Electronic healthcare record and telehealth	Mack, Brantley, & Bell, 2007
	Providing mental health consultation for the affected population	Web-based programmes	Price et al., 2012
Long-term Psychological Impact	Providing follow-up psychological care	Electronic medical record	van der Velden et al., 2007
		Electronic healthcare record and telehealth	Mack et al., 2007
		Web-base	Price et al., 2012
	Deliver psychotherapy	m-Health	Aggarwal, 2012

3- **Healthcare planning:** All the long term activities for planning tasks of delivering healthcare services and taking care of citizen health after disasters and in the recovery phase are classified in this group with the following goals:

- Pregnancy and contraception
- Public Health

Based on the above goals, the scenarios presented in Table 6.18 are proposed.

Table 6.18

Sample of Scenarios for Healthcare Planning Group

Goal	Scenario	Proposed e-Health Technology	Reference
Maternity	Providing support for transferring the necessary information on healthcare for pregnant women	Wireless LAN	Sutjiredjeki et al., 2009
	Promoting healthy behaviour related to pregnancy and contraception	m-Health	Eisenman et al., 2009
Public Health	Providing information for health situation awareness	Ad hoc surveillance system	Mirhaji et al., 2006
	Observing public health and healthcare planning	Electronic healthcare record	S. H. Brown et al., 2007
	Making post-disaster announcements	m-Health	Fajardo & Oppus, 2010
		Internet of things	Bouet & Pujolle, 2010

6.4 Summary

In this chapter, the systematic way of generating functional scenarios (goals) and their related scenarios for this study was addressed. To create meaningful disaster scenarios within the DEH scope, the top-down hierarchy consisting of '**Sector'**, '**Segment'**, '**Group**', '**Goal'**, and '**Scenario'** was implemented and followed. The selected sector was healthcare divided into 'Mitigation', 'Preparedness', 'Response', and 'Recovery' segments. Then, based on the extracted disaster challenges for each segment, different groups were created each of which covered the challenges with the same root-cause. Finally, based on each group's specifications and requirements, different functional scenarios were created followed by proposing scenarios for that particular goals.

CHAPTER 7

DELPHI METHOD AND FINDINGS

7.1 Introduction

This chapter outlines and presents the activities to conduct phase 3 of the study (Figure 7.1). The objectives of this phase were furthering data gathering and validating the findings of the previous phases. For this purpose, the Delphi method was employed to gather experts' feedback and ideas to:

- evaluate the results of the scoping study (phase 1)
- assess the completeness of the proposed DEH scope
- confirm the proposed scope for DEH
- assess, through the generated scenarios (phase 2), the RFID applications within disaster management cycle (DMC)

In this phase, a group of experts in the field were consulted to validate the findings. The outcome of this phase was the refined and finalised scope for the DEH and the experts' ideas regarding utilising RFID technology for a specific set of scenarios (applications) within the DMC and the DEH scope. The latter outcome can be used as the list of identified and accepted applications of RFID for different disaster phases according to the experts' knowledge.

In section 7.2, the background of the Delphi method implementation and the required considerations and employed criteria are discussed. Section 7.3 provides information regarding the procedure for conducting the Delphi and its related details, such as participant selection and data collection. Afterwards, in section 7.4, the recruited data analysis model for this Delphi in both rounds is explained. The results of the Delphi are discussed in sections 7.5 and 7.6.

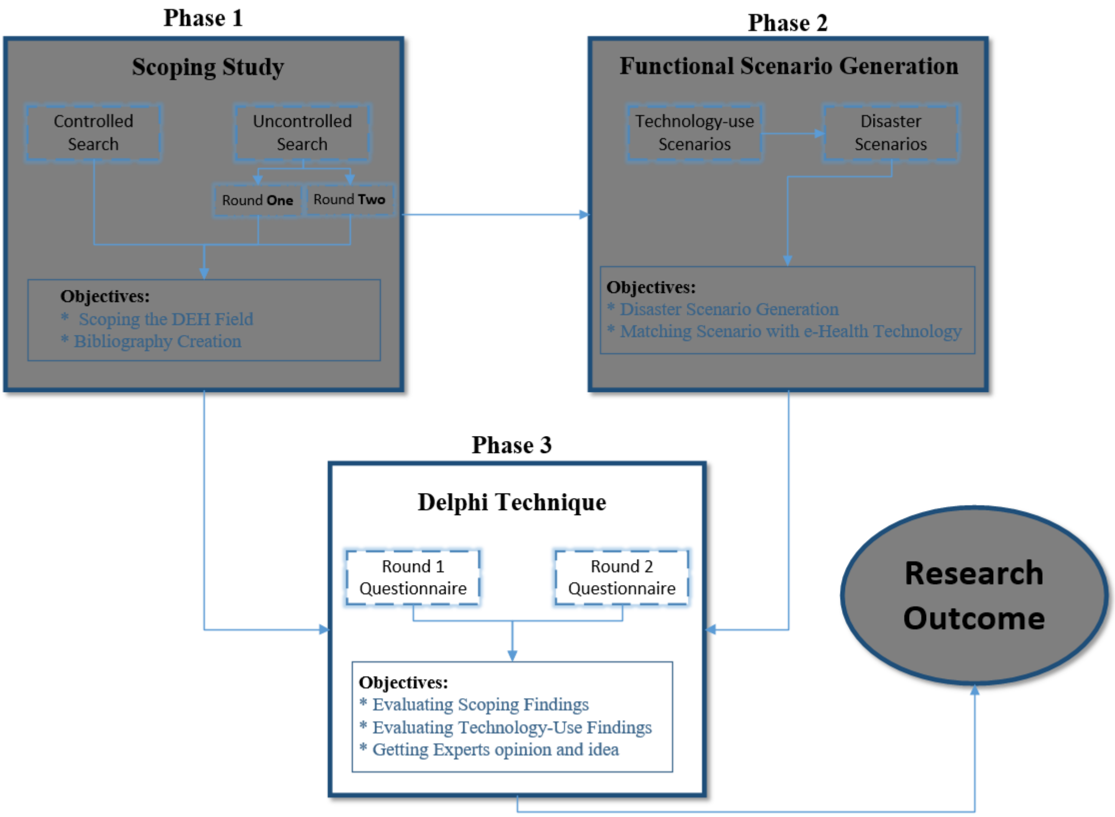

Figure 7. 1 Phase 3 of the overall research activities framework

7.2 Delphi Method

In phase 1 (scoping study) an initial scope of DEH was identified and proposed (see chapter 5). Then, in phase 2 (functional scenario generation), based on the DEH scope, the researcher defined and proposed a number of goals, applications and scenarios within DMC (see chapter 6). To assess these findings and finalise the proposed scope, a validation procedure was required that forms the sixth stage in the DEH scoping study framework. Therefore, in phase 3 (Delphi method), the goals were to evaluate the proposed scope for DEH and to examine the role of RFID within DEH for the proposed applications, as discussed in chapter 5.

For this purpose, the Delphi method was used to get feedback and confirmation from the experts in the fields. This validation procedure was resulted in obtaining a more trusted outcome due to the improved individual judgments, and reducing researcher's bias. According to Giannarou and Zervas (2014) and Hallowell and Gambatese (2010), Delphi is a proper choice when:

- there is a paucity of knowledge
- there is lack of agreement on a subject
- experimental methods are not practical

Since Delphi is a systematic, interactive and iterative method, it is used to establish a group communication to gain the most reliable consensus among the panel of experts regarding a complex problem (Okoli & Pawlowski, 2004; Wamba & Ngai, 2011).

Häder and Häder (2002 cited in Nowack et al., 2011) states that Delphi can be used for idea generation and judgment. For the former, the panel of experts identifies a broad range of possible views on a specific topic; while for the latter one, the panel has a moderating function. In the same context, Okoli and Pawlowski (2004) introduced the following three functions: brainstorming, ranking, and narrowing down. Through these functions, Delphi provides trustworthy and creative examination of ideas (Paré et al., 2013) in addition to evaluating the research results for the field of investigation.

In this study, the panel evaluated the results, brainstormed to complete the DEH scope, and finally identified possible views on the DEH and ranked its technologies. The objectives of the Delphi method in this research are demonstrated in Table 7.1.

Table 7.1

Delphi Method Objectives in the DEH Research

Research Questions	**Delphi Objective**
RQ 1: What is the scope of DEH?	- Evaluating the result of the (phase1) scoping study - Evaluating proposed scope for DEH - Finalising the DEH scope, based on the experts' comments and recommendations - Identifying the most influential technologies within the DEH scope
RQ 3: What is the role of RFID technology in DMC and within the DEH scope?	- Assessing the role of RFID technology for a number of proposed disaster scenarios generated according to the functional scenario generation method in phase 2 of the research.

RQ 4: Among the identified roles for RFID, in the view of the experts, which of them are the most desirable and applicable?	- Assessing the application of RFID technology for a number of proposed disaster scenarios generated according to the functional scenario generation method in phase 2 of the research.

As the number of rounds in Delphi depends on the group size, this research was conducted in two rounds due to the time constraints and small panel size. The minimum required rounds is two, and most likely two to three rounds are enough for most research studies, especially when the panel size is small (Delbecq, Van de Ven, & Gustafson, 1975; Penelope, 2003; Thangaratinam & Redman, 2005). Figure 7.2 delineates its general structure of deployment together with the objectives for each round.

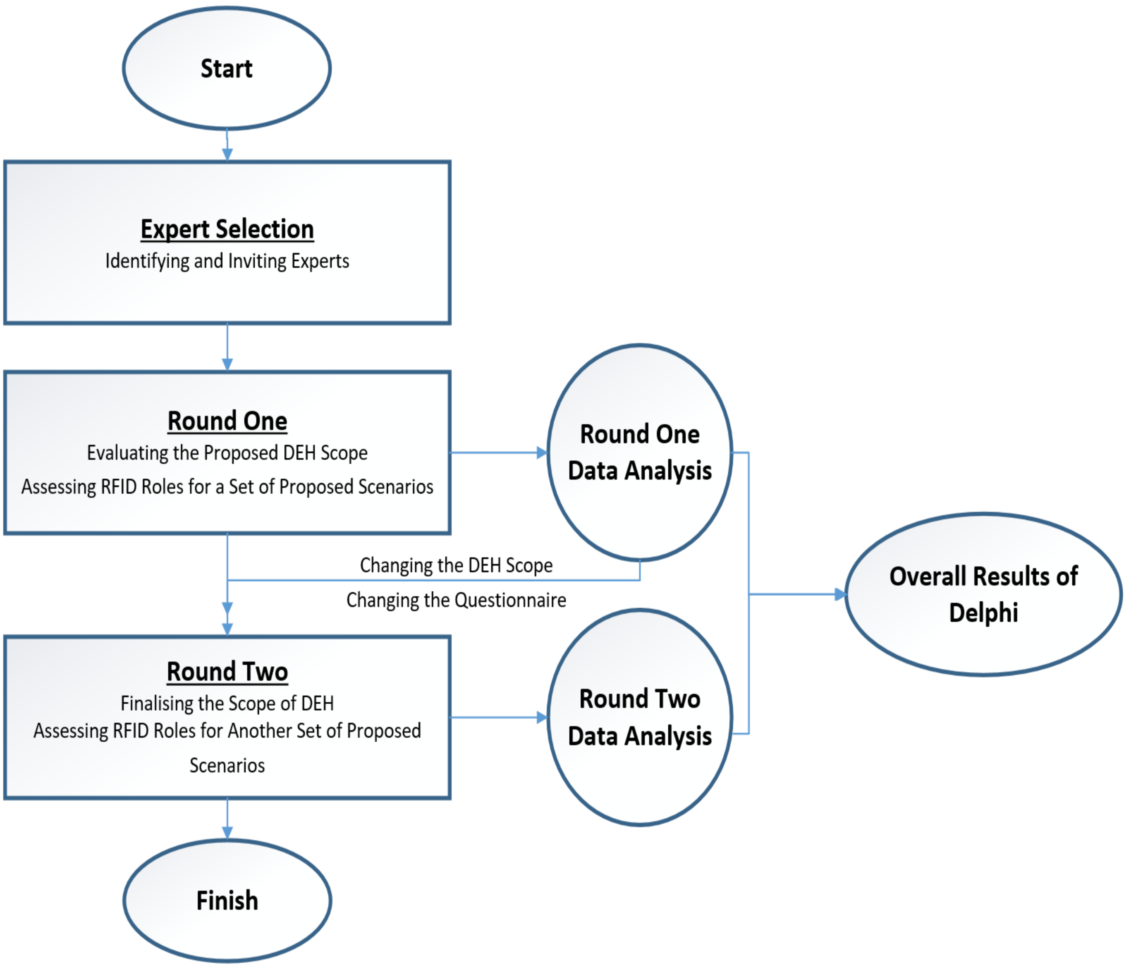

Figure 7.2 The overall structure of the Delphi method for the DEH research

In the Delphi method, recruiting experts from the field who have the required knowledge and background is essential. These experts participate in a survey asynchronously at times and places convenient to them (Linstone & Turoff, 2011). The main advantages of this method as stated by Okoli and Pawlowski (2004) and Powell (2003) are:

- providing **anonymity** that encourages people to explain their ideas based on their knowledge and experience freely and restricts possible bias or influence arising from peers.
- achieving **consensus** in a given area of uncertainty or lack of empirical evidence
- providing **richer data** due to having multiple iterations and response revision
- having **flexibility** in selecting participants (experts) without being concerned about their geographical location.
- avoiding experts direct confrontation

7.3 Delphi Method for the DEH Research

The Delphi method started with expert identification and selection, as one of the most important tasks. In each round, a questionnaire (Appendixes G and H) was used as the data collection instrument. Both questionnaires consisted of open- and closed-ended questions and the same questionnaires were sent to each of the selected experts to ask for their feedback and comments. The participants were asked for comments on the proposed DEH scope and to rank the RFID applications in DMC in the proposed scenarios generated in phase 2.

The first questionnaire was prepared based on the research findings (phases 1 and 2) by taking into account the research objectives and questions. The questionnaire was sent to the selected experts and a two-week deadline was set for responses. After the deadline, the researcher collected and analysed the responses.

In the second round, the questionnaire was prepared in light of reflection on the experts' feedback in the first round and its related data analysis. The second questionnaire was submitted to the experts along with the first round report. In the second round, the panel also had the opportunity to refine and reconsider their original feedback if they wished or to develop new ideas. The overall framework of the conducted Delphi and all its procedure are illustrated in Figure 7.3.

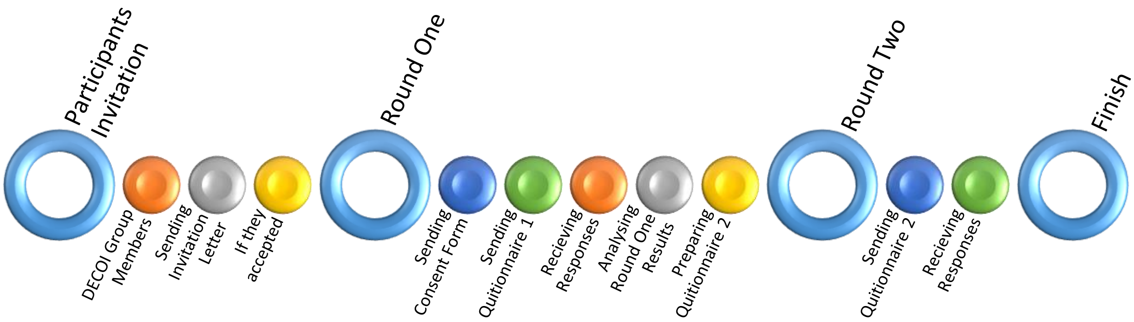

Figure 7.3 Delphi process for this research

7.3.1 Participant Selection

Delphi does not depend on a representative sample of a population (Okoli & Pawlowski, 2004). Therefore, the initial task in the Delphi method is creating a qualified panel of experts in which the participants are required to have a high level of expertise and thorough background knowledge in the area of the research. Since the decision of the panel has a great influence on the overall result of the research, careful selection of Delphi participants is mandatory. The level of experience and knowledge of participants is a way of measuring the reliability and validity of the Delphi results (Giannarou & Zervas, 2014) and can impact the overall success of the method. In this regard, the selection procedure should be defined clearly and its criteria need to be identified at the early stages.

For selecting the Delphi participants in this study, the Okoli and Pawlowski's experts selection procedure (Okoli & Pawlowski, 2004) was modified according to the features of this study (Figure 7.4).

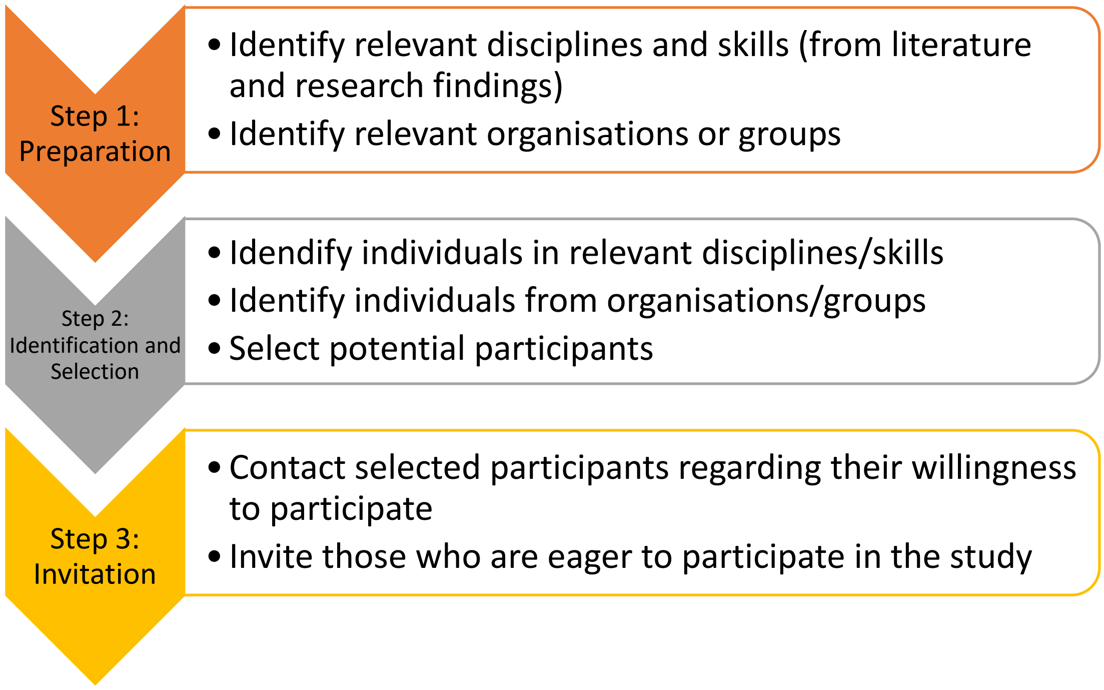

Figure 7.4 Experts selection procedure (adapted from Okoli & Pawlowski, 2004)

The objective of step 1 was to identify the kind of knowledge the participants were required to have (Seuring & Müller, 2008) and could be defined based on the literature review and the preliminary results of the research. As a result, the relevant disciplines and domains according to which the experts were to be selected had to be identified. In addition, relevant organisations or groups who work in the areas related to the field of research needed to be identified. It is recommended to recruit different kinds of panellists so that an appropriate mix is created (Scheele, 1975) to enable the researcher to collect a wide range of views.

For the optimum support and participation of the experts, some criteria needed to be considered to keep them motivated throughout multiple rounds; otherwise, the participants may not contribute effectively. Some motivation criteria, as indicated by Adler and Ziglio (1996) and Delbecq et al. (1975), are:

- feeling personal involvement in the research problem;
- having relevant information to share;
- feeling the study will benefit them
- obtaining knowledge and experience through the research;
- being interested in taking part besides their other commitments.

In step 2, regarding the targeted disciplines, organisations, and groups, individuals need to be appointed based on their extensive knowledge and experience in the related fields. This could be identified through the number of research publications in the targeted fields (Burns, Rivara, Thompson, & Johansen, 2003; Wamba & Ngai, 2011), through a literature search (Gordon, 1994) or through other experts' recommendations.

Regarding the number of panellists, as with the number of rounds, in the Delphi method literature there is no consensus. Different studies come up with a different number of participants ranging from four to 1,000. However, Linstone (1987) (cited in Thangaratinam & Redman, 2005) and Day and Bobeva (2005) recommends that a suitable number of Delphi participants is seven, and Hogarth (1978, cited in Habibi, Sarafrazi, & Izadyar, 2014) had previously suggested that a panel size of between six and 12 members is ideal. Meanwhile, Clayton (1997) had proposed that five to 10 expert panellists suffices if they have different specialties. The reason for these fluctuating panel numbers can be related to the flexibility of the Delphi method, the topic under investigation, or the quality of the panel judging the criteria not their number.

Finally, in step 3, the researcher had to contact each selected expert individually.

For this research, since DEH is a new field, finding the experts in the exact field was almost impossible. Further, DEH is a multidisciplinary field; therefore, to gather a wide range of opinion, multidisciplinary experts (researchers, academics, and practitioners) from diverse disciplines and areas and with different backgrounds were selected. For the background selection, the researcher referred to the areas that constitute DEH: disaster management, disaster medicine, and e-health.

For the purpose of this research and by considering all the criteria, it was decided that the DECOI (Disaster e-Health Community of Interest) group could make a suitable panel. This group, which was originally founded by the universities of AUT (New Zealand), Agder (Norway) and Omaha (USA), brings together researchers from different related disciplines (for more information about this group refer to http://www.aut.ac.nz/study-at-aut/study-areas/engineering-computer-and-mathematical-sciences/research/disaster-ehealth-community-of-interest). DECOI members have a background knowledge of the DEH and, as stated by Hasson, Keeney and McKenna (2000), it is necessary that the selected experts have knowledge of the area of the research. Since the validity of the result depended upon the experts being able to convey a sound opinion on this issue, these criteria was of prime importance in this study. Additionally, DECOI members:

- are from different disciplines related to the DEH
- are expert (relevant experience) in at least one of the mentioned fields
- have a number of publications in the mentioned fields
- have been recommended by the other experts
- (most of them) have outstanding articles in their area found in the literature search

Moreover, the potential participants (23 people of the DECOI group) had the experience and knowledge related to the fields and comprehensive understanding of the fields' issues at hand. Therefore, working with this group of experts could ensure the collection of a wide range of viewpoints as the input for this research. After contacting the members through email, 11 members out of 23 replied and showed their interest in participating in this Delphi study.

In the beginning, clear information was provided in an invitation letter and was emailed to all DECOI members. This letter contained the required information about the ethical consideration, the research, its objectives, questionnaire guideline, time requirement, and the expected number of rounds (participant Information Sheet – Appendix F). The AUT ethical approval was also sent to the panellists (Appendix B)

Next, the consent form (Appendix G) was sent to the 11 members and they were asked to accept their participation by signing the form and returning it to the researcher; however, ultimately, there were nine members who officially accepted the invitation by signing the consent form.

7.3.2 Designing Questionnaire

The common data collection instrument used in the Delphi method is the questionnaire, and for its development the same design instructions similar to surveys (Okoli & Pawlowski, 2004) are considered. In the Delphi method, questionnaires can be used to gather both qualitative and quantitative data through both open- and closed-ended questions. As Nowack et al. (2011) explains, each type of question has its own function. The open-ended question is used for idea generation while the closed-ended one is used for judgment purposes.

Regarding the response time for the questionnaire, since the Delphi method has multiple iterations, it is more time consuming for the participants who normally have other commitments. Therefore, the questionnaire should be designed in such a way that it does not take more than 30 minutes (Okoli & Pawlowski, 2004).

The scope of the designed questionnaires in this Delphi was DEH and RFID application within DMC and DEH. Both questionnaires were designed to provoke opinions on the proposed DEH scope and to find out whether or not the proposed scenarios could be supported by RFID. For designing the questionnaires in this study, both open- and closed-ended questions were used.

The qualitative data were captured from open-ended questions mostly in the evaluation of the proposed DEH scope to see if the participants agree with the research findings or not. Open-ended questions give the respondents the opportunity to explain their ideas as much as they want. At the same time, these questions help researchers to get an insight into the field of the research.

On the other hand, in the RFID application section, the most important application of the RFID in DMC was to be recognized. This section was designed in a way to measure constructs not directly countable through using "multiple-item scales and summated ratings to quantify the construct(s) of interest" (Gliem & Gliem, 2003, p. 82). In this regard, the five-point Likert scale (ranging from strongly disagree to strongly agree, Figure 7.5) was utilised; this Likert scale allows neutrality as well.

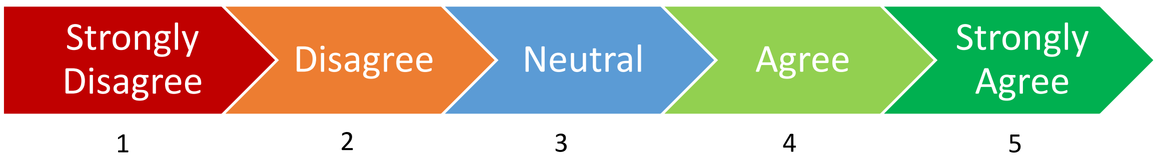

Figure 7.5 Liker 5-point scale

As recommended by Giannarou & Zervas (2014), to investigate the agreement level, the participants were asked to rate RFID utilisation in DMC for the proposed scenarios according to their experience and to suggest any other suitable e-health technologies.

The questionnaires for both rounds contained questions aligned with the initial research objectives and questions and were based on phases 1 and 2 results. The questionnaires were designed not only to evaluate the results but also to gather further data from the fields' experts.

Therefore, the questionnaires (Appendixes F and G) asked specific question to confirm: the DEH scope (RQ 1); and to assess the RFID utilisation within DEH scope and DMC (RQ 3 and RQ 4). For example:

1- By referring to Figure 2, what are your thoughts about including the technologies in the scope of DEH? You may add/remove technologies based on your experience. Please indicate the reasons for your choices.
2- What is your viewpoint regarding RFID application in the below scenarios:
    - Improving timely decision making in healthcare organisations including reallocation of hospital resources and staff as the need arises by using RFID capabilities such as automatic and real-time capturing the number and location of medical and human resources

The questionnaires were designed so that there was a chance for experts to present their viewpoint, even for closed-ended questions in which a space was provided for participants to express their ideas, provide additional comments and justify their responses if they were willing to do so.

In order to be certain about the common understanding of the participants, at the beginning of the questionnaire the research background and purpose were clearly defined. For the same purpose, a short discussion on the DEH background, DMC and RFID technology was also provided. Then, a brief instruction of how to complete the questionnaire was given (Table 7.2).

Table 7.2

The Questionnaire Sections

Questionnaire Section	Sample of Provided Information
Research Objective	The study aims to determine the scope of DEH and the role of RFID as an e-health technology
Questionnaire Objective	I am interested in your opinion/idea, as an expert in the field related to one or more of the topics of disaster management, disaster medicine, and e-health, on the general application of e-health throughout the disaster management cycle, and in particular, on the distinctive role that RFID can play in these situations.
Research Background: DEH Background	DEH is a new paradigm based on the existing disciplines of disaster management, disaster medicine and e-health (Figure 1) and can be recognised as a juxtaposition of healthcare and information science
Research Background: RFID Technology	RFID is an auto-identification technology (sub category of IoT) and consists of three main elements; tags, readers and middle ware. The applications of RFID are numerous and tend to grow since they help to use information better, faster, and more accurately than the other technologies such as barcode

To enhance the clarity, validity and reliability of the questionnaire (both design and question type), before starting the first round, a pilot test was conducted. For this purpose, the round 1 questionnaire was forwarded for review and feedback to one of the DECOI members who is an expert in disaster management, e-health and the Delphi method. According to the provided feedback, to enhance clarity of the instructions some minor insights were added and some wording was modified. In addition, one more question was added and the rest remained the same.

The first questionnaire was based on the collected research information and findings from phases 1 and 2. Its main purpose was to collect a wide range of opinions regarding the proposed scope for the DEH and assess the applicability of RFID technology in the generated scenarios with both DMC and DEH scope. Therefore, its final objective was validating findings from the previous phases and completing the DEH scope as well as assessing the place of RFID within DEH scope.

The first round of the Delphi began with the nine experts. The questionnaire was sent to them via email, and after two weeks a reminder and a follow up email was sent to request the responses to the questionnaire. All the experts had provided the researcher with their responses one week after getting the reminder.

The second questionnaire was designed according to the results of analysing the responses to the first round questionnaire (section 7.6). Based on the provided feedback, the scope of the DEH was revised and another set of disaster scenarios were proposed to assess the RFID application. The objective of this round was to finalise the DEH scope and examine the RFID role for certain other disaster scenarios. As with the first round, after two weeks a reminder and a follow up email was sent. Seven out of the nine experts responded to the second round of the Delphi one week after receiving the reminder.

7.3.3 Administration Procedure

To deploy the Delphi method properly, an efficient managerial method is required to apply suitable techniques for analysing individual opinions. In this study, the researcher was responsible for collaborating with each expert, distributing questionnaires in each round, and collecting the responses. In this regard, after studying several means of questionnaire distribution methods in Delphi, namely, hard copy, online, fax, post, and email, it was decided to send the questionnaires electronically via email. This approach was chosen because the number of participants was not high, and they were easily manageable. Therefore, the questionnaire was created as a fillable form in PDF format; however, a word version was also created and sent upon request.

The first round started late July and, following the recommendation of Delbecq et al. (1975), a two-week time frame was given to the experts to prepare their responses. In each round, as mentioned above, a prompt email was also sent to the respondents to remind them of the end date.

After collection of the first round responses, it took another two weeks to extract the information, perform data analysis, prepare the report and, based on them, prepare the second questionnaire. The second round began in late August with the same procedure followed as for round 1.

7.4. Delphi Data Analysis

Since one of the most important aspects of the Delphi method is reaching consensus among the panel of experts, the feedback analysis and consensus measurement is of prime importance and should be considered as a key element of the Delphi method. These analysis and measurement methods vary significantly (Rayens & Hahn, 2000; von der Gracht, 2012), and different research studies followed different methods according to their research objectives. Therefore, decision rules need to be decided upon to collect and shape the judgments and viewpoints provided by the Delphi panel (Hsu & Sandford, 2007).

In the Delphi method, both quantitative and qualitative analyses are common. If the Delphi questionnaire consists of open-ended questions, qualitative analysis needs to be performed; however, for using Delphi with ranking or prioritising purposes, the quantitative data analysis is common to support and quantify the gathered data although using qualitative analysis is also common (Rayens & Hahn, 2000).

In this study, since both questionnaires had two different major sections with different objectives, the analysis of each part also needed to be different. Moreover, as the questionnaires in both rounds comprised both open- and closed-ended questions, qualitative and minor quantitative data analysis were employed; and like a lot of Delphi research, subjective criteria and descriptive analysis were utilised to quantify the degree of the consensus (von der Gracht, 2012). Likewise, in both rounds, qualitative and subjective analysis and measurement were performed for the DEH scope section and for the RFID application to analyse the feedback and measure the level of agreement.

For measuring the consensus or the degree of agreement among the experts, different methods and criteria can be used (Table 7.3), as is pointed out by von der Gracht (2012) and Rayens and Hahn (2000). This diversity of measuring methods is rooted in the research aims and objectives in addition to questionnaire design; for example, there are different criteria for measuring consensus in different Likert-type scales.

Table 7.3

Consensus and Agreement Measurements

Measurement Method	Criteria for Consideration
Subjective Analysis	* Some investigators ask panels of experts to prioritise ideas by assigning a rank score, but they analyse the responses using qualitative methods (Cookson, 1986; Jairath & Weinstein, 1994)
Frequency Distribution	* 51% responding to any given response category is used to determine consensus (McKenna, 1989) * 60% of the respondents were in agreement and the composite score fell in the "agree" or "disagree" range" (on a 5 point Likert scale) (Seagle, 2001)
APMO Cut-off Rate (Average Percent of Majority Opinions)	* APMO Cut-off Rate of 69.7% (Cottam, Roe, & Challacombe, 2004)
Central Tendency (Mode, mean/median ratings and rankings, standard deviation)	* Mean responses within acceptable range (mean±0.5) and with acceptable coefficient of variation (50% variation) were identified as signalling firm consensus (Chakravarti, Vasanta, Krishnan, & Dubash, 1998)
Interquartile Deviation (IQD)	* IQD of 1.00 or less as an indicator of consensus (Raskin, 1994)
Interquartile Range (IQR)	* IQR of 1 or less is found to be a suitable consensus indicator for 4- or 5-unit scales (Raskin, 1994; Rayens & Hahn, 2000)

According to Table 7.3, in both rounds of the conducted Delphi, for the DEH scoping section subjective analysis was followed to measure the consensus; and in the RFID section, first the utilisation of the central tendency and standard deviation were examined. Since no significant difference was found, by consulting to a professional statistician in AUT from departments of mathematics, it was decided to use the frequency distribution method. This method is often used and consensus will be achieved if at least 51% of all the responses fall in one category of the Likert scale (Loughlin & Moore, 1979; McKenna, 1989, 1994). In this regard, those who supported the RFID application for the proposed scenarios, by choosing agree and strongly agree, were considered as one category and the rest who disagreed with or were neutral regarding the RFID application were placed in another category (refer to sections 7.5.3 and 7.6.2 for the results).

In this study, the researcher decided to adopt the procedure discussed above to assess the amount of agreement for each given scenario in the questionnaire in rounds 1 and 2. The results of the Delphi analysis in both rounds are provided in sections 7.5 and 7.6, respectively.

7.4.1 Reliability Testing

After gathering the responses for the RFID section, as proposed by Gliem and Gliem (2003), the internal consistency reliability of scales was one aspect of validity of the given questionnaire that needed to be measured and assessed. This validity refers to the construct consistency of the questionnaire. Therefore, using a statistical method was necessary as a test of reliability of the distributed questions of a given questionnaire. To this end, from among several methods available for estimating internal consistency of the questions, Cronbach Alpha, as one of the two most frequently reported methods (Brown, 2002), was employed. As maintained by Reynaldo and Santos (1999, p. 1) this method "determines the internal consistency or average correlation of items in a survey instrument to gauge its reliability". Its range is from 0 to 1, the higher the figure, the better the reliability scale. Some researchers (see, for example, Nunnaly, 1978) believe that a reliability coefficient of 0.7 is an acceptable score. As for this study, the results of Cronbach Alpha for questions in each phase of disaster and for the whole RFID section in both rounds are depicted in Tables 7.4 and 7.5, respectively.

Table 7.4

The Results of Cronbach Alpha Calculation –First Round

Reliability Statistics		
Phase	**Cronbach's Alpha**	**N of Items**
Mitigation	.742	5
Preparedness	.756	4
Response	.797	4
Recovery	.862	5
Overall	.936	18

Table 7.5

The Results of Cronbach Alpha Calculation –Second Round

Reliability Statistics		
Phase	**Cronbach's Alpha**	**N of Items**
Mitigation	.750	4
Preparedness	.643	5
Response	.801	5
Recovery	.948	3
Overall	.873	17

As it can be seen in Table 7.4 and Table 7.5, the amount of Cronbach Alpha for each of the four phases and for the overall score is high enough to confirm that there was a high internal consistency among the questionnaires' items.

7.5 Round 1 Data Analysis

The Delphi round 1 questionnaire (Appendix H) consisted of three different sections: Demographic category, Disaster e-Health Scope, and RFID Technology. These sections represented the result of phase 1 (scoping study) and phase 2 (use-case methodology); the latter only concentrated on one of the e-health technologies, RFID. The aim of this questionnaire was to ask experts to assess the proposed scope of DEH and then examine the role of RFID technology and its appropriateness for the proposed scenarios in each phase of disaster.

Through the entire questionnaire, the experts were encouraged to provide explanation if it was required, and for the last section (the RFID part), propose a substitute and more appropriate technology that can support the given scenarios. It should be mentioned that for clarity of the responses, the researcher modified them so that they became grammatically correct.

The questionnaire began with demographic questions, and the rest of the questions focused on the DEH scope and the RFID applications, respectively. For the DEH scope section, the respondents were asked to provide feedback about the proposed scope and its elements, while they were free to add their desired items into the scope or removed them. In the last section of the questionnaire, the participants were asked about their familiarity with RFID technology, and then they were requested to rate the proposed RFID applications in a set of predefined scenarios. For the rating purposes, experts were also asked to rank the role of RFID from one to five. In this section, a space was also provided for experts to provide comment if they wished. The intention was to collect feedback on scenarios and RFID applications and to identify other technologies that they considered more appropriate as compared to RFID.

The rest of this section is dedicated to the first round analysis.

7.5.1 Demographic Section

The first question of the first round was dedicated to collecting the demographic information of the participants to assess their background to decide about their homogeneity. This section should be well prepared by researchers so that the readers are able to assess the relevancy and reliability of the research participants (Schmidt, 1997).

In this study, the responses were gathered from international experts with different fields of expertise and work backgrounds to help the researcher to collect different viewpoints in the area of the study. The experts' background information is shown in Tables 7.6 to 7.9.

Table 7.6

Geographical Location of the Experts

Country	**Number of Participants**
USA	2
Spain	1
Norway	2
New Zealand	1
Canada	1
Bulgaria	1
Sweden	1

One of the reasons for applying the Delphi method, as discussed previously, is that it enables the researcher to recruit the fields' experts worldwide. This issue helps the researcher to gather a wide range of views and become familiar with different countries' perspective in the area of the research.

Table 7.7

*Experts' Level of Education**

Level of Education	**Frequency**
Doctorate degree	8
Master's degree	1
MBA degree	0
Bachelor's degree	0
Other	1 (Diploma Engineer)

* For this question, the experts were able to choose more than one category

Table 7.8

*Experts' Occupation**

Participants' Background	Frequency
Academia	9
Healthcare	1
Consulting	1
Research	6
Government	0
Disaster Manager	2
Healthcare IT	0
Disaster Medicine	1

* For this question, the experts were able to choose more than one category

In Tables 7.7 and 7.8, with regard to the participants' background, since they were allowed to choose multiple categories it resulted in 20 selections.

Table 7.9

Experts' Experience Year

Total years of Experience	Frequency
0-5	1
6-10	2
11-15	1
16-20	0
21-30	5
More than 30	0

As can be seen from Table 7.9, five experts out of nine had more than 20 years' experience, which can be considered as a valuable criteria for this Delphi research since experience is one of the key factors that can affect the quality of the Delphi results. In this regard, based on recruiting experienced participants, there can be an assurance regarding the validity and the quality of the Delphi outcome.

As it can be seen from the above tables, the participants were mostly academics; however, some of them chose other organisation types such as healthcare and disaster management. Although most participants were from academia, because of their positions, several of them were knowledgeable in multiple domains. This provided extensive expertise over an acceptable range of participants' backgrounds for this study.

7.5.2 The Scope of DEH Section Questions

This section of the questionnaire included four open-ended questions regarding different aspects of the DEH scope that needed to be evaluated by the experts. In each question, the experts were asked to add/remove their desired elements to/from the diagram list by considering the given diagrams. One of the questions in this section asked experts to choose the five most important technologies they thought could enhance the quality and efficiency of the DMC activities.

In this section, qualitative data were collected through open-ended questions with the purpose of validating the DEH scope. Different diagrams were provided to illustrate each aspect of the DEH scope, and the participants were asked to state whether they agree or not and to freely add or remove any item to/from the scope by considering the proposed scope of DEH.

After collecting the experts' feedback in the first round of the Delphi, the researcher analysed qualitatively their comments for the DEH scope section, and since all this section's questions were open-ended, the amount of consensus was measured subjectively. The gathered qualitative data in this section considered the scope of DEH in the following areas:

- Technologies
- Applications
- Stakeholders

Moreover, in this section a question was provided asking experts to select the top five technologies they consider as having the greatest potential to benefit disaster victims as well as the planners/providers of disaster healthcare.

7.5.2.1 Technologies in the DEH Scope

The DEH scope section started with Question 2, which was about the e-health technologies within the DEH scope. This question asked experts to add/remove technologies to/from the list of given technologies that could be considered in the scope of DEH. The intention here was to prepare a comprehensive list of technologies that could be considered in the scope of DEH and be utilised within DMC. Table 7.10 provides the given feedback by experts. Furthermore, the summary of the experts' comments is provided in Table 7.11. (Hereafter, all the italic parts in this chapter represent the exact wordings of the experts without any modifications).

Table 7.10

Suggested Added and Removed Technologies

Expert	**Add to the DEH Technology List**	**Remove from the DEH Technology List**
1	- Collaboration technologies - Process MGMT (slack; scrum do)	
2	- Communication technologies - Authentication - Authorisation/Access control - Machine learning - Automatic data evaluation - Pervasive technologies - Automatic voice/speech recognition - Text-to-speech (TTS) - Storage devices	- Network Technologies -Auto Identification - Big Data

3	- Technology Enabled or Enhanced Teaching (TEET, or e-learning) - Communication - Biometrics - Old fashioned PC - Drones	- Cloud Computing
4	Systems for dynamic resource allocation	
5	No comment	
6	- Technologically implemented triage - 4G, 5G, … - Artificial intelligence e-Learning systems	
7	No comment	
8	- Telemedicine - Big data - Cloud technologies - All type of sensors - GPRS - 3G - Satellite - Social network - Ad hoc network - Portal - Auto identification - Information system - Image interpretation computer assisted	
9	No comment	

Table 7.11

Experts' Comments on Question 2

Expert	Experts' Feedback on the DEH Scope
1	No Comment
2	**Added:** - *Machine Learning for utilising "Big Data"* - *Automatic data evaluation (utilising knowledge from machine learning)* - *Pervasive Technologies (complementing "ubiquitous technology")* - *Automatic Voice/Speech Recognition (AVR; as basis for communication with an intelligent emergency response system)* - *Text-to-speech (TTS) - important HMI-technology* - *Storage devices (for health related information, beyond the purpose of "auto identification")* **Removed:** - *Network Technologies" is not that frequently used in this context* - *"Auto Identification" would be a sub-group of "Authentication"* - *"Big Data" is rather a buzz-word than a technology* - *IoT is the technology to collect "Big Data" for further purposes*
3	**Added:** - *A difficult question to respond to since any technology should only be used when it appropriately responds to a specific and identified need.* - *I do not see any focal point for 'Communication', into which I would insert old and simple devices such as hand held voice radios (for multi-directional communication) and receive only radios (for one-way transmission of information)* - *'Drones' which may well end up flying essential medical supplies around* **Removed:**

	- *My only other thought about 'removal' is that nothing should be 'discounted'* - *Nothing should be included for frontline consideration unless the solution is idiotically simple, utterly foolproof, truly intuitive, and fully tested/proven in the cold light of day.* - *m-Health is nothing more than (potentially) a combination of health informatics and telehealth - just using a mobile device; it need not stand alone* - *Decision support systems are merely a sub-component of Information Systems* - *Telemedicine (tele 'medicine') should be telehealth*
4	- *Systems for dynamic resource allocation (sending the adequate nearest resources to the incident site)*
5	No Comment
6	No Comment
7	- *I am not an expert in the technologies and I am not familiarised with some of them that are placed in figure 2.*
8	No Comment
9	No Comment

7.5.2.2 Top Five Technologies

In this section the responses to Question 3 are discussed. This question asked panellists to select the top five technologies within the scope of DEH that have the greatest potential to help and benefit disaster victims and authorities who respond to those needs. These technologies may have the potential to enhance the quality or effectiveness of the DMC activities. The participants' suggested technologies and their rationale(s) are presented in Table 7.12.

Table 7.12

Suggested Top Five Technologies and Their Rationales

Expert	Top Five Technologies	Rationale(s)
1	*1- Positioning systems*	*1- Locationing is important in*
	2- HIS/HIT	
	3- Telemedicine	*3- Remote care*
2	*1- Communication Technologies* *2- Telemedicine / Telehealth;* *3- m-Health* *4- Decision Support System* *5- Positioning System* *6- Computer Devices*	*- These technologies belong closely together, and depend on each other, hence they can't be ranked (e.g. Communication Technologies are the basis for Telemedicine / M-Health; Computer Devices are the basis for interaction with disaster victims, for collection of data and provision of support)* *- This group of technologies is essential to collect data about the disaster, the status/condition of victims (including their location), and to efficiently analyse/evaluate the data in order to support the disaster healthcare providers and victims*
3	*1- Telehealth*	*1- Telehealth - providing immediate access to greater expertise for immediate treatment/evacuation decisions through mobile/web-based tele-consultation with needed experts.*
	2- Positioning systems	*2- Positioning systems - answer the essential question of 'what resources (human and material) are available where?' Maybe even 'tag' emergency personnel (for safety and resource needs) as well as vehicles etc.*

	3- Social networking	*3- Social networking (various apps and sites) - has been shown to be surprisingly beneficial and effective for a host of needs (linking family members; passing messages about resource centres (food, water, clothing); gathering practical disaster and health related surveillance information) - capability needs to be refined and encouraged.*
	4- Mobile devices (including drones)	*4- Mobile devices - including drones. This assumes connectivity is available (or can be provided very locally through drones) and / or 'two-way' radios. Communication (ideally bi-directional) is crucial during a disaster. (I slipped in drone here for 2 reasons - they may be able to provide communication linkage, but also for health needs - surveillance, medication/blood supplies, etc.)*
	5- Auto identification	*5- Auto identification - if healthcare/ medication / etc. is to be provided to people, it will become necessary to not only track them physically (perhaps as they are evacuated, or become refugees), but also to unequivocally identify them in some unique manner - various biometrics may offer the best solution for this.*
4	*Cannot rank, do not have the sufficient knowledge*	
5	*1- Computer devices*	*1. Mobility of devices will be key during an emergency. Most often healthcare providers will need to work with first responders, who*

		will likely have mobile devices. Same for disaster victims.
	2- Auto identification	*2. Auto identification for health related issues - possibly RFID, Smartcard or the mobile devices themselves.*
5	*3- The Internet*	*3. Internet, because most will need to save or send information to a larger system.*
	4- Positioning	*4. Positioning may help locate victims under disaster debris.*
	5- IoT	*5. The more integration, the better in terms of planning and locating individual victims.*
6	*1- Technologically Implemented Triage (e.g., early warning system)*	*1- Rapid and standardised assessment*
	2- e-Learning systems (e.g., how-to video)	*2- Learn what to do by untrained personnel*
	3- Internet	*3- Connectivity and communication*
7	*I am not able to assess this.*	
8	*1- Telemedicine;* *2- Simulation technologies;* *3- Image interpretation computer assisted;* *4- Remote wearable sensors.*	*Providing fast two-way communication between the casualties and disaster medical support managers*
9	No Comment	

7.5.2.3 Applications Included in the DEH Scope

Based on the involved technologies, DEH scope can also encompass different applications. Therefore, in the fourth question, the experts were asked to evaluate the research findings and add/remove application(s) to/from the DEH scope based on their experience by considering the involved technologies (see Figure 7.6). All the modifications requested by the participants are illustrated in Table 7.13 followed by their comments in Table 7.14.

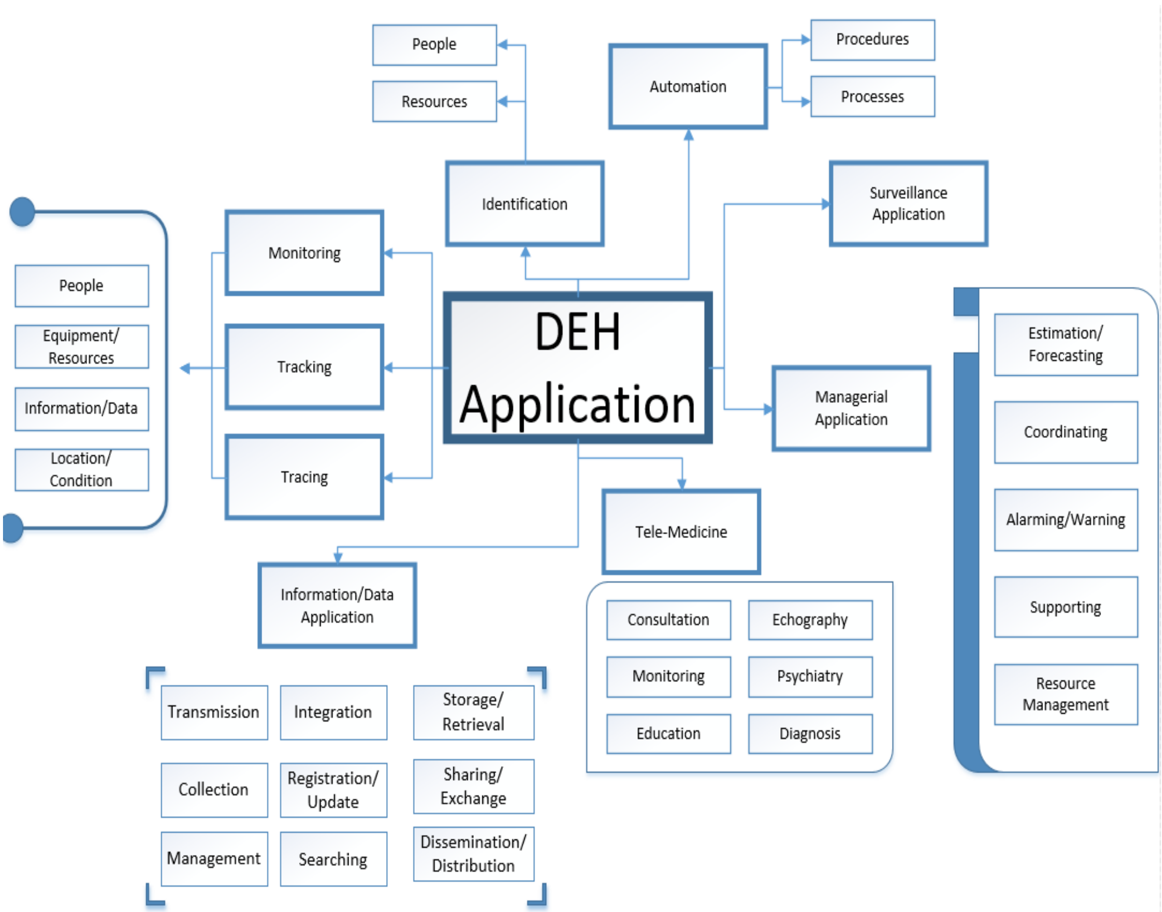

Figure 7.6 DEH applications

Table 7.13

Included and Excluded Applications in the DEH Scope

Expert	Added Application(s)	Removed Application(s)
1	- Collaboration (teaming); - Process management	
2	- Authentication & Authorisation (complementing "Identification") - Analysis application (automatic detection of disaster conditions, based on "Monitoring"/"Surveillance"/"Collected Data")	Surveillance Application
3	No comment	
4	No comment	
5	- Modelling applications; - Decision making applications	
6	- Training - Education	
7	No comment	
8	No comment	
9	- Social media communication tools – Facebook, Twitter, etc.	

Table 7.14

Experts' Comments on Question 4

Expert	Experts' Feedback on the DEH Applications
1	No comment
2	- *"Surveillance Application" seems redundant, covered by Monitoring/Tracking/Tracing*

3	*1. Any technology should only be used when it appropriately responds to a specific and identified need. In other words, we must always avoid the 'technological imperative' - i.e., the tendency to introduce and apply technology 'just because we can'.* *2. Nothing should be included for frontline consideration unless the solution is idiotically simple, utterly fool proof, truly intuitive, and fully tested/proven in the cold light of day. The immediate post disaster response and recovery period is no time to play with neat ideas ...... lives are at stake.* *So - in summary, the specific 'application' does not matter, as long as it is a) needs-based and b) a proven solution.* *I can get into other issues, which some may say fall by the wayside during disaster. Our technological solutions must be 'environmentally sensitive' also - otherwise we are simply contributing to yet another 'slow' type of disaster.* *Finally, my only additional comment would be - it is essential that any solution be capable of 'seamless' integration into existing disaster software solutions*
4	No comment
5	*- Alerting/warning is dependent. Should be left to the authorised emergency manager*
6	No comment
7	*I think all of them are useful*
8	*Accept all proposed and none to be removed*
9	No comment

7.5.2.4 DEH Stakeholders

The last question in this section was about the stakeholders who could be involved in the scope of DEH. Stakeholder identification is one of the key elements in the DEH scope since their requirements and demands need to be considered in different disaster phases. Therefore, the participants were asked about their ideas regarding the DEH stakeholders (see Figure 7.7). Their responses are depicted in Tables 7.15 and 7.16.

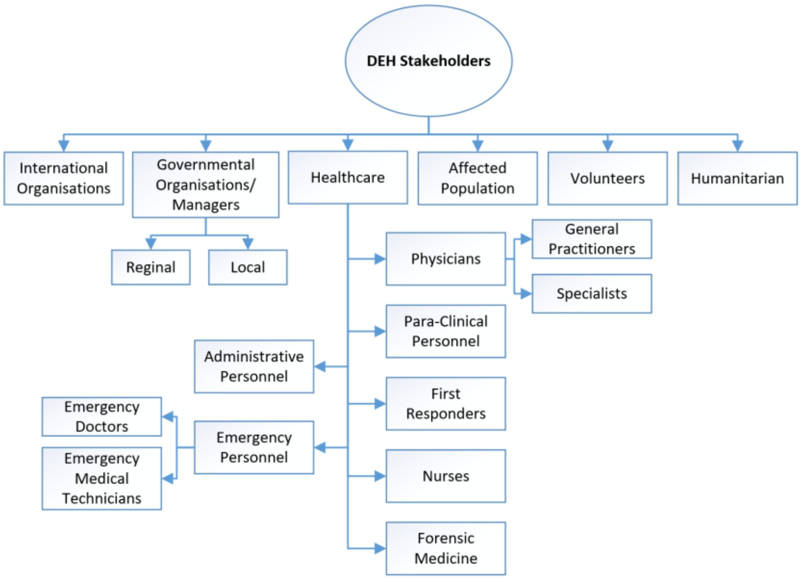

Figure 7.7 DEH stakeholders

Table 7.15

DEH stakeholders

Expert	**Added Stakeholders**	**Removed Stakeholders**
1	- Technologists - Students - Organisations	
2	- Vendors of communication systems - Operators of communication infrastructure - Vendors of eHealth system - Operators of eHealth infrastructure (might be "organisations") - Vendors of disaster/emergency management systems - Operators of emergency management systems	
3	- Faith-based organisations (FBOs) - NGOs - Military - Disaster managers	

	- The 'command and control' centre personnel - Health responders may be allowed into a disaster area anyway. - MSF	
4	No Comment	
5	- In the US the private sector - National/Federal Emergency Managers - Governmental organisations - Non-profit organisations - Faith-based organisations	International organisations
6	- Young people - Refugees - Immigrants - Disabled people organisations	
7	No comment	
8		Forensic medicine
9	No comment	

Table 7.16

Experts' Comments on Question 5

Expert	**Experts' Feedback on the DEH Stakeholders**
1	No comment
2	No comment
3	*Faith-based organisations (FBOs) and 'NGOs'. Not all NGOs are FBOs, and many FBOs may (typically) be NGOs, but their 'raison d'etre' differs significantly, and it is worthwhile identifying them separately.* *It should stretch further - disaster managers (indeed anyone involved in disaster response, recovery, or rehabilitation is a legitimate stakeholder - what they need to know, and the depth of insight each group requires will vary). In a hierarchical setting during a disaster, the 'command and*

	control' centre personnel may be in overall charge, and are stakeholders who need to know about DEH and what it can and cannot do for them. They may also have the ultimate say about whether health responders may be allowed into a disaster area anyway. *You will find crossover. MSF is (I think) an NGO, as well as being International and Humanitarian*
4	*None, but volunteers can be divided into organised volunteers and spontaneous volunteers (ah-hoc organisation)*
5	*In the US the private sector (businesses) are added as disaster stakeholders National/Federal Emergency Managers are added, as well Gov. Orgs are often separated from those that are charged with the function of response, recovery, mitigation and preparedness (i.e. emergency management agencies) Non-profit organisations Faith-based organizations* *Removed: International organisations are often considered Humanitarian Volunteer organisations aren't the same as Non-profits*
6	No comment
7	*All of them are useful*
8	*Accept all proposed*
9	No comment

7.5.3 The Application of RFID Technology

The purpose of this section of the questionnaire was to determine the most applicable RFID role within DMC in the scope of DEH from the experts' viewpoint. In this regard, 18 potential RFID applications were explained through numerous scenarios categorised according to the disaster phases. Then the participants were asked to use the five-point Likert scale to rank the RFID applications with regard to the applicability and desirability of having them for each proposed scenario. Furthermore, the participants were asked to comment on the application if they wish and name the other e-health technology(ies) that can support the same scenarios in more appropriate ways. It should be remembered that in the first question of this section, the participants were asked about their knowledge regarding RFID technology; one of the experts, because of their unfamiliarity with RFID technology, did not respond to the questions in this section. Table 7.17 provides the participants' answers to the first question, and Table 7.18 presents the obtained responses from the experts to the rest of the questions in this section.

Table 7.17

Experts Familiarity with RFID Technology

Participants' Familiarity with RFID	**Frequency**
I am an RFID technology expert	1
I have good knowledge of RFID	2
I have some knowledge of RFID	5

Table 7.18

The Overall Participants' Answers to the RFID Questions – Round One

		Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9
Mitigation	**Q1**	3	2	5	-	3	3	5	4	4
	Q2	5	5	1	-	5	3	5	3	4
	Q3	3	4	1	-	5	3	5	4	3
	Q4	5	3	1	-	5	5	5	5	3
	Q5	5	1	1	-	4	3	5	5	3
Preparedness	**Q1**	4	3	4	-	2	3	4	4	3
	Q2	4	3	4	-	3	3	5	5	3
	Q3	4	4	2	-	4	3	5	4	3
	Q4	4	1	1	-	3	3	5	4	3

Response	**Q1**	4	2	2	-	4	3	5	1	3
	Q2	5	3	2	-	2	3	5	2	3
	Q3	5	3	1	-	5	5	5	3	4
	Q4	4	3	3	-	5	3	5	5	3
Recovery	**Q1**	5	1	2	-	5	5	5	4	3
	Q2	5	1	2	-	5	5	5	3	3
	Q3	5	1	2	-	5	3	5	5	2
	Q4	5	2	4	-	3	3	5	4	3
	Q5	5	5	3	-	4	3	5	5	2

Based on the obtained responses for the RFID questions, Table 7.19 shows the minimum, maximum, and mean values of the experts' responses to each question.

Table 7.19

Minimum, Maximum, and Mean of the Responses to the RFID Questions (Round One)

Phase	Question	No of Experts	Minimum	Maximum	Mean
Mitigation	1	8	2	5	3.62
	2	8	1	5	3.87
	3	8	1	5.	3.50
	4	8	1	5	4.00
	5	8	1	5	3.37
Preparedness	1	8	2	4	3.37
	2	8	3	5	3.75
	3	8	2	5	3.62
	4	8	1	5	3.00
Response	1	8	1	5	3.00
	2	8	2	5	3.12
	3	8	1	5	3.87
	4	8	3	5	3.87
Recovery	1	8	1	5	3.75
	2	8	1	5	3.62
	3	8	1	5	3.50
	4	8	2	5	3.62
	5	8	2	5	4.00

Since the scenarios were presented according to the disaster phases, the researcher tried to find the most suitable RFID application for each disaster phase as perceived by the experts. For this purpose, the researcher considered frequency distribution of the responses. In other words, the answers that supported the scenarios (that is, agree and strongly agree) were placed in one group, and the rest of the answers (that is, neutral, disagree, and strongly disagree) were put in another category. The following sub-sections represent the analyses of the obtained responses for each disaster phase.

7.5.3.1 Disaster Mitigation

In the mitigation phase, five scenarios were provided asking about different areas. The areas and the related responses are depicted in Table 7.20.

Table 7.20

Disaster Mitigation Scenarios and Experts' Responses

	Scenario	**Agree**	**Neutral or Disagree**	**Response Mean**
Q1	Improving timely decision making in healthcare organisations including reallocation of hospital resources and staff as the need arises by using RFID capabilities such as automatic and real-time capturing the number and location of medical and human resources	4	4	3.62
Q2	Using RFID to automatically identify and capture healthcare products/equipment by location and analyse usage pattern for each region to predict future specific demands at the time of disaster and constantly monitor the condition of healthcare centres	5	3	3.87

Q3	Improving integration of information about increased demand on different hospital sectors for the purpose of strategic decision making based on the real-time and precise information captured by RFID tags	4	4	3.50
Q4	Availability of victims' vital health information like blood type, special disease or potential medication allergies and storing them on RFID tags and protecting those valuable medical information from local disasters (unlike paper records)	5	3	4.00
Q5	By recording medical/resource information on RFID tags, electronically, precise and real-time information is available to access and exchange across all medical facilities that would improve and enable healthcare organisations to prepare for emergency planning and cope with next natural disaster	4	4	3.37

According to the responses and the number of experts who supported the RFID role in the scenarios, Q2 and Q4 were selected with the highest 'agree' vote, and the mean score of those scenarios supported the frequency distribution. Furthermore, the analysis of the participants' comments showed that experts considered the RFID role as critical in the mitigation phase for supply chain of resources and logistic services. The experts' comments to support the mentioned applications were:

- *Associate the technology to individual information seems more reliable in case of disaster.*

- *Logistic services can be significantly supported by RFID technology when it comes to usage and demands of products and equipment.*

- *Knowing where staff HR resources are important*

On the other hand, the experts' concern regarding the rest of the applications were security and privacy, out-building positioning, and accessibility of the technology in the time of the disaster.

7.5.3.2 Disaster Preparedness

Four scenarios were developed for the disaster preparedness to assess the role of RFID for the particular applications. The scenarios and the obtained answers together with the mean score for each scenario are provided in Table 7.21.

Table 7.21

Disaster Preparedness Scenarios and Experts' Responses

	Scenario	Agree	Neutral or Disagree	Response Mean
Q1	Through matching the population size of each region and their pattern of health needs/demands and combining them with available hospital resources in each region, we can be better prepared for disasters, and in this regard RFID helps us to keep track of available medical resources on a real-time basis to match with the region's health demands.	4	4	3.37
Q2	Through automatic data capturing, RFID helps us to track and share information on a regional healthcare centre and make sure about types and availability of the medical resources	4	4	3.75
Q3	RFID can be used to collect and utilise the critical information needed for Just-in-Time disaster plan as well as medical resource planning and allocation of new resources to depots	5	3	3.62

Q4	Patients' medical data (important ones) should be pre-entered into RFID tags so that data are immediately available at the time of disaster and can facilitate disaster response mission.	3	5	3

Among the given scenarios, there was a consensus among the participants only on the RFID application for facilitating Just-in-Time disaster plan, medical resource planning, and allocation of new resources to depots. The barriers and challenges for the other scenarios were:

- the applicability of the solution for the multi-organisations
- limited regional localisation capabilities
- security and privacy of data

Among these challenges, the biggest concern was security and data privacy reflected in the score of the last scenario that dealt with patients' medical data.

7.5.3.3 Disaster Response

In this phase, all the proposed scenarios were to cover some of the vital tasks of the disaster response phase. Furthermore, RFID was considered as a technology that could enhance the quality and efficiency of the suggested activities. The results of this phase are presented in Table 7.22

Table 7.22

Disaster Response Scenarios and Experts' Responses

	Scenario	Agree	Neutral or Disagree	Response Mean
Q1	Paper triage complicates information turnover and has several limitations such as being easily damaged or destroyed and having the limited space for information, but RFID tags facilitate the response	3	5	3

	mission and eliminate the drawbacks of paper triage. RFID tags have this capability that the first responder writes triage once and after that all information can be captured automatically and even transferred to the database and all of which brings time efficiency during response mission.			
Q2	By using RFID tags (especially if people start using them from the previous stages), since all the important health information is already available on their tags, patients care continuity would be guaranteed.	2	6	3.12
Q3	By using RFID tags during response phase, victim identification and tracking would be facilitated, something which is time consuming and in certain circumstances impossible through the traditional way. Patients/medication misidentification and generally medicinal care can be very vulnerable to different kinds of errors, even fatal ones; however, RFID can help to recognise the patients faster and more easily improve disaster victim tracking, triage, patient care, and facility management; moreover, it can improve response times, help to present more effective ‘first response’, and thus reduce the mortality rate.	5	3	3.87
Q4	By using RFID in the healthcare centres (especially from preparedness phase), since responders have the real-time information on the available medical	4	4	3.87

	resources on each healthcare centre, they are able to transport victims to the correct facility as quickly as possible.			

Among all the available scenarios, experts came into an agreement on one of them that tried to enhance the patient identification task. The experts' comments included:

- *Victim identification is an important aspect where RFID can help*

- *Associate the technology to individual information seems more reliable in case of disaster*

- *As noted, victim identification is important (particularly for evacuated / refugee communities)*

In this phase, like the previous phase, the scenario that dealt with casualties' information received the lowest rating due to the privacy and security concern over RFID technology and the need for a validation procedure.

Regarding the first two scenarios, the participants suggested EHR technology rather than RFID; their viewpoints were:

- *paper being replaced by EHR, EMRs, and patient portals*

- *probably EHRs will be providing this in the future*

Furthermore, one of the experts believed that:

- *limited feasibility of RFID for this purpose; also, data has to be read directly from RFID tag located at citizen/victim, and hence health data is not available for remote decision making*

The last comment was about transferring disaster victims to the correct healthcare facilities. The experts suggested that there was a need for central disaster management to get support from "automatic response system(s)" and in this regard:

- *information about available resources gained from RFID can help*

7.5.3.4 Disaster Recovery

For disaster recovery, the RFID role was evaluated through five scenarios, and the participants supported the first and last scenarios as suitable applications for RFID in the recovery phase. Although one of the experts believed that tele-monitoring systems with healthcare sensors were designed specifically for this purpose, and another one said, "*Likely EHR will perform this role in future*." The details of the gathered scores are shown in Table 7.23.

Table 7.23

Disaster Recovery Scenarios and Experts' Responses

	Scenario	**Agree**	**Neutral or Disagree**	**Response Mean**
Q1	By using RFID special tags this opportunity is given to healthcare providers to continuously monitor patients' health conditions, record and report vital signs all of which lead to optimising care management and reducing.	5	3	3.75
Q2	By using RFID tags, since all the victim's health condition information before disaster and during response time is available on the tag, care disruption caused by disasters will be reduced, specifically for people with chronic disease, and continuity of care becomes possible	4	4	3.62
Q3	Through real-time monitoring capabilities of RFID, it would be possible to provide special advice to remote patients	4	4	3.50
Q4	One of the tasks in this stage is fatalities identification which can be improved through using RFID tags instead of paper ones that would facilitate further related procedures like	4	4	3.62

	their location tracking and transferring to their relatives.			
Q5	Since, top managers have real-time and precise information about medical resources either used or in stock, they would be able to do medical planning for recovery more effectively and efficiently.	5	3	4

7.6 Delphi Round 2

After finishing the first round, a report summarising the gathered responses in round 1 was prepared for the participants (Appendix J). Then the second questionnaire (Appendix I) was prepared based on the analyses of the first round responses with the same design considerations. This questionnaire had two sections: a section for the scope of DEH and the other for the RFID applications.

The first section of the questionnaire was prepared based on the experts' feedback in the first round and its analysis. However, in the second section, due to the large number of identified scenarios or potential usages of RFID, it was decided to examine the role of RFID with a new set of scenarios. Like the previous round, some scenarios were proposed for each disaster phase to examine the role of RFID technology, and the experts were asked to rank the applications.

This round followed two major objectives:

1- Getting the experts' feedback on the proposed changes and finalising the DEH scope
2- Identifying the RFID role for a range of applications defined in the scenarios

In this round, the questionnaire was sent to the same group of experts, but only seven replied (Table 7.24). The following sections discuss the obtained responses in round 2.

Table 7.24

Participants Participation in the Second Round

	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9
Round 1	✓	✓	✓	✓	✓	✓	✓	✓	✓
Round 2	✕	✓	✕	✓	✓	✓	✓	✓	✓

7.6.1 The Scope of DEH

In this section, the participants were asked to comment on different aspects of the DEH scope as modified based on their feedback from the first round. Similar to questionnaire 1, this section started with the questions related to the DEH scope, and the experts were asked to provide their viewpoints regarding the revised scope elements. Each element is discussed in the following sub-sections.

7.6.1.1 Technologies in the Scope of DEH

The first question of this section was about the technologies included in the DEH scope based on the gathered responses from the first round (Figure 7.8).

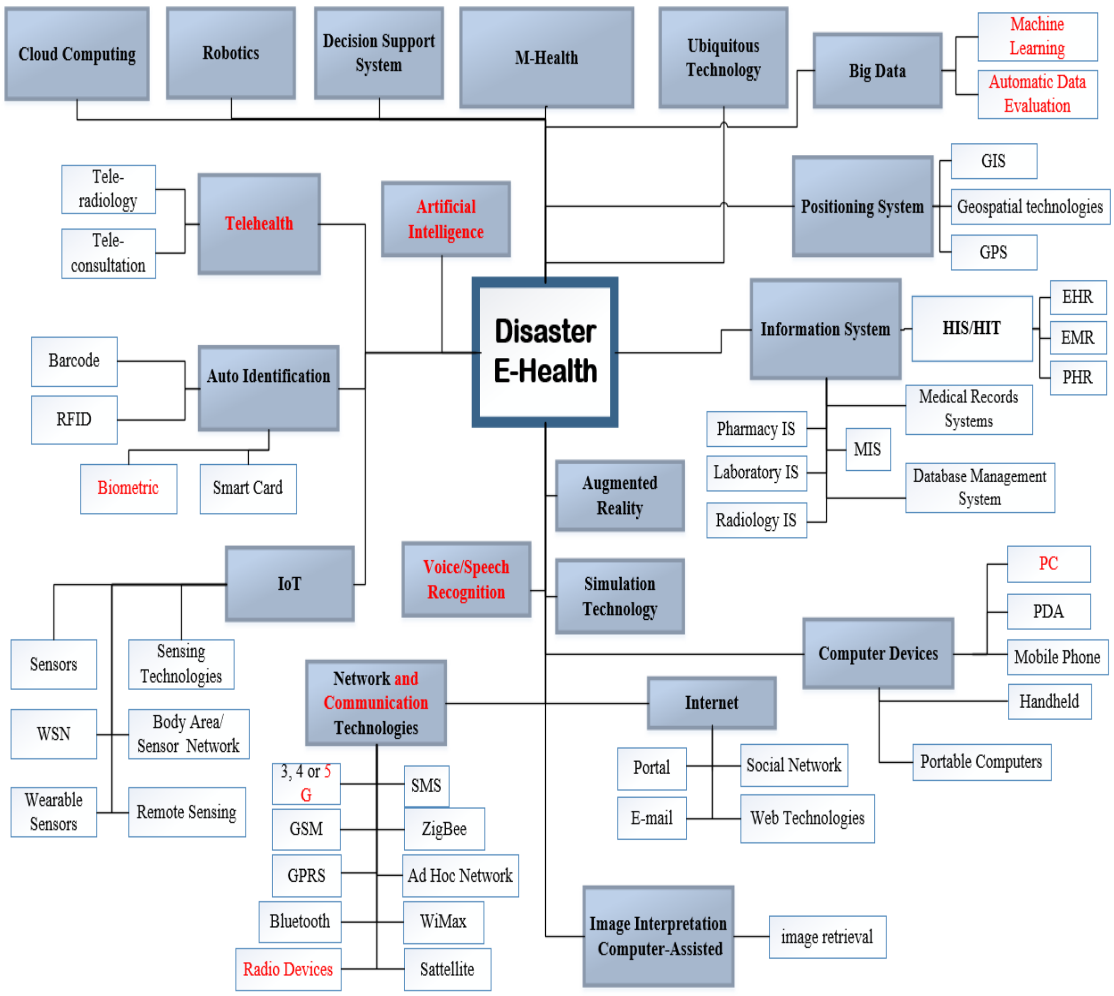

Figure 7.8 DEH technologies based on the first round responses

For this question, only the following comments were collected:

- *adding command and control systems*
- *xG (referring to 5G and future generations)*
- *Legacy technology (such as radio, telephone landlines, and any other old system that is not electronics based)*

Except one expert, all the other experts who commented on the biometric technologies agreed on the added technologies from the last round. That one expert stated:

- *Biometric Identification will slow down the process. I cannot see great value of adding machine learning*

7.6.1.2 Application Included in the DEH Scope

In the second question, the experts were asked to comment on the modified version of DEH application (Figure 7.9)

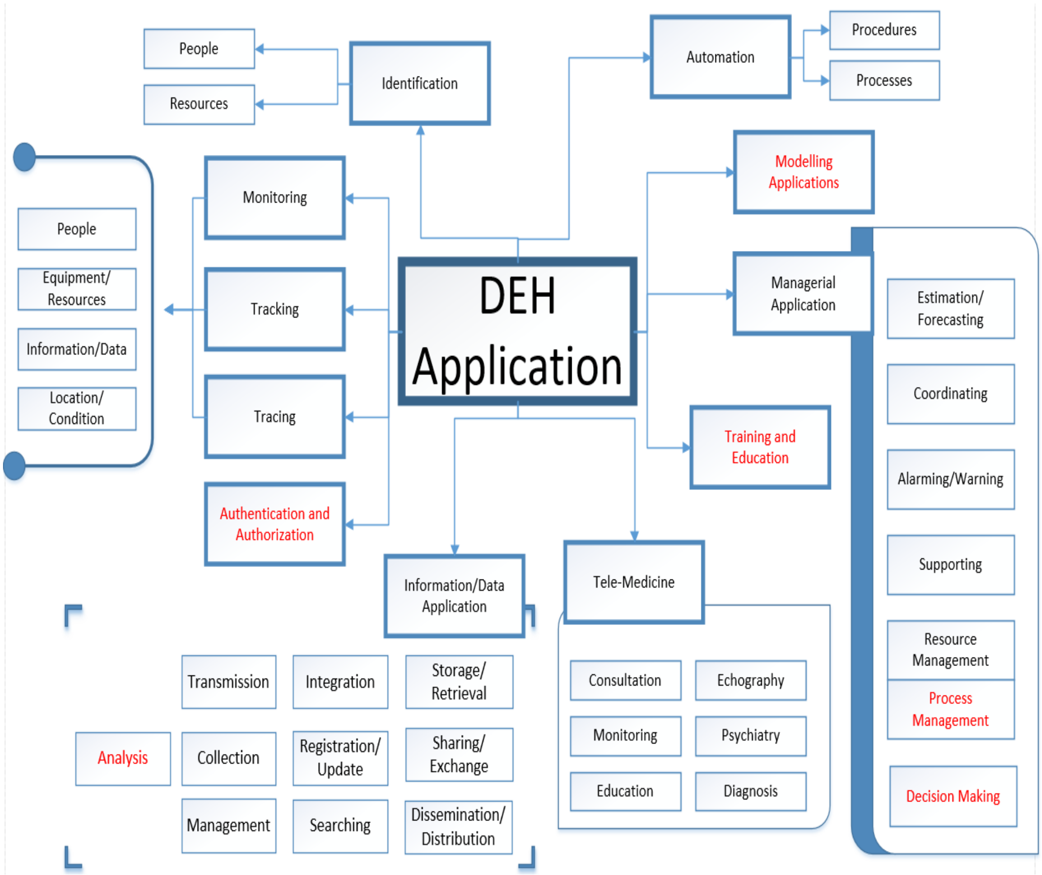

Figure 7.9 DEH applications based on the first round responses

The following comments (Table 7.25) were given on the DEH application and its modification resulted from round 1 of the Delphi.

Table 7.25

Experts' Feedback on the DEH Application – the Second Round

Expert	Added	Removed
2	*"Policy Making" should be part of "Managerial Applications" "Identification" and "Authentication and Authorisation" are closely related; BUT: the authorisation can/should be condition based, e.g. other access rights should get in place in a disaster situation than normally!*	*"Automation" hangs a bit in the air as an own application (with procedures and processes); seems to be rather a technology, that is part of "Information/Data Applications", also of "TeleMedicine"*
4	*Evaluation should be represented as activity and also simulation (can be used for both training an evaluation purposes)*	
5	*No Comment*	
6	- *Agreed with red ones* - *Disaster Management* - *Emergency Medicine* - *Preventive medicine* - *Ethical* - *Cultural* - *Organisational* - *Political* - *Policy-making*	
7	*No Comment*	
8	*All added are valuable*	
9	*What about data visualisation applications to be added, including social network analysis apps*	

7.6.1.3 DEH Stakeholders

In the last question of this section, the participants were asked to give their viewpoints with regard to the stakeholders that can be a part of DEH scope. This round's diagram was created according to their previous comments (Figure 7.10). In this round, the experts added a number of other stakeholders to the scope (Table 7.26).

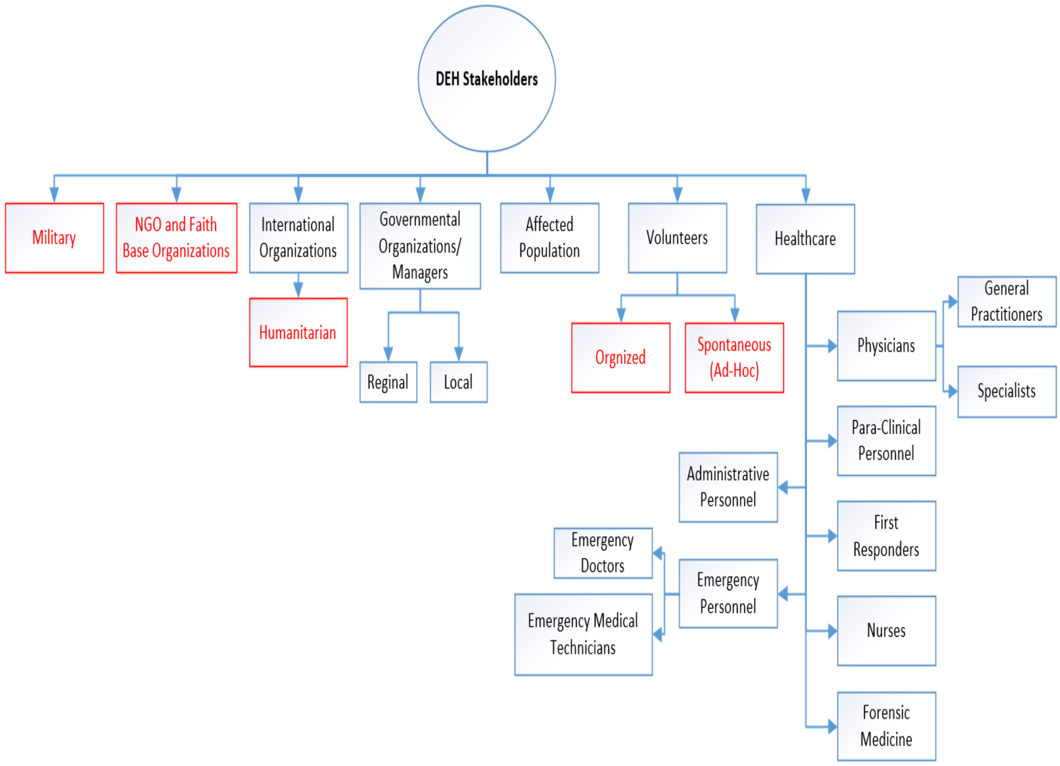

Figure 7.10 DEH stakeholders based on the first round responses

Table 7.26

DEH Stakeholders – Round 2

Expert	Added	Removed
2	*Vendors and operators of infrastructure*	
4	*Collaboration partners with whom emergency personnel need to communicate, e.g. the rescue services*	

	and the Police (or are they included in first responders category)?	
5	*Bio-Containment units; Clinics; Hospital* *(within healthcare, you focus on individuals; however you also have organisational stakeholders mentioned except the ones above)*	
6	*Politicians (local, regional, national, international)* *Law and order (e.g., Police not only as first-responders but involved in decision making and planning)*	
7	*No Comment*	
8		*Faith Based Organisation could trigger great tension during disaster management with their restrictions and caveats. For some of the NGOs it's the same, therefore I will add such an organisation after careful analyses.* *Spontaneous volunteers could hamper the efforts in the rescue phase when the time is crucial, so it's better to add them into the recovery phase.*
9	- *Police* - *USAR* - *Civil defence*	

	- *In terms of international organisations it's more than just humanitarian it includes international police, civil defence, USAR, military – health personnel.*	

7.6.2 The Application of RFID Technology

In this round of the Delphi, another set of scenarios were provided, and like the previous round, they were categorised into different disaster phases to identify the application of RFID for further utilisations within DMC and DEH scope. In this section, a total number of 17 scenarios were designed and the participants were asked to rank them based on the desirability of having them within DMC. The overall responses to these scenarios are shown in Table 7.27.

Table 7.27

The Overall Participants Answers to the RFID Questions – Round Two

		Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9
Mitigation	**Q1**	-	3	-	-	4	3	5	5	3
	Q2	-	3	-	-	3	3	5	5	4
	Q3	-	4	-	-	3	3	5	5	3
	Q4	-	5	-	-	1	3	4	3	3
Preparedness	**Q1**	-	5	-	-	4	3	4	5	3
	Q2	-	4	-	-	3	3	4	4	3
	Q3	-	2	-	-	2	3	5	4	3
	Q4	-	1	-	-	2	3	5	4	3
	Q5	-	3	-	-	3	3	3	3	3

Response	**Q1**	-	5	-	-	5	5	4	5	3
	Q2	-	4	-	-	5	5	4	5	3
	Q3	-	1	-	-	5	5	5	5	3
	Q4	-	3	-	-	5	5	5	3	3
	Q5	-	2	-	-	3	5	5	5	3
Recovery	**Q1**	-	1	-	-	5	5	4	4	2
	Q2	-	2	-	-	3	5	3	4	2
	Q3	-	1	-	-	4	5	4	4	2

Based on the obtained responses for the RFID questions, in the second round, Table 7.28 shows the minimum, maximum, and mean values of the experts' responses to each question.

Table 7.28

Minimum, Maximum, and Mean of the Responses to the RFID Questions (Round Two)

Phase	Question	No of Experts	Minimum	Maximum	Mean
Mitigation	1	6	3	5	3.83
	2	6	3	5	3.83
	3	6	3	5	3.83
	4	6	1	5	3.17
Preparedness	1	6	3	5	4
	2	6	3	4	3.5
	3	6	2	5	3.17
	4	6	1	5	3
	4	6	3	3	3
Response	1	6	3	5	4.5
	2	6	3	5	4.33
	3	6	1	5	4
	4	6	3	5	4
	5	6	2	5	3.83
Recovery	1	6	1	5	3.5
	2	6	2	5	3.17
	3	6	1	5	3.33

The following subsections represent the obtained scores for each RFID scenario in the disaster phases together with the experts' feedback.

7.6.2.1 Disaster Mitigation

In this section, different scenarios were proposed to assess the RFID utilisations. The scenarios are presented in Table 7.29.

Table 7.29

Disaster Mitigation Scenarios and Experts' Responses

	Scenario	Agree	Neutral or Disagree	Response Mean
Q1	By equipping medical resources at each health centre with RFID tags, there could be a potential for improvement in the quality and accuracy of the local, regional and even national medical resources assessment.	3	3	3.83
Q2	There is a potential to develop an information system based on RFID to automatically gather medical resources data and integrate them into different levels of local, regional, federal and, finally, the disaster plan.	3	3	3.83
Q3	At health centres if medical resources, staff, and patients are equipped with RFID tags, current healthcare situation can be assessed by considering the available medical resources, in-patients and their conditions, and pattern of medical resources usage, for essential medical plan in relation to disaster vulnerability analysis	3	3	3.83

Q4	One of the issues that hinders providing a proper disaster response plan is lack of research. One of the reasons is, during response due to overwhelming conditions and chaotic environments, limited statistics or reports are available regarding the quality and effectiveness of the response activities, shortage in medical supplies, etc. However, if RFID is being utilised, this problem can be solved at least to some extent because of automatic data capturing. Therefore, for future disaster preparedness and response planning, past disasters can be referred to and reduce the probability of the same shortcoming appearing.	2	4	3.17

Based on the obtained responses, although different experts found each scenario applicable and supported it, none of the proposed scenarios for RFID application obtained the experts' agreement, according to the frequency distribution. The main reason, especially for scenarios 2 and 3, according to one expert who has good knowledge on RFID, is:

> - *Potential is there, but we need to be concerned with privacy and security of personal health data at least here in the US.*

On the other hand, the experts' concern regarding the rest of the applications was security and privacy, out-building positioning, and accessibility of the technology at the time of the disaster.

7.6.2.2 Disaster Preparedness

The proposed scenarios for this phase were designed with regard to preparation for future disasters by utilising RFID technologies for different purposes. These purposes included future demand prediction and, accordingly, preparing appropriate disaster response plans by identifying and monitoring pattern of medical usage, and monitoring level of medicine stock. The proposed scenarios and the frequency distribution of the responses are delineated in Table 7.30.

Table 7.30

Disaster Preparedness Scenarios and Experts' Responses

	Scenario	Agree	Neutral or Disagree	Response Mean
Q1	By tagging all medical resources, their pattern of usage (drug consumption) can be monitored automatically. Then, by sharing the identified pattern among healthcare centres, a warning system can be developed. This system has the potential to identify epidemic outbreaks and forecast epidemiology disasters by analysing medical resources usage pattern.	4	2	4
Q2	If all the medicine is tagged with RFID by the pharmaceutical companies, authorities might be able to match inventory level of medicine with population size in each region and their demands. Therefore, societies can be well prepared for disasters.	3	3	3.5
Q3	By using RFID tags on medical resources, patients and medical documents, the integration of health centres into existing EMR/EHR systems can be facilitated since all information can be gathered automatically and regularly without human intervention	2	4	3.17

	and the latter one also improves information quality.			
Q4	If in each region all medical resources and equipment or even medical staff are equipped with RFID tags, the authorities are able to match patient loads and needs with available hospital resources for each healthcare centre. This scenario specifically benefits people with chronic diseases or those who need constant health monitoring and medicine. The ultimate advantage can be preparing a disaster response plan based on the available medical resources and people's medical requirements.	2	4	3
Q5	If people in healthcare centres (or any other places) tagged with RFID, the pattern of their movement within the area can be captured automatically. By analysing the captured patterns, more effective plans can be developed for evacuation in healthcare centres.	0	6	3

In this phase, most experts found applicable the first scenario regarding the potential to improve identification of an epidemic outbreak. In contrast, the last scenario received no supporters, and five experts voted 'neutral' and the last one completely disagreed with the proposed scenario. The gathered experts' comments once again highlighted the privacy concerns:

> - *I would caution about privacy considerations. It depends on who has access to match inventory.*

Regarding the fourth scenario, one of the experts mentioned:

- RFID is not the right technology for wide-area tracking of resources at regional level

7.6.2.3 Disaster Response

In this phase, all the RFID applications concentrated on enhancing information availability, communication and quality, facilitating medical resources identification, and improving decision-making. The proposed applications were explained through five different scenarios demonstrated in Table 7.31 together with responses.

Table 7.31

Disaster Response Scenarios and Experts' Responses

	Scenario	Agree	Neutral or Disagree	Response Mean
Q1	Using RFID makes it possible to keep track of the origin of the goods along each step of their delivery to the affected area. So RFID can be used to identify, mobilise, dispatch, and track the resources required to support incident management activities.	5	1	4.5
Q2	By tagging medical equipment and supplies, managing and coordinating these supplies as well as identifying idle resources at the disaster site can be facilitated. So disaster authorities can provide better management and coordination of disaster response activities	5	1	4.33
Q3	Due to infrastructure degradation, communication is one of the bottlenecks of disaster response tasks. In this regard, RFID can be useful because of its ability to collect	4	2	4

	information without Internet connectivity and store the data until connectivity is available.			
Q4	If RFID is deployed properly in healthcare centres, during disaster response, authorities are able to analyse the number of patients inbound with number of available hospital beds and medical resources. Therefore, they can make rapid and accurate decisions	2	4	4
Q5	Replacing paper triage with RFID tags can reduce the number of over triage and wasting medical resources. Also, they can be used for early identification of epidemiological crisis in a camp of displaced refugees (based on the gathered information of the used medicine and casualties' health status).	3	3	3.83

Among the five scenarios, the first three achieved experts' consensus. One of the experts commented on scenario four and supported the proposed application of RFID *"within the hospital system"*. Another expert explained their viewpoint on the last scenario as below:

> *- not sure how RFID should replace "paper triage" (or other electronic triage", as RFID can only provide an identifier (of a patient, a resource, etc.)*

7.6.2.4 Disaster Recovery

In this phase, the focus of the proposed application was on replacing the paper documentation with RFID tags to facilitate information availability and tracking after the disaster response. In this regards, three applications were proposed that are shown in Table 7.32 together with the frequencies of the responses.

Table 7. 32

Disaster Recovery Scenarios and Experts' Responses

	Scenario	Agree	Neutral or Disagree	Response Mean
Q1	If during response time all disaster casualties were equipped with RFID tags, reuniting families can be facilitated because the (near) real-time information of all people and their locations is available.	4	2	3.5
Q2	Instead of paper documentation, RFID tags can be used to keep track of disaster victims' health nutrition plans. In this regard, the chance of losing document(s) or medical error due to people's handwriting can be reduced.	2	4	3.17
Q3	Mental health consequences of disasters are one of the common disaster effects that needs long-term medical planning. In this case, RFID can be used to hold people's mental health background and their current treatment. Therefore, patients will be able to refer to any healthcare centres without needing to have paper medical documents or explaining to a new physician their mental conditions and symptoms from the beginning.	4	2	3.33

Among the scenarios, the first and the last ones were generally accepted by the participants. However, some of the experts provided the following comments:

- *RFID is not applicable for wide-area localisation*

- *No idea how RFID should be applicable for "holding people's mental background and their current treatment"*

On the other hand, one of the experts supported the last proposed application but mentioned the following concern:

- *While this will be helpful for medical professionals, this may be a concern for information leaving the hospital environment*

The other experts for the first and second scenarios provided the following reasons for their rejections, respectively:

- *RFID is not applicable for wide-area localisation*

- *RFID tags as such cannot store nutrition plans, medication plans etc.*

7.7 Summary

In this chapter, first the conducted Delphi Method was comprehensively discussed including all the processes and procedures that were taken in this phase. All the research and questionnaire design and distribution considerations were also discussed in details. Then, in the second section of this chapter, the results of the obtained responses from conducting the two rounds of the Delphi method were presented.

CHAPTER 8

DISCUSSION AND CONCLUSIONS

8.1 Introduction

This chapter provides an explanation for the research results and then discuss issues arising from them. It concludes the thesis with an overview of the research study, how the research achieved its initial objectives and the answers to the research questions (RQ). In this chapter, the outcome of the Delphi method is integrated and correlated with the scoping study and the functional scenarios. Therefore, the main objective of this chapter is to integrate, summarise, and explain all the obtained research results in a context of the healthcare-related challenges within the disaster management cycle (DMC) and utilising e-health technologies to address those challenges.

In section 8.2, an overview of the research and its objectives is outlined. Then, in section 8.3, the implications of the research findings related to the research questions (section 1.6) are discussed. Furthermore, in sections 8.4 and 8.5, the overall research contributions and implications are presented, respectively. The research conclusion is explained in section 8.6 and then research limitations are identified in section 8.7. According to these limitations, some recommendations for future work are given in section 8.8. Finally, section 8.9 summarises this chapter.

8.2 Overview of the Research

Integrating and systematically utilising e-health technologies can significantly enhance the efficiency and effectiveness of disaster management and disaster medicine activities within DMC. This integration forms the DEH domain, which is an intersection of disaster management, disaster medicine, and e-health. DEH's main aim is integrating e-health technologies within DMC so that these technologies can be used more routinely rather than on an ad hoc basis. This integration may lead to improving the performance of healthcare and enhancing the quality of its delivered services at the three stages of before, during and after disasters.

For successful deployment and usage of DEH by different groups, such as disaster management and disaster medicine personnel, it is necessary to identify its scope so that people know the field's goals, functionalities, abilities, and potentials. Therefore, in this thesis, certain approaches and procedures (discussed in chapters 5 and 6) have been followed to identify and propose a DEH scope that was the core of the research. In this context, there was a need to understand by extracting from the published research the current challenges of disaster management and disaster medicine, particularly those related to healthcare (chapter 2). To this point, the proposed research objectives 1 and 2 (chapter 1, section 1. 5) were covered. In the next stage, the potential and advantages of e-health utilisations, both in healthcare and in the disaster management cycle (DMC), were investigated. In this way, an opportunity was provided for the researcher to identify the potential of e-health technologies that facilitate their incorporation in the DMC.

The initial scope was identified and formed through conducting an extensive and rigorous scoping study based on the results of the controlled and uncontrolled searches (see chapter 5). All the steps of the conducted scoping study were comprehensively explained in chapter 5.

Then, the possibility of systematic and meaningful scenarios generation, for each phase of disasters, was examined. The related processes and procedure to create such scenarios were discussed in chapter 6. In addition, to facilitate the scenarios' implementation in DMC, some e-health technologies were proposed based on the DEH scoping results. Considering the generated scenarios and discussed results of chapter 6, it can be concluded that different DEH stakeholders can use 'functional scenario generation method' and the followed approach for further possible expansion in disaster related scenarios. The implemented method in this thesis will allow disaster managers or any other authorities to employ it to generate meaningful scenarios based on the disaster phase and type that, in turn, allows them to forecast healthcare requirements and identify the appropriate-health technology(ies) to address them.

In the final stage of the research, the experts were asked to evaluate the proposed scope for DEH as well as a number of scenarios for the RFID applications within DMC, which were produced according to the scenario generation method. For this purpose, the Delphi method was conducted in two rounds in which the participants assessed the DEH scope and RFID applications and gave their feedback. The rationale behind experts' evaluation was to finalise the scope of DEH and identify the most suitable applications of RFID within DMC and the DEH scope. The results of the questionnaire and the experts' responses were presented in chapter 7 and are discussed in this chapter. In the following sections, each research question is addressed and answered separately.

8.3 Addressing Research Questions

The purpose of this section is to discuss the initial research questions by reflecting on the research findings pertinent to each question.

8.3.1 RQ 1: What is the scope of DEH?

To ensure successful implementation and application of the DEH, a range of different factors should be identified. These factors can significantly influence the DEH adoption as well. Therefore, they should be identified as 'the elements of the scope of the DEH domain'.

This particular research question can be considered as residing at the core of this thesis. Therefore, this research was undertaken with the main objective of identifying and defining the DEH scope (addressing research objective 4). This need arose from the research undertaken by Sieben et al. (2012) and Maturana et al. (2012), in which they pointed out several issues set out below:

1. No one has systematically examined maximising integration of using e-health within DMC.
2. e-Health technologies need to be integrated with DMC and disaster management practice before a disaster happens – not as the disaster's aftermath.
3. There is no focused study yet regarding the integration of e-health within DMCs.

4. Although some e-health tools are employed in disaster settings, no systematic examination is available as to how and where in disaster management it is possible to apply e-health.

These issues led various researchers to define the DEH field which, in turn, necessitates identifying its scope (Althwab & Norris, 2013; Norris et al., 2015).

Consequently, this thesis sought to address the above points related to the research deficiencies through implementing a very comprehensive scoping study across the three different fields of disaster management, disaster medicine and e-health. This comprehensive review of the past research studies was necessary as Templier and Paré (2015) maintain that the essential step for developing any field is revealing prior knowledge.

To conduct the scoping study, a framework was developed based on the original framework proposed by Arksey and O'Malley (2005). The main difference between the employed framework and the original one was the former having an additional step for evaluating the results of the scoping study. Furthermore, some other enhancements, such as clarity of the fields' definitions and their main boundaries, and controlled and uncontrolled keywords selection, were implemented. The scoping study findings were discussed in chapter 5, and the fields' experts evaluated them through the Delphi method (see chapter 7). Therefore, based on the second round of Delphi, the finalised scope of DEH is defined below:

a. Technologies: The included technologies based on the research findings and gathered feedback from the fields' experts in two rounds of the Delphi are demonstrated in Figure 8.1.

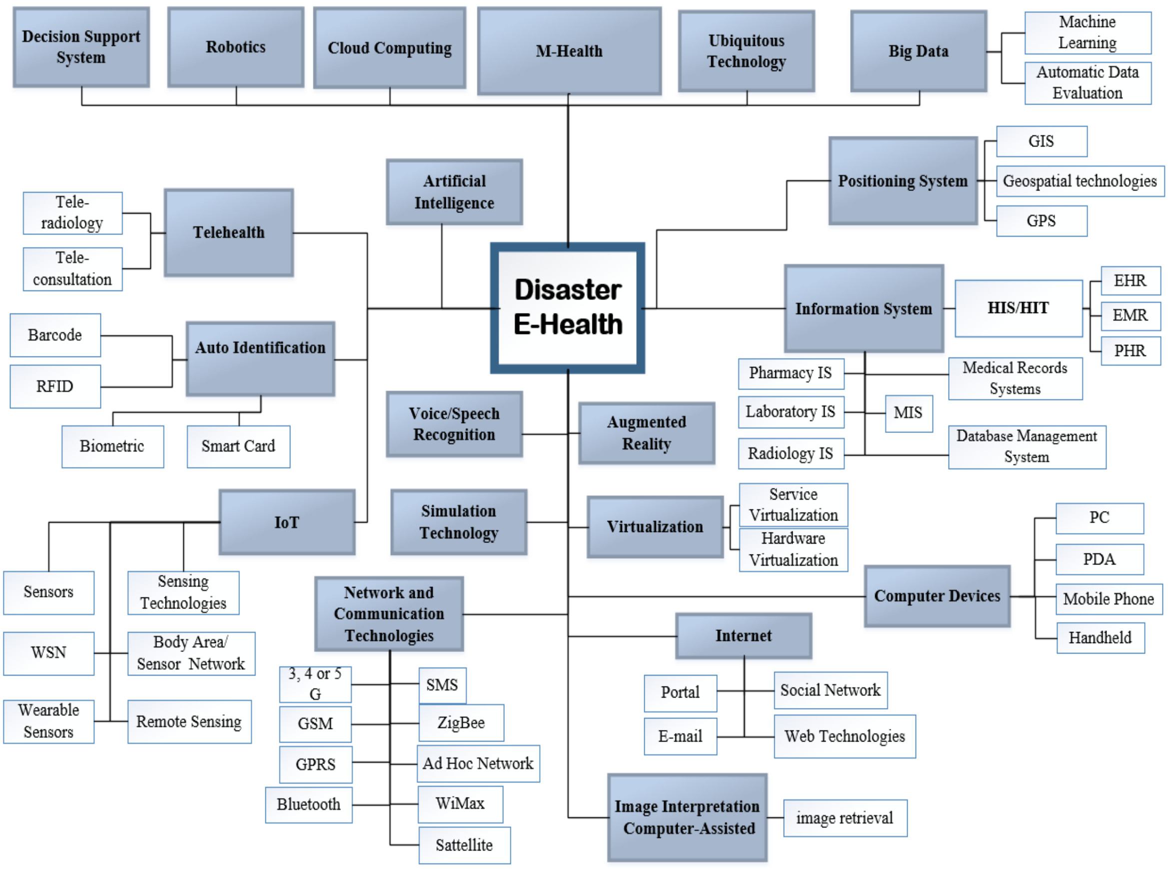

Figure 8.1 Included technologies in the DEH

The identified e-health technologies within DEH were used in the technology-use scenarios model (chapter 6) in which one or more e-health technologies were proposed for the identified scenarios to address DMC challenges. This model helps to identify how current e-health technologies can be used in DMC to facilitate DMC activities.

b. Application: Based on the included technologies in the DEH scope, a variety of applications can be expected in that scope. These applications have been divided into different categories as illustrated in Figure 8.2.

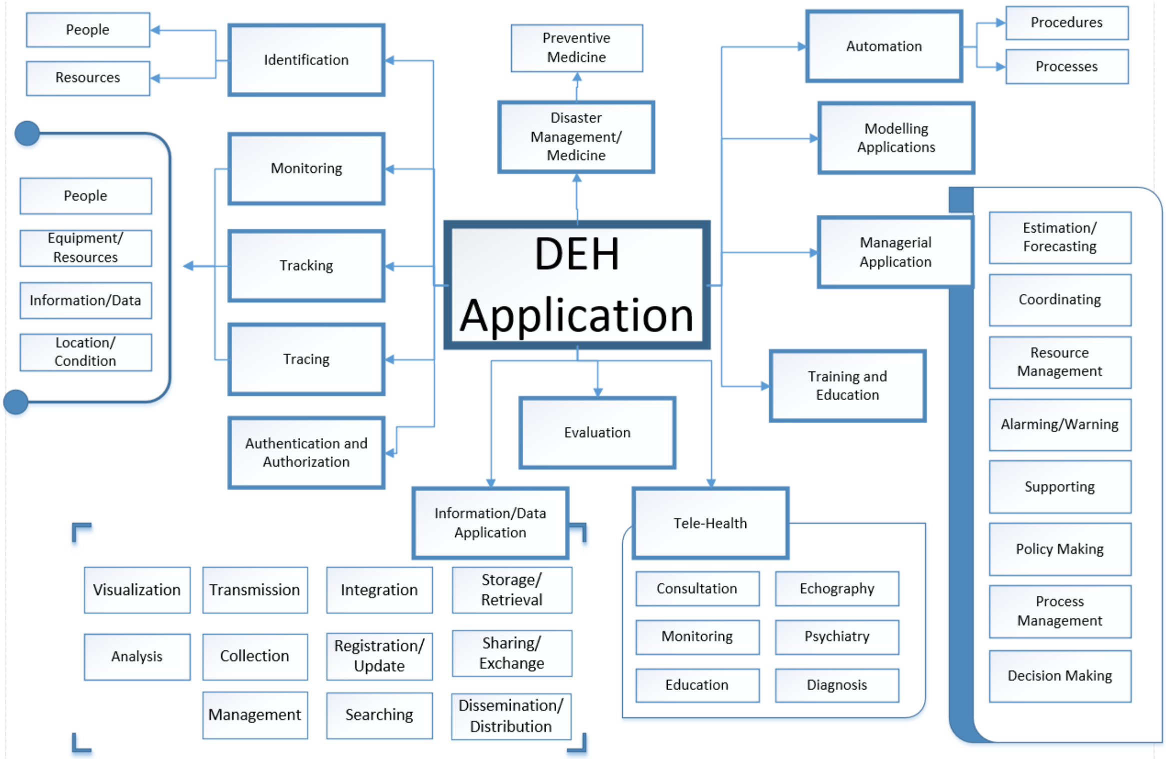

Figure 8.2 Included applications in the DEH

These identified applications within the DEH scope were also used in the model that was proposed for the functional scenarios in chapter 6. This model demonstrates the use of e-health technologies in DEH that shows how, when, and where these applications may facilitate DMC activities. As such, these applications clearly illustrate how DEH can support practitioners in the disaster management and disaster medicine fields.

c. Stakeholders: as discussed in chapter 6, if DEH is considered as a system, several actors or stakeholders are working with this system to achieve their goals and objectives. These stakeholders, based on the scoping study results and the experts' comments, are shown in Figure 8.3.

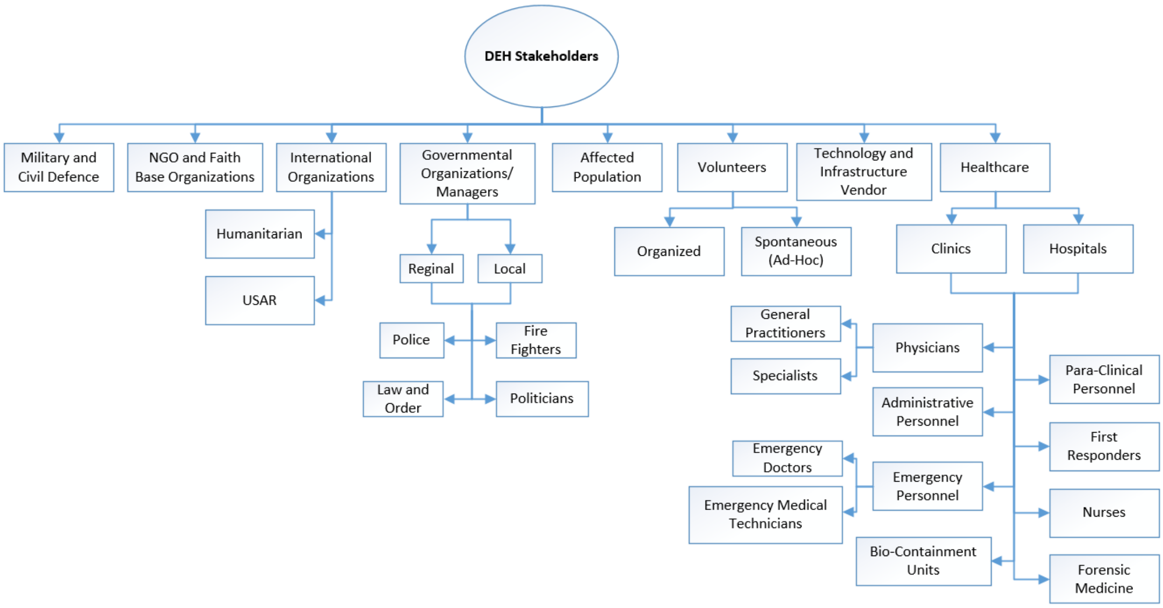

Figure 8.3 DEH stakeholders

Regarding the DEH technologies, their applications, and the involved stakeholders, the DEH scope also may involve several services. These services sit at three levels - operational, tactical and strategic - for both clinical and non-clinical purposes. Also, a variety features of e-health applications and services can be identified as discussed in chapter 5, sections 5.5.5 to 5.5.7. Moreover, depending on the technologies and applications involved in the DEH scope, DEH can provide local as well as remote services for all disaster phases in almost all disaster types, including natural, manmade, and disease epidemics. However, it should be noted that DEH is still a live and dynamic field that can be influenced by rapid advances in the e-health field. Therefore, it is possible to add more technologies in the DEH field, which, in turn, can modify and expand the applications, features, and some other aspects of the DEH scope.

Furthermore, to successfully utilise DEH in different countries, there is a need to refer to the available infrastructure in those countries. Since the infrastructure in developing and developed countries are significantly different, it is possible that some of the technologies and their applications are just suitable for developed nations. However, for the developing countries, one can refer to the technologies with minimal required infrastructure.

8.3.2 RQ 2: In the identified functional scenarios which e-health technologies are appropriate to satisfy healthcare requirements within DMC and DEH scope?

Although the scope of DEH has been introduced in previous sections, several factors can influence technology utilisations, their applications and the stakeholders' expectations. These factors include disaster phase and type, current or available infrastructure, and the targeted people/stakeholders. Their influence can be assessed by considering the requirements of each and which competencies are available to satisfy those requirements. Moreover, due to the specific characteristics of each disaster type and the main objectives of the disaster phases, there is a possibility that some technologies and their applications are more appropriate in a certain disaster phase than others. Therefore, the factors mentioned above should be specified through comprehensive scenarios.

In this respect, research question 2 was set specifically to guide an examination of the applicability of representing e-health technologies usage in functional scenarios and generating systematic and meaningful scenarios in the DEH field. Generating meaningful scenarios for each disaster phase and within the DEH scope entails following a systematic method as DEH has a wide scope that encompasses several technologies, applications and services, and it has several stakeholders. Each of the identified stakeholders may have different expectations from the DEH, its technologies, and applications. Therefore, to identify DEH capabilities to meet stakeholder demands, as well as their goals and objectives, the need for a systematic method was highlighted. In other words, this method makes it possible to demonstrate simply what DEH does and with what aim.

To answer this question, the researcher was inspired by use-case methodology from a system engineering perspective, but only up to the level of functional scenarios. For this purpose, DEH is considered as a system that has specific goals or objectives that the system stakeholders, such as disaster managers or disaster medicine personnel, want to achieve. In this study, how the stakeholders can achieve the specific goals was represented through scenarios; for each scenario, some e-health technologies were proposed that have the potential to help and support stakeholders to achieve their goals.

In order to systematically identify DEH functional scenarios and introduce a standard way of scenario generation, as discussed in chapter 6, the model implemented by Poenaru and

Poenaru (2013) for large systems was followed. Based on the introduced model, by following the procedure explained in chapter 6, in each disaster phase DEH can accommodate the requirements of its stakeholders through the specific set of goals. Each goal can further be broken up into several scenarios each of which specifically explains some requirements or intended activities the stakeholders intend to perform to reach their objective. To this end, any potential DEH confusions are minimised as the goals and stakeholders are limited. Then, to support DEH stakeholders to reach their intended objectives more effectively and efficiently and to facilitate the procedure for this achievement, some e-health technologies within the DEH scope can be proposed.

For the purpose of this research, for each identified goal, due to time limitation, just a few scenarios were identified and the related e-health technologies were proposed. However, by considering each goal, several other scenarios can be generated to demonstrate the detailed interaction between DEH and its users. Additionally, the scenarios can be used for analysing and designing further application(s) or tool(s) within the DEH scope. This model of development is highly appealing to stakeholders as they are able to explain their requirements and demands in non-technical and practical terms (Safdari et al., 2013).

In addition, by answering this research question and generating disaster scenarios for disaster phases it was clearly demonstrated how the current e-health technologies that are within the DEH scope can be applied and fit into the DMC. In this way, it was expected that the demonstrated scenarios be able to contribute to revealing the potential advantages of different types of e-health technologies and provide a better understanding of their influences on minimising at least some, if not all, of the current challenges in the area of disaster management and disaster medicine.

8.3.3 RQ 3: What is the role of RFID technology in DMC and within the DEH scope?

For the identified DEH goals in each disaster phase, a number of scenarios were proposed for which a number of e-health technologies were recommended (chapter 6). Those technology recommendations were based solely on the DEH scoping study. According to the results, the proposed technologies were utilised either in normal healthcare or in

DMC. However, the focus of this particular research question was only on RFID technology.

As it can be seen in chapter 6, sections 6.3.1 to 6.3.4, the role of RFID is highlighted mostly in disaster response and recovery, although some applications based on RFID technology in disaster preparation have also been identified. Based on the DEH scoping study, RFID can be used in disaster response for various goals among which its application for supply chain management (SCM) is dominant. In SCM, where implemented, RFID has proven successful for resources identification, tracking and tracing, and facilitating coordination of the whole supply chain. Therefore, the researcher believes that it is possible to solve through utilising RFID applications a high percentage of the disaster response challenges related to the disaster supply chain, such as identifying and tracking medical resources and their accurate coordination in the response missions, determining idle resources, and maximising their utilisation during response activities. Besides medical resources, there is the possibility of using RFID for the same purposes for people who might be medical people or first responders in different disaster phases.

Furthermore, RFID application for SCM possibly can benefit activities in disaster mitigation and preparedness phases. In these phases, RFID can be used for timely identification of resources and tracking their usage. Therefore, authorities are able to check the inventory level of healthcare environments, distribution centres and even pharmaceutical companies. This application during disaster mitigation and preparedness not only may enhance early detection of disease epidemics, but also may improve medical resources distribution and maintaining stockpile levels.

Also, according to the DEH scoping study results, RFID can improve and facilitate data/information management. Since RFID automatically collects information and stores it on the embedded memory or transfers it to a central repository, different parties in the response missions can have real-time or near real-time information from disaster sites. This feature helps decision makers to have precise and real-time information from disaster sites that helps to enhance the quality of their decisions. The same feature is useful if network infrastructure in the disaster site is affected by disaster. In such circumstances, RFID can be used as a standalone technology that has the ability to capture information and save it on its memory. Subsequently, when connection between disaster-affected areas and other areas is re-established, the stored information can be uploaded to a central database and be accessible to any authorised person outside the disaster areas.

As discussed in chapter 3, RFID also has a proven record of applications in the healthcare sector. RFID can serve purposes on top of all the identifications, tracking and tracing functionalities for both physical objects and people. All these applications for both healthcare and disasters have been comprehensively discussed in chapter 3. However, according to material presented in chapter 6 and DEH goals, RFID can be considered as an appropriate technology for early identification of epidemics. People's health conditions can be monitored by physicians, saved on RFID tags and sent to central databases, where further analysis can be performed and any epidemic's trends can be captured based on accurate and timely data. RFID can also solve the over-triage problem in the aftermath of disasters if paper triage is replaces by RFID tags. Therefore, the problem of damage or lost paper triage can be resolved as all the triage information is available on RFID tags to pass through the medical chain. These applications turn all the static paper-based patient data into a dynamic electronic format that can be modified or transferred anytime and anywhere.

Besides the mentioned applications extracted from the DEH scoping study, the researcher identified the possibility of integrating RFID within all disaster phases, and its implementation at the mitigation phase could possibly exploit RFID's full potentials. As Sieben et al. (2012) argued, e-health technologies should be integrated into the DMC before the disaster happen and not just after it. RFID, too, could be one of the few technologies that can be implemented in all disaster phases for various goals, purposes, and applications because it has the potential to bring integration and facilitate cooperation through its unique features. The RFID application for SCM of medical resources is one of the examples of this group.

RFID can be seen as a technology that, by automatically capturing the information in real-time or in pre-set periods, can provide a good infrastructure and rich data. If these data are transferred in giant datasets on the cloud, they can provide a good infrastructure for big data and its analysis. If this trend starts from mitigation, it might detect any possible epidemics disasters from the early stage and significantly minimise their consequences. Additionally, RFID's automatic data capturing can feed peoples' EHR so that after disaster strikes, medical teams have access to a good amount of information about citizens' health backgrounds.

RFID possibly can also be a good fit for research purposes. One of the problems, especially in the disaster response, is that almost all the involved organisations try to provide healthcare support for disaster-affected communities, and data gathering is not undertaken properly. Yet if the data are gathered properly, their analysis can reveal so many hidden aspects of disasters and DMC activities such as: the real bottleneck of response activities and probably their root causes; the performance of each participating organisation within DMC; and possibly the triggers that cause disasters. RFID may well be able to solve this problem due to its automatic data gathering features. If RFID is implemented properly during disaster response, at least some of the data can be gathered automatically and precisely in a way that may enable data analysts to extract some valuable information after disasters.

8.3.4 RQ 4: Among the identified roles for RFID, in the view of the experts, which of them are the most desirable and applicable?

Based on the DEH goals (discussed in chapter 6), for each disaster phase a number of scenarios were selected and expanded. These scenarios constituted a dedicated section in both rounds of the Delphi method. The objective was to consult the fields' experts and gather their feedback on the applicability and desirability of having such applications by utilising RFID technology. Therefore, to answer this research question, the results of the two rounds of Delphi were scrutinised in each disaster phase. The following sub-sections discuss the RFID role within DMC and present the participants' attitudes toward them.

8.3.4.1 Disaster Mitigation

The research participants strongly supported RFID utilisations for the availability of people's vital health information on an RFID tag. Although EHR is the specific technology that deals with such requirements and even provides full and comprehensive healthcare information of individuals, its accessibility during disaster is not guaranteed. The reason is that if the disaster devastates the whole, or a part of the infrastructure, such as the telecommunications network and power, the information cannot be reached. However, with RFID tags and their related readers, the vital information can be retrieved due to its storage on tags embedded memory. In this regard, one of the experts pointed to using a *general purpose smart card for core identification and healthcare data* and another one mentioned the need for *universally compatible readers*.

The experts also found RFID application useful for medical resources identification and localisation. In addition, different information systems can be developed to utilise captured information by RFID tags. These study participants recommended implementing RFID together with an information system in the mitigation phase. The overall system can provide different opportunities such as:

- automatically gathering resources' data and integrating all data into a central repository;
- improving the quality and accuracy of medical resources assessment;
- analysing the medical resources usage pattern;
- predicting associated future demands by identifying the resources in high demand.

These opportunities possibly can be used in medical planning in relation to disaster vulnerability analysis and enhance the quality of decisions of the top managers, authorities and decision makers at different local, regional, and national levels. Equipping medical resources with RFID can provide constant monitoring of the condition of healthcare centres and assessing their situations. This application can identify the efficiency or effectiveness of the healthcare activities in terms of utilised healthcare resources. Since RFID application has proven successful in the area of logistics, its integration into the DMC from the mitigation phase can exploit its full potential. It may also provide a fast and effective response when disasters strike as the information for the medical products and equipment and their number for each healthcare centre is available on a real-time basis.

8.3.4.2 Disaster Preparedness

For the disaster preparedness phase, the automatic data capturing feature of RFID can facilitate data sharing on a regional healthcare centre. The fields' experts supported this technology utilisation for disaster preparedness. Although such data sharing requires the support of some other technologies, for example, cloud computing, the researcher proposes that RFID can play a vital role because the basic requirement of data sharing has precise, and preferably timely, data.

It is also expected that this application has the potential to expand further and facilitate national data sharing. This automatic data sharing application could ensure that the top managers and authorities have key information about the types and availability of the medical resources. It also has the potential to support the Just-in-Time (JIT) disaster plan concept in which the aim is to decrease the procedural and response times. Although the real application of JIT might be in disaster response, without proper preparedness the deployment is most likely to fail. This study's participant experts accepted the concept of RFID utilisation for disaster plan purposes. The requirement for successfully implementing this JIT concept is having accurate and real-time information supported by RFID. If an information system is developed according to these features, by taking advantage of the availability of the (near) real-time information and utilising the critical information, it can facilitate medical resources planning and allocation of new resources to depots. In addition, disaster managers can access this information and, by correlating it with their possible additional datasets, they can exploit the full potential of the system. For example, by using this system and integrating it with people's demographic data at each level, authorities are able to match inventory level of medicine with population size and their demands in each region. Such a system may have the ability to prepare different societies and their communities for disasters.

Based on the above discussion highlighting RFID features and the potential context for their utilisation, the facilitation of data sharing could contribute to the development of a warning system. Such a system has the potential and ability to identify epidemic outbreaks and forecast epidemiology disasters by analysing medical resources usage patterns. The Delphi expert participants found this application useful and desirable to have.

8.3.4.3 Disaster Response

In the disaster response phase, RFID can be used for a variety of applications. In this section those that the experts found useful and applicable are discussed.

Among all the examined scenarios by the experts, RFID applications for victim identification and tracking along the medical chain got the highest acceptance rate. This application can facilitate and enhance the efficiency and effectiveness of some other disaster management activities. The advantages of this application become more tangible if the information is provided before disasters happen (such as those mentioned in section 8.3.4.1). Currently, there is no effective way of victim identification except by reading their paper triage or asking them or those accompanying them directly, which is sometimes challenging not due to the time-intensive and ineffective procedure but because the injured or referral person is a child or an unconscious who is unaccompanied. Also, tracking casualties' situation in the medical chain is almost impossible through the traditional way. However, RFID can address these challenges and to some extent solve them. Moreover, RFID not only can help practitioners to identify victims faster and more easily, but it can also decrease the possible medical errors that result from the chaotic disaster situations. By identifying the victims, a great percentage of medical errors related to their misidentification can be eliminated to a great extent.

RFID can also facilitate large-scale resource management. The experts found medical resource tagging useful in the disaster response activities. If this tagging is employed properly in healthcare centres, preferably before disasters, it enables top managers to identify, mobilise, dispatch, and track the resources required to support incident management activities, and track the origin of the goods along each step of their delivery to the affected area. This application facilitates the management and coordination of the supplies as well as identifying idle resources at the disaster site. As a result, disaster authorities can provide better management and coordination of disaster response activities. In addition, authorities are able to analyse the number of inbound patients and the number of available hospital beds and medical resources. Therefore, they can make rapid and accurate decisions.

On the other hand, if the network infrastructure is damaged due to disasters, first responders can use RFID tags to store the data until connectivity is re-established. Also, responders, by having timely information about the available medical resources at each healthcare centre, they are able to transport victims to the correct facility as quickly as possible. This application along with victim identification can decrease a range of different kinds of errors.

8.3.4.4 Disaster Recovery

After disaster response, some activities require further follow-up. In this regard, the Delphi participants identified RFID as a suitable technology to follow up victims' physical or mental health conditions. Since a victim's health condition information before the disaster and during the response time is available on the RFID tag, care disruption caused by disasters will be reduced. This application can benefit people with chronic diseases, and continuity of their care becomes possible, even after disasters. For the other casualties, RFID could provide the opportunity to healthcare providers to continuously monitor patients' health conditions, record and report vital signs, all of which leading to optimising care management and reducing consultation times and also possible healthcare errors.

Even if RFID tags started to be used from the disaster response phase, they could possibly improve the follow-up health process and time efficiencies as patients would not be required to explain fully their health conditions or problems in their first visits after disasters. If RFID tags are used in disaster response, it can possibly enhance reuniting families. The peoples' names are entered into the tags during response, and in the recovery phase, tracking their location becomes possible. Moreover, RFID tags can be used instead of papers for the identification of fatalities. This application can facilitate further related procedures like tracking the victim's location and transferring them to their relatives.

8.4 Research Contribution

Based on the research questions and objectives that have been answered and achieved, this research has made novel contributions to the body of knowledge as outlined in the following sections.

8.4.1 The Scope of DEH

This research has extended the current body of knowledge in the areas of disaster management and disaster medicine by utilising e-health technologies and exploring the DEH area. Although both disaster management and disaster medicine have been used for decades, their efficiencies and effectiveness have been far from perfect. Some of the related evidence for this was discussed in chapter 1. Notably, none of these fields systematically employ and integrate e-health technologies, especially the new technologies, into their practices and activities within DMC. Therefore, this research undertook to investigate the systematic incorporation of e-health technologies into DMC activities leading to exploring the area of DEH.

After successful introduction of the DEH field, it was necessary to define its scope, boundaries and features. For this purpose, a scoping study of the three fields of disaster management, disaster medicine, and e-health was carried out to identify a scope for DEH. Consultation on the proposed scope was sought from the fields' experts by way of two rounds through the Delphi method. The final scope of DEH was discussed in this chapter section 8.3.

In the proposed DEH scope, the scope was mapped in terms of e-health technologies and their applications, research areas and stakeholders.

8.4.2 Disaster Scenario Generation

For each phase of disaster, a comprehensive list of its current challenges related to healthcare were extracted. The result was an overwhelming number of challenges for each phase that, if needed to be dealt with individually, required extensive work. Therefore, the researcher referred to the identified challenges and tried to detect their root cause. At that point, all the challenges with the same root cause were categorised under the same category. The next step was to refer to the DEH scope and, based on that, recognise different goals for each category that the researcher believed had the potential to solve the challenge or at least decrease its negative consequences. The final step was to define different scenarios for each goal of DEH for which one or more e-health technologies were proposed. The proposed technologies were according to the DEH scoping result and have a potential to support practitioners to reach that specific goal more effectively and efficiently.

This method of dealing with disaster challenges in each phase is possibly the most effective method since instead of each and individual challenge, a group of them that have the same root cause can be addressed. In addition, identifying a specific scenario by considering different factors, such as disaster phases, facilitates e-health utilisation and integration into DMC which is the final goal of DEH.

Furthermore, to the best knowledge of the researcher, the outcome of phase 2 and its different elements have not been addressed previously. In this thesis, a comprehensive list of disaster management and medicine challenges were extracted, and accordingly, different objectives or goals addressing them were recognised. The final outcome was a model that clearly demonstrated the use of e-health technologies in DEH.

8.4.3 Investigating the Role of RFID Technology in DMC within DEH Scope

Several e-health technologies were identified within the DEH scope. However, this study sought to understand, more particularly, the role of RFID within DMC. According to the literature review, RFID currently is utilised in the healthcare sector for various purposes (chapter 3, section 3.6). This was the starting point for the researcher to investigate RFID's role for DMC activities which had not at that point been identified in the literature of the fields.

In this regard, based on the DEH scoping results and considering the current applications of RFID in normal medicine, this technology was proposed for different scenarios (chapter 6). Furthermore, in both rounds of the Delphi method, comprehensive scenarios were created for potential RFID applications. Then the Delphi participants were consulted about those scenarios and the potentials of RFID and its applications for the healthcare purposes within DMC (see chapter 7 for the results).

8.5 Implications of the Research

Based on the insights gained from the scoping study (phase 1), functional scenario generation (phase 2), and the Delphi method (phase 3), regarding the DEH and its scope, generated functional scenarios within DMC, the role of e-health technologies within DMC and the specifying the role of RFID technology within DEH scope and DMC, the following implications are proposed.

a. DEH Domain, Its Implication, and Acceptance

The DEH domain has been introduced mainly to facilitate addressing the current challenges within disaster management and disaster medicine that hinder their operations and created many debates as to their efficiency and effectiveness. DEH emergence contributes to the design of a systematic model for the e-health technologies that are currently used in non-disaster circumstances but have a potential to be utilised in disasters' situations along with those technologies that were used in DMC previously and made a significant impact on DMC operations.

However, the success and acceptance of DEH is dependent on a number of elements. These elements were investigated and included in the DEH scope. Therefore, based on this research findings, people involved in disaster management, disaster medicine, and healthcare may refer to the DEH scope and utilise its different types of technologies, applications, services, and objectives. Above all, this researcher believes that the following are the strong points of the DEH area:

- DEH covers the whole range of DMC activities, and it addresses all disaster phases.
- DEH is not a disaster-specific model since it accommodates all disaster types.

These points, on their own, make DEH appealing for different groups who are involved in DMC and for a variety of purposes.

DEH tries to engage healthcare into the DMC more because an effective and successful response is almost unachievable without appropriate levels of readiness. This involves the healthcare sector as well since one of the most important elements, and a huge pressure on disaster response, is related to healthcare. In this regard, DEH seeks to enhance disaster-related awareness, education, elements, standards, and procedures in clinical and non-clinical healthcare personnel, mainly in disaster mitigation and preparedness phases. This could possibly result in better response and in meeting wider healthcare demands, as the medical team would be familiar with the very concept of disaster.

On the other hand, for disaster management and disaster medicine people, DEH may facilitate technology adoption in their field. One of its consequences, possibly, is rapid communication among involved parties in DMC. This results in enhancing access to precise information in a timely manner. This, in turn, may result in improving the quality of decisions while decreasing the decision making time.

DEH may also appeal to ordinary citizens who may be affected by different types of disasters. DEH, based on its defined goals, raises disaster awareness among all people, especially those communities in disaster prone areas. Through this awareness, people become familiar with disaster consequences and the ways to prepare for them. Therefore, it can be said that they are well prepared against disasters and if any disasters strike their areas, they are able to take care of their basic healthcare requirements until disaster responders arrive. Then, since disaster responders have proper training and are equipped with different types of e-health technologies, they are able to transfer timely and accurate information from disaster site to top authorities so that they can make appropriate decisions. This, in turn, results in providing better healthcare services to disaster casualties.

b. Deriving Scenarios for e-Health Technologies

As discussed earlier, one of the challenges of using technologies, specifically e-health technologies, within disaster management or disaster medicine is that there is no model for their utilisations, and their applications are more ad hoc rather than regular. Because of this, the full potentials of e-health technologies have not been exploited which, in turn, makes different stakeholders uncertain about these potentials and how they can be used to enhance the efficiency and effectiveness of DMC activities.

However, the model proposed here for generating functional scenarios may help different stakeholders to realise:

- what exactly can be expected from e-health technologies utilisation within DMC;
- what sort of challenges in different phases of disasters can be omitted or at least reduced through e-health technologies; and
- how e-health technologies may fit into current DMC activities and practices.

In other words, stakeholders may be in a position to understand clearly the real implications of DEH, e-health applications, goals, and objectives through the introduced functional scenarios. Therefore, by referring to the model, it would be easier for them to recognise, for the specific goal (application), which e-health technology can be used in a specific disaster phase that would facilitate their intended task(s).

Furthermore, this researcher, according to the results of the scoping study, believes that each e-health technology is appropriate for a specific set of goals or applications. Consequently, the designed model can possibly assist stakeholders to identify and extract the most appropriate or effective applications and purposes of e-health technologies and their related disaster phase. Moreover, in the model, as a goal is defined for a group of challenges with the same root cause, it is expected that through utilising the recommended e-health technology(ies), it is possible to address more challenges.

Not only does this model enable stakeholders to derive scenarios for e-health applications, but it also enables them to generate a particular scenario through following the explained stages in the model if that scenario is not defined in the model. This can be done by considering a disaster type and its characteristics. Then, through utilising these scenarios, the stakeholders may ask technology experts to recommend e-health technologies that match their requirements as they have been specified in the functional scenarios or even design the technology or system to take care of their demands.

c. RFID Application within DMC

Among all the e-health technologies, in phase 3 of this research, the researcher selected RFID to be assessed by the fields' experts in relation to its role through a number of scenarios. The assessment was undertaken by two rounds of Delphi. The results revealed that a number of RFID applications have achieved the experts' acceptance and a majority of the research participants agreed to them. These RFID applications have the potential to be implemented within DMC to take care of some of the requirements of the stakeholders as mentioned in the related scenarios.

Thus, the results and analysis of the third phase of the research may assist the stakeholders to understand the potential benefits and the role of RFID. By referring to the respondents' comments, it can be clearly seen that, although RFID technology has some limitations, such as privacy and security issues, the provided opportunities through RFID implementations outweigh, in the specific generated scenarios, its shortcoming.

8.6 Research Conclusion

Disasters are mostly inevitable, and the current statistics (such as that in Figure 1.1 and 1.2) show that their severity, and complexity are increasing and so is susceptibility to natural emergencies and environmental disasters. By referring to this trend, it can be anticipated that more people will be affected by disasters in the coming years. To mitigate the worst effects of disasters and alleviate their consequences, sufficient preparing and planning is necessary. If involved organisations in disaster management procedures are unable to effectively and efficiently control and lead disaster management, the probability of re-occurring disturbance, wasting resources, delivering inappropriate services and amortisation increases. This, in turn, results in not meeting the needs of the victims. Also, the unpredictable nature of most disasters and the need for making immediate and appropriate decisions have necessitated a more organised approach. Therefore, preparing a plan in terms of rescuing and preventing life loss in disasters is becoming one of the highest priorities of any government.

Many attempts have been made in the past few decades to develop strategies to cope with disaster situations. These attempts and strategies are a part of disaster management and disaster medicine disciplines which, if enacted properly, can lessen the harmful effects of disasters to a great extent. These disciplines cover a wide range of activities in different fields, for different purposes and in pre- and post-disaster phases. However, among all these activities, citizens' health requirements are of prime importance. Before any disaster, the healthcare requirements of the people need to be identified, and after the disaster's occurrence responding to the casualties and recovering them from the disaster situation back to the normal situation should be the main concern. Despite the fact that disaster management and disaster medicine have been in place, for a long period of time, to take care of the range of key issues (see chapter 1), there are still many debates around their effectiveness. Maturana et al. (2012) argue that healthcare has always been incapable of responding properly to major disasters; and if we refer to disaster damage statistics, it can be found out that this is not an area-specific problem as it affects both developed and underdeveloped nations alike. In this respect, governments can clearly see the inefficiency and ineffectiveness of their disaster management approach and the deficiencies and problems in their planning to deal with disasters.

In this respect, the current research, along with some other research studies such as Norris et al. (2015) and Sieben et al. (2012) is seeking ways to overcome the above-mentioned weaknesses and, in particular, to develop systematic principles for coordinating disaster management and disaster medicine more effectively. Therefore, in this thesis, e-health technologies utilisations have been proposed in order to improve the response to healthcare demands before or after disasters. e-Health technologies can be used to improve overall disaster management, facilitate response when disasters occur, enhance support after disasters, and keep records for better future preparedness. Although some e-health tools are employed in disaster settings, (Maturana et al., 2012), their applications are not generally systematic and routine; rather they are more ad hoc and driven by individuals mostly. However, information technology, if implemented systematically, offers promising benefits for e-health (Bliemel & Hassanein, 2004).

Based on the current extracted challenges identified in the disaster management and disaster medicine fields (chapter 2 section 2.7) and considering the e-health applications in healthcare and their potential for the disaster management cycle (DMC) (chapter 3, sections 3.4.1 and 3.4.2, respectively), the research to overcome the challenges has already been started. E-Health technologies can be appropriate tools since currently their emphasis is on using technology innovatively for ease of decision making and communication, coupled with a growing recognition of the importance of human and organisational factors (Pagliari et al., 2005). Although researchers have been investigating the incorporation of IT and e-health technologies in the DMC over decades, there remains a paucity of knowledge and systematic utilisation of e-health technologies within the disaster management and disaster medicine disciplines. Therefore, the initial proposal here was to integrate e-health technologies into the disaster management and disaster medicine disciplines through a structured and systematic method that allows different parties to make more of e-health's potential. This integration resulted in constituting concept of Disaster e-Health (DEH).

The DEH paradigm takes advantage of e-health technologies to facilitate the DMC task and activities, enhance their efficiency and effectiveness, and last but not least, enhancing healthcare delivery and providing more quality healthcare services to the wider population regardless of their geographical location, or even disaster types and phases.

8.7 Research Limitations

Although the initial research questions have been answered and the research objectives have been achieved, this research encountered several limitations. These limitations are explained below.

a. **Time limitation:** like many other studies, one of the significant limitations of the current research was time limitation. Due to this, the researcher in certain stages employed different selection and facilitation methods to overcome this challenge. Limiting the research to certain databases, excluding white papers and grey literature, and utilising Pareto Analysis were among the methods to overcome the time limitation.
b. **Concentrating on only one technology:** DEH encompasses several e-health technologies; however, due to the time limitation it was not possible to deal with each and every technology. Therefore, only one technology was selected for further review and investigation to extract its role and potential within DMC and most importantly the DEH scope.
c. **Academic panel of experts:** to conduct the Delphi, selecting and forming a panel of experts was required. Based on the criteria explained in chapter 7, a panel of experts was formed to participate in two rounds of Delphi. The participants were mostly from academia, although some of them had practical experience. The participants' being mostly academic was one of the limitations of the research in this particular section.

8.8 Recommendation for Future Work

Due to the extensive scope of DEH, widespread utility and functionality is expected. However, because of the highlighted research limitations, not all aspects of the DEH domain were cover in this research. Therefore, the researcher proposes a number of studies the results of which, in combination with the knowledge provided in this thesis, might benefit wider fields. These studies are advanced as potential roads for future work to enrich the DEH area.

Extensive Research on Other e-Health Technologies

In this thesis, extensive research was carried out to identify the role and application of RFID, as one of the e-health technologies, within DMC. During the research, the potential benefits of RFID were explored in each disaster phase. Then the researcher defined and represented each benefit in a functional scenario model. In the next stage, the proposed applications of RFID were evaluated by a panel of experts. The results of their feedback produced a list of agreed and desired applications for DMC. It is, therefore, recommended that future studies follow this approach in order to investigate and identify the potential role of the other e-health technologies within DMC. These research studies could facilitate the identification of the most appropriate applications of e-health technologies within DMC that in turn support DEH stakeholders in their missions. For this purpose, one can refer to the proposed scenarios and recommended e-health technologies and select those with a higher potential based on their frequency.

Employing Functional Scenario Model

To identify the most appropriate usage of the DEH technologies in each disaster phase, utilising the designed model of functional scenario can significantly enhance the systematic scenario generation. However, this researcher believes that this model can be improved through a more extensive literature survey which purely concentrates on extracting the disaster management and disaster medicine challenges within DMC.

Additionally, utilising the same approach outlined in this study is recommended for other areas of disaster management and disaster medicine, as this study focused solely on the healthcare-related challenges.

Considering Grey Literature and White Papers

The focus in the second phase of the scoping framework (see chapter 5), was mostly on academic studies and the reports from international organisations such as WHO. However, it would also be interesting to explore the grey literature and white papers to extract more possible e-health technologies and their applications within the DEH scope.

This recommendation, if addressed, may enrich the DEH scope and align it with the current industrial work and trends in addition to academia. Moreover, by considering the grey literature or company white papers, it may be possible to identify more disaster management and disaster medicine challenges that have not been addressed by academics. The other advantage of this suggestion would be that identifying the in-field applications of the e-health technologies may help researchers to become familiar with the real-case and implemented e-health technologies, their barriers, weaknesses and challenges. Consequently, researchers may consider these factors in their studies and come up with ideas with a higher chance of being used in real-life.

Engaging Practitioners from Disaster Management and Disaster Medicine

In the DEH scope, several types of stakeholders from different sectors were identified. To extend the DEH field, it would be important to gather the viewpoints of all groups of DEH stakeholders. Such feedback may have the potential to reveal unexplored challenges and identify the need for particular tools or applications that can be vital for either disaster management or disaster medicine.

RFID System and Application Development

With regard to the RFID applications that were accepted by the fields' experts in the two rounds of the Delphi method, it is recommended that further research, either industrial or academic, be conducted to develop and implement the required systems or applications. The scenarios proposed in this study were functional scenarios and merely covered the systems' functionalities at a high level. Therefore, further research is required for each accepted scenario to gather details of the stakeholders' requirements which would then enable the developers to come up with a highly detailed system and application functionalities for those particular RFID scenarios.

Identifying the Required Competencies and Protocols for e-Health Technologies

Several e-health technologies have been identified in the DEH scope. However, the stakeholders require a set of basic skills in order to effectively employ, and integrate them within their current practices. Moreover, to fully deploy these e-health technologies within organisational activities, identifying protocols for their usage is essential.

Consequently, it is recommended that further research should be done to explore and identify the required competencies and protocols for each e-health technology. This researcher believes that this is crucial because in the absence of such competencies and protocols, smooth integration with the available infrastructure and practices within different organisations is unlikely. This, in turn, may hinder technology acceptance and cause unwillingness among stakeholders to use these technologies.

8.9 Summary

This chapter concluded the thesis with integrating the research results from various research activities. In this chapter, all the research questions were answered and the research conclusion was provided. Finally, the limitations encountered during the research activities were highlighted, and, accordingly, a number of suggestions for further research were made.

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APPENDICES

Appendix A - e-Health Technologies Strengths and Weaknesses

Technology	Strengths	Weaknesses
DSS	improved decisions and the individual's decisional capacity; increase in work productivity (Cioca & Cioca, 2010); reducing the time needed to make crucial decisions; guiding longer-term decisions (Thompson et al., 2006); possible solutions to the lack of trained clinical personnel (Blaya et al., 2010)	lacking human traits like creativity, hardware and software limitations, designed with a specific purpose, component part of the global computer system (Cioca & Cioca, 2010); requiring timely data in order to provide high quality recommendations (Thompson et al., 2006); highly dependent on inputs so unreliable inputs and their quality affect the DSS performance; not being able to cope with the environment, and its condition changes rapidly; DSSs mostly work with perfect information
EHR	improves patient provider relationships, enhances patient physician shared decision making, and enables the healthcare system to evolve toward a more personalized medical model (Archer et al., 2011); minimizes error and maximizes efficiency (Chia et al., 2011); gives access to up-to-date data from care at any	No standardization of the content and structure of EHRs (Häyrinen, Saranto, & Nykänen, 2008); risks associated with: data storage and management functionality (Black et al., 2011); needs proper infrastructure and due to this reason its development in the developing countries is impractical

	site, timely decision making, improved communication and care coordination, healthcare support during disasters (S. H. Brown et al., 2007); patient identification and continuity of care following a disaster (James & Walsh, 2011); reduces the frequency of medical errors (Bliemel & Hassanein, 2004)	
IoT	operating in harsh environments	deployed to recharge or replace their batteries; privacy and security concerns
MH	delivering real-time data from the field (Jokela et al., 2008), improving communication, accessing to diagnostic tools, and ability to store and access personal medical data in central repositories (Kahn et al., 2010), effectively improving basic care and help on the combat against endemic and epidemic diseases; reducing the need of displacing patients over long distances for receiving basic	mHealth today exists in isolated, small-scale pilot projects (Iwaya et al., 2013); therefore, its work in real situation is still unknown. Highly depends on network infrastructure; different systems working on different platforms and network communication infrastructures

	care; facilitating the communication with the local community (Iwaya et al., 2013)	
TH	provides remote triage and treatment consultation (Ajami & Lamoochi, 2014) to improve health services for people in underserved areas (Sutjiredjeki et al., 2009)	Highly dependent on network infrastructure; any delay in communication can cause disaster
SN	Accessible for everyone; critical bridge between the population and the organisation (Lettieri et al., 2009), important information sharing tools (Kelley et al., 2011)	The shared data on social network suffer from lack of reliability; dependent on network infrastructure for its work; difficulty in analysing and prioritizing huge amount of data in short amount of time; still there is doubt about their being effective or efficient for providing trustworthy and quality data
CC	Decreasing operational load off on healthcare providers, reducing the operational and maintenance costs, supporting collaborative work among different healthcare, establishing networks	security and privacy, risk of loss of data, lack of legislation and standards, systems unavailability (AbuKhousa et al., 2012); high dependency on network infrastructure

	to coordinate and exchange information more efficiently (AbuKhousa et al., 2012)	
BD	Help to have better evidence-based medicine, decision making based on the best available information, providing the most robust evidence (Kayyali et al., 2013)	It is still under way in healthcare (Kayyali et al., 2013); highly dependent on network infrastructure; highly reliable and quality data is needed.

Appendix B - Ethics Approval Letter

AUTEC Secretariat

Auckland University of Technology

D-88, WU406 Level 4 WU Building City Campus

T: +64 9 921 9999 ext. 8316

E: ethics@aut.ac.nz

www.aut.ac.nz/researchethics

19 June 2017

Dave Parry

Faculty of Design and Creative Technologies

Dear Dave

Re Ethics Application: **17/111 Disaster E-Health Scope and the role of RFID for healthcare purposes**

Thank you for providing evidence as requested, which satisfies the points raised by the Auckland University of Technology Ethics Sub Committee (AUTEC).

Your ethics application has been approved for three years until 19 June 2020.

Standard Conditions of Approval

1. A progress report is due annually on the anniversary of the approval date, using form EA2, which is available online through http://www.aut.ac.nz/researchethics.
2. A final report is due at the expiration of the approval period, or, upon completion of project, using form EA3, which is available online through http://www.aut.ac.nz/researchethics.
3. Any amendments to the project must be approved by AUTEC prior to being implemented. Amendments can be requested using the EA2 form: http://www.aut.ac.nz/researchethics.

4. Any serious or unexpected adverse events must be reported to AUTEC Secretariat as a matter of priority.
5. Any unforeseen events that might affect continued ethical acceptability of the project should also be reported to the AUTEC Secretariat as a matter of priority.

Non-Standard Conditions of Approval

1. Amendment of the Information Sheet where it refers to the whole thesis, rather than summary of findings.

Please quote the application number and title on all future correspondence related to this project.

AUTEC grants ethical approval only. If you require management approval for access for your research from another institution or organisation then you are responsible for obtaining it. You are reminded that it is your responsibility to ensure that the spelling and grammar of documents being provided to participants or external organisations is of a high standard.

For any enquiries, please contact ethics@aut.ac.nz

Yours sincerely,

Kate O’Connor

Executive Manager

Auckland University of Technology Ethics Committee

Cc: sam.madanian@aut.ac.nz; Tony Norris

Appendix C – Uncontrolled Search

Disaster Management		
Database		**Search Terms**
	Google Scholar	Disaster management cycle, “Disaster management cycle”, disaster management, “disaster management”, emergency management, “emergency management”, "disaster preparedness challenge", disaster preparedness challenge, disaster definition
	Emerald	Disaster management cycle, “Disaster management cycle”, disaster management, “disaster management”, emergency management, “emergency management”, "disaster mitigation", disaster definition, "mass casualty incident"
	Elsevier	Disaster management cycle
	IEEE Xplore	"Disaster Management cycle", disaster management, “disaster management”, "mass casualty incident"
	CINAHL	disaster management, "disaster mitigation", "disaster definition", disaster definition, "disaster management" AND challenges, "disaster management" AND failure
	ProQuest Central	"disaster mitigation"

Disaster Medicine		
Database		**Search Terms**
	Google Scholar	disaster medicine, “disaster medicine”, “disaster medicine” AND RFID, "disaster Medicine" AND challenge, "disaster medicine challenges"
	Emerald	disaster medicine, "disaster medicine", "disaster medicine" AND e-health, "disaster medicine" AND ehealth, "disaster medicine" AND RFID, "disaster medicine" AND disaster, "emergency medicine" AND disaster, "emergency medicine" AND RFID, "disaster Medicine" AND challenge
	IEEE Xplore	“disaster medicine” AND RFID
	CINAHL	disaster medicine, disaster medicine AND e-health, "emergency medicine" AND disaster, “emergency medicine’ AND RFID, ("disaster medicine") AND (failure), ("disaster medicine") AND (challenge)
	Science Direct	“disaster medicine” AND RFID,
	Springer Link	"disaster medicine" + RFID

e-Health			
Database	Google Scholar	Search Terms	"ehealth technologies" AND disaster, "ehealth technology" AND disaster, "e-health" + disaster, "mass casualty incident" AND RFID
	Emerald		RFID AND disaster, "Radio Frequency Identification" AND disaster, IoT AND disaster, Internet of Things AND disaster, "Internet of Things" AND disaster, “disaster mitigation” AND RFID, "disaster response" AND RFID, "disaster recovery" AND RFID, "disaster preparedness" AND RFID, "disaster preparedness" AND ehealth, "disaster recovery" AND ehealth, "disaster response" AND ehealth, "disaster mitigation" AND ehealth, “disaster management” AND RFID, “disaster medicine” AND RFID
	CINAHL		RFID AND disaster, radio frequency identification AND disaster, Internet of Things AND disaster, RFID AND "emergency management", RFID AND "emergency situation", RFID AND "disaster management", mHealth AND disaster, “mobile Health” AND disaster,
	ProQuest		e-health AND disaster, EHR AND disaster, cloud Computing AND disaster, IoT AND disaster, internet of thing AND disaster, decision support system AND disaster, “decision support system” AND disaster, mHealth AND disaster, mobile health AND disaster, "Electronic Health Record" AND disaster, "social network" AND disaster, social network AND disaster, RFID AND disaster, radio frequency identification AND disaster, telemedicine AND disaster, telecare AND disaster, telemedicine AND disaster, "disaster mitigation" AND RFID, "disaster recovery" AND RFID, "disaster response" AND RFID, "disaster preparedness" AND RFID, “disaster management” AND RFID, “disaster medicine” AND RFID, "mass casualty incident" AND ehealth, "mass casualty incident" AND RFID, "mass casualty incident" AND IoT
	MEDLINE (via EBSCO)		disaster AND (RFID OR radio frequency identification)
	Science Direct		ehealth technologies, ehealth AND disaster, RFID AND disaster, "radio frequency identification" AND disaster, IoT AND disaster, Internet of Things AND disaster, "social media" AND disaster, "disaster preparedness" AND RFID, "disaster mitigation" AND RFID, "disaster response" AND RFID, "disaster recovery" AND RFID

	EBSCO		“disaster management” AND RFID, "mass casualty incident" AND RFID
	ACM Digital Library		"disaster mitigation" AND RFID, "disaster response" AND RFID, "disaster recovery" AND RFID, "disaster preparedness" AND RFID, "disaster preparedness" AND ehealth, "disaster mitigation" AND ehealth, "disaster response" AND ehealth, "disaster recovery" AND ehealth

Appendix D – Extended Uncontrolled Search

Disaster Management, Disaster Medicine			
Database	CINAHL Plus with Full Text (via EBSCO)	Search Terms	"disaster management" AND "disaster medicine" AND "ehealth"; "disaster management" AND "disaster medicine" AND "e-health"; "disaster management" AND "disaster medicine" AND "electronic health"; "disaster management" AND "electronic health"; "disaster management" AND "ehealth"(0); "disaster management" AND "e-health"; "disaster Medicine" AND "ehealth"; "disaster Medicine" AND "e-health"; "disaster Medicine" AND "electronic health"; "disaster Medicine" AND "health informatics"; "disaster management" AND "health informatics"; "disaster management" AND "medical informatics"; "disaster Medicine" AND "medical informatics"; "disaster management" AND EHR; "disaster management" AND "electronic health record"; ("disaster management") AND (technology); ("disaster medicine") AND (technology)
	SocINDEX with Full Text (EBSCO)		"disaster management" AND "disaster medicine" AND "ehealth" (0); "disaster management" AND "disaster medicine" AND "e-health" (0); "disaster management" AND "disaster medicine" AND "electronic health"(0); "disaster management" AND "electronic health"(1); "disaster management" AND "e-health"(0); "disaster Medicine" AND "ehealth"(0); "disaster management" AND "health informatics"(0); "disaster management" AND "medical informatics"(0); "disaster medicine" AND technology (1); "disaster management" AND technology (73);
	Scopus		(TITLE-ABS-KEY ("disaster management") AND TITLE-ABS-KEY ("electronic health")) (4); TITLE-ABS-KEY ("disaster medicine") AND TITLE-ABS-KEY ("electronic

			health")) AND (LIMIT-TO (LANGUAGE , "English")(5); ("disaster medicine") AND TITLE-ABS-KEY ("ehealth")) AND (LIMIT-TO (LANGUAGE , "English")) (2); (TITLE-ABS-KEY ("disaster management") AND TITLE-ABS-KEY ("ehealth")) AND (LIMIT-TO (LANGUAGE , "English"))(3); (TITLE-ABS-KEY ("disaster management") AND TITLE-ABS-KEY ("e-health")) AND (LIMIT-TO (LANGUAGE , "English"))(8); (TITLE-ABS-KEY ("disaster medicine") AND TITLE-ABS-KEY ("e-health")) AND (LIMIT-TO (LANGUAGE , "English")) (2); (TITLE-ABS-KEY ("disaster medicine") AND TITLE-ABS-KEY ("health informatics")) AND (LIMIT-TO (LANGUAGE , "English")) (3); (TITLE-ABS-KEY ("disaster medicine") AND TITLE-ABS-KEY ("medical informatics")) AND (LIMIT-TO (LANGUAGE , "English")) (7); (TITLE-ABS-KEY ("disaster management") AND TITLE-ABS-KEY ("medical informatics")) AND (LIMIT-TO (LANGUAGE , "English")) (12); (TITLE-ABS-KEY ("disaster management") AND TITLE-ABS-KEY ("health informatics")) AND (LIMIT-TO (LANGUAGE , "English")) (5); (TITLE-ABS-KEY ("disaster management") AND TITLE-ABS-KEY ("disaster medicine") AND TITLE-ABS-KEY ("ehealth")) → Satellite-enabled eHealth applications in disaster management-experience from a readiness exercise (TITLE-ABS-KEY ("disaster management") AND TITLE-ABS-KEY ("disaster medicine") AND TITLE-ABS-KEY ("e-health")) → Disaster E-health: A new paradigm for collaborative healthcare in disasters & Satellite-enabled eHealth applications in disaster management-experience from a readiness exercise

e-Health			
Databases	IEEEXplore	Key words	"disaster management" AND "disaster medicine" AND "e-health" → 6404 articles → "disaster management" AND "disaster medicine" AND "e-health" + healthcare → 9 "disaster management" AND "disaster medicine" AND "ehealth" + healthcare (3); "disaster management" AND "disaster medicine" AND "ehealth" + "health care" (5); "disaster management" AND "disaster medicine" AND "e-health" + "health care" (8); "disaster management" AND "ehealth" + "healthcare" (382); "disaster medicine" AND "ehealth" + "healthcare" (278); "disaster medicine" + "ehealth" + "health care" (19); "disaster management" + "ehealth" + "health care" (25); "disaster management" + technology + healthcare (5230) → "disaster management" + technology + healthcare + ICT (25); "disaster management" AND EHR (3); "Disaster management" AND "electronic health record" (2); "Disaster Medicine" AND technology (7); "Disaster management" AND technology (1585) → "Disaster management" AND technology AND healthcare (65); "Disaster management" AND EMR (2); "Disaster management" AND "cloud computing" (59); "Disaster management" AND "social network" (37); "Disaster management" AND "IoT" (10); "Disaster management" AND "telemedicine" (48); "Disaster management" AND "mhealth" (2); "Disaster management" AND "mobile health" (6); "Disaster management" AND "decision support system" (86); "Disaster management" AND "big data" (22)
	Google Scholar		"disaster management" + "ambient intelligence" "disaster medicine" + "ambient intelligence" ehealth + "ambient intelligence" + disaster

Appendix E – PubMed MeSH Heading

- All MeSH Categories
  - Disciplines and Occupations Category
    - Health Occupations
      - Medicine
        - **Telemedicine**
          - Telepathology
          - Teleradiology
          - Telerehabilitation

- All MeSH Categories
  - Information Science Category
    - Information Science
      - Communications Media
        - Telecommunications
          - **Telemedicine**
            - Remote Consultation
            - Telepathology
            - Teleradiology
            - Telerehabilitation

- All MeSH Categories
  - Health Care Category
    - Health Services Administration
      - Patient Care Management
        - Delivery of Health Care
          - **Telemedicine**
            - Remote Consultation
            - Telepathology
            - Teleradiology
            - Telerehabilitation

Figure E.1 PubMed MeSH searching for term ‘e-Health’

- All MeSH Categories
  - Information Science Category
    - Information Science
      - Informatics
        - **Medical Informatics**
          - Health Information Exchange
          - Medical Informatics Applications
            - Decision Making, Computer-Assisted +
            - Decision Support Techniques +
            - Information Storage and Retrieval +
            - Information Systems +
          - Medical Informatics Computing
            - Data Curation

Figure E.2 PubMed MeSH searching for term ‘Health Informatics’

- All MeSH Categories
  - Disciplines and Occupations Category
    - Health Occupations
      - Medicine
        - **Disaster Medicine**

Figure E.3 PubMed MeSH searching for term ‘Disaster Medicine’

- All MeSH Categories
  - Health Care Category
    - Environment and Public Health
      - Environment
        - **Disasters**
          - Disaster Planning
            - Strategic Stockpile
          - Emergencies
          - Emergency Shelter
          - Mass Casualty Incidents
          - Relief Work
          - Rescue Work

Figure E.4 PubMed MeSH searching for term “Disaster”

Appendix F – Information Sheet

Participant Information Sheet

Date Information Sheet Produced:

13 June 2017

Project Title

Disaster E-Health Scope and the Role of RFID for Healthcare Purposes

An Invitation

My name is Samaneh Madanian, PhD candidate at AUT University, Auckland, New Zealand and this Delphi survey is a part of doctoral research project. Participation in this survey is purely optional and you may, at any time, discontinue your participation.

What is the purpose of this research?

The study aims to determine the scope of Disaster e-Health and specifically the role of Radio Frequency Identification (RFID) as an e-health technology in disasters in some particular scenarios. This research contributes to publishing a number of papers in journals, advancing the study of disaster e-Health and also to finalize my PhD thesis.

How was I identified and why am I being invited to participate in this research?

At this stage of my research, I need opinion and feedback from experts in the field to check the results of the scoping study and assess potential uses of RFID in disaster ehealth. In this regard, you have been chosen/suggested through either the DECOI group (Disaster e-Health Community of Interest) or by me as the main researcher. The criteria of selection are having outstanding experience in the areas of disaster management, disaster medicine or e-health, related projects or scientific publications in one of the mentioned fields.

How do I agree to participate in this research?

Your participation in this study is voluntary. Before I send the questionnaire to you, a consent form will be sent to allow you to formally agree to participate in the research. However, you are able to withdraw from the study at any time.

What will happen in this research?

There will be three rounds of questions, delivered via email, with 2 weeks between each round.

I want to share my research findings with on the scope of DEH and the role of RFID to collect your opinion and feedback. To this end, your answering the questionnaire is a valuable contribution. Most of the questions are closed; however, please feel free to provide any additional comments if you would like.

For each round, issues and corrections identified at the previous round will be included, so that a consensus is reached

What are the discomforts and risks?

In general, no appreciable risk is expected for participants from this part of the research. However, you will need to spend approximately 20 to 30 minutes filling out the questionnaire. To protect your privacy, your Identity will not be published in any outputs or revealed to other participants.

What are the benefits?

The following points are considered as the benefits of the research:

1- Researcher will get her PhD
2- Understanding the scope of disaster e-health (DEH)
3- Identifying the potential use of RFID in healthcare in the disaster management cycle the last two points may will be of interest to participants and wider community.

How will my privacy be protected?

The main researcher (Samaneh Madanian) will know the identities of the Delphi experts but these identities and any personal information will not be shared between the participants themselves, only responses will be shared.

What are the costs of participating in this research?

Each round of the Delphi process will take around 20-30 mins to complete, there will be three rounds with two weeks between them

What opportunity do I have to consider this invitation?

It would be very helpful if you could let me know that you are happy to take part within 2 weeks **Will I receive feedback on the results of this research?**

The feedback will be shared and disseminated with the participants in the form of scholarly articles (conference or journal papers) and the participants will be able to access the whole thesis after its completion.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Associate Professor Dave Parry (dave.parry@aut.ac.nz or +64 9 921 9999 ext 8918).

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEC, Kate O'Connor, *ethics@aut.ac.nz*, 921 9999 ext 6038.

Whom do I contact for further information about this research?

Please keep this Information Sheet and a copy of the Consent Form for your future reference. You are also able to contact the research team as follows:

Researcher Contact Details:

Samaneh Madanian

PhD candidate

School of Engineering, Computer and Mathematical Sciences

AUT University, Auckland, New Zealand

E-mail: sam.madanian@aut.ac.nz

Project Supervisor Contact Details:

Associate Professor Dave Parry

School of Engineering, Computer and Mathematical Sciences

AUT University, Auckland, New Zealand

Phone: +64 9 921 9999 ext 8918

Email: dave.parry@aut.ac.nz

Approved by the Auckland University of Technology Ethics Committee on *19 June 2017*, AUTEC Reference number *17/111*.

Appendix G – Consent Form

Consent Form

Project Title: Disaster E-Health Scope and the Role of RFID for Healthcare Purposes

Project Supervisor: Associate Professor Dave Parry

Researcher: Samaneh Madanian

- I have read and understood the information provided about this research project in the Questionnaire information sections.
- I have had an opportunity to ask questions and to have them answered.
- I understand that I may withdraw myself or any information that I have provided for this project at any time prior to completion of data analysis, without being disadvantaged in any way.
- If I withdraw, I understand that the data I contributed up to the date of my withdrawal from the study may be included in the study if it has already been included in an analysis. If analysis has not yet taken place my data will be destroyed at the time of my withdrawal. I am under no obligation to continue attending the think-out-loud interview sessions when I choose to withdraw.
- I agree to take part in this research (please, tick one) : ☐ Yes ☐ No
- I wish to receive a copy of the report from the research: ☐ Yes ☐No

Date:

____

Participant's Signature:

____

Participant's Name:

____

Participant's Contact Details (if you wish to receive a copy of the report):______________________

____

____

Approved by the Auckland University of Technology Ethics Committee on 19 June 2017 AUTEC Reference number 17/111

Note: The participant should return a copy of this form

Appendix H – Delphi Questionnaire: Round One

THE SCOPE OF DISASTER E-HEALTH AND THE ROLE OF RFID TECHNOLOGY FOR HEALTHCARE PURPOSES

DELPHI STUDY

Dear Panellist,

Thank you for agreeing to participate in this Delphi survey as part of doctoral research project on "The scope of disaster e-health (DEH) and the role of RFID[3] technology for healthcare purposes". The study aims to determine the scope of DEH and the role of RFID as an e-health technology [4] in disasters in the proposed scenarios/tasks for different disaster phases (mitigation, preparedness, response and recovery). I am interested in your opinion/idea, as an expert in a field related to one or more of the topics of disaster management, disaster medicine, and e-health, on the general application of e-health throughout the disaster management cycle, and in particular, on the distinctive role that RFID can play in these situations.

This questionnaire is the first of three rounds and at the end of each round, after collecting and summarising the findings, the next questionnaire and the feedback of the previous round will be given to the participants.

This questionnaire consists of closed questions; however, space is provided for you to comment and please feel free to extend the comment boxes and explain your ideas in detail as much as you wish. Please try to answer all questions, even though you may not have in-depth knowledge of all of them. Please do not hesitate to comment on any aspect of the questionnaire, terminology or approach. Moreover, your participation and responses to this survey will be strictly confidential to the research team and will not be

[3] Radio Frequency Identification
[4] E-health is defined by WHO as the cost-effective and secure use of ICT in support of health and health-related fields

divulged to any outside party, including other panellists. You may withdraw from the process at any time without any given reason. In that case, all your data will be consequently deleted and you will not be included in the study.

A- Demographic Category

Question 1

Level of Education (you can choose more than one)

Doctorate degree ☐ Master's degree ☐ MBA degree ☐ Bachelor's degree ☐

Others ☐ Please Specify ________

Occupation (you can choose more than one)

Academia ☐ Healthcare ☐ Consulting ☐ Research ☐

Government ☐ Disaster Manager ☐ Healthcare IT ☐

Disaster Medicine ☐ Other ☐ Please specify ________

Total Years of Experience

0-5 ☐ 6-10 ☐ 11-15 ☐ 16-20 ☐

21-30 ☐ More than 30 years ☐

B- Disaster e-Health Scope

DEH is a new paradigm based on the existing disciplines of disaster management, disaster medicine and e-health (Figure 1) and can be recognized as a juxtaposition of healthcare and information science; DEH is defined as "the application of information and e-health technologies in a disaster situation to restore and maintain the health of individuals to their pre-disaster levels."(1)

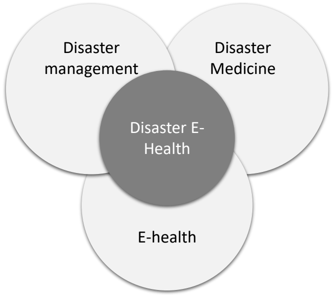

Figure 1. Disaster e-health and its components (Norris et al., 2015)

Now based on the above definition, please kindly answer the following questions extending the text boxes as necessary to accommodate your answers.

Question 2

By referring to Figure 2 (placed on the next page), what are your thoughts about including the technologies in the scope of DEH? You may add/remove technologies based on your experience. Please indicate the reasons for your choices.

These technologies should be **ADDED**	These technologies should be **Removed**

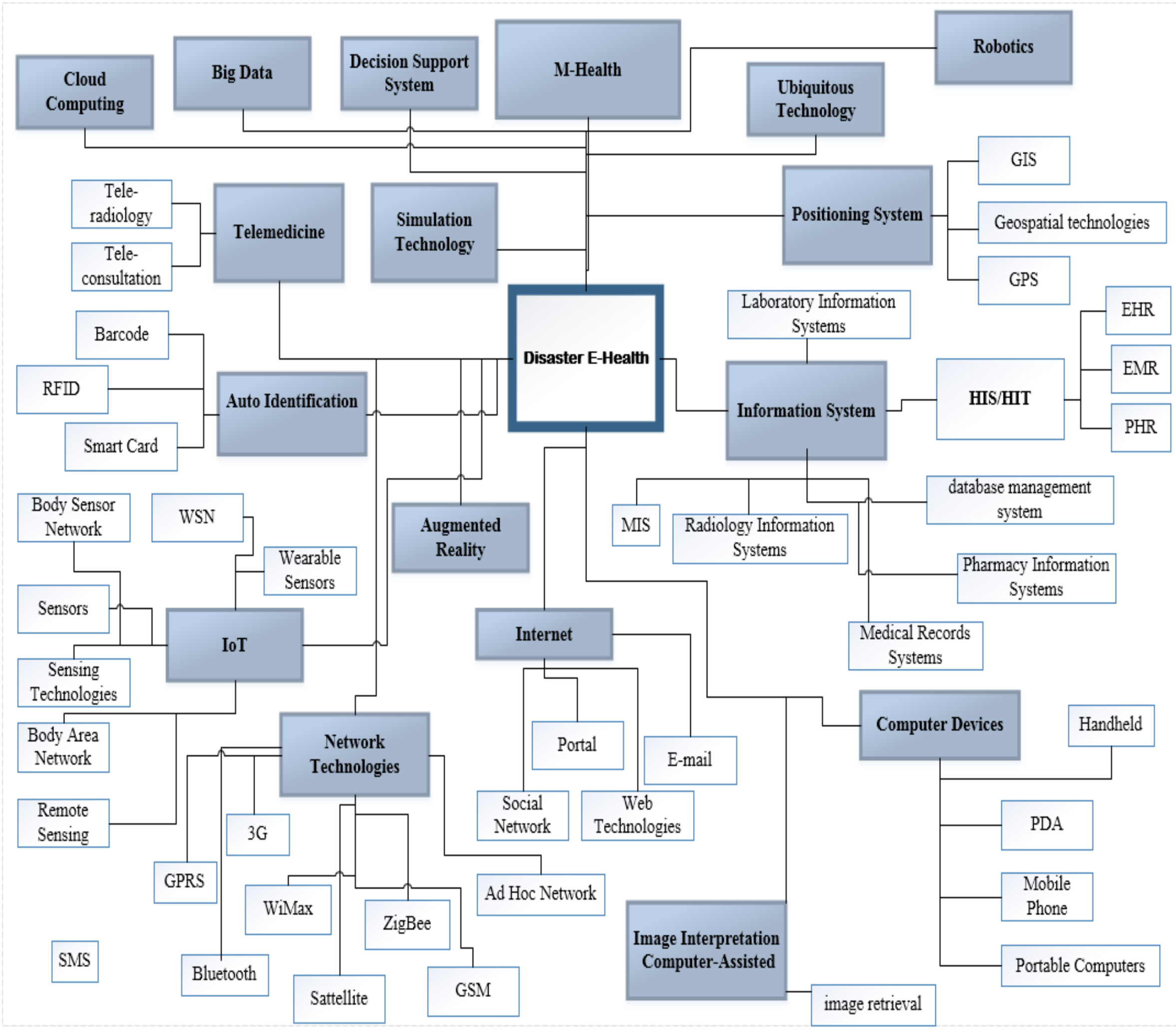

Figure 2. eHealth technologies within the DEH scope

Question 3

By referring to Figure 2, please select five technologies from the figure that you consider as having the greatest potential to benefit disaster victims and the planners/providers of disaster healthcare providers. Please rank these technologies in order of importance briefly indicating your reasons.

5 Most important technologies (Ranked)	Reasons for Ranking

Question 4

By referring to Figure 3, what are your thoughts regarding including the applications within the scope of DEH? You may add/remove applications based on your experience.

These applications should be **ADDED**	These applications should be **Removed**

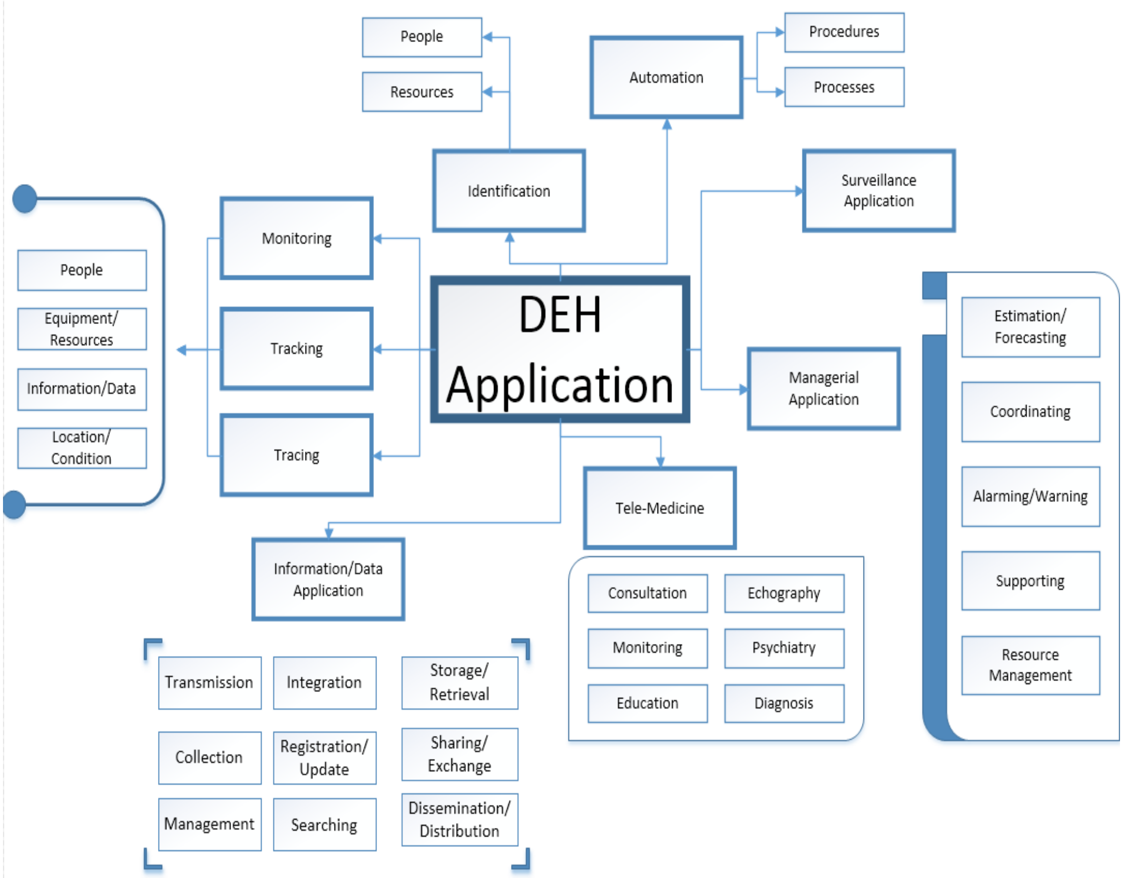

Figure 3. Applications within the DEH scope

Question 5

By referring to Figure 4, what is your idea about including stakeholders within the scope of DEH? You may add/remove stakeholders based on your experience (please show in the table below).

These stakeholders should be **ADDED**	These stakeholders should be **Removed**

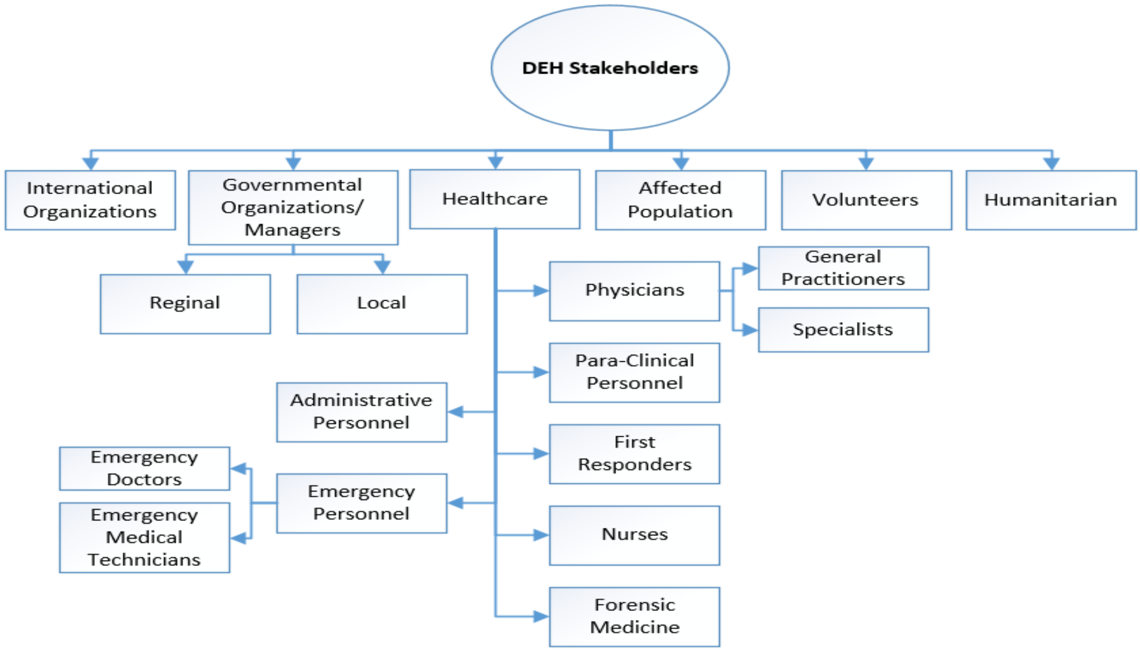

Figure 4. DEH stakeholders

C- RFID Technology

Based on the researcher's studies, RFID is seen as currently one of the most important and enabling technologies for disaster e-health. Moreover, it has enormous potential to assist and integrate the data collection, analysis, and decision making needed to ensure equity of access to quality and safe healthcare during all disaster phases. The use of RFID will only increase further as a consequence of falling costs due to advances in the Internet of Things. Thus, against a background of a range of disaster e-health applications, these considerations suggest a more detailed consideration of RFID and its possibilities.

RFID is an auto-identification technology (sub category of IoT[5]) and consists of three main elements; tags, readers and middle ware (Figure 5). The applications of RFID are numerous and tend to grow since they help to use information better, faster, and more accurately than the other technologies such as barcode. RFID, through providing automation and minimizing human interference as well as unique features distinct from its similar technologies, features such as not needing line of sight and having writing capabilities (compared to barcode), able to work in building and other enclosed environments (compared to GPS).

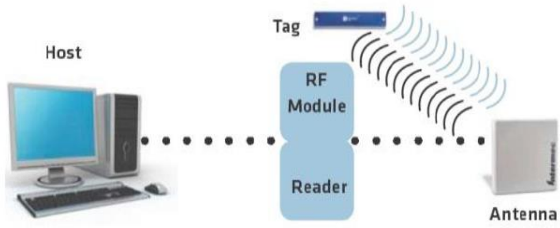

Figure 5. RFID system components

Question 6

Please indicate your level of knowledge of RFID technology

- I am an RFID technology expert ☐
- I have a good knowledge of RFID technology ☐
- I have some knowledge of RFID technology ☐

D- DEH Category

Question 7

Below is the list of scenarios/tasks which are categorized into disaster phases based on the disaster management cycle includes Mitigation, Preparedness, Response and Recovery. For each phase a brief introduction is given; based on the phase

[5] Internet of Things

objective(s)/aim(s) and RFID, in your opinion on a scale of 1 to 5 how important is the role of RFID on improving efficiency and effectiveness of the following tasks (a space is provided for your further comments, and if you do not agree on using RFID for the proposed task, please suggest and explain your choice of an alternative technology).

Section 1 – Mitigation Phase

This phase objective is to reduce disaster hazards. It can consist of studying and assessing the risk, investigating the causes of the hazard, and taking administrative measures to prevent or reduce the level of a hazard when it occurs and lessen the vulnerability of both the eco- and social systems (i.e. the community) (Lettieri et al., 2009). This phase includes activities like building codes and zoning; vulnerability analyses; public education.

	Task/Scenario	**Rating (1=least important – 5=most important)**
1	Improving timely decision making in healthcare organizations including reallocation of hospital resources and staff as the need arises by using RFID capabilities such as automatic and real-time capturing the number and location of medical and human resources	
	Comment:	
2	Using RFID to automatically identify and capture healthcare products/equipment by location and analyse usage pattern for each region to predict future specific demands at the time of disaster and constantly monitor the condition of healthcare centre	
	Comment:	

3	Improving integration of information about increased demand on different hospital sectors for the purpose of strategic decision making based on the real-time and precise information captured by RFID tags	
	Comment:	
4	Availability of victims' vital health information like blood type, special disease or potential medication allergies and storing them on an RFID tags and protecting those valuable medical information from local disasters (unlike paper records)	
	Comment:	
5	By recording medical/resource information on RFID tags, electronically, precise and real-time information is available to access and exchange across all medical facilities that would improve and enable healthcare organization to prepare for emergency planning and cope with next natural disaster	
	Comment:	

Section 2 – Preparedness Phase

Preparedness: Means to ensure that appropriate systems, procedures and resources are in place to assist those affected by the disaster and enable them to help themselves (Ahmed & Sugianto, 2007; Baldini, M. Braun, E Hess, F Oliveri, & H Seuschek, 2009). It comprises gathering information, establishing preparedness plans and organizing management structures, doing drills, exercises and training to enhance the capabilities of the society when faced with crisis, and creating warning systems (Lettieri et al., 2009).

	Task/Scenario	Rating (1=least important – 5=most important)
1	Through matching the population size of each region and their pattern of health needs/demands and combining them with available hospital resources in each region, we can be better prepared for disasters, and in this regard RFID helps us to keep track of available medical resources on a real-time basis to match with the region's health demands.	
	Comment:	
2	Through automatic data capturing, RFID helps us to track and share information on a regional healthcare centre and make sure about types and availability of the medical resources	
	Comment:	
3	RFID can be used to collect and utilize the critical information needed for Just-in-Time disaster plan as well as medical resource planning and allocation of new resources to depots	
	Comment:	
4	Patients' medical data (important ones) should be pre-entered into RFID tags so that data are immediately available at the time of disaster and can facilitate disaster response mission.	
	Comment:	

Section 3 – Response Phase

Response: Measures taken during or immediately after a disaster in order to bring relief to people and communities affected by disaster its purpose is to transfer disaster responders, resources and services to the disaster site (Baldini et al., 2009). The response phase includes the measures taken to control and manage different effects of disaster and to minimise losses to property and human life. It consists of an array of emergency services following the crisis with the aim of saving human lives and property, providing relative welfare, and preventing the spread of the crisis including search and rescue, emergency relief controlling the crisis, the establishment of order in society, and arranging temporary housing.

	Task/Scenario	**Rating (1=least important – 5=most important)**
1	Paper triage complicates information turnover and has several limitations such as being easily damaged or destroyed and having the limited space for information, but RFID tags facilitate the response mission and eliminate the drawbacks of paper triage. RFID tags have this capability that the first responder writes triage once and after that all information can be captured automatically and even transferred to the database and all of which brings time efficiency during response mission.	
	Comment:	
2	By using RFID tags (especially if people start using them from the previous stages), since all the important health information is already available on their tags, patients care continuity would be guaranteed.	
	Comment:	

3	By using RFID tags during response phase, victim identification and tracking would be facilitated, something which is time consuming and in certain circumstances impossible through the traditional way. Patients/medication misidentification and generally medicinal care can be very vulnerable to different kinds of errors, even fatal ones; however, RFID can help to recognize the patients faster and more easily improve disaster victim tracking, triage, patient care, and facility management; moreover, it can improve response times, help to present more effective 'first response', and thus reduce the mortality rate.	
	Comment:	
4	By using RFID in the healthcare centres (especially from preparedness phase), since responders have the real-time information on the available medical resources on each healthcare centre, they are able to transport victims to the correct facility as quickly as possible.	
	Comment:	

Section 4 – Recovery Phase

Recovery: Refers to those actions after a disaster that attempt to bring order to the disaster site and aid in bringing the situation back to normal. (Ahmed & Sugianto, 2007); it aims to restore the disaster-stricken area to before-crisis state. This phase is a stabilization phase and it may last for a long time (Baldini et al., 2009). Recovery phase includes "long-term activities which should be performed after disasters to help the community to regain its normal conditions and become stabilized" (Altay & Green III, 2006, p. 480). In other words, it comprises taking necessary measures after the crisis to restore the normal conditions to include: restoration, reconstruction, development, establishing normal conditions, evaluating and assessing the programs, and studying and evaluating the performance.

	Task/Scenario	Rating (1=least important – 5=most important)
1	By using RFID special tags this opportunity is given to healthcare provider to continuously monitor patients' health conditions, record and report vital signs all of which leading to optimizing care management and reducing.	
	Comment:	
2	By using RFID tags, since all the victim's health condition information before disaster and during response time is available on the tag, care disruption caused by disasters will be reduced, specifically for people with chronic disease, and continuity of care becomes possible	
	Comment:	
3	Through real-time monitoring capabilities of RFID, it would be possible to provide special advice to remote patients	
	Comment:	
4	One of the tasks in this stage is fatalities identification which can be improved through using RFID tags instead of paper ones that would facilitate further related	

	procedures like their location tracking and transferring to their relatives.	
	Comment:	
5	Since, top managers have real-time and precise information about medical resources either used or in stock, they would be able to do medical planning for recovery more effectively and efficiently.	
	Comment:	

Appendix I – Delphi Questionnaire: Round Two

THE SCOPE OF DISASTER E-HEALTH AND THE ROLE OF RFID TECHNOLOGY FOR HEALTHCARE PURPOSES

DELPHI STUDY – ROUND 2

Dear Panellist,

First, I appreciate your participation in this Delphi survey and completing the Round 1 questionnaire.

In the first Round of the Delphi, your opinion and feedback regarding DEH scope and RFID application within DMC[6] were gathered. Accordingly, I have revised the DEH scope and proposed scenarios for RFID application. This round's aim is reaching a consensus regarding the mentioned issues.

This round of questionnaire consists of closed questions; however, space is provided for you to comment. Please feel free to extend the comment boxes and explain your ideas in detail as much as you wish. Please do not hesitate to comment on any aspect of the questionnaire, terminology or approach.

A- Disaster e-Health Scope

Question 1

By referring to Figure 1, what are your thoughts about including the technologies in the scope of DEH? You may add/remove technologies based on your experience. Please indicate the reasons for your choices.

[6] Disaster Management Cycle

These technologies should be **ADDED**	These technologies should be **Removed**

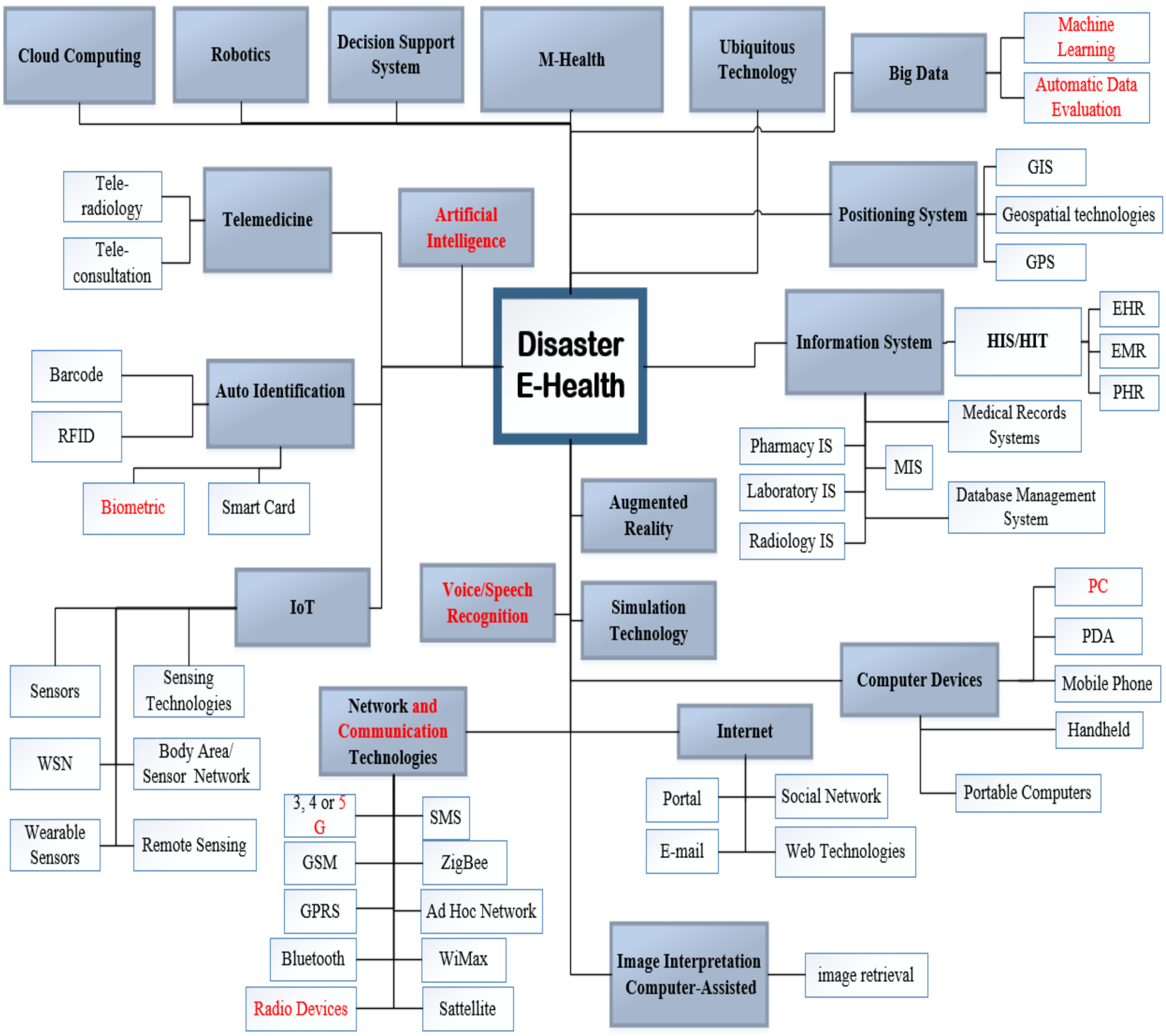

Figure 1. e-Health technologies within the DEH scope

Question 2

By referring to Figure 2, what are your opinion regarding including the applications within the scope of DEH? You may add/remove applications based on your experience.

These applications should be **ADDED**	These applications should be **Removed**

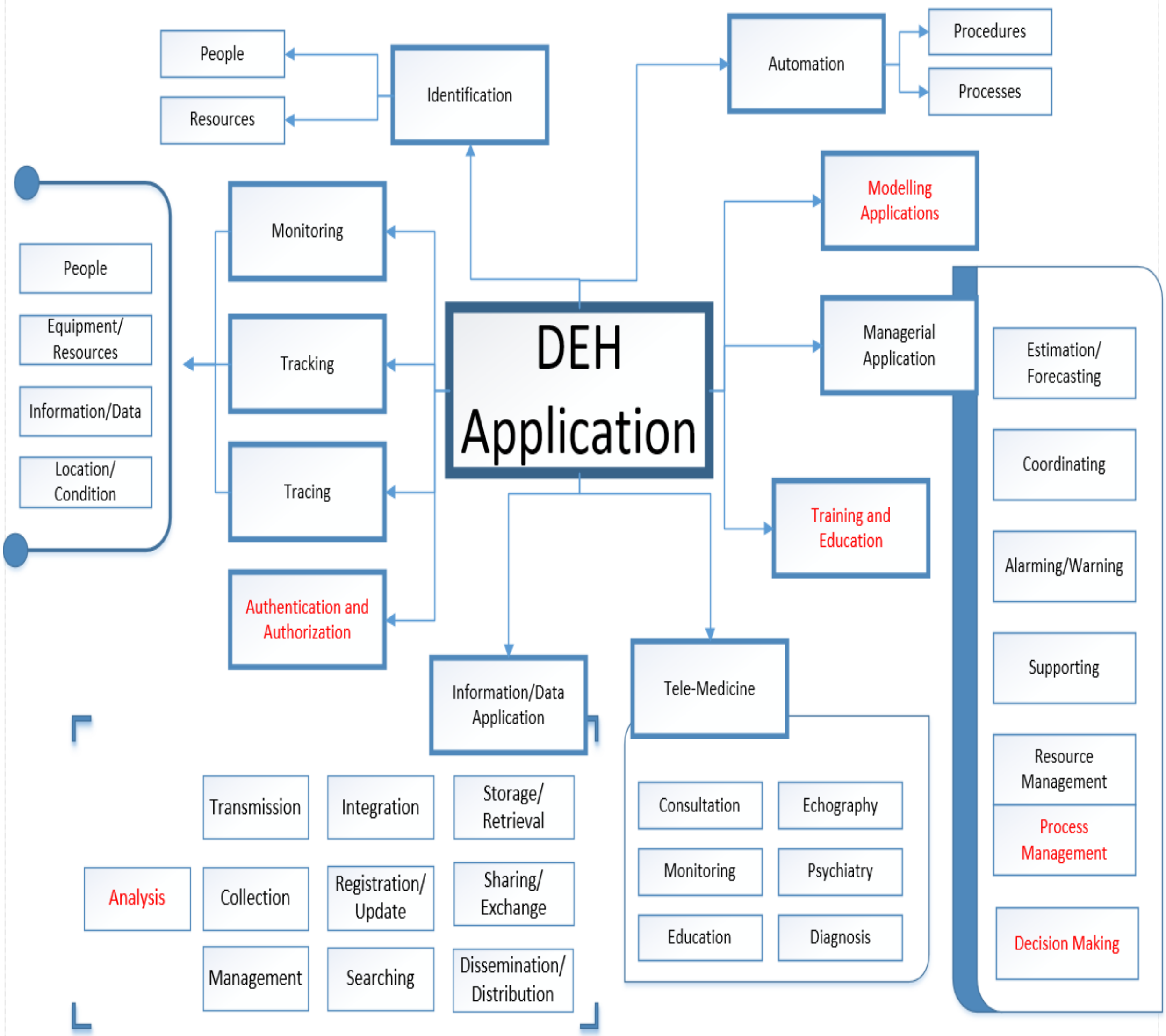

Figure 2. Applications within the DEH scope

Question 3

By referring to Figure 3, what is your idea about including stakeholders within the scope of DEH? You may add/remove stakeholders based on your experience (please show in the table below).

These stakeholders should be **ADDED**	These stakeholders should be **Removed**

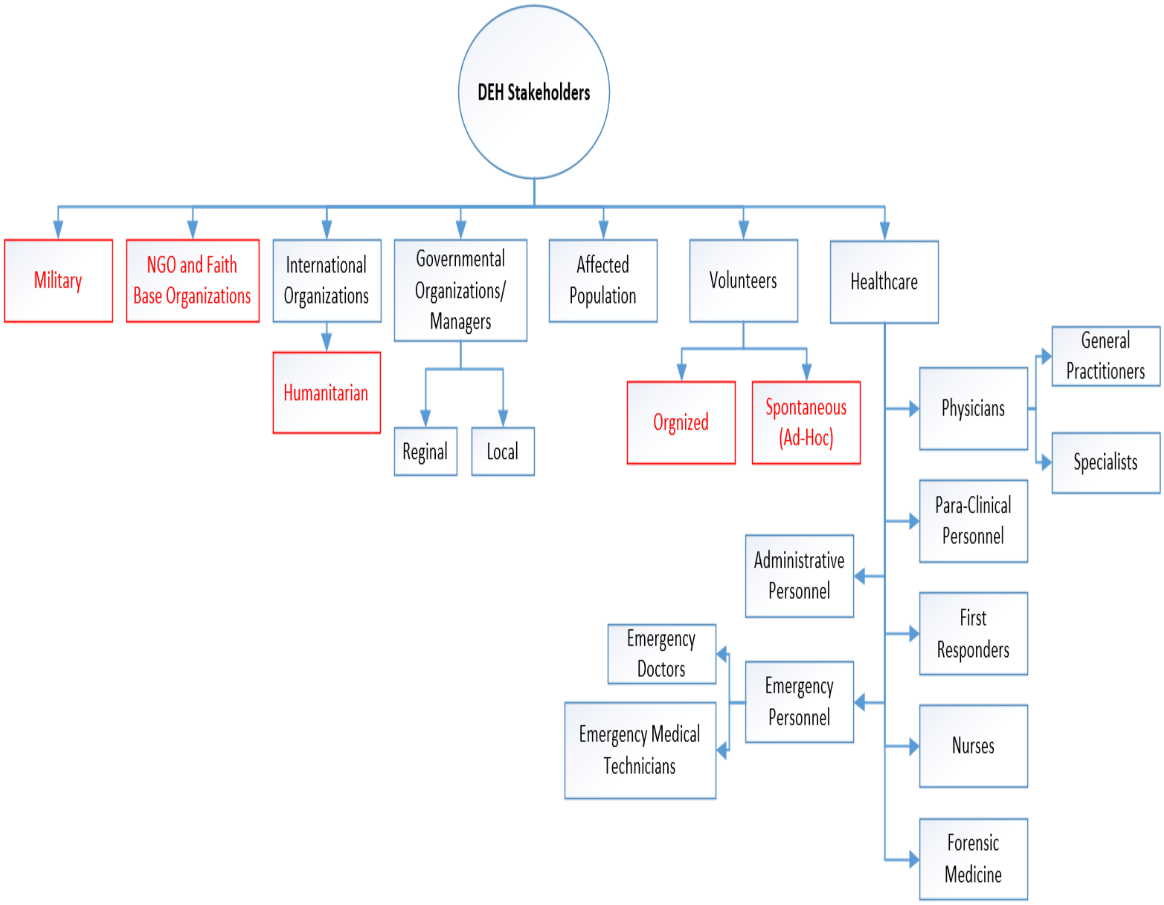

Figure 3. DEH stakeholders

B- RFID Application within DMC

Below is the list of scenarios/tasks which are categorized into disaster phases based on the disaster management cycle, that is, Mitigation, Preparedness, Response and Recovery (Figure 4).

Figure 4. Disaster Management Cycle (1)

For each phase a brief introduction is given. With regard to the phase objective(s)/aim(s) and RFID characteristics, in your opinion on a scale of 1 to 5, how important the role of RFID is in improving efficiency and effectiveness of the following tasks. (Space is provided for your further comments, and if you do not agree on using RFID for the proposed task, please suggest and explain your choice of an alternative technology).

Section 1 – Mitigation Phase

The objective of this phase is to reduce disaster hazards. It may consist of studying and assessing the risk, investigating the causes of the hazard, and taking administrative measures to prevent or reduce the level of a hazard when it occurs and lessen the vulnerability of both the eco- and social systems (i.e. the community) (1). This phase includes activities like building codes and zoning, vulnerability analyses, and public education.

	Task/Scenario	**Rating (1=least important – 5=most important)**
1	By equipping medical resources at each health centre with RFID tags, there could be a potential for improvement in	

	the quality and accuracy of the local, region and even national medical resources assessment.	
	Comment:	
2	There is a potential to develop an information system based on RFID to automatically gather medical resources data and integrate them into different levels of local, regional, federal and, finally, the disaster plan.	
	Comment:	
3	At health centres if medical resources, staff, and patients are equipped with RFID tags, current healthcare situation can be assessed by considering the available medical resources, in-patients and their conditions, and pattern of medical resources usage, for essential medical plan in relation to disaster vulnerability analysis	
	Comment:	
4	One of the issues that hinder providing proper disaster response plan is lack of research. One of the reason is, during response due to overwhelmed conditions and chaotic environments, limited statistics or reports are available regarding the quality and effectiveness of the response activities, shortage in medical supplies, etc. However, if RFID is being utilized, this problem can be solved at least to some extent because of automatic data capturing. Therefore, for future disaster preparedness and response planning, past disasters can be referred to and reduce the probability of the same shortcoming happening.	
	Comment:	

Section 2 – Preparedness Phase

Preparedness: this phase ensures that appropriate systems, procedures and resources are in place to assist those affected by the disaster and enable them to help themselves (2);(3). It comprises gathering information, establishing preparedness plans and organizing management structures, doing drills, exercises, and training to enhance the capabilities of the society when faced with crisis, and creating warning systems. (1).

	Task/Scenario	**Rating (1=least important – 5=most important)**
1	By tagging all medical resources, their pattern of usage (drug consumption) can be monitored automatically. Then by sharing the identified pattern among healthcare centres, a warning system can be developed. This system has a potential to identify epidemic outbreaks and forecast epidemiology disasters by analysing medical resources usage pattern.	
	Comment:	
2	If all the medicine are tagged with RFID by the pharmaceutical companies, authorities might be able to match inventory level of medicine with population size in each region and their demands. Therefore, societies can be well prepared for disasters.	
	Comment:	
3	By using RFID tags on medical resources, patients and medical documents, the integration of health centres into existing EMR/EHR systems can be facilitated since, all	

	information can be gathered automatically and regularly without human intervention and the latter one also improve information quality.	
	Comment:	
4	If on each region, all medical resources and equipment or even medical staff are equipped with RFID tags, the authorities can be able to match patient loads and needs with available hospital resources for each healthcare centre. This scenario specifically benefits people with chronic diseases or those who need constant health monitoring and medicine. The ultimate advantage can be preparing a disaster response plan based on the available medical resources and people's medical requirement.	
	Comment:	
5	If people in healthcare centres (or any other places) tagged with RFID, the pattern of their movement within the area can be captured automatically. By analysing the captured patterns, more effective plans can be developed for evacuation in healthcare centres.	
	Comment:	

Section 3 – Response Phase

Response: this phase includes measures taken during or immediately after a disaster in order to bring relief to people and communities affected by disaster. Its purpose is to transfer disaster responders, resources and services to the disaster site (3). The response phase includes the measures taken to control and manage different effects of disaster and to minimise losses to property and human life. It consists of an array of emergency services following the crisis with the aim of saving human lives and property, providing relative welfare, and preventing the spread of the crisis including search and rescue, emergency relief controlling the crisis, the establishment of order in society, and arranging temporary housing.

	Task/Scenario	**Rating (1=least important – 5=most important)**
1	Using RFID makes possible keeping track of the origin of the goods along each step of their delivery to the affected area. So RFID can be used to identify, mobilize, dispatch, and track the resources required to support incident management activities.	
	Comment:	
2	By tagging medical equipment and supplies, managing and coordinating them these supplies as well as identifying idle resources at the disaster site can be facilitated. So disaster authorities can provide better management and coordination of disaster response activities	
	Comment:	
3	Due to infrastructure degradation, communication is one of the bottlenecks of disaster response tasks. In this regard, RFID can be useful because of its ability to collect information without Internet connectivity and store the data until connectivity is available).	
	Comment:	

4	If RFID is deployed properly in healthcare centres, during disaster response, authorities are able to analyse the number of patients inbound with number of available hospital beds and medical resources. Therefore, they can make rapid and accurate decisions	
	Comment:	
5	Replacing paper triage with RFID tags can reduce the number of over triage and wasting medical resources. Also, they can be used for early identification of epidemiological crisis in a camp of displaced refugees (based on the gathered information of the used medicine and casualties' health status).	
	Comment:	

Section 4 – Recovery Phase

Recovery: This phase refers to those actions after a disaster that attempt to bring order to the disaster site and aid in bringing the situation back to normal. (2); its aim is to restore the disaster-stricken area to before-crisis state. This phase is a stabilization phase and it may last for a long time (3). Recovery phase includes "long-term activities which should be performed after disasters to help the community to regain its normal conditions and become stabilized" (4). In other words, it comprises necessary measures taking after the crisis to restore the normal conditions and they include restoration, reconstruction, development, establishing normal conditions, evaluating and assessing the programs, and studying and evaluating the performance.

	Task/Scenario	Rating (1=least important – 5=most important)
1	If during response time all disaster casualties were equipped with RFID tags, reuniting families can be facilitated because the (near) real-time information of all people and their locations is available.	
	Comment:	
2	Instead of paper documentation, RFID tags can be used to keep track of disaster victims' health nutrition plans. In this regard, the chance of losing document(s) or medical error due to people's handwriting can be reduced.	
	Comment:	
3	Mental health consequences of disasters is one of the common disaster effects that needs long-term medical planning. In this case, RFID can be used to hold people's mental background and their current treatment. Therefore, patients will be able to refer to any healthcare centres without needing to have paper medical documents or explaining to a new physician their mental conditions and symptoms from the beginning.	
	Comment:	

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