A NEW TECHNOLOGY-BASED TELE-EMERGENCY FRAMEWORK FOR EMERGENCY HEALTHCARE PROVISION IN THE UNITED ARAB EMIRATES

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Declaration of Original Content

I declare that the work in this assessment was carried out in accordance with the regulations of the University of Gloucestershire and is original except where indicated by specific reference in the text. No part of the assessment has been submitted as part of any other academic award.

Any views expressed in this assessment are those of the author and in no way represent those of the University.

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Abstract

Research Aim: This study evaluates the current healthcare system in the United Arab Emirates (UAE) with the aim of developing a new technology-based tele-emergency framework for emergency healthcare provision in the UAE. To develop such a framework the UAE's Information and Communications Technology (ICT) and telecom infrastructure, availability of medical equipment, Health Information Systems (HIS) and Health Information Exchange (HIE) systems, first responders' capabilities, the requirements of resources, and operational and regulatory environments were studied, providing the basis for the development of a new blueprint for the provision of tele-emergency services in the UAE.

Methodology: This research is conducted within a constructionist paradigm. The research participants included healthcare policymakers, medical specialists, and healthcare management professionals. A sample size of 30 was considered suitable and data was gathered through semi-structured interviews, mostly online (virtual) during the COVID-19 pandemic; and transcribed and analysed through the NVivo software using thematic content analysis. Themes were analysed using the Heeks (2002) technology deployment model, identifying the change dimensions of processes, technology, and people. These dimensions were assessed within the regulatory and operational environments.

Findings: After conducting an extensive literature review and interviews with healthcare professionals within the UAE, the research found that an Emirate-level Central Command Centre (CCC) will be a critical central element in this new tele-emergency framework, supporting operations, monitoring medical devices and equipment, assessing audio-visual capabilities, providing data streaming architecture, and utilising and unifying medical apps. The other blueprint elements are technology infrastructure regarding ICT and telecom, and unified medical records, these being prerequisites for real-time data capturing, sharing, processing, and decision-making capabilities. Finally, the research emphasised the importance of laws and standards as the final element for supporting the implementation of this framework.

Conclusions: This research has identified numerous beneficial outcomes expected from implementing this proposed technology-based tele-emergency framework. These include enabling greater transparency and accountability in instilling higher efficiency in emergency care, and instilling a preventive approach to emergency management. This technology-based framework will also ensure faster and more secure data sharing from emergency scenes, leading to accurate data-driven decision-making and the delivery of emergency care without loss of time, thus preventing the loss of lives. By improving accountability and transparency, this framework will reduce risks related to medical liabilities, and the in-built provisions of traceability and accountability are expected to encourage healthcare professionals to perform at their optimum levels, with enhanced vigilance to reduce errors. To clarify, this framework is a proposal that has not been implemented yet. This research analysed an eclectic amalgamation of literature and first-hand interview material to propose a practical blueprint for the UAE. Earlier studies have worked on organisational level technological implementations in healthcare, but this study is unique in providing a nationwide perspective on a technology-based tele-emergency framework.

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Abbreviations

AESOP	Automated Endoscopic System for Optimal Positioning
AI	Artificial Intelligence
ATM	Asynchronous Transfer Mode
BERA	British Educational Research Association
BSA	British Sociological Association
CAGR	Compound Annual Growth Rate
CCC	Central Command Centre
CFs	Community Facilitators
COAS	Clinical Observation Access Service
COVID-19	Coronavirus Disease of 2019
CP-C	Community Paramedic-Certified
CTI	Client Tele-diagnosis Interface
DCAS	Dubai Corporation for Ambulance Services
DHA	Dubai Health Authority
DHCC	Dubai Healthcare City
DOH	Department of Health – Abu Dhabi
DR	Disaster Recovery
ECG	Electrocardiogram
ED	Emergency Department
EE	Energy Expenditure
EGDPR	European General Data Protection Regulation
EHR	Electronic Health Record
EID	Emirates Identity
EMR	Electronic Medical Record
EMS	Emergency Medical Services
EMT	Emergency Medical Technician
ePCR	electronic Patient Care Records
ER	Emergency Room
ERP	Enterprise Resource Planning

ETA	Estimated Time of Arrival
EU	European Union
EWS	Early Warning Score
FDA	Food & Drug Administration
fECG	Foetal Electrocardiogram
FHIR	Fast Healthcare Interoperability Resources
fHR	Foetal Heart Rate
FICEMS	Federal Interagency Committee on Emergency Medical Services
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GSM	Global System For Mobile
HAAD	Health Authority-Abu Dhabi
HIE	Health Information Exchange
HIPAA	Health Insurance Portability and Accounting Act
HIS	Healthcare Information Systems
HL7	Health Level Seven
HRS	Health Resource Service
ICA	Federal Authority for Identity and Citizenship
ICT	Information and Communication Technologies
ICU	Intensive Care Unit
I-EHR	Integrated Electronic Health Record
IoT	Internet of Things
IS	Indexing Service
LIS	Laboratory Information System
MENA	Middle East and North Africa
MOHAP	Ministry of Health and Prevention
MOI	Ministry of Interior
MOPA	Ministry of Presidential Affairs
MPDS	Medical Priority Dispatch System
MSHA	Multi-Sources Healthcare Architecture

MVP	Millennium Villages Project
NABIDH	Network & Analysis Backbone for Integrated Dubai Health
NCEMA	National Emergency, Crisis and Disaster Management Authority
NGO	Non-Governmental Organisations
NHS	National Health Service
NRI	Network Readiness Index
NTCA	National Telephone Cooperative Association
NUMR	Unified National Medical Records
OCC	Operation Command Centre
PC	Priority Codes
PIDS	Patient Identification Service
PIS	Patient Identification Systems
POC	Proof of Concept
POTS	Plain Old Telephony System
PSE	Plastic Surgery Educators
REST	Representational State Transfer
RPM	Remote Patient Monitoring
SAP	Systems Applications and Products
SHA	Sharjah Health Authority
SLA	Service Level Agreement
TAM	Technology Acceptance Model
T-O-E	Technology, Organisation, Environment Model
TRA	Telecommunications Regulatory Authority
TS	Terminology Service
UAE	United Arab Emirates
UB	Update Broker
UEMS	Ubiquitous Emergency Medical Service
UN	United Nations
UTAUT	Unified Theory of Acceptance and Use of Technology
VR	Virtual Reality

VST	Victorian Stroke Telemedicine
WHO	Word Health Organization

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CHAPTER ONE: INTRODUCTION

1.1 Research Scope and Context

Being among the highest-income countries, the United Arab Emirates (UAE) has invested considerably in the public healthcare system. Healthcare is state-managed and regulated by several authorities, both federal and Emirate levels. The Department of Health - Abu Dhabi (DOH), Dubai Health Authority (DHA), Sharjah Health Authority (SHA), and the Ministry of Health and Prevention (MOHAP) work in coordination with each other to deliver healthcare services across the UAE. According to the embassy of the United Arab Emirates (2019), the country has eradicated several infectious diseases (chickenpox, measles, poliomyelitis, pertussis, and rotavirus); and has one of the lowest maternal mortality rates (0.01 per 100,000) and infant mortality rates (0.07). With these achievements, the healthcare system now delivers more advanced care for residents, aligning with the UAE Vision 2021 (Fares, 2019). However, the country is moving toward a growing elderly population and a breakout of lifestyle-related diseases such as diabetes, obesity, and associated problems. Additionally, with the pandemic adding further pressures and stress on the UAE healthcare system, the UAE healthcare system is tasked with providing adequate, timely, and need-based interventions and cures to its people. This is where telemedicine can be and has been a valuable addition to the healthcare scene. During the COVID-19 pandemic, the UAE government launched several telemedicine initiatives, for example, ‘Doctor for Every Citizen’ (Swidan et al., 2022).

Telemedicine provides a valuable way to achieve healthcare delivery and has enhanced the country’s adoption, especially during the Coronavirus Disease of 2019 (COVID-19) pandemic. Additionally, the UAE government is committed to the digital transformation of its healthcare system. The country already has one of the region’s best Information and Communications Technology (ICT) and telecom infrastructures. However, there are shortcomings in healthcare delivery, especially in emergency care delivery through remote applications. The country needs an integrated and comprehensive nationwide tele-emergency care delivery system to match the needs of the growing population. There are several challenges related to the adequacy and capacity of staff (Bell, 2014; Cevik et al., 2018b; Fares et al., 2014; Oxford Business Group, 2016; Partridge, Abbo, & Virk, 2009; Salama, 2018), lack of connectivity and communications between hospitals and other stakeholders such as first responders, diagnostic services (Al Ruwaithi, 2019; Alruwaili, Islam, & Usher, 2019; Fares, 2019), problems associated with health records sharing (Fares, 2019), and lack of Emergency Department (ED) capacity (Blair & Sharif, 2012; Fares et al., 2014; Knettel et al., 2022, Paulo, Loney, & Lapão, 2017), that lead to delays and other barriers in the delivery of emergency care, especially, tele-emergency care.

As defined by the World Health Organization (WHO), telemedicine is “the use of electronic communications and information technologies to provide clinical services when participants are at different locations’’ and “a tool that can be used by health providers to extend the traditional practice of medicine outside the walls of the typical medical practice (Taha et al., 2022). So telemedicine has three main components:

1. The use of electronic information and communications technologies,
2. Healthcare and medical uses
3. Distance between the participants (Field, 1996).

The information exchanged, transferring information from one location to another, between the participants (doctors, physicians, medical professionals, and patients), can be in the form of a phone conversation, voice files, image transfers, or video conferencing (Abdool et al., 2021; Field, 1996). This definition includes clinical and non-clinical applications. Basically, telemedicine includes any virtual conveyance of healthcare-related information between different locations (Swidan et al., 2022). This research has identified several sub-specialities of telemedicine, but the list does not encompass all of the sub-specialities of telemedicine existing today: tele-radiology, tele-pathology, tele-education, tele-surgery, tele-mentoring, tele-monitoring, tele-consultation, and tele-emergency. This study focuses on the sub-speciality of tele-emergency and evaluates the status and capabilities of the current healthcare system in the UAE for developing a large-scale nationwide technology-based tele-emergency framework for the UAE. There are several definitions of tele-emergency in the literature, but for the purpose of this study, tele-emergency is defined as an immediate, synchronous, real-time, interactive audio-visual connection between the central command centre, first responder, designated emeregecy medicine team and the patient(s) at the emergency scene.

Toward this end, the country’s ICT infrastructure, telecom infrastructure, availability of medical devices and equipment, Health Information Systems (HIS) and Health Information Exchange (HIE) systems, the availability and relevance of first responders, and the existence of additional resources were studied, providing the basis for the development of a new blueprint for the provision of tele-emergency services in the UAE.

1.2 Problem Overview

A preliminary literature review indicated the practical application of tele-emergency frameworks for delivering remote emergency care. So, with established advantages such as timely and accurate attention and care delivery to patients at their location (Anwar et al., 2019), such tele-emergency frameworks should be emulated for the UAE, which lacks any tele-emergency system.

A review of the current situation indicated the lack of connectivity and related issues during an emergency, which is difficult to explain, given that the UAE has one of the most advanced ICT and telecom infrastructures globally. There appear to be substantial delays and a lack of appropriate care delivery to emergency patients due to the lack of a standardised mechanism for care delivery or standardised processes that should harness and deploy technology toward care delivery. A predominant issue reported is the lack of data sharing and connectivity between hospitals, primarily due to their diverse ICT platforms and infrastructures that prevent interoperability (Everson & Adler-Milstein, 2020; Gunter et al., 2016). This situation warrants a thorough exploration of the current state of ICT, telecom, medical devices, HIE systems, and additional resources within the country's healthcare sector to evaluate the scope and utility of developing and implementing a tele-emergency framework. This study will identify specific issues in technology and technology-related policies and laws; then propose developing a comprehensive technology framework for a unified tele-emergency care delivery system for the UAE.

1.3 Research Aims and Objectives

The UAE is undergoing digital transformation ushered in by the Vision 2030 plan (Fares, 2019; Emery, 2017) and powered by the target to become a technology and business hub in the region (Al-Samarraie et al., 2020). The country also aims to become a centre for medical tourism and attract global patients with its expertise in healthcare technology and personnel (McArthur, 2020a). However, locally, an unmet need is evident in the lack of accessibility to emergency healthcare across the entire country. The country's emergency management systems are primarily geared toward dealing with national scale emergencies such as natural disasters or terrorism (Al-Samarraie et al., 2020). There appears to be no uniform system of delivering emergency care to patients in remote areas and no provision for retrieving and sharing medical records across geographically distanced hospitals. Such a scenario is unpalatable, as the loss of time in accessing and retrieving medical records often proves fatal. Additionally, first responders may arrive and transport patients to the nearest EDs, which may not be equipped to handle specific cases due to a lack of in-house specialists. Such issues were the basis and motivation to help develop this proposed tele-emergency framework, which spans the Emirate-level borders (nationwide) and engages specialists globally to deliver timely and on-the-spot emergency care to patients at any location within the UAE.

The research aims to develop a new technology-based tele-emergency framework for emergency healthcare provision in the UAE. As such, this research has the following objectives:

- To explore the availability of emerging technology-based medical equipment, sensors, and devices that can be enlisted as part of the tele-emergency healthcare system in the UAE.
- To evaluate the current Information and Communications Technology (ICT) and network infrastructure of the UAE, focusing on assessing its potential to support a scalable, private and secure, traceable, and interoperable system of tele-emergency healthcare.
- To explore the existing technology used for Healthcare Information Systems (HIS) and Health Information Exchanges (HIEs) in the UAE, focusing on evaluating them for integration across ERs (Emergency Rooms) in the country to create a comprehensive blueprint for a new tele-emergency framework for the UAE.

1.4 Research Methodology

This research is conducted within a constructionist paradigm that allows for the exploration of reality or the status quo in a contextual and in-depth manner, using the perspective of the interview participants. Since the research is focused on evaluating and suggesting technological solutions for the tele-emergency framework, policymakers and decision-makers are considered experts and knowledgeable. The opinions and perceptions of such participants are worthy of inclusion in any proposed tele-emergency framework. The research participants included healthcare policymakers, medical specialists, and healthcare management professionals. A sample size of 30 was considered suitable, as the data collected was saturated or repetitive beyond this number of participants. The research was conducted through semi-structured interviews, mostly online (virtual) during the COVID-19 pandemic, and transcribed and analysed through the NVivo software using thematic content analysis.

The themes that emerged from the analysis were discussed extensively using the Heeks (2002) technology deployment model, which recognises the change dimensions of processes, technology, and people. These dimensions were assessed within two environments – the regulatory and operational environments. The analysis also included a comparison and contextualisation of the findings with the existing literature to emphasise the issues and differences from and within the UAE healthcare system. Finally, the analysis led to developing a detailed tele-emergency blueprint, which was this study's ultimate objective.

1.5 Significance of the Study

The UAE has a growing population expected to become 11 million by 2030, with 4.4% of them being elderly (Baldwin, 2018). Both the growth in population and the demographic shifts are expected to place an added burden on the healthcare system and resources of the country. The UAE government is committed to digitalising most of its services, including healthcare delivery systems (Bodolica & Spraggon, 2019). However, the recent COVID-19 crisis has further highlighted the pressing need to make healthcare systems more accessible to the masses and in non-traditional and innovative ways. Telemedicine runs at the forefront of such endeavours, where patients can receive consultations, diagnosis, and even procedures performed from the safety of their homes or at their local ERs (Weigel, MacKinney, & Heppner, 2020). The UAE has seen a surge in cases related to cancers and lifestyle diseases such as diabetes, obesity, and cardiovascular diseases (Emery, 2017; Taha & Eltom, 2018), which requires constant healthcare support in regular testing, medication, and monitoring for symptoms. Telemedicine is of direct relevance to these needs. Living with a disease can be made easier if local ERs have access to specialist support to deliver regular and instant healthcare solutions for patients without the need to travel. This research is aligned with the UAE's Vision 2021 (Fares, 2019) to transform health services and digitalise healthcare delivery to make it more accessible, efficient, and effective.

1.6 Organisation of the Thesis

Chapter One (Introduction) introduces the research topic and provides an overview of the research context. The research aims and objectives are presented, and the methodology employed is briefly described. Finally, the chapter discusses the significance of this research and the expected outcomes.

Chapter Two (Literature Review) critically discusses the technology frameworks of tele-emergency developed through previous studies and evaluates the benefits and drawbacks of using tele-emergency care, including the barriers and facilitators. Finally, the chapter provides a critical analysis of technology models such as the Technology Acceptance Model (TAM), Technology, Organisation, Environment Model (TOE), Unified Theory of Acceptance and Use of Technology (UTAUT), and Heeks (2002) technology deployment model.

Chapter Three (Conceptual Framework) develops a conceptual framework for examining both the regulatory and operational environments, underpinned by the Heeks technology deployment model. This conceptual framework forms the basis of developing the final tele-emergency framework blueprint using the insights obtained from interviews.

Chapter Four (Methodology) develops a case and rationale for the paradigm, design, and methods used in this research project. It critically reviews research paradigms and methodology and provides a detailed discussion about the suitability of the selected approach and methods.

Chapter Five (Findings) is based on the findings obtained from the interviews, which are analysed using the NVivo software. This chapter presents and examines the emergent themes of ICT, telecom, uniform medical records, medical devices, first responders, and emergency care resources, along with the current operational and regulatory environments relevant to these themes.

Chapter Six (Analysis) presents a critical analysis of the findings, using material from the literature review and the conceptual framework to evaluate the current status of ICT, telecom, medical devices, uniform medical records, first responders, and additional resources. The chapter also presents the operational and regulatory environment issues and develops a case for addressing those issues in the proposed blueprint presented in the next chapter.

Chapter Seven (New Framework) uses the dimensions of change from the Heeks (2002) technology deployment model, namely processes, technology, and people, and addresses issues in the current tele-emergency healthcare delivery system. The chapter also analyses the change dimensions within two change environments, operational and regulatory, to evaluate specific issues and presents recommendations to improve the operational and regulatory environments of the country to support the proposed tele-emergency framework. Finally, the chapter develops a detailed blueprint comprising the essential components of a large-scale nationwide tele-emergency framework for the UAE.

Chapter Eight (Conclusion) summarises the research findings as they address the research objectives; and discusses the research contribution to the academic literature, practice, policy, and operational management. The chapter ends by considering research limitations and scope for future research.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reviews the existing literature related to the emergence of digital technologies in healthcare and the impacts of telemedicine regarding the quality of care, structure of healthcare delivery systems, organisational effectiveness, and the healthcare industry's carbon footprint. The chapter also presents the costs and benefits and the barriers and facilitators of telemedicine. The chapter further presents the diverse specialities within telemedicine, focusing on tele-emergency services. Next, an exhaustive review of tele-emergency frameworks is undertaken to critically evaluate the technological requirements and gaps in previous frameworks. The review includes a detailed discussion on telemedicine and tele-emergency care available in the UAE, and explores the issues that need to be addressed to attain the full potential of tele-emergency services in the country. Finally, a presentation of the technology deployment models that are evaluated critically to select the most suited model for this research framework.

2.2 Digital Technologies in Healthcare

The healthcare value chain is getting reshaped with the deployment of emerging technologies such as big data, Artificial Intelligence (AI), machine learning, 3D printing, cloud computing, robotics, augmented reality and virtual reality, and enhanced integration of "symbiotic human robots" (Knettel, et al., 2022; Manogaran et al., 2017). Healthcare 4.0 has been symbolised by the introduction of wearable devices that can collect sensory information, transmit and store it in the cloud, and then through the usage of big data analytics, provide new medical insights for policymakers and healthcare professionals, which can lead to the targeted and specific diagnosis and treatment. Closely aligned to this new phenomena is the Internet of Things (IoT), which has further enhanced the capacity for data capturing, transmitting, and sharing between various devices and networks, reducing the need for user-interface-driven data entry and data sharing; hence, eliminating errors of data integrity (Khalil & Abdo, 2022; Pang et al., 2018). However, these developments have also raised privacy and security-related issues, calling for robust regulatory and legal frameworks.

2.3 Impacts of Telemedicine on the Healthcare Industry

Telemedicine comprises three main aspects: distance separation between the patient and the medical professional, the deployment of technology, and healthcare delivery (Nota et al., 2019). According to Waller and Stotler (2018), the telemedicine sector's Compounded Annual Growth Rate (CAGR) is between 13% and 27%. This increasing interest in telemedicine is also reflected in the fact that there has been an increase in research papers dedicated to evaluating telemedicine's benefits, limitations, scope, applications, and implementation-related aspects (Waller & Stotler, 2018). The rapid penetration of telemedicine in mainstream healthcare has been possible due to innovations in supporting ICT, personal analytics developments, and high-speed internet penetration (Morais-Almeida et al., 2022; Waller & Stotler, 2018). However, despite the scope and the investment in telemedicine, there has not been a mass deployment of telemedicine on a national or a regional scale, and we have a long way to go in applying telemedicine in primary and public healthcare (Beheshti et al., 2022), and most telemedicine projects have been scattered or simplistic and app-based.

The deployment of telemedicine in healthcare has been based on both theoretically perceived benefits and evidence-based benefits. These benefits mostly revolve around telemedicine, leading to greater access to quality healthcare and lower costs when compared to traditional healthcare systems. However, the impacts of telemedicine may be far more expansive and even disruptive to the healthcare industry in terms of its potential to change the industry's structure and reshape its competitive strategies. The following sub-sections examine the potential impact of telemedicine on the quality of care delivery, the structure of the health industry, organisational effectiveness, and the carbon footprint of the healthcare industry.

2.3.1 Impact on quality of care delivered by the healthcare industry.

Evidence from numerous clinical trials and systematic reviews indicated positive outcomes from utilising telemedicine. For example, an extensive review based on 81 systematic reviews that collectively included a total of 579 randomised controlled trial-based articles found telemedicine to be beneficial in the management of ongoing long term ailments such as diabetes and cardiovascular diseases, as well as asthma, chronic obstructive pulmonary disease, and mental health issues related to substance abuse (McLean et al., 2013). Similarly, numerous studies have evaluated the positive outcomes of telemedicine in different healthcare situations, including in wound care (Fagerström et al., 2022) and diabetes (Ma et al., 2022).

2.3.2 Impact on the structure of healthcare delivery systems.

Telemedicine is expected to lead to a distinct differentiation between specialist services, diagnosis, and consultation services; thus, enabling a more efficient resource utilisation. Specialists are highly skilled, knowledge-based workers, and by eliminating the need for local hospitals to have specialists on-call or as residents, there can be substantial savings in terms of costs for healthcare facilities and time savings for specialists who would not have to travel (Yilmaz et al., 2019). Since telemedicine allows for triage at the primary healthcare service providers' level and then referring patients to specialists if needed, telemedicine allows for more effective workforce utilisation. The new healthcare delivery structure provides a better hierarchy based on medical competencies rather than a flatter structure based on the geographical distribution of specialists to cater to the needs of the physical population

(Kasemsap, 2017). While the traditional healthcare industry is structured to reduce costs or enhance regional operations, the telemedicine-enabled healthcare structure focuses on service delivery. It allows for smoother integration of healthcare organisations both horizontally and vertically. The service-oriented integration of healthcare is premised on collaboration and cooperation between healthcare professionals supported by ICT and digital technologies (Mashamba et al., 2022). However, while telemedicine provides knowledge sharing, effective communications, and a smooth and multi-directional flow of information, it should be accompanied by physical changes in organisational structure and culture (Cockcroft & Hendy, 2018). The mere availability of technical capabilities may not be sufficient to enable telemedicine adoption and should be accompanied by cultural, environmental, and ecosystem changes (Luciano, Mahmood, & Rad, 2020).

2.3.3 Impact on organisational effectiveness.

In addition to the environmental benefits to the healthcare industry, there is evidence from studies claiming that telemedicine enables organisational learning and knowledge management (Meadows et al., 2022), both of which are found to be precursors to enhanced organisational effectiveness and efficiency (Fechina et al., 2022). According to Hojabri et al. (2012), who based their findings on research undertaken at the Petroleum Industry Health Organization, Iran, reported that telemedicine enabled the company to attain a competitive advantage in the sector and enhanced its productivity many folds. There is a growing perspective that telemedicine is expected to change the way organisations operate and compete. Since telemedicine is likely to remove the barriers to access, which was a competitive advantage for hospitals that could attract specialists and large population sections, healthcare organisations will need to compete on service quality and costs (Hoyt & Reynolds, 2022; Hu et al., 1996).

2.3.4 Impact on the carbon footprint of the healthcare industry.

The impact of telemedicine on the healthcare industry has not yet been studied comprehensively. There is, nevertheless, some research from diverse perspectives on how telemedicine may impact the healthcare industry. For example, telemedicine's positive impact can reduce its carbon footprint and become greener with telemedicine applications (Donald & Irukulla, 2022; Yellowlees et al., 2010). Healthcare delivery is associated with extensive usage of paperwork and travel, thus adding to pollution and environmental degradation. Through telemedicine, not only environmental benefits are possible, but also economic benefits can accrue in the form of savings and reduced maintenance costs (Ravindrane & Patel, 2022). This research was based on calculations of time, energy, and money saved through the University of California Davis, Sacramento tele-consultation program that enabled over 2,500 teleconsultations, reduced 4.7 million miles of travel, and saved 188,000 gallons of gas, thus reflecting benefits such as time-saving, environmental protection, and overall cost savings. The economic implications of similar savings from a large-scale telemedicine program can be expected to be significant.

2.4 Costs and Benefits of Telemedicine

The extant literature contains very little about telemedicine's large-scale and macroeconomic impacts. Most research about evaluating economic outcomes is limited to cost-benefit analysis or a comparative analysis between the traditional healthcare system and telemedicine system in isolated case studies or regions. However, telemedicine's scope and benefits have been well documented in these studies. Since the focus is mainly on telemedicine benefits, the next section will focus on the benefits and limitations associated with telemedicine. For example, Yilmaz et al. (2019) compared the economic costs of tele-psychiatry services for native Americans and Alaskans in the USA across different states, with traditional service costs that involved either patient travel or healthcare specialist travel. Yilmaz et al. (2019) found that the telemedicine cost per session amounted to only $93.90 in comparison to the traditional care costs when the provider travelled ($183.34) and when the patient had to travel to the facility ($268.23). These cost differences were magnified for patients needing services in remote regions, which led the study to conclude that large-scale telemedicine frameworks covering the states could be cost-effective for the country. Another study from Italy has shown that video-conferencing-based telemedicine services such as tele-consultation and tele-diagnosis of patients at the extreme altitude of 1,500 to 3,500 meters enabled low-cost access to healthcare (Martinelli et al., 2020). The e-Rés@MONT platform allowed trained nurses in high altitude locations to transfer patient data to hospitals in Aosta, which was diagnosed by the experts and formed the basis of further action, for instance, point-of-care treatment or transportation to the hospital (Martinelli et al., 2020).

A study published by the National Telephone Cooperative Association - (NTCA) -The Rural Broadband Association stated that using telehealth services in rural parts of four states in the USA could lead to an average of $81,000 annual savings for each of the 24 hospitals included in the survey, in terms of their direct cost reductions (Schadelbauer, 2017). Additionally, the report suggested that telehealth programs reduced indirect costs to the community. It was estimated that people could save in terms of a reduction in travel costs by about $24,000 and reduce work-loss/wage-loss by $17,000. Telemedicine was found by the Schadelbauer (2017) report to likely increase the business of local labs and pharmacies, as telemedicine would allow the patients to get their tests done locally and send in reports to remote medical professionals. Schadelbauer (2017) report on telemedicine concluded that this could also increase the local economy manifolds and ensure a more even regional growth.

However, studies that included targeted rural areas are rare, emphasising the need for further research (Tsou et al., 2020).

Reflecting the outcomes of these studies have identified the economic impact at a regional level, other studies have focused on specific requirements needed for when telemedicine is deployed. For example, telemedicine has been reported to be cost-effective when used in, for example, cardiology (Datta et al., 2010; Kędzierski et al., 2022; Nelson et al., 2011), pulmonary diseases (Goldklang et al., 2022), ophthalmology (De Arrigunaga et al., 2022; Rein et al., 2011), obesity care (Kahan et al., 2022), and radiology (Paro et al., 2022). In chronic ailments or lifestyle-related disease management such as eating disorders and diet management (Crow et al., 2009; Haghshomar et al., 2022; Graves et al., 2009), physiotherapy (Kumar et al., 2022), depression (Blackstone et al., 2022; Simon, Ludman, & Rutter, 2009), and orthopaedic fracture cases (Snoswell, North, & Caffery, 2020), telemedicine is economical in comparison to traditional healthcare. Research has also indicated that tele-ICU provides economic benefits compared to the physical Intensive Care Unit (ICU) (Franzini et al., 2011; Michael Robie et al., 2022). However, telemedicine has not been reported to be cost-effective or comparable in cases of asthma (Persaud, 2022; Ryan et al., 2012) and airway cancers (Choi et al., 2022; van der Pol & McKenzie, 2010). Barring isolated calculations of costs and benefits, country-wide estimates of the economic impact of telemedicine do not seem to have been the focus of research.

While most of the impacts stated earlier are assessed at a micro-level and use a narrow set of indicators, there is research dedicated to developing an exhaustive list of impact indicators on which telemedicine projects can be evaluated. For example, according to the Lewin Group Incorporated (2000), the economic impact of telemedicine applications needs to be calculated using indices such as costs of transportation of patients and healthcare providers, costs related to capital investment, in terms of equipment, applications, and location development, the cost of staffing and training healthcare professionals, costs of maintaining the systems and managing communication channels, benefits associated with a reduction in patient and doctor times, benefits associated with changes in productivity, and capacity utilisation of the services (Lewin Group Incorporated, 2000). Therefore, most of the costs related to telemedicine may be offset by the health benefits accrued by patients, which could lower the burden on the overall economy (Stewart & Bird, 2022). Costs of illness that the economy has to bear are not just associated with the direct costs of diagnosis, medicine, and hospital fees, but costs associated with travel, childcare costs, workdays, and productivity loss (Onukwugha et al., 2016; Stewart & Bird, 2022). For these costs and benefits to be calculated accurately and credibly, telemedicine applications need to be evaluated over extended periods to calculate the economic benefits related to better patient outcomes - and most studies that have undertaken the task of assessing economic impacts have failed to consider the time factor. Data from macro-level assessments of telemedicine projects have revealed that the trend is toward economic benefits through an overall reduction in illness cost, which is likely to multiply and aggregate with the extension of telemedicine services country-wide.

A considerable amount of research has focused on evaluating the benefits of telemedicine. For example, a systematic review of 221 studies by Granja, Janssen, and Johansen (2018) found that successful telemedicine interventions could enhance the quality of healthcare provided by healthcare professionals, empower patients to self-manage, and are in alignment with the cost policies of the health systems. Tele-mentoring, tele-surgery, tele-consultation, and tele-emergency provide increased access to healthcare for people living in remote areas or in times of disaster when time is of the essence and transferring patients to remote hospitals is considered risky (Harting et al., 2019). Besides, it also offers the added benefit of saving time and travel to patients (Gunter et al., 2016; Ravindrane & Patel, 2022). Telemedicine enables hospitals to open up spaces for other patients and reduces the need for post-operative patient visits for wound care (Viers et al., 2015; Ye et al., 2022). Several studies have reported higher patient and provider satisfaction with telemedicine (Gunter et al., 2016; Ravindrane & Patel, 2022; Stewart & Bird, 2022; Viers et al., 2015;).

While the research studies of Granja et al. (2018), Harting et al. (2019), and Viers et al. (2015) focused on a broad understanding of telemedicine, others have evaluated the benefits of specific specialities of telemedicine. Gunter et al. (2016) and Nota et al. (2019) found that patient outcome for tele-surgery and traditional surgery were comparable, while Shahzad, Chawla, and Gala (2019) found that tele-surgery provides enhanced dexterity, high-quality 3D visualisation of 10X magnification, better sensitivity settings, better natural hand-eye coordination than that in traditional laparoscopic surgery, and near-zero hand tremors. Shahzad et al. (2019) contended that telemedicine had a substantial potential for military, naval, or space exploration fields. Healthcare professionals provide care and diagnostics to personnel posted in remote locations otherwise inaccessible to physicians.

While there are clear advantages or benefits, telemedicine has limitations, including technology-related time-lags, unreliable connectivity, and signal availability. For accuracy, the time lag should be maintained at less than 200 milliseconds during tele-surgery. However, low internet speed or an unreliable connection leading to higher time lag may result in severe complications. The lack of infrastructure connectivity and internet in rural and remote areas further limits the scope of applicability (Shahzad et al., 2019). Additionally, concerns of cyber-attacks, hacking, deletion of confidential and vital data, leakage of information, malicious attempts to block the communication channels and disruption of the healthcare system are reported by Shahzad et al. (2019). Besides the potential technical issues related to telemedicine, Harting et al. (2019) pointed out other barriers represented by the costs of investing in new technology, infrastructure, and training. Craig and Chamberlain (2018) added to the list of limitations by stating the difficulty of developing legal and ethical protocols, legislation, and regulations to cover emerging technology uses. For Craig and Chamberlain (2018), data sharing, data ownership, and patient privacy still need to be addressed. Shahzad et al. (2019) extended these concerns by highlighting the lack of consensus across the globe regarding the regulations, legalities, and ethical implications of telemedicine.

Based on the earlier sections, telemedicine provided numerous benefits, such as enhanced access to quality and expert care, time-and-cost savings, reduced treatment times, reduced need for post-operative care, and patient empowerment. Telemedicine provided unique benefits for military, naval, and space operations, as well as war zones or disaster-affected areas. Some of the limitations of telemedicine included risks associated with time-lags during technology usage, lack of internet connectivity and speed, cyber-attacks, hacking, and data leakage. Finally, there are limitations, such as the high cost of the initial investment in infrastructure development, personnel training, and lack of consensus on legal and ethical considerations related to telemedicine.

2.5 Barriers and Facilitators of Telemedicine

This section draws on the existing literature and evaluates factors that may act as barriers and facilitators for a successful application of telemedicine. Since this thesis will focus on technology as a critical theme for a successful telemedicine application, this section will focus on how technology can facilitate telemedicine usage.

2.5.1 Barriers to telemedicine.

Several barriers to the effective adoption of telemedicine are discussed in the following sub-sections.

Lack of infrastructure.

Cai et al. (2016) and Mbunge et al. (2022) contended that telemedicine implementation and capacity utilisation could be hampered by lacking information technology infrastructures such as high-speed internet or other network services. While governments invest in acquiring telemedicine technology and equipping hospitals with the necessary medical equipment and infrastructure, there are often lapses in developing the required networking capabilities and connectivity for the region. The lack of high-speed fibre internet or other network services limits the full utilisation of telemedicine capabilities. Often, this is a planning stage failure because the regional developmental plans may not be integrated within the national-level vision in real-time (Cai et al., 2016; Mbunge et al., 2022).

Lack of standardised laws.

An associated barrier facing telemedicine is the lack of a concerted, standardised, and globally accepted set of laws concerning liability, healthcare delivery, and ethical protocols (Adepoju, 2020; Cai et al., 2016; Mbunge et al., 2022). Privacy-related laws are stringently applicable in some countries, while others may lack the necessary implementation or support, making it challenging to implement telemedicine in cross-border situations (Alami, Gagnon, & Fortin, 2016; Kaplan, 2020). Data sharing is another complex area since content distribution needs to be defined by time, location, and format (Kim et al., 2019; Suominen et al., 2016). Similarly, there are issues related to the rules governing data hosting services (Raposo, 2016; Zulkipli et al., 2022). For example, most cloud service providers, such as IBM, Amazon, Alphabet, or Microsoft, are required to be compliant with European General Data Protection Regulation (EGDPR), since the data belongs to European Union (EU) citizens, even though the service providers are mainly Americans, thus creating problems related to data usage when telemedicine services span across the continents, with American specialists providing care for European patients or vice-versa.

In a related study, Parimbelli et al. (2018) provided legal and ethical frameworks that apply to more active forms of telemedicine, where real-time, non-mediated interactions occur between the end-user and the remote service provider and are also mired in some controversies regarding liabilities and data privacy. This concern is also voiced by Hervey and Sheldon (2017), who presented the case of certain procedures such as abortion, the legality of which is location dependent; consequently, utilising tele-mentoring or tele-consulting services from these locations could be subject to legal complications and ethical concerns.

Privacy issues.

Privacy concerns may lower the use of telemedicine; as discussed by Molfenter et al. (2018), they found that in addiction treatment cases, users/addicts may be concerned with privacy and confidentiality issues. Ramalingam (2022) pointed out that telemedicine delivery involves using medical devices designed to capture patients' data and can be shared by third parties. Those medical devices are approved by the Food and Drug Administration (FDA), where the FDA is more concerned with the functional and safety aspects of the device rather than its impact on the privacy or security of the user (Hall & McGraw, 2014; Ramalingam, 2022). Similarly, the Health Insurance Portability and Accounting Act (HIPAA) requires that identifiable information be encrypted, but only information related to insurers or healthcare providers, not patients (Persaud, 2022).

Accountability and liability.

Parimbelli et al. (2018) postulated that it would be difficult to establish accountability if there were inaccurate recommendations by the telemedicine apps' algorithm. Zulkipli et al.

(2022) also contended that medical liability laws should be updated to establish liability and accountability for data breaches and theft. Since telemedicine brings together both information services and healthcare services, there is a need for regulations that can be applied to both, establishing responsibility and accountability. Comprehensive regulations and standards should be developed to ensure sensitive data-sharing traceability to prevent third-party usage of patients' personal demographic, health, or data records (Raposo, 2016; Zulkipli et al., 2022).

Lack of ease-of-use.

Another barrier to telemedicine application is the lack of user-friendly telemedicine technology and awareness regarding managing telemedicine devices and applications (Parimbelli et al., 2018). Mbunge et al. (2022) also added that patients' lack of knowledge in manoeuvring through new technologies acts as a barrier to utilisation, and the need for greater awareness regarding managing telemedicine devices and applications (Parimbelli et al., 2018). Therefore, patients should be educated to use telemedicine devices and apps to provide accurate inputs and relevant data; they should be aware of the risks associated with malware and harmful downloads that could jeopardise their device's security and privacy. Parimbelli et al. (2018) further added that healthcare professionals need to be skilled in operating within the telemedicine framework. Lack of training in operating technology is one of the prime reasons for errors in healthcare. Thus, healthcare professionals should be adequately trained in technology procedures and prevent the probability of errors while processing patient data into the system (Parimbelli et al., 2018).

Lack of interoperability and technological integration.

Kluge et al. (2018) contended that lack of interoperability and inability to share and transfer data in its integrated and accurate form could disrupt services that are crucial for providing telemedicine services. Also, the lack of functional reliability of devices based on innovative technology or not being tested in local settings could create problems for providing seamless service (Kluge et al., 2018). Kluge et al. (2018) also expressed concerns over the lack of integration of the legacy systems with the updated telemedicine tools; and mentioned that it could lead to the loss of patient data and records and act as a barrier to telemedicine adoption. Gunter et al. (2016) and Tshikomana and Ramukumba (2022) further extended these themes and pointed out the lack of alignment of telemedicine platforms with clinical processes as one of the leading causes of inaccuracies in telemedicine systems, which may get logged as technical issues rather than work-flow problems. While telemedicine seems to clarify how technology-enabled workflows can be performed, there is no clarity on healthcare providers' roles and tasks post-telemedicine. Such clarity is needed for patient follow-ups, account management, data analysis, and patient data integration, which, when clarity is absent, may lead to duplication of functions and wasteful usage of resources. Lastly, the healthcare workforce can experience a high churn, which means healthcare organisations require regular training and learning for newly hired staff, which usually translates into higher overall costs.

Lack of face-to-face interactions.

Yadav et al. (2022) stated that the lack of personal touch through face-to-face interactions between healthcare professionals and patients might also be a barrier to patients' adoption of telemedicine practices. Jafarzadeh et al. (2022) and Payán et al. (2022) added that doctors, too, might hesitate to provide consultations to patients over telemedicine mediums due to their lack of familiarity with the new technology or their negative attitude towards its potency.

Summary of barriers.

The above sections summarised some of the barriers to implementation of telemedicine observed from the literature, including the lack of ICT and network infrastructure, lack of standardised laws on data storage and usage, user privacy and ethical considerations, lack of adequate means of supporting accountability and responsibility, lack of user-friendliness of the technology-based healthcare delivery system, lack of inter-operability and technological integration, and lack of human interactions inherent in telemedicine usage.

2.5.2 Facilitators of telemedicine.

Since this study focuses on technology as a critical theme for successful telemedicine (tele-emergency) application, this section will focus principally on technology that aids and supports telemedicine. This section will include a discussion on technology devices that can be deployed in healthcare, communication platforms that have the potential to be utilised for telemedicine, and robotic systems that can be operationalised to further automate the delivery of healthcare service at the point of care.

Technology as a facilitator of telemedicine application.

Technology is an integral part of telemedicine, and audio-visual devices, cell phones, iPad-based apps (Paik, Granick, & Scott, 2017; Pang et al., 2022), and messaging apps - for instance, WhatsApp (Ittefaq et al., 2022; Johnston et al., 2015; Mukherjee et al., 2022; Nardo et al., 2016), and Instagram (Ittefaq et al., 2022; Kamel Boulos, Giustini, & Wheeler, 2016) – have all aided in the telemedicine delivery. WhatsApp is potentially useful for tele-education, where physicians can seek guidance from experts (Freitas et al., 2022; Nardo et al., 2016) in modalities or specialities such as tele-surgery and tele-mentoring cases (de Assis et al., 2022; Mukherjee et al., 2022; Johnston et al., 2015). WhatsApp has been reported as a valuable tool for tele-emergencies, where local doctors caring for critically ill patients in remote sites can get support from experts (Adetunji et al., 2022; Thota & Divatia, 2015).

Telemedicine is seeing an infusion of more advanced and emerging technology tools. Robotic technology can facilitate the delivery of not only expert advice and diagnostics but also the performance of actual surgery – a feat that has expansive scope and application. Currently, robots such as the da Vinci and the Zeus systems perform tele-surgery (Ayoub et al., 2022; Nehme, Neville, & Bahsoun, 2017). Zeus uses Asynchronous Transfer Mode (ATM) technology that enables video-conferencing and online communications between the two sites. The da Vinci surgical system uses a more sophisticated robot equipped with better manoeuvring prowess for surgical performance. Automated Endoscopic System for Optimal Positioning (AESOP) is a system that enables an expert to tele-monitor; and guides the performance of the operations at remote sites by other surgeons (Nehme et al., 2017). Breakthrough technologies such as haptic feedback technology, represented by the Telelap ALF-X, are enabling the transfer of tactile data to the tele-operator; thus, making it possible for the surgeon to continuously monitor the consistency of tissues to adjust the force of the instruments while controlling robots for remote surgery (Shahzad et al., 2019).

Technology can also deliver workable solutions around legal, ethical, and privacy concerns by making telemedicine systems more traceable and accountable. For example, Therap-e is a telemedicine platform that allows caregivers to share data with and obtain advice from specialists in remote locations through the use of a mobile network or the institution provided network (Ambroise et al., 2019), but without storing any information on devices through which the communication occurs. Instead, all records and clinical outputs from physicians are automatically transferred to the patient's Electronic Medical Record (EMR) to ensure traceability and accountability (Ambroise et al., 2019).

Therefore, technology not only facilitates the healthcare delivery process and improves the accuracy, efficiency, and effectiveness of telemedicine; it also increasingly improves traceability, accountability, transparency, and privacy of the telemedicine system. Besides technology, other factors are considered vital for the successful application, adoption, and implementation of telemedicine. These non-technological factors are essential to acknowledge since they can facilitate or act as barriers to any telemedicine project's developmental and implementation stages. Technology frameworks should be developed within these non-technological factors to fully complement them and effectively incorporate them within the healthcare delivery system. Therefore, the following section discusses these factors to illustrate their importance and interrelationship with technology as a facilitating theme to the applicability of telemedicine.

Other facilitators of telemedicine application.

Several studies on telemedicine have reported other facilitating factors besides technology, such as communication effectiveness, stakeholder participation, clarity of roles and workflows, mutual trust, teamwork, costs, examples of previous success, and many others. For example, based on a qualitative focus group-based study, Fang et al. (2018) reported that effective communications and engagement of all stakeholders in training and education were crucial in facilitating the implementation of tele-neonatology. Fang et al. (2018) added that reliable and straightforward clinical workflow designs and maintaining the professional and supportive relationship between the local and remote teams are considered equally crucial facilitating factors.

From an addiction rehabilitation context, Molfenter et al. (2015) found that telemedicine adoption and implementation were facilitated by the availability of funds for smartphones, telemedicine platforms, and services. Similarly, knowledge of local success stories of using telemedicine and encouragement by local treatment agencies promoted the use of telemedicine apps (Baird et al., 2022). Parimbelli et al. (2018) further extended the need for training and education for end-users, especially when an active telemedicine system was used and users had access to healthcare services without the mediation of a local physician. Additionally, well-thought-out protocols and suitable technological devices can facilitate telemedicine (Parimbelli et al., 2018).

Chang, Pines, and Thorpe (2018) provided a more comprehensive view of themes that can facilitate telemedicine implementation by categorising them as organisational themes (designing clear job roles, workflows, and protocols to ensure accountability; participative culture; and top management support), personal themes (the ability to educate oneself to use telemedicine, acceptance of telemedicine, cultural background, and attitudes towards telemedicine), and legal and regulatory factors. Similarly, the EU developed the 2015 EU guidelines to facilitate factors represented by the regulatory framework and enhance communications. For example, the EU allows physicians licensed in one country to provide telemedicine services in other countries without seeking further licences in the point-of-care country and ensures that communications are transcribed into the destination language to facilitate better understanding and seamless service (Raposo, 2016). Such a legal framework does not exist in the USA, where different states require individual licensing, insurance claims, accountability claims, patient data retrieval, and sharing protocols differ across state lines, complicating telemedicine delivery (Chang et al., 2018).

Summary on facilitators of telemedicine application.

Technology is a facilitator for telemedicine application by reducing barriers related to the impersonal nature of telemedicine, improving the accuracy of data collected and the services delivered, and reducing legal and ethical issues that hinder the adoption and scaling of telemedicine. In addition to technology, other factors facilitate telemedicine applications, such as the clarity of roles and workflows, communication effectiveness, trust, teamwork, past successes, stakeholder participation, and costs. An appreciation of telemedicine's advantages, limitations, barriers, and facilitators can help develop a new tele-emergency framework, which this research seeks to deliver as its ultimate goal. First, however, reviewing the existing literature on various healthcare specialities where telemedicine has been adopted is critical in developing a basic understanding of telemedicine's overall utility and scope. The following section will present some of the available and already existing telemedicine specialities, giving special attention to the tele-emergency speciality.

2.6 Telemedicine Uses and Specialities

Since most of the studies regarding telemedicine focused on specific telemedicine specialities, this section will reference some of the key themes with an emphasis on a speciality that this study will focus on, tele-emergency. In setting this out, the review will focus on a diverse set of telemedicine specialities, including tele-radiology, tele-pathology, tele-education, tele-surgery, tele-mentoring, tele-monitoring, tele-consulting, and tele-emergency.

2.6.1 Tele-radiology.

While tele-radiology can be traced back to 1947, when radiographic images were transmitted over telephone lines, more recent applications of tele-radiology are reported to provide added benefits such as a reduction in inter-departmental patient transfers, repeated hospitalisation, and the overall hospital stay (Bashshur et al., 2016; Kahan et al., 2022). Bashshur et al. (2016) systematically reviewed empirical studies from 2005 to 2015 and found a common theme that most studies reported similar outcomes regarding diagnostic reliability and accuracy of traditional radiology and tele-radiology.

2.6.2 Tele-pathology.

In reviewing the existing literature, the concept of tele-pathology and the application of molecular tele-pathology revealed substantial scope for deploying telemedicine to the field. Cusack et al. (2022) and Roy et al. (2016) highlighted that clinical pathology laboratories could share electronic molecular data with referencing laboratories and with regulatory agencies, as and when needed using tele-radiology applications. The molecular data transmitted could be used to validate rare diseases with the help of foreign data banks or test the accuracy of results against standards and benchmarks; thus, enhancing the accuracy of pathological tests.

2.6.3 Tele-education.

Considerable research is emerging, indicating the scope of tele-education for healthcare professionals. Foroughi and Ahmadvand (2018) underscored the successful use of Telegram, a cloud-based messaging app by pathologists in Iran for tele-education of their colleagues through sharing of typical or novel cases on a group chat. Similarly, Azlan (2018) reported the increasing use of Twitter as a medium of tele-education for medical students and interns and updating knowledge for practising pathologists.

2.6.4 Tele-surgery.

Many papers have focused on tele-surgery using AI, Virtual Reality (VR), Machine Learning, Big Data Analytics, and personal analytics technologies. Tele-surgery involves using robotic devices and systems based on emerging technologies, such as Zeus and da Vinci, that can be operated by remote surgeons (Harting et al., 2019). Several writers have discussed the increasing deployment of tele-surgery within the operating room and for pre-and-post-surgery care, using synchronous audio-video and supported by texts or tele-monitoring (Gunter et al., 2016; Mancini et al., 2022), mainly because outcomes of tele-surgery are comparable or surpasses those of traditional surgery (Danesh et al., 2022; Gunter et al., 2016). This is reflected in the vast amount of studies that have focused on tele-surgery, including pediatric surgery (Harting et al., 2019), cancer surgery (Nota et al., 2019), hernia surgery (Janssens et al., 2019), head and neck surgeries (Poon et al., 2018), colorectal surgery (Weitman et al., 2018), and plastic and reconstruction surgeries (Kalfa, 2022; Nehme et al., 2017).

However, Raison, Khan, and Challacombe (2015) and Takahashi et al. (2022) cautioned that tele-surgery comes with certain limitations due to the probability of technical failure and differences in patients' size, and the possibility of complications. Therefore, the physical presence of surgical experts must also be available at hand. However, tele-surgery is being performed just in case of emergencies such as power, equipment, or technical failures. According to Almansoori et al. (2022), while tele-surgery is safe and accurate, there is probably no replacement for human supervision for such operations.

2.6.5 Tele-mentoring.

Tele-mentoring involves an expert remotely teaching or providing guidance and instructions using audio-video devices (Catterwell et al., 2018). Tele-mentoring may include tele-proctoring, where the expert monitors to assess the performance (Hung et al., 2018). Assad-Kottner et al. (2014) provided an example of tele-mentoring. A surgical team member, wearing a Google Glass, received mentoring from a remote structural-heart expert during a live catheterisation process. Several similar examples of tele-mentoring are available in the literature in the context of tobacco addiction (Cofta-Woerpel et al., 2018), neurosurgical training (Akhigbe, Zolnourian, & Bulters, 2017; Pfennig et al., 2022), laparoscopy (Mizota et al., 2018), and emergency trauma surgery (Dawe et al., 2018), indicating at the increasing deployment of tele-mentoring to aid point-of-care professionals. Tele-mentoring, therefore, can provide on-the-job training and support from specialists and experts to the in-field emergency healthcare professionals and the point-of-care ED professionals.

2.6.6 Tele-monitoring.

Tele-monitoring involves the transfer of physiological and biological data from the patient to remote locations that are equipped with specialised abilities such as data-mining and decision-support systems to monitor, analyse, and interpret data and provide clinical decisions based on analytics (Solanki et al., 2022; Thelen et al., 2015). A considerable amount of research exists, discussing and evaluating the scope for tele-monitoring for diverse healthcare needs. For example, Salvador et al. (2005) provided 89 cardiology patients with a portable Electrocardiogram (ECG) device and a mobile/cell phone to transport data from the device back to a central location for tele-monitoring by remote cardiologists. Aranki et al. (2016) evaluated a more expansive tele-monitoring system using a smartphone-based app for patients to gauge their Energy Expenditure (EE) on a minute-by-minute basis and track vital signs and cardiovascular symptoms daily. Vermeulen-Giovagnoli et al. (2015) developed a tele-monitoring system that could enable home measurement of the Foetal Heart Rate (fHR), Foetal Electrocardiogram (fECG), and uterine activities and transmission of the data over a secure wireless network to hospitals where real-time monitoring could be done for foetal health. The same modality allowed tele-monitoring and consultation in cases of home-based deliveries. Telemonitoring has also found application in intensive care, as Ramnath and Khazeni (2014) stated in a systematic review that indicated a positive impact of tele-monitoring in the form of reduced patient mortality. Robie et al. (2022) and Ramnath and Khazeni (2014) also found that a centralised monitoring tele-ICU model led to improved mortality and reduced length of stay. Aranki et al. (2016) and Farooqi et al. (2022) similarly found that tele-monitoring systems adapt to diabetes and other health conditions. By extension, it can be assumed that tele-monitoring can be deployed across the spectrum of most healthcare delivery.

2.6.7 Tele-consultation.

Tele-consultation is a consultation conducted through telecommunications (Paik et al., 2017). Tele-consultation literature has dwelt on plastic surgery, neuropsychiatry, post-mortem examinations, and providing support to local doctors in remote or rural areas. For example, Paik et al. (2017) found that remote Plastic Surgery Educators (PSE) could provide accurate guidance to point-of-care ED physicians based on digital images and patient history provided to them. Agarwal et al. (2019) emphasised the use of tele-consultation for neuropsychiatry support in prisons for delivering specialist care to 53 inmates by adequately recommending them for pharmacotherapy or further evaluation at a referral hospital. Similarly, Kale et al. (2016) evaluated a program in rural areas of India that delivered psychiatric specialist care to 316 patients through 1200 successful tele-consultations. Tele-consultation has also found a place in forensic consultations, as the research by Smits et al. (2017) documented. They examined 938 cases in Amsterdam where telephonic consultations were provided by remote forensic experts regarding post-mortem examinations and found that correct advice was furnished in 828 cases, thus indicating tele-consultation's effectiveness along with the apparent ability to save time and costs that may have been spent on travel. The literature, therefore, indicates the scope and efficacy of tele-consultation.

2.6.8 Summary of telemedicine uses and specialities.

Telemedicine has found considerable scope and utility in healthcare-related specialities of tele-radiology, tele-pathology, tele-surgery, tele-monitoring, and tele-consultation. Telemedicine is reported to have provided positive outcomes when applied in the education or training contexts in tele-education and tele-mentoring.

2.6.9 Tele-emergency.

Telemedicine has also found applications in emergency care, both by providing support for hospital EDs and providing preparedness, support, and recovery during disasters or calamities (Friedman et al., 2022; Kelton, Szulewski, and Howes, 2018). Since this research focuses on developing a tele-emergency framework, this sub-section will solely discuss emergency telemedicine applications - namely telemedicine applications within the ED and telemedicine applications in disaster management.

Telemedicine in EDs.

Ward, Jaana, and Natafgi (2015) conducted a systematic review and found that telemedicine improved clinical processes and outcomes, throughput and dispositions, technical quality, and user satisfaction in rural hospital EDs. Paik et al. (2017) have reported the efficacy of telemedicine applications in ED consultations, mentoring, and surgeries in the context of emergency plastic surgery in remote locations. This was supported by Ambroise et al. (2019), who tracked the deployment of the Therap-e application in a pediatric ED for three months to successfully service 45 requests for specialist opinions related to maxillofacial trauma. However, Ward et al. (2015) noted that research methodologies and the research vigour of studies they found had limitations. As such, their findings regarding outcomes of tele-emergency in EDs needed to be corroborated with further evidence. Kelton et al. (2018) found evidence supporting Ward et al. (2015) doubts and reported a lack of research supporting improved patient outcomes in EDs. As such, it can be assumed that any telemedicine framework proposed or developed via this study needs to be substantiated with extensive empirical research gathered from patient-outcome data and suggestions and opinions obtained from stakeholders such as healthcare providers and policy-makers.

In a study funded by the Health Resources and Services Administration, Australia, Harris et al. (2017) scanned tele-emergency-specific measures employed by rural hospitals. They found that hospitals did not have clearly defined and measurable outcome objectives to assess tele-emergency services. Harris et al. (2017) also found that most of the measures used in practice were not evidence-based or tested for validity or reliability. The findings undermined the expected benefits of tele-emergency and emphasised the need to establish clear, specific, and measurable performance outcomes for tele-emergency services. Besides, there have also been concerns regarding the financial aspects of tele-emergency, especially in the context of a rural ED's ability to afford such services. MacKinney et al. (2015) and Weigel et al. (2020) postulated that rural EDs could make tele-emergency cost-effective only if they were to reduce their onsite staff or physicians or conduct other cost-saving activities.

Telemedicine in disaster management.

In the context of emergency care during disaster management, telemedicine has been found to have applicability at all stages of the process – from the preparation phase to the action and response phases, and finally to the recovery phase (Anwar et al., 2019). For example, Anwar et al. (2019) highlighted that live video conferences or broadcasts via drones can be used for tele-consultation; for collecting and sending the patient's vital signs data and biological information; for tele-mentoring local physicians to perform surgeries or other procedures; and tele-monitoring the performance of healthcare workers in the field. Cai et al. (2016) also provided a framework for telemedicine in EDs in remote locations in northwest China to support ill-equipped local hospitals to handle emergencies and provide support during any disastrous events.

Summary of tele-emergency and disaster management.

The above section has highlighted that tele-emergency has found application in both EDs and disaster management. However, the existing literature indicates the need to develop evidence-based frameworks that can deliver measurable results for healthcare service delivery. Also, there appears to be a need to define telemedicine deliverables further, establish metrics for performance appraisal, and develop extensive cost-benefit analysis before developing a new tele-emergency framework.

2.7 Existing Telemedicine Frameworks

Telemedicine has been discussed widely in the existing literature regarding its utility and scope, as presented in the previous sections. A considerable amount of research has focused on developing frameworks for the effective implementation of telemedicine. Several frameworks have evolved globally over time - most notably that of Warren et al. (1999), which has emerged primarily from specific legislative initiatives to deploy telemedicine regionally, and range from generic frameworks to healthcare-speciality-focused frameworks. These frameworks vary in detail and specificity and are often implemented with modifications to suit specific needs. The following section evaluates these frameworks and assesses their scope and applicability to the UAE.

2.7.1 Generic frameworks for telemedicine.

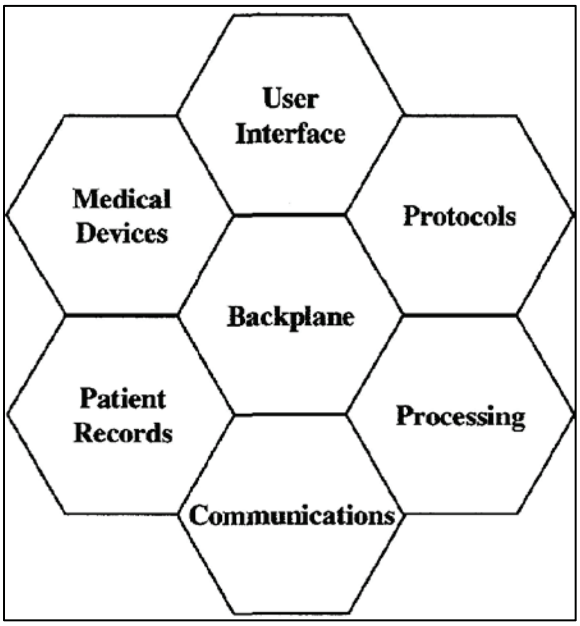
Warren et al. (1999) framework.

One of the earliest frameworks of telemedicine was proposed by Warren et al. (1999) to facilitate interaction between system components using an object-oriented information architecture that enabled components to interact with each other through a plug and play system. This framework proposed seven system services that can lead from one service to another through integration (see Figure 2.1). The framework included: (1) the user interface service (the user interacts with the technological devices and people); (2) medical devices service (service that enables patient data acquisition and analysis); (3) patient records service (or patient data storage and retrieval); (4) processing service (intelligent agents to diagnose and manipulate data to identify trends); (5) communications service (enables devices to communicate with each other); (6) protocols service (the sequence of actions that are needed to deliver a telemedicine service – the brain); and (7) backplane services (a repository of information that allows different components to interact in a plug-and-play fashion).

The Warren et al. (1999) framework attempted to initiate integration and interoperability within the HIS. However, it dealt with 20th century technologies and could not have envisaged more complex service components brought forth in the current century. Distributed computing and cloud-based systems had not evolved during that time, which would warrant updated technology frameworks.

Figure 2.1

General types of services represented in the proposed telemedicine device architecture



Note. From "A proposed information architecture for telehealth system interoperability," by Warren, S., Craft, R. L., Parks, R. C., Gallagher, L. K., Garcia, R. J., & Funkhouser, D. R, (p. 4), 1999, *United States: N. p., 1999. Web.*

Mykkänen, Porrasmaa, Rannanheimo, and Korpela (2003) framework.

In contrast to the plug and play system of Warren et al. (1999), Mykkänen et al. (2003) proposed an integrated framework that can integrate the already existing HIS with the new telemedicine system. Mykkänen et al. (2003) suggested the following before attempting such integration:

(1) Identifying the data and functionality that can be shared between the different systems.

(2) Locating the points of integration in the interoperable parts of the systems.

(3) Developing a suitable interoperability model and supporting them with integration technologies.

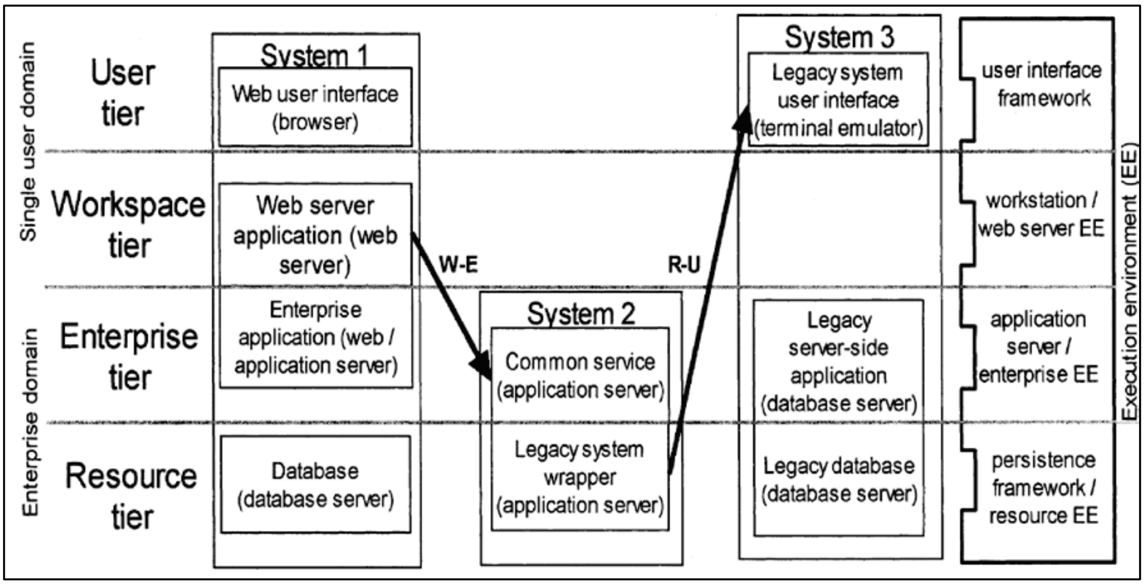
(4) Supporting interoperability during the transition period.

The framework developed a seven-layered interoperability model (see Figure 2.2) that included: (1) technical interface – technologies used for the implementation of interoperability, (2) technical infrastructure – technical support of communication, (3) application infrastructure – positioning integration points in multi-tier application architecture, (4) functional interfaces – interfaces of the services, (5) semantics – knowledge about the meaning of the functional interfaces, (6) functional reference model – underlying system-specific models that affect interoperability, and (7) development lifecycle – extends the interoperability between systems that include the early phases of the lifecycle.

The framework was validated in Finland with the PlugIT project and enhanced the efficiency of the HIS applications through interoperability and information sharing between diverse systems. However, while focusing on the integration process, the framework did not include guidance regarding implementation issues related to cultural and personal factors, unlike Warren et al. (1999) framework. The framework also fails to include provisions for ensuring access to data and records during downtimes in telecommunications (Ghani, 2010). Nevertheless, Mykkänen et al. (2003) integrated framework is expected to be a good starting point for any proposed technology-based telemedicine system since it can connect existing HIS systems with more powerful technology, provided there are provisions for interoperability and scalability.

Figure 2.2

Four Distribution Tiers



Note. From "A process for specifying integration for multi-tier applications in healthcare," by Mykkänen, J., Porrasmaa, J., Rannanheimo, J., & Korpela, (p. 176), 2003, *International Journal of Medical Informatics, 70*(2-3), 173-182.

Doolittle and Spaulding (2006) framework.

Doolittle and Spaulding (2006) premised their framework on the assumption that a general model can guide the technical, economic, and clinical implementation of telemedicine. This framework provides a sequential, step-based approach to telemedicine. The framework emphasises processes that entail six sequential steps:

(1) Defining the need for a telemedicine service
(2) Planning a service
(3) Conducting a needs assessment
(4) Developing a healthcare team
(5) Marketing
(6) Evaluating the programme.

This framework, however, does not provide detailed guidance on the technological implementation like Mykkänen et al. (2003) or cultural and personal factors in telemedicine implementation considered by Warren et al. (1999). Instead, it provides a broad structure and sequence of actions necessary for telemedicine implementation. It can, therefore, guide the detailing of a technology-based tele-emergency framework that this study expects to propose for the UAE.

2.7.2 Speciality-based framework.

Further attempts to initiate a technology framework for telemedicine pushed for greater integration, rather than just a "plug and play" of different service components and functionalities. The following framework illustrates a speciality-based telemedicine framework focused on a telemedicine platform for a specific clinical service.

Tsiknakis, Katehakis, and Orphanoudakis (2002) framework.

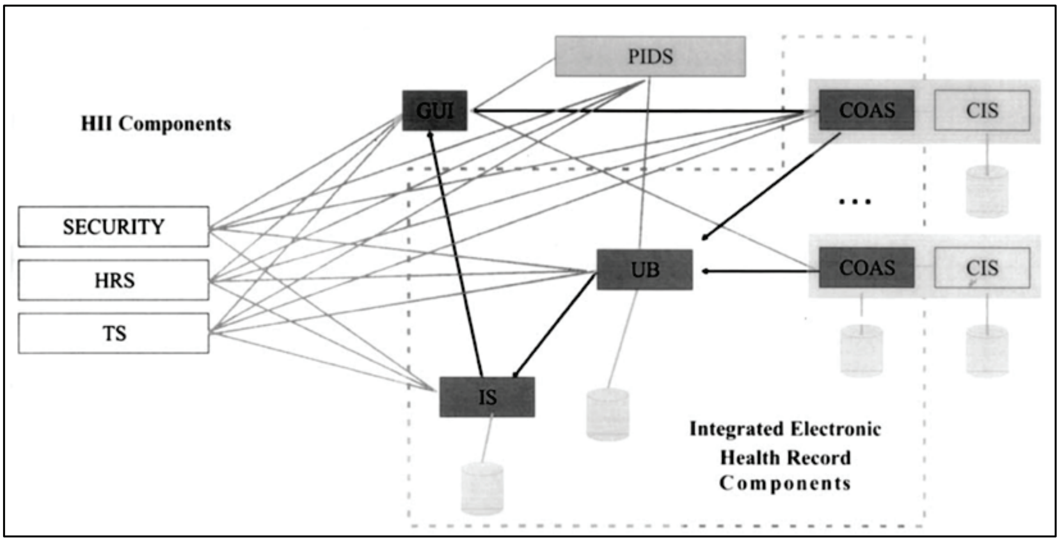
Tsiknakis et al. (2002) 's HYGEIAnet provided an integrated healthcare delivery and medical training system for the Crete island in Greece. Like Mykkänen et al. (2003) framework, Tsiknakis et al. (2002) sought to provide seamless access to the Electronic Health Record (EHR) during a patient-doctor encounter, including:

(1) Patient Identification Service (PIDS)
(2) Health Resource Service (HRS)
(3) Indexing Service (IS)
(4) Update Broker (UB)
(5) Clinical Observation Access Service (COAS)
(6) Terminology Service (TS). (see Figure 2.3)

Fundamentally, integrated PIDS allows for centralised indexing of patient data, and Integrated Electronic Health Record (I-EHR) enables integration of all patient-physician interactions from diverse departments and records. The data is updated with the latest information through the UB service and a public interface that allows access to different stakeholders for clinical observation. Furthermore, HRS provides any point with access to information related to the availability of equipment, resources, and physicians. HYGEIAnet provided a robust integration system within diverse and, to a certain extent, between different service components, but it has further scope for developing an integrated framework.

Figure 2.3

The I-EHR architecture component synergies



Note. From "An open, component-based information infrastructure for integrated health information networks," by Tsiknakis, M., Katehakis, D. G., & Orphanoudakis, S. C. (p. 17), 2002, *International Journal of Medical Informatics, 68*(1-3), 3-26.

2.7.3 Tele-emergency frameworks.

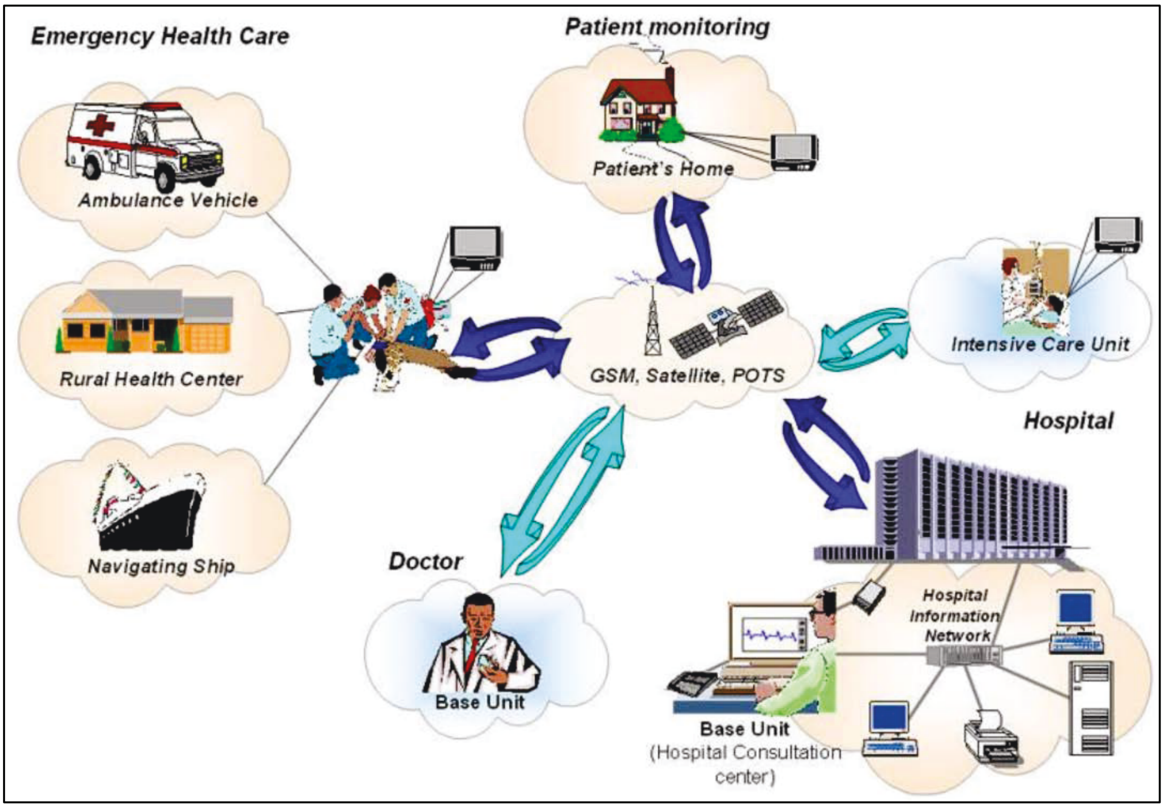
The four frameworks discussed earlier have primarily focused on integrating technology systems and interoperability. However, these frameworks do not dwell on the implementation process or consider the socio-cultural or human factors that may be operant during implementation. Equally, it should be noted that all the frameworks discussed till now were developed to suit the needs of a specific healthcare setting and not focused on tele-emergency delivery. Therefore, the following frameworks will address telemedicine delivery in emergency and disaster cases.

Kyriacou et al. (2001) framework.

Kyriacou et al. (2001) used a client-server model and flexible networks that can handle diverse modes of telecommunications, such as Global System for Mobile (GSM) and Plain Old Telephony System (POTS). The framework allows data transmission, including images from disaster areas to the base unit, as shown in Figure 2.4.

Figure 2.4

All Weather Telemedicine System



Note. From "Multipurpose health care telemedicine system," by Kyriacou, E., Pavlopoulos, S., Koutsouris, D., Andreou, A., Pattichis, C., & Schizas, C, (p. 1), 2001, Paper presented at the 2001 Conference Proceedings of the 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society.

The telemedicine unit is where data is captured in the form of biosignals, images, or text. The base unit is where data is retrieved or displayed, decisions made, and advice delivered. The hospital database unit, as mentioned earlier, manages the storage of the data that is shared between the other two units. The Kyriacou et al. (2001) framework has been implemented successfully in different locations such as Cyprus, Italy, Greece, and Sweden. It appeared to be a flexible and adaptable system for tele-emergency service delivery. However, this framework does not provide for a direct video feed from the patient's location in emergencies, which could have added to the information received by the remote doctors and probably enhanced the quality of the consultation. Also, the Kyriacou et al. (2001) framework does not provide system integration that could have enabled updating and integrating patients' records in the hospital database and facilitated long-term support.

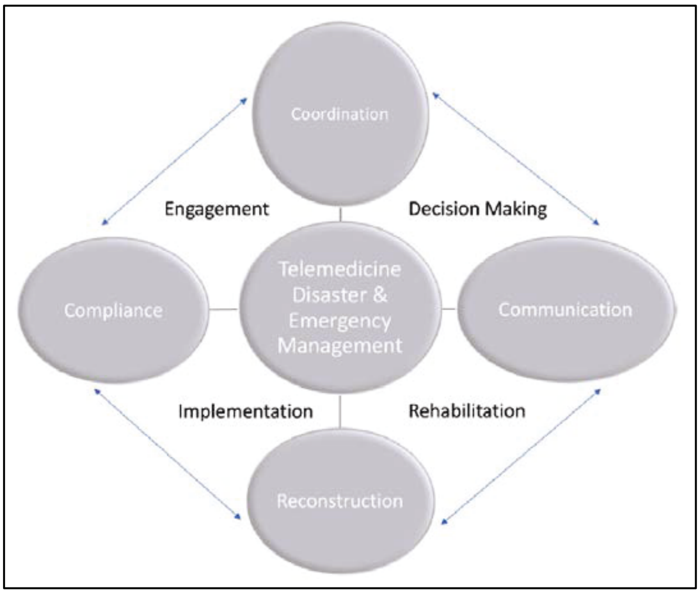
Anwar et al. (2019) framework.

Anwar et al. (2019) proposed a Surveillance Model for emergency telemedicine, but in the broader context of disaster management as opposed to the Kyriacou et al. (2001) framework that targeted single emergency events. This model guides the performance of four essential functions that need to be performed during disaster management:

(1) Coordination of multi-agency efforts
(2) Facilitation of effective communications
(3) Compliance
(4) Reconstruction and recovery (see Figure 2.5):

Figure 2.5

Fundamental Elements and Stages of Disaster or Emergency Care Management



Note. From "A telemedicine platform for disaster management and emergency care" by Anwar, S., Prasad, R., Chowdhary, B. S., & Anjum, M. R, (p. 193), 2019, *Wireless Personal Communications, 106*(1), 191-204.

According to Anwar et al. (2019), by utilising telemedicine applications, agencies have access to accurate, reliable, and updated data on the victim's conditions and facilitate coordination of multi-agency efforts for rescue. The function of having a constant communication tool, which is based on the understanding that agencies should be able to update their inputs into a central database that other agencies in real-time can access, is performed better with the help of a telemedicine system. Having access to a constant communicating tool, tele-monitoring or tele-consulting experts in remote locations, and even in transnational locations, can aid field-workers in providing adequate and targeted support to victims. By enabling telemedicine, where experts and specialists can tele-mentor and provide proper guidance, there is a higher probability of ensuring such compliance. Telemedicine can help detect and deal with relapses during the recovery process, unhealthy behavioural patterns, stress levels, and the spread of diseases. Using collected data, medical professionals can analyse patterns related to health conditions, incidences of stress, or other health complications and develop an adequate plan of action for support and rehabilitation.

However, although the Surveillance Model provides valuable insights for developing a telemedicine framework in emergencies, it lacks specificity and is not well developed; therefore, it cannot be applied directly. While the model illustrates the four essential functions that need to be performed, it does not chalk out a framework of operation to follow or provide specific guidance on including tele-emergency in disaster management scenarios. The model merely provides a broad framework that focuses on four functions that need to be performed during disaster management scenarios while leaving out the technological intricacies and practical implementation issues.

Summary of tele-emergency frameworks.

There have been both generic frameworks and speciality-focused frameworks proposed in the literature. The generic frameworks, such as the Warren et al. (1999) framework that is based on the integration of new telemedicine apps with legacy systems, are based on outdated technology; Mykkänen et al. (2003) framework is based on an updated technology; Doolittle and Spaulding (2006) give specific implementation guidelines and can be used to guide the development of a comprehensive and expansive telemedicine framework. On the other hand, speciality-based frameworks such as those proposed by Tsiknakis et al. (2002), Kyriacou et al. (2001), and Anwar et al. (2019) frameworks provide technological details that can be used for the practical development and implementation suggestions for the tele-emergency framework that this study aims to propose. These frameworks are reviewed in this chapter because they are considered of particular relevance and value to this study. However, other and more recent frameworks were also reviewed, and these are listed in a table in Appendix E. These frameworks include others (UEMS by Tan et al. (2017) and the Telemedicine Framework for EMS and 911 organizations by the Federal Interagency Committee on EMS, (2021)) that, as the research progressed, appeared of relevance to the research findings and evaluation of the proposed framework for the UAE. These evaluation frameworks are discussed in more detail in chapter 8.

2.8 The UAE Context

2.8.1 The UAE's healthcare system.

This section provides an overview of the UAE healthcare system, healthcare concerns, and the UAE's strategy and vision for healthcare. The UAE is facing several healthcare challenges that are typical to the region, such as the incidence of heart diseases, cancers, and lifestyle-related diseases that include obesity, metabolic syndrome, diabetes due to a sedentary lifestyle, and congenital diseases owing to consanguineous marriages prevalent in the country

(Algurg, 2014; Emery, 2017; U.S.-U.A.E. Business Council, 2019). The UAE Vision 2021 aims to reduce incidences of diabetes by 14%, cardiovascular diseases by 25%, cancers by 18%, and tobacco-related respiratory diseases by 15% (Algurg, 2014), and aims to cater to healthcare for a growing population that is expected to become 11,055 million by 2030 (Baldwin, 2018). The demand for healthcare is also expected to expand due to demographic shifts in the population, with the country expected to have 4.4% of people above the age of 65 by 2030 (Baldwin, 2018). Healthcare expenditure was $17 billion in 2017 and is expected to rise to $21.3 billion by 2021, with the UAE spending 4.6% of its Gross Domestic Product (GDP) on healthcare by 2026 (U.S.-U.A.E. Business Council, 2019).

Challenges such as these have led to the ambition to grow and modernise the UAE healthcare sector and transition the UAE into a medical tourism hub (U.S.-U.A.E. Business Council, 2019). In alignment with the UAE Vision 2021, the healthcare system is steadily transforming towards focusing on public-private partnerships and a gradual shift to private sector service providers. Therefore, developing strategic partnerships with international medical institutions, such as John Hopkins and Cleveland Clinic, using novel modes of financing, expanding access, and improving service standards and performance targets for a better quality of healthcare (Embassy of the United Arab Emirates, 2019).

The UAE is one of the highest-income countries globally, and currently, the country has a robust, government-funded public healthcare system. Healthcare comes under both federal and Emirate level jurisdiction, and it is regulated by several authorities that include DOH, DHA, MOHAP, and SHA. Over the years, the coordinated efforts of these authorities have ensured the complete eradication of infectious diseases, including measles, poliomyelitis, and malaria, and targeted eradication of chickenpox, rotavirus, and pertussis (Embassy of the United Arab Emirates, 2019). The country has world-class pre-and-post natal care facilities, with infant mortality rates at 7 per 100 and maternal mortality rates of 0.01 per 100,000 (Embassy of the United Arab Emirates, 2019).

Although the healthcare system has managed commendable achievements, a need is felt to modernise it further and contextualise it within the emerging needs, which is where the UAE Vision 2021 has made a difference.

2.8.2 ICT in the UAE.

This section discusses the UAE ICT Strategy 2021, the current ICT status and future strategy, and ICT-enabled health informatics initiatives undertaken by the UAE. The UAE's ICT background is discussed to understand the country's current availability of resources and capabilities to help evaluate the needs and issues that must be addressed for developing a comprehensive nationwide tele-emergency framework based on the latest technology available today.

UAE ICT strategy, 2021.

The UAE has the vision to transition to a knowledge-based economy and smart government in the coming years (Khan, Khan, & Juneio, 2020); ICT Strategy 2021 formed a strategic pillar for attaining this aim. Accordingly, the UAE 2021 Strategy aimed to facilitate the business and economy sectors and boost the education and healthcare sectors, too, due to the added connectivity and the scope of harnessing the power of the internet. The strategy also aimed to create over 45,000 jobs by 2021 (Khan, 2014). These are ambitious aims but not impossible for the UAE, as exemplified in the following section.

Current ICT status of the UAE.

The ICT Strategy 2021 was built upon an already strong ICT sector in the UAE. The UAE ranks as one of the most advanced countries in the Gulf Cooperation Council (GCC) and the Middle East and North Africa (MENA) region in terms of its ICT infrastructure. Globally, the UAE leads the world in mobile penetration rates and has a robust regulatory environment and sector readiness. According to the Network Readiness Index (NRI) report by the World Economic Forum, the country ranked 1st among the Arab countries and ranked 23rd out of 143 countries (Baller, 2016). The UAE also ranked high in the following individual attributes:

- Government emphasis on ICT deployment for the betterment of its future;
- The role of ICT in developing new services and products;
- The deployment of ICT in government services and maintaining governmental efficiency;
- ICT's role in accessing essential services and utilities; governmental success in ICT deployment and population coverage (Khan, 2014; Telecommunications Regulatory Authority, 2015).

According to the United Nations (UN) International Telecommunications Union, by 2016, 90% of the UAE's population was using the internet (OBG, 2019). ICT Strategy 2021 has been supported by technology investments from both the government and the private sectors. In 2018, the UAE IT budget was $7.7 billion, driven by projects related to the UAE Vision 2021 and Dubai Expo 2020 (Cherrayil, 2018). The expected growth in the IT service sector is rated at 6%, and in the server, storage, and networks at 2.3%. The software sector is expected to grow by 4.8%, mobile devices by 2.2 %, and cloud expenditure is expected to be over $1.1 billion, with big data and analytics moving to over $2.4 billion. The expenditure on emerging technologies leads the country to new innovative service design and delivery methods, as seen in how the education, healthcare, and government services sectors are changing (Cherrayil, 2018).

Health Information Systems (HIS) in the UAE.

Technology deployment in the healthcare sector for the UAE has been relatively straightforward, owing mainly to the fact that the traditional healthcare system was basic and not burdened by legacy technology systems that needed phased transitions. Instead, the UAE rapidly purchased and deployed the latest available technology superseded by several intermediary technologies and introduced the latest state-of-the-art systems. This is reflected in the Future Health Index (2016) report that ranked the UAE the highest on the perception of integration and accessibility of its healthcare systems and delivery, which is a substantial achievement since 'Wareed', a preliminary health information system that linked the Ministry of Health-affiliated hospitals and clinics across the Northern Emirates with Dubai, was only started on 2009 (Alzain, 2014; Emerging Technologies, 2013).

DOH (formerly known as Health Authority – Abu Dhabi (HAAD)) initiated the Weqaya Program that collected health and screening data from UAE nationals; developing a country-wide database that could be used for population epidemiological research (Department of Health of Abu Dhabi, 2019). DHA has similarly initiated several smartphone apps, such as the Tummy Fish app that reminds children to drink water regularly and the Smart Toothbrush app that teaches children how to brush their teeth correctly (Emery, 2017). Rashid Medical Library content is also available to physicians online to facilitate easy reference and continuous education (Emery, 2017). These initiatives added to the overall drive towards health informatics in the daily lives of the nationals. Additionally, HIS in the UAE has come a long way from the 'Wareed' time, with Blockchain technology being deployed to provide data integrity and security and prevent any abuse of patient records (Emery, 2017).

The government primarily drives such innovations in the healthcare sector in the UAE to expand access and improve the quality of care in a sustainable manner (U.S.-U.A.E. Business Council, 2019; Uluc & Ferman, 2016). Such a claim is aligned with Dulaimi and Ellahham (2016); they found that the critical success factors for implementing innovation in a healthcare setting in the UAE were top management support and employee participation. The UAE government has made strides toward developing an ecosystem to support technology deployment in HIS, which, as Alloghani et al. (2015) mentioned, is essential for implementing innovation. Alloghani et al. (2015) suggested using their Technology Acceptance Model (TAM) model to assess the UAE's readiness in m-health regarding its cultural, ethnic, social, educational, and demographic profiles. Alloghani et al. (2020) and Uluc and Ferman (2016) proposed enhancing factors such as the quality of ICT infrastructure, funding, supply chain management, and the need to build a legal framework to support privacy and manage compliance for big data technologies. Therefore, it is safe to presume that health informatics services development needs technological investments and a comprehensive ecosystem that can support adoption and optimal use. While the non-technological aspects are not the focus of the current study, their importance is equally recognised and acknowledged.

2.8.3 Telemedicine in the UAE.

There have also been attempts to develop frameworks for tele-monitoring for diabetic patients using smartphones (Al-Shorbaji et al., 2018; Jihad et al., 2016), tele-emergency care in ICUs (Bender, Hiddleson, & Buchman, 2019), and telemedicine platforms for disaster management (Anwar et al., 2019). In practice, however, telemedicine is a relatively recent introduction within the UAE healthcare system. For example, in 2014, the Abu Dhabi Telemedicine Center started providing 24/7 tele-consultation supported by Telemed. This mobile app allows patients to upload photos and share additional data with a physician without the need for a hospital visit (Abu Dhabi Telemedicine Center, 2014). “A Doctor For Every Citizen” initiative by the government of Dubai through the smart government apps was proceeded by the development of a telemedicine platform that provides tele-consultation services and Remote Patient Monitoring (RPM) services to patients from specialists located in the Dubai Healthcare City (DHCC) using video-conferencing (Government of Dubai Media Office, 2019). It can, therefore, be surmised that telemedicine is, as yet, in nascent stages in the UAE, which underlines the scope for developing a telemedicine framework.

However, with the COVID-19 pandemic, MOHAP, representing the government of the UAE, launched TRACE COVID, an app that helps identify people within the vicinity diagnosed with COVID-19 (McArthur, 2020a). This app is supported by the National Emergency, Crisis and Disaster Management Authority (NCEMA) of the UAE and helps people with information, awareness, and support during the pandemic. Similarly, DOH has introduced the DOH RemoteCare platform, a smartphone application that citizens can use to check their symptoms and then consult with doctors online using video or voice calling applications (UAE Government, 2020). The UAE’s Telecommunications Regulatory Authority (TRA) has added six new telehealth service providers, vSee, GetBEE, NextGen Healthcare, OKADOC, Mind Mina Telemedicine, and doxy.me as part of the government's initiative to support telemedicine services within the country (McArthur, 2020a). In addition to government initiatives, private healthcare companies such as HealthHub and Aster DM Healthcare launched telemedicine services for non-emergency care during the COVID-19 pandemic (McArthur, 2020b).

2.8.4 Summary of the UAE context.

The above sections outlined the Healthcare Vision 2021 of the UAE that aimed to meet the needs of a growing and ageing population with increasing lifestyle-related diseases. Vision 2021 drove the healthcare delivery system’s modernisation and supported investments in infrastructural development and health informatics. The section also provided insights into the current state of technology infrastructure and health informatics available in the UAE and assessed their alignment with the UAE ICT Strategy 2021. It is evident that while the UAE ranks among the most advanced countries in the GCC and MENA regions in terms of its ICT, there continues to be a need for an integrated and expansive telemedicine framework based on the latest technological breakthroughs in the healthcare sector. The current telemedicine initiatives in the country have grown substantially from their earlier days in 2014. So during the COVID-19 pandemic, those initiatives have expanded multifold, yet, there is a scope for integrating and developing a comprehensive nationwide framework for telemedicine delivery; and this study emphasises the tele-emergency framework specifically.

2.9 Shortcomings in the ERs.

2.9.1 Shortcomings in ERs in general.

A significant issue identified in the existing literature related to the effective functioning of ERs is overcrowding. Most ERs appear to function with minimum resources and cater to low capacity (Cooney et al., 2011; McCabe et al., 2020; Sen-Crowe et al., 2021). ER overcrowding may result in severe implications in the form of patient safety, patient wait times, and even chances of patient survival (Chuang et al., 2020; Eniwumide et al., 2022). The COVID-19 crisis has further highlighted the problem of ER overcrowding and enumerated the fatal outcomes of such conditions. A nation's healthcare system needs to be equipped with minimum service capacity to serve its populations in disasters and pandemics. However, more often than not, countries seem to have poorly managed emergency healthcare capabilities (Baum et al., 2021; Lafortune, 2020; Searle et al., 2015). ER overcrowding seems to occur due to diverse reasons, including the ER location and the population density (Cruz-Rodríguez et al., 2019; Wang et al., 2015). Overcrowding may also result from the lack of adequate space, equipment, or staff; since hospitals tend to minimise the capacity of their ERs to avoid under-utilization costs (Fleury et al., 2019).

Hospitals are inclined to focus on specialist services that generate revenue for healthcare institutions (Searle et al., 2015; White et al., 2019). Lack of adequate ER capabilities has dire consequences, both for patients and the hospital's reputation, and several studies have explored plausible solutions to overcome ER overcrowding. For example, solutions such as the expansion of ER capabilities (Baugh et al., 2020; Paul, Reddy, & DeFlitch, 2010), reducing the average waiting time per patient, reducing the number of patients waiting at any given time, increasing in the number of beds (Savioli et al., 2022), changing the layout of the ED to improve work-flow (Caselli et al., 2021; Morgareidge, Cai, & Jia, 2014), and changing the staffing policy (Bees, 2022).

Other measures to reduce or avoid overcrowding include diversion of ambulances to other ERs (Cooney et al., 2011; Davis et al., 2020), deploying process mining such as question-driven methodologies to screen stroke emergency patients (Ibanez-Sanchez et al., 2019), and changing the triage process (Zodda & Underwood, 2019); so that ERs are presented with fewer patients. Most studies that have aimed to provide solutions for ER overcrowding have failed to reconcile the cost associated with making the changes to pre-empt overcrowding. Hospitals typically struggle with the trade-offs between capacity under-utilisation and overcrowding; they need to develop a more dynamic solution to solve this problem. Telemedicine may well provide such a solution due to the inherent scope of scalability on demand by linking ERs to specialists remotely and preventing people from presenting to urban ERs by facilitating treatment at their local or rural ERs (Pförringer et al., 2019). For Example, according to Sun, Lu, and Rui (2019), on average, telemedicine reduced patients' length of stay and thus reduced healthcare costs. Since telemedicine allows for flexible and need-based resource allocation to service patients even during an upsurge in demand or during low demand times, it prevents conditions of overcrowding as well as under-utilisation of capacity (Moeckli, Gutierrez, & Kaboli, 2020) while maintaining the quality of service delivered (Sun et al., 2019).

One of the reasons for ER overcrowding identified in a few studies was the lack of practising or available family doctors (Pförringer et al., 2019). With the penetration of the internet in most regions of the world, people are likely to research and self-diagnose and take a decision to meet a specific specialist or visit emergency services even when their illness or symptoms may not be of high priority level - leading to crowding of ERs and preventing high priority patients from getting the necessary care (Déry, 2020). Here, again, telemedicine finds usage by enabling a greater connection between patients and their general practitioners or community facilitators who can provide primary healthcare services locally, utilising telemedicine-based support of specialists from ERs, and hence preventing patient travel and ER overcrowding (Martínez-Fernández et al., 2015; Tsou et al., 2020). Patients can get relevant and credible information through telemedicine apps to make better-informed decisions regarding ER visits (Pförringer et al., 2019). Therefore, the existing shortcomings in ERs are likely to be filled by the deployment of telemedicine. As such, it supports the case for developing a tele-emergency framework proposed by this study.

2.9.2 Shortcomings in ERs in the UAE.

Staffing challenges.

Although the UAE has invested substantially in developing its healthcare services, the country continues to face challenges in the context of emergency services and emergency medicine. The UAE faces a shortage in the adequate number of trained emergency care healthcare professionals (Alshahrani et al., 2021; Bell, 2014; Oxford Business Group, 2016). Not only that there is a shortfall in the number of people graduating as emergency care professionals, but also, those who move into the healthcare workforce are likely to have avoided residency training. According to Fares et al. (2014), less than 10% of all emergency physicians practising in the UAE have undergone residency training. There is also a scarcity of board-certified emergency professionals in the UAE that can teach and conduct much-needed research (Cevik et al., 2018a; Fares et al., 2014). Currently, the Arab Board of Health Specializations is not recognized or at par with the North American boards (whether the American Board of Medical Specialities or the Medical Council of Canada), which is the main reason that majority of consultants leave to undergo their residencies in the United States or Canada and are likely to continue to stay out of the country (Oxford Business Group, 2016). These conditions lead to low-quality care in terms of patient outcomes and low job satisfaction in terms of the existence of healthcare professionals (Al-Neyadi et al., 2018; Partridge et al., 2009). ER physicians in the UAE would most likely be trained in surgery or medicine (Dubai Health Authority, 2018). However, they refer patients to various services at ERs, thus indicating a wasteful usage of resources.

One reason for this low capacity and staff capability in the ERs of the UAE is that ER positions are likely to be held by professionals who failed to secure high-status specialists jobs, either due to their lack of academic calibre or due to their lack of adequate connections with decision-makers (Fares et al., 2014; Salama, 2018). ER healthcare professionals have a lower status among the hierarchy of professionals, draw lower salaries, and rarely get recognition. Emergency medicine does not offer lucrative career progression opportunities, which also acts as a deterrent for healthcare professionals to opt for emergency services (Cevik et al., 2018b). The UAE lacks high-quality residency options for emergency medicine professionals at an institutional level, which encourages taking jobs out of the country (Alshahrani et al., 2021; Fares et al., 2014; Oxford Business Group, 2016).

The UAE ERs need qualified emergency medicine physicians who are not specialists or experts but can triage, diagnose, treat patients at emergency locations or stabilise, and refer patients if and when needed. In addition to creating optimal infrastructure to support training and development opportunities for emergency medicine professionals, the country also needs to work on changing the mindsets related to the status of emergency services and bring them at par with specialist services by creating equality in salaries, status, and career progression opportunities (Fares et al., 2014). Technology deployment, as in the case of a comprehensive telemedicine program that connects ERs to specialists region-wide, could be one of many solutions enabling less-trained emergency care professionals at emergency scenes to provide adequate support to patients.

Communication and coordination challenges (with pre-and-post emergency care services).

Another problem repeatedly cited in recent literature and news on emergency services in the UAE is the lack of coordination and communication between the different agencies involved in delivering emergency services care. For example, according to Fares (2019), there appeared to be lapses in the pre-hospital care that led to low-quality care being delivered at the ERs, or there were communication problems at the ER's end, both pre-and-post care, which lowered the ability of the paramedics to provide adequate pre-hospital support. These situations led to frustrations and conflicts between ER professionals and paramedics and ultimately resulted in a subpar experience for patients. The problem is aggravated by the fact that there are often several agencies involved in emergencies, for instance, the police, Non-Governmental Organizations (NGO)s, and paramedics, so the absence of a well-laid-out communication channel and chain of command, or adequate communication technology that could connect various agencies on the need-to-know basis, could increase the chances of error and confusion (Al Ruwaithi, 2019; Alruwaili et al., 2019).

Another problem highlighted by Fares (2019) was the burden of trauma that ER professionals had to face without support in any systematic form. Fares (2019) highlighted a need to ensure effective communications between paramedics and ERs during emergencies and pre-hospitalisation treatment procedures, which is possible with a telemedicine framework that allows smoother communication and handover process (Bilotta et al., 2020). These findings indicate the need to develop a more comprehensive nationwide framework for emergency care services that allows for communication, cooperation, and coordination between diverse agencies and professionals involved during emergencies.

Overcrowding.

The UAE has a low penetration of healthcare services, including emergency care services in rural and remote areas. This paucity leads to overcrowding of urban ERs as people travel from their villages or small towns searching for suitable healthcare services (Fares, 2019; Paulo et al., 2017). The UAE offers a wide variety of cases, ranging from diseases rooted in the diverse ethnic makeup of the population, a large amount of industrial and construction work-related injuries and traumas, and more recently, growing incidences of lifestyle diseases such as obesity and diabetes (Fares, 2019; Blair & Sharif, 2012). The diversity of cases is suited to overwhelm ER professionals who are not adequately trained or staffed to deal with these cases. The UAE, therefore, needs to focus on extending emergency services to rural areas and further empowering local ERs or point of entry personnel to conduct high-quality triage to prevent non-emergency patients from reporting to ERs (Al Amiry & Maguire, 2021; Bell, 2014; Fares et al., 2014).

2.10 Impact of telemedicine on the healthcare industry in the UAE.

The telehealth app market for the UAE was estimated at $23 billion in 2017 by Health at Hand (2018), based on estimates drawn from YouGov MENA's telehealth data. As highlighted by the Health at Hand (2018) report, the latest trends in the adoption of telemedicine indicated that the healthcare industry might be in for a disruptive transformation. According to Health at Hand (2018) report, almost 43% of the UAE's population has already used telehealth services. This percentage is likely to increase as telemedicine is reported to give people benefits such as reducing travel time and costs, reducing waiting time, and enhancing doctors' choice for consultations. The COVID-19 pandemic provided a working demo to patients regarding the ease of use of telemedicine services (Zaman, 2020) and thus is likely to have created enhanced demand in the coming years. Online consultations can not only provide time and cost savings, but they also enable better management of chronic illnesses requiring long-term and continuous care. So, telemedicine has proved its utility during the pandemic to help patients suffering from such diseases (Zaman, 2020). Therefore, a change can be expected in how chronic illnesses are managed in the coming future. As perceived by the UAE's population, telemedicine has added benefit in ensuring that patient consultations remain confidential and private, especially since technology provides a sense of anonymity (Abdool et al., 2021; Al-Qirim, 2007). While this may encourage the population in general to adopt telemedicine alternatives, it is likely to substantially impact women's healthcare by providing safe and private means of consultations regarding their sensitive health-related issues (Abugabah et al., 2020; Al-Krenawi et al., 2004).

Although many independent players offer direct stand-alone app-based services to patients, the telemedicine sector is strengthening. Independent tele-health services provided by the government and private hospitals deliver video-conferencing-led consultations. These are often linked with laboratories that offer home-testing services and pharmacies that offer home deliveries of prescriptions. An exhaustive review of papers, news, government, and media sites did not reveal any evidence of consolidation or a master plan by the government or private enterprises that could develop and implement a nationwide comprehensive telemedicine framework inclusive of emergency services and local practitioners to deliver healthcare at the community level. However, DHA launched "A Doctor for Every Citizen" app in 2019, allowing patients to get free video and voice consultations and follow-ups with DHA certified healthcare professionals. Another app, the DOH RemoteCare app, enables patients to check their symptoms and self-diagnose, book appointments, and receive consultations via video and voice (UAE Government, 2020).

2.11 Impact of telemedicine on the UAE's economy.

There appear to be close to no studies undertaken to purely assess telemedicine impacts on the UAE's economy, as indicated by an exhaustive literature review on telemedicine focused research in the UAE (Weber et al., 2017). Very limited studies were found in the literature that evaluated the cost-benefit impacts of independent telemedicine projects in the UAE. For example, both Abdool et al. (2021) and Al-Qirim (2007) reported benefits such as reducing healthcare professionals' travel distance and time away from families and homes; and more efficient staff utilisation in the two hospital case studies used in the research, namely, Tawam hospital and Mafraq Hospital. The lack of research on the impact of telemedicine on the UAE's overall economy is probably because telemedicine is still in a nascent stage in the country and is only implemented in a scattered and fragmented manner (Abdool et al., 2021). However, it can be presumed, as indicated from the international studies discussed in the previous sections and the initiatives driven by the UAE government during and post-COVID-19 era, that a nationwide deployment of telemedicine can be expected to impact the UAE's economy positively by reducing direct costs of wait and travel time for both the healthcare professionals and patients; by encouraging efficient utilisation of resources, and by reducing indirect costs of illnesses related to work and wage losses (Abdool et al., 2021; Sun et al., 2019). The UAE's healthcare sector is poised to expand further, and telemedicine's contribution is also estimated to grow further, based on recent studies on telemedicine adoption in the UAE (Health at Hand, 2018).

Reflecting this, the UAE's healthcare sector is expected to grow 60% from 2016 to AED 103 billion by 2021 (Moideen, 2018), primarily driven by technology, based on the estimated adoption rates of AI. Overall, the MENA region is expected to invest AED 530 billion in healthcare development by 2020 (Moideen, 2018). The UAE government expenditure amounts to 66% of the total budget of AED 55 billion spent on healthcare, but the private sector's contribution is expected to rise. While government expenditure is expected to grow by a CAGR of 4.4% only, private investment growth is estimated at a CAGR of 9.5% (Stolz, 2020). There is already an exponential rise in the smart wearable devices market, which translates into enhanced scope for remote monitoring of patients with chronic illnesses (Geronimo, 2018). Also, there is a rise in new devices such as the HD Steth, which is a stethoscope integrated with an EKG (elektrokardiographie - German) or ECG system and can deliver cardiac diagnosis instantly, thus reducing the need for scheduling lab appointments and saving waiting and travel times (Moideen, 2018). Such devices are expected to aid the proliferation of telemedicine in an institutionalised manner by enabling local physicians or ERs in remote areas to diagnose remotely. It is, therefore, presumable that telemedicine is likely to drive growth in the healthcare sector and add further value to the UAE's economy.

Lastly, the UAE government's Health Strategy 2013-2025 aims to invest substantially in building the healthcare infrastructure to cater to the over 500,000 medical tourists that are expected to visit the country by 2020 (Sochacki & Tithecot, 2015), which is expected to position the country as a tourism hub and lead to a continuous source of non-oil revenue. As envisaged in this strategy, the development of 40 healthcare centres and three major hospitals can also be used to provide healthcare services to the rural and remote population of the country through telemedicine (Sochacki & Tithecot, 2015).

2.12 Emirates ID for Telemedicine

2.12.1 Background on Emirates ID.

The Federal Authority for Identity and Citizenship (ICA) in the UAE issued the Emirates ID card. All UAE citizens and residents must mandatorily hold this official identity card. While this card acts as a primary identification document, it is also linked with numerous government and non-government services and utilities, allows people to vote in the Federal National Council elections, and can be used as a travel document within the GCC countries and for passing immigration through the eGates across the UAE airports (Federal Authority for Identity and Citizenship, 2020; UAE Government, 2020). The Emirates ID is an electronic chip-based smart card that operates on fingerprint biometric technology and vital public infrastructure using the cardholders' authentification certificates and digital signatures. It can store about 32,000 letters of information and uses line drawing and ultraviolet ink (Federal Authority for Identity and Citizenship, 2020). The Emirates ID card has nine layers of security, which far exceed the current banking cards' security, making it almost impossible to copy or misuse.

The card provides each cardholder with a unique 15-digit identification number that enables traceability for all their transactions. The card also contains all relevant personal data of the holder, which can be read by using the card through a machine that can authenticate the user's credentials on the spot (Federal Authority for Identity and Citizenship, 2020). Although the card has extensive and multiple uses, some of its data is encrypted and readable or writable only through authorised authorities to protect the cardholder's privacy. The card needs to be continuously updated by the holders based on their changed details, for instance, the birth of a child, death of a dependent, or change in marital or occupation status. It is also illegal for employers to keep the Emirates ID card or extract personal data (UAE Government, 2020).

2.12.2 Health data on Emirates ID.

In 2017, the Emirates ID was allowed to be used as the standard insurance card to avail healthcare services in the country, with Oman Insurance Company starting the trend (Maceda, 2017). More recently, the government has announced its intention of linking the medical data of all residents to their Emirates ID into what is called the “Smart Health Card”. This initiative is expected to give access to medical data of all residents to healthcare professionals across the GCC countries and allow for better quality medical services (Zain, 2020). MOHAP plans to start the integration process with only primary healthcare centres and hospitals under the Ministry, where the requirements are to add data on five categories for all patients - their blood type, allergies, intention for organ donation, any chronic conditions or diseases, and current diagnosis. Therefore, the Smart Health Card would allow healthcare professionals to access relevant information immediately during emergencies through point-of-care service providers, who usually do not have the authentication or permission to add or modify data. The Smart Health Card will identify if a person is registered as an organ donor since the UAE government launched the Hayat app, which is linked to the Smart Health Card to allow citizens and residents to register for organ donation (Zain, 2020).

2.12.3 Emirates ID as part of the technology-enabled framework.

The Emirates ID card has shown potential for integrating many services, including healthcare. It provides a single and straightforward platform for delivering services to residents and is based on Blockchain technology that is safe, secure, and allows for private transactions and multi-level security based on data access protocols (Federal Authority for Identity and Citizenship, 2020). The card, therefore, contains all the potential parameters that are sought for any application where large-scale private and personal data need to be stored, analysed, and used to make decisions, namely traceability, accountability, interoperability, privacy and security, and scalability. All of the data is input through ICA, whether updated through forms filled by the cardholders or at primary healthcare centres managed by the government. All transactions, be it insurance, emergency healthcare services, routine healthcare services, emigration, and other services, are updated by ICA. Centralised data management ensures traceability and accountability by recording electronic footprints.

Since the Emirates ID card (see Figure 2.6) is based on Blockchain technology, it keeps all personal data private, confidential, and secure; and allows sharing only on a need-to-know basis. Additionally, since the Emirates ID is ubiquitous, all residents' health data can be obtained from a single platform. As a Smart Health Card, the Emirates ID has already displayed its potential to deliver better healthcare both for routine medical issues and emergency care. Therefore, linking the card to all of the HISs across the country ensures that patients presenting at local EDs can get quick and accurate services, where the point of care healthcare professionals can access their records in real-time, make quicker and more informed decisions regarding procedures needed or referrals made, and finally referring them to the expert services delivered through telemedicine applications.

Figure 2.6

Emirates Identity Card

Note. From "Federal Authority for Identity and Citizenship" www. ica.gov.ae

2.12.4 First Responders

First responders comprise many healthcare professionals, including paramedics and emergency medical technicians, firefighters, and police personnel (Fares, 2019). Depending on the country, first respondents may have different skills, training, duties, authorisations, and responsibilities (England, 2016; Nord-Ljungquist et al., 2021). Still, first responders are considered to be the first to arrive at the disaster or emergency scenes (Al Ruwaithi, 2019), and as such, have the potential to make a significant impact on the tele-emergency operations' success based on their skills, training, attitude, and motivation (Paulo et al., 2017). Several agencies are often involved in emergencies, including paramedics, firefighters, police personnel, and even NGOs, which may lead to miscommunications and errors if not managed well (Alruwaili et al., 2019). Therefore, there is a need for effective communication between ERs and first responders for pre-hospitalisation treatment procedures (Fares, 2019). First responders are essential to tele-emergency operations, provided they have adequate skills and training to use ICT and medical technology to enable successful and real-time exchange of information across ERs and specialists.

2.13 Technology Deployment Frameworks

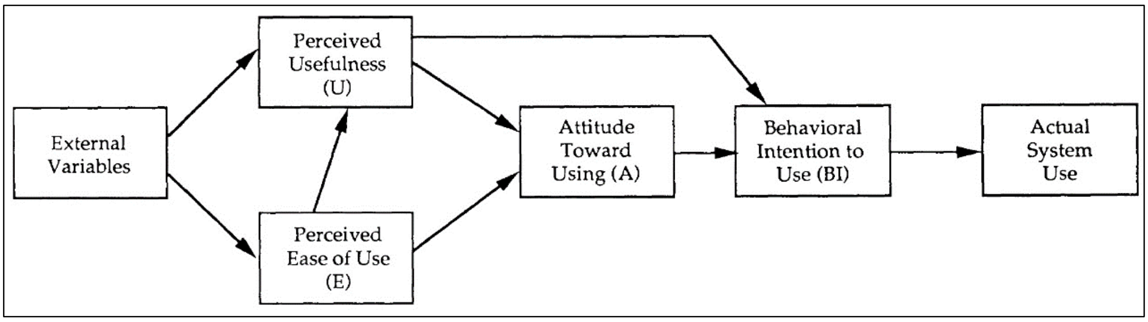
There are several technology deployment frameworks explored in the literature, and the following section discusses four frameworks in detail - Technology Acceptance Model (TAM) of Davis (1989); Technology, Organization and Environment Model (TOE) of Tornatzky, Fleischer, and Chakrabarti (1990); Unified Theory of Acceptance and Use of Technology (UTAUT) of Venkatesh et al. (2003); and Heeks (2002) technology deployment model.

2.13.1 TAM model.

Technology Acceptance Model (TAM) is introduced in the Theory of Reasoned Action and explains the acceptance of technology behaviour of individuals (Wallace & Sheetz, 2014). TAM was first introduced by Davis (1989), using two factors to explain the users' acceptance behaviour, perceived usefulness of technology, and the perceived ease of utilising new technology (Venkatesh et al., 2003). Based on TAM, people assess new technology on its utility to enhance their progression in the organisation and assess its complication of usage (Wallace & Sheetz, 2014). These two factors are impacted by external factors such as the experience of technology usage and the availability of training resources. It leads to the development of attitudes and behavioural intentions, which are precursors of the actual acceptance and use of the new technology.

Figure 2.7

Technology Acceptance Model (TAM)



Note. From "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models," by Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). (p. 985), *Management Science, 35*(8), 982-1003.

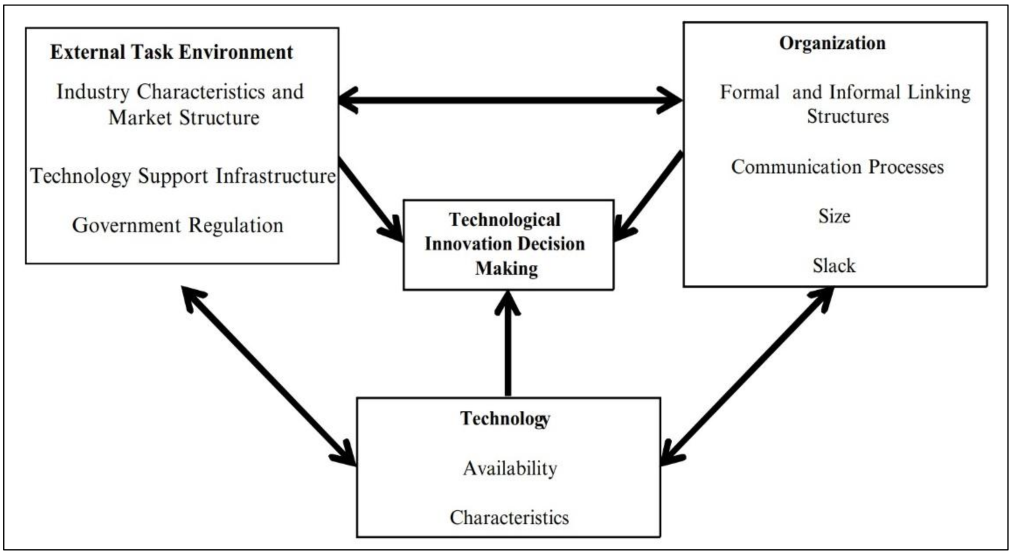
The TAM model is valuable for organisations that want to motivate their employees to adopt new technology (Wallace & Sheetz, 2014). However, TAM has a narrow focus and cannot support the implementation of a large-scale framework that requires connectivity and cooperation between numerous organisations.

2.13.2 TOE model.

The Technology, Organisation, Environment Model (TOE) is a popular framework used to explain technology adoption at the organisational level. It is based on the Contingency Theory of Organisations and considers factors such as the availability of the technological development, the conditions internal to the organisation, and the external factors such as the industry conditions, political situation, and competition (Tornatzky, Fleischer, & Chakrabarti, 1990; Awa, Ojiabo, & Emecheta, 2015). However, this model has been criticised due to a lack of consistency among scholars regarding organisational, external factors, or technological factors (Gangwar, Date, & Ramaswamy, 2015). Furthermore, the model does not consider individual-level factors such as cognitive factors, readiness to adopt technology, or the organisational culture.

Figure 2.8

Technology, Organisation, Environment Model (TOE)



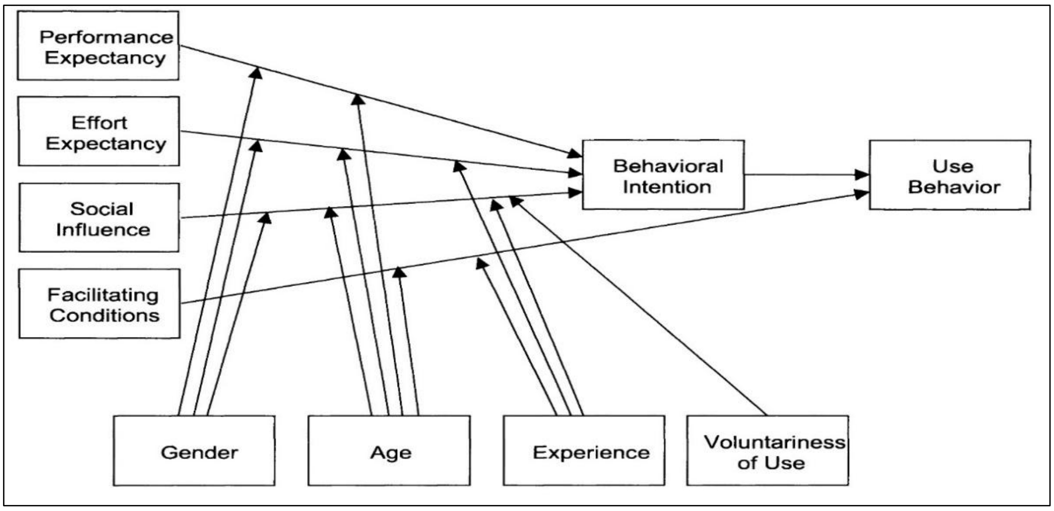
Note. From "Processes of technological innovation" by Tornatzky, L. G., Fleischer, M., & Chakrabarti, A. K. (1990), Lexington books.

2.13.3 Unified Theory of Acceptance and Use of Technology model.

The Unified Theory of Acceptance and Use of Technology (UTAUT) amalgamates several earlier technology-related behavioural models (Venkatesh et al., 2003); it is a complex and intricate model based on many factors. For example, the UTAUT model implies that behaviour intention, which preceded use behaviour, depends on factors that include performance expectancy, effort expectancy, social influence, facilitating conditions, gender, age, experience, and voluntariness use (Chao, 2019). However, the model links these variables in a complicated manner, with 49 independent variables predicting two dependent variables: intention and behaviour (Bagozzi, 2007).

Figure 2.9

Unified Theory of Acceptance and Use of Technology (UTAUT) Model



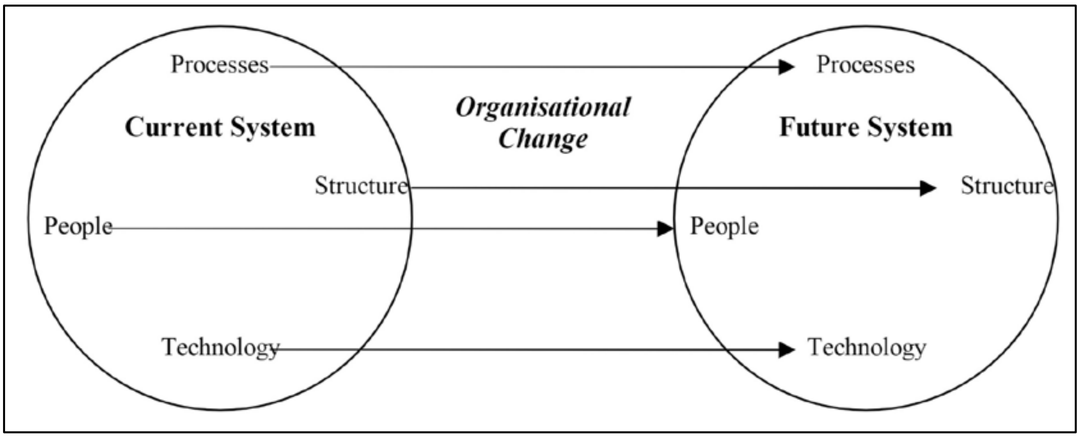
Note. From "User acceptance of information technology: Toward a unified view" by Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D, (p. 447), 2003, *MIS quarterly*, 425-478.

2.13.4 Heeks model.

Heeks (2002) technology deployment model of technological change provides a more dynamic view of the factors that play a role in technological adoption and usage. It focuses on the dimensions of change represented by technology, processes, people, and structures that need to be considered while implementing large-scale technological frameworks.

Figure 2.10

Temporal, Systematic Contingency



Note. From "Information Systems and Developing Countries: Failure, Success, and Local Improvisations" by Heeks, R., (p. 6), 2002, *The Information Society, 18*(2), 101-112.

The Heeks (2002) model was constructed to analyse the information systems of developing countries, which is based on the dimensional contingency of Leavitt's (1965) diamond. The model has been applied in a range of contexts. For example, Bojang (2019) used the Heeks model to examine the failures and successes of e-Gov services in developing countries; and Akeel and Wynn (2015) applied the model to assess the impact of an Enterprise Resource Planning (ERP) system in a Libyan oil company. Therefore, the model allows for implementing technological changes on a much larger scale than envisioned by any of the earlier models, such as TAM, which focuses on the individual level adoption of technology, and TOE, which explains organisational level technological changes (Heeks, 2002). The Heeks technology deployment model uses factors related to operational and environmental contexts, but focuses primarily on how these contexts can impact technology, processes, people, and structural aspects in what he called design-actuality gaps.

2.14 Summary

This chapter discussed the existing literature related to telemedicine in the context of healthcare technologies and delved into the costs and benefits and barriers and facilitators of telemedicine. The chapter also provided a critical review of telemedicine specialities such as tele-radiology, tele-pathology, tele-surgery, tele-education, tele-mentoring, tele-consultation, and tele-monitoring. It also presented an in-depth review of tele-emergency in its scope and applicability in EDs and disaster management. This was followed by a review of telemedicine applications in the UAE, situating it within the background of the existing healthcare system and healthcare innovative technologies deployment. This led to a review and critical discussion of the issues in the UAE healthcare system, represented by issues in ER facilities in general.

A key aspect of security, scalability, traceability, and accountability was introduced through the Emirates ID, including the benefits of integrating it within the telemedicine framework. One of the most important elements of the telemedicine framework is the first responders. This chapter briefly explained their contribution and importance to the emergency management process. Several tele-emergency frameworks were reviewed, compared, and contrasted to evolve an understanding of the technology infrastructure and resources required for developing large-scale tele-emergency frameworks. Finally, the chapter concluded with a discussion regarding technology adoption and implementation models that underpins and guide the primary research undertaken in this study.

CHAPTER THREE: CONCEPTUAL FRAMEWORK

3.1 Introduction

The literature review included a discussion of numerous frameworks that examined the impacts of technology deployment. A review of these frameworks made it clear that the proposed technology framework deployment should be set within an established framework or contextualised within one or more of them. Reviewing these frameworks revealed certain advantages and disadvantages inherent in each. For example, the TOE model (Depietro & Byrd, 1990), TAM (King & He, 2006), and UTAUT models (Venkatesh et al., 2003) are more suited for technology deployment within an organisational context rather than in a nationwide context. While the above frameworks included considerations of change management approaches and discussed the structural and organisational changes needed for successful technological deployment, these frameworks did not fully account for process improvements and re-engineering. The Heeks (2002) technology deployment model is based on a temporal, systematic contingency model, a model that uses contingency theory to suggest solutions for gaps in design and actuality (Heeks, 2002), and which uses four dimensions of change - technology, processes, people, and structure - and is a more suitable fit for this study. The Heeks (2002) model has been used by other scholars such as Akeel and Wynn (2015) and Rezaeian and Wynn (2016). This study will use the Heeks (2002) model as opposed to the other three models presented in chapter 2 because it is based on analysing and identifying gaps within the change dimensions in information systems of developing countries (Bojang, 2019; Heeks, 2002). According to the UN's World Economic Situation and Prospects (WESP) report, the UAE is considered a developing nation (WESP, 2022). Therefore, using the Heeks dimensions of change will instead help to propose recommended actions by analysing the gaps within the UAE emergency healthcare setting. This chapter will present a conceptual framework using three dimensions of change envisioned by Heeks (2002): processes, technology, and people. The structure dimension of the model is not used in this framework, as it falls beyond the scope of the current study; and also, because, in extensive other studies on technological implementation frameworks, structural changes are omitted from inclusion because organisational structures are presumed to stay stable over long periods (Röglinger, Pöppelbuß, & Becker, 2012).

3.2 Dimensions of Change

Numerous large-scale technology implementation projects worldwide have predominantly used three dimensions of change: processes, technology, and people (Heeks, 2002; Rezaeian & Wynn, 2016; Wynn & Olayinka, 2021; Wynn, 2018). This section discusses these dimensions of change as part of the proposed technology-based tele-emergency framework for implementation in the UAE.

3.2.1 Processes change.

A large-scale tele-emergency framework is envisioned with the accompaniment of new or re-engineered processes. Processes determine the 'how': how technology will be deployed most effectively, accurately, and scalable to enable complete connectivity, accountability, and transparency of operations. In order to assess the current processes, elements of whether processes are scalable and ensure transparency will be used. Then, suggestions and recommendations are presented to address issues raised to ultimately bring about process change and improvement to deploy the final tele-emergency framework for the country.

3.2.2 Technology deployment.

While technology is at the forefront of the change framework, the goal is that any technology deployment should deliver greater value to end-users (Chao, 2019). For a large-scale tele-emergency framework, the aim is to deliver excellent and efficient tele-emergency care at emergency sites to patients. To help in this, the current ICT and telecom technology should be assessed based on capacity and adequacy, including the existing HIE and HIS systems regarding their ability to serve widescale nationwide tele-emergency operations. Medical devices and their connectivity (in terms of the Internet of Things or telecommunications platforms) should be assessed as part of the technology deployment. Connectivity, traceability, scalability, and transparency will also be used to evaluate the existing technology. The review of the current scenario is expected to reveal issues that this proposed tele-emergency framework is expected to address.

3.2.3 People skills and competencies.

With technological changes come changes in required skills for operating new technology. Therefore, a crucial dimension for change is assessing the current skill levels, evaluating the skill gaps, and addressing them in the proposed tele-emergency framework. Existing skills and competencies will be reviewed, and recommendations will be made via the proposed tele-emergency framework to implement changes. Additionally, the utility and scope of introducing other roles, such as first responders, additional specialists, or allied health professionals, should be considered to serve a large-scale tele-emergency delivery system better.

3.3 Change Environments

The tele-emergency framework is expected to operate within an eco-system comprising of political, economic, socio-cultural, legal-regulatory, and operational environments. However, political, economic, or socio-cultural environments are beyond the scope of the current study, and this research is conducted solely in the context of the operational and legal-regulatory environments within which the tele-emergency framework is expected to be implemented.

3.3.1 Regulatory environment.

The regulatory environment includes the laws associated with procedural processes, technologies, and people change issues. More specifically, this encompasses laws governing medical data storage, data sharing, accountability and medical liability, ICT and telecom, legal use of medical devices, and laws related to managing the personnel and professionals involved in delivering care.

3.3.2 Operational environment.

For the purpose of this research, the operational environment will focus, in the main, on structural aspects such as the chain of commands and organisational structure for the management of the tele-emergency framework. Additionally, the operational change environment will include the existing resources and how these can be enhanced, modified, or otherwise changed to serve the needs of a nationwide tele-emergency framework.

3.4 The Conceptual Framework

The literature review revealed valuable insights regarding the dimensions of change that should be studied in the context of the UAE. Based on the findings from the literature review, the following guideline is developed, using two change environments and three dimensions of change, within which the UAE tele-emergency framework will be assessed and proposed. The first column in Table 3.1 depicts change dimensions (processes, technology, and people). The second and third columns indicate how the operational and regulatory environments may impact the changes proposed for processes, technology, and people. This outline framework will be further developed based on the interview findings and used to develop the technology-based nationwide tele-emergency framework.

Table 3.1

Conceptual Framework: Provisional Elements of Change

Change Dimensions	Environments	
	Regulatory	**Operational**
Processes	- Laws related to data access, storage, transfer - Laws related to the medical practice of specialists and first responders. - Laws governing the allocation of roles and responsibilities at each stage of the tele-emergency delivery framework.	– Main and Sub-processes of: ○ Emirate Health Emergency Control and Management Processes ○ CCC-Hospital ED Communications ○ Ambulance Services Processes ○ First responder processes ○ Hospital processes - Process Flows and Linkages - Process Inefficiencies and Standardisation issues
Technology	- ICT Laws - Telecom Laws - FDA Laws or Local UAE - Laws governing the use of Medical Devices Emirate-level Laws for HIE, data transfer, data storage.	- ICT infrastructure - Telecom infrastructure - Medical devices - HIE
People	- Laws governing hiring and training of healthcare professionals.	- Current Skills gaps in use of: ○ ICT ○ Medical Devices - New Role Briefs and Responsibilities ○ First Responders - Development of New Competencies

3.5 Summary

This chapter developed a conceptual framework that will inform the conduct of this empirical research. The conceptual framework is primarily influenced by the Heeks (2002) model of technological change, using three of the four dimensions of change – processes, technology, and people - to be evaluated within the context of regulatory and operational environments. The chapter developed the conceptual framework that will guide the development of the interview questions and help gather data and assess findings that are expected to lead to the development of the final technology-based nationwide tele-emergency framework for the UAE. The following chapter will explain and justify the research methodology and design in some detail.

CHAPTER FOUR: METHODOLOGY

4.1 Introduction

This study's primary purpose is to develop a technology-based telemedicine framework for emergency healthcare in the UAE. Reflecting on this is essential to understand the current state of healthcare, Health Information Systems (HIS), Health Information Exchange (HIE), and any existing telemedicine apparatus already operational in the UAE. It is crucial to investigate and explore the current state of network connectivity, technology, medical equipment, and devices, including the higher-end emerging technologies, so that the framework can suggest improvements if necessary. To understand the existing situation and assess the scope of improvement before suggesting a tele-emergency framework, it is essential to obtain the perspective of experts, decision-makers, and other stakeholders within the industry. This chapter will discuss the research methodology used to develop this understanding through data collection and data analysis activities.

The research aim is used as a starting point to understand the diverse research philosophies and critique and defend them before selecting the most suitable and appropriate philosophical stance to guide the study. The selection of the research philosophy was essential to ensure that the research is conducted with rigour, is valid and reliable, and the findings are practically applicable (Aldag & Fuller, 1995).

The following section begins with a discussion of research philosophies and paradigms, resulting in selecting the most suitable research perspective. Next, the chapter will discuss the simulation results (see Appendix A for the details) of three different research paradigms (realist, interventionist, and constructivist) to emphasise the suitability of the constructivist paradigm for this research's aim. The following section presents the development of the rigid research design and the judgmental sampling technique used for selecting participants. The chapter also discusses designing the interview questions based on the existing literature and works of other scholars. It presents an overview of the data collection process and data analysis method. Finally, the chapter describes the data quality and ethical considerations, including study limitations (see Figure 4.1).

Figure 4.1

Structure of the Chapter

4.2 Research Perspective and Research Approach

To fulfil the research aim, it is essential to understand the research paradigm and be guided by the research philosophy. However, there are differing opinions on whether it is required to have a rigid, method-based approach to conducting research or follow a broad philosophical stance and conduct the research in an individual and customised manner (Holden & Lynch, 2004). The choice of the research paradigm and research methods impact research outcomes and research quality (Lee & Lings, 2008). Therefore, a method-based approach was considered suitable because by selecting a suitable philosophical approach to research, appropriate choices can be made regarding epistemology, ontology, axiology, and methodology that enables the researcher to collect data reliability and arrive at authentic and credible findings (Killam, 2013). This research proceeded by developing a simulation for using different paradigms, namely the realist paradigm, interventionist paradigm, and constructionist paradigm (see Appendix A for complete details of the simulation); and selected the constructionist perspective because it provided the most suitable research philosophy, research design (axiology), and research methods as discussed in this chapter.

4.3 Realist Perspective: Description

Realism was used initially in the social sciences as early as the 1970s by scholars such as Bhaskar (1975) and Burrows (1989). Realism is premised mainly on the understanding that reality or the truth exists externally as an independent entity that can be studied or understood in its universal and singular form (Easterby-Smith, Thorpe, & Jackson, 2012). Table 4.1 provides an overview of the realism paradigm.

Table 4.1

Realist Paradigm: Ontology, Epistemology, Axiology and Methodology

Traditional Realist Perspective	
Ontology	Objective (Reality as external, 'out there,' and independently observable by the researcher).
Epistemology	Post-Positivism (knowledge is manifested in law-like, generalised cause and effect relationships.
Axiology	Etic (Researcher is expected to be 'value-free').
Methodology	Quantitative (Objective reality can be measured in a quantified manner).

4.3.1 Realist ontological position.

Realism derives from an objective ontological stance, with the conception of reality as external, 'out there,' and independently observable by the researcher. It is contrasted with the subjective stance of the constructionist approach (that reality is constructed by the context and the people engaged with it) in the way it identifies the nature of reality as objective and context-independent. It is also different from the interventionist view that reality is interpreted through the researchers' involvement and engagement with it (Creswell & Creswell, 2017).

4.3.2 Realist epistemological position.

Following the objective ontological perspective, epistemology, or the approach to capturing a singular and external reality, should ideally lean towards objectively measurable cause-effect relationships. However, there are several different opinions on the epistemological stance that is better suited to realism. One approach considers knowledge to be manifested in law-like, generalised cause and effect relationships, thus, rendering them measurable and amenable to objective capturing and interpretation (Easterby-Smith et al., 2012). This epistemological view is primarily adopted by traditional or classical realism proponents (Creswell & Creswell, 2017). In the context of this study, this would mean that there is a singular way to develop a tele-emergency framework for the UAE and that all variables involved in doing so, are already known, which, for practical reasons, is not valid. It is logical to presume that no such singular or unique way may be available, and also, that there are many variables operant in the situation, which are not known at the onset of this research.

Conversely, internal realists propose that reality or knowledge is objective; it is not always amenable to direct measurement and can only be measured indirectly (Wahyuni, 2012). According to the internal realist's view, empirical evidence that researchers collect is only indirect evidence, or rather a concise or abstract representation of the actual phenomenon, in which case, it becomes essential for the researcher to be aware of the linkages between the actual reality and its manifestation, which can only be done by factoring in the context (Kelemen, Rumens, & Klaes, 2012). So, there appears to be an inherent contradiction in the conceptualisation of realism. It is simpler to presume that reality is almost always contextualised, and hence it should be studied within the situation and from the perspective of those involved in the situation.

4.3.3 Realist axiological position.

Similarly, the researchers' axiological position may vary between 'value-free' and 'value-laden', depending on how scholars interpret realism. For example, traditional or classical realists believe in the absoluteness of reality. The researcher is expected to be 'value-free', thus placing faith in the researcher's ability to be completely unbiased and objective in measuring and interpreting reality (Wahyuni, 2012); therefore, the researcher calls for an etic stance. The critical realists acknowledge that the researcher could be 'value-laden' due to personal background, education, upbringing, or culture, which could lead the researcher to interpret the objective reality, to a certain extent, subjectively (Sobh & Perry, 2006). Critical realists, therefore, suggest that the researcher should be aware of personal biases and perspectives to maintain objectivity. However, critical realists still maintain that reality is external to the researcher, unlike constructionists, where the researcher takes an emic stance and is 'value-bound'. In constructionism, the researcher is acknowledged as being instrumental in creating reality (Wahyuni, 2012), which is a more honest understanding of the researcher as a human being. Hence, constructionism is a more practical research approach, as it considers the limitations and the value added to the study by the researcher.

On the other hand, like the interpretivism position, the realist perspective portrays the researcher as detached and objective, or at least acts detached and objective (Sobh & Perry, 2006). In reality, it is unlikely that a researcher can be completely objective or realise the total extent of one's own preconceived beliefs that may lead to a value-laden interpretation of reality. Therefore, a constructionist approach is more balanced and practical because it works within a pragmatic understanding of human nature and behaviour.

4.3.4 Realist methodological position.

The methodological approach adopted by realism is dependent on whether traditional realism or critical realism is being adopted. Traditional realism derives from the adherence to the objective nature of reality and post-positivism epistemology, and an etic stance for the researcher, and thus, favours the nomothetic and quantitative approaches to the methodology that includes the use of experiments, surveys, modelling, and simulation (Holden & Lynch, 2004). The methodology is based on the premise that law-like cause-and-effect relationships can be captured objectively, which again, is a forced and unrealistic interpretation of reality since it exists outside of a laboratory.

4.4 Interventionist Perspective: Description

Interventionism is a perspective that is almost diametrically opposite to the realism perspective in the way it conceptualises reality and defines the role of the researcher. Interventionism developed out of the works of Lewin (1946) and was further developed and promoted by Wagner et al. (2008) and Suomala, Lyly-Yrjänäinen, and Lukka (2014). Initially, interventionism was presented as a response to the restrictive and limiting realism perspective. However, it developed further as an extension or a complementary enhancement of the constructivism approach as well (Creswell & Creswell, 2017). More specifically, interventionism places the researcher as an essential ingredient in the situation and attributes the interpretation of the situation to the researcher. This view sharply differs from the realism perspective in terms of ontology, axiology, epistemology, and methodology. As Table 4.2 below depicts, interventionism postulates that the researcher is central to creating reality because the researcher explicitly impacts reality by being a part of the context. This paradigm assumes that the researcher is value-laden, yet can restrain from bias in interpretation. However, it needs to be noted that interventionism is still at its nascent stages; and although it has been used substantially in management, educational, and social sciences, it is still in the theory-building and developmental stages (Roberts & Westin, 2010). Table 4.2 presents an overview of the interventionism paradigm concerning its ontology, epistemology, axiology, and methodology.

Table 4.2

Interventionist Paradigm: Ontology, Epistemology, Axiology and Methodology

Interventionism Perspective	
Ontology	Subjective (Reality is the result of the researcher's interaction and situation. The researcher explicitly impacts interpretation).
Epistemology	Interventionism (Researcher is part of the situation and actively enables the reality's evolution).
Axiology	Etic/Emic; Value-Laden (Researcher is value-laden, but can also maintain objectivity when interpreting findings and linking to theory).
Methodology	Qualitative and quantitative (Longitudinal case studies, iterative action research).

4.4.1 Interventionism ontological position.

The ontological stance for interventionism is that reality is not objective; instead, it results from the researcher's interaction and the situation; and is impacted by the researchers' perspective and values (Roberts & Westin, 2010). This is in contrast with realism's positivistic stance. This view also varies from constructivism subjective reality conceptualisation, where reality is constructed by the situation's dynamics and the people involved (Jönsson & Lukka, 2006).

While the researcher is likely to have personal opinions and values, the opinions and perceptions of stakeholders such as policymakers and healthcare professionals should take centre stage in the context of this research. Since this research seeks to understand the existing technology deployed in emergency services delivery in the UAE, it is more appropriate to consult with the stakeholders directly involved in healthcare delivery and policy-making. Also, the values and opinions of the researcher are not of sole or substantial importance to this research, as the researcher intends to function as a facilitator for the development of the tele-emergency framework.

4.4.2 Interventionism epistemological position.

Following the above ontological stance, interventionism follows the epistemology that knowledge can be obtained through the researcher being part of reality and impacting reality through their intervention (Creswell & Creswell, 2017). This inherent belief of interventionism, therefore, places the researcher at the centre of the knowledge acquisition process and maintains that by being present in the situation, the researcher is also affecting the evolution of reality and bringing about change in the context that they are observing (Jönsson & Lukka, 2006).

The over-emphasis on the researchers' involvement in the interpretation of reality does not appear to be justified in the context of this study because it would entail the researcher being pivotal to the interpretation process, and by extension, the researcher being an expert on the subject. Therefore, the researcher does not claim to have expertise in healthcare technologies or healthcare delivery systems. As such, the researcher does not intend to become a pivotal contributor to the data and information used to develop the technological framework for tele-emergency services in the UAE. Consequently, the researcher has adopted the role of a seeker, focusing on the stakeholders as the experts on the existing situation; therefore, the interventionism ontological position, which places the researcher at the centre (Jönsson & Lukka, 2006), is not suitable for the current research.

4.4.3 Interventionism axiology position.

The interventionist perspective is often abductive (deductive and inductive), which guides the axiology and attributes the researcher to both etic and emic styles. The study is acknowledged as a part of the reality and as being subjectively engaged to impact the other actors and their dynamics within the situation by their participation. The researcher is also expected to have an etic style where the researcher can step back from the subjective stance and relate the findings to the theory objectively. So, while the researcher is value-laden and participates in creating and interpreting reality, the researcher is also objective when interpreting those findings and linking them to existing theories. This approach is probably similar to the constructivist view, where the researcher is etic or value-laden but is likely to possess the ability to guard against bias while enabling the construction of reality.

4.4.4 Interventionism methodological position.

The interventionism perspective, driving from the subjective ontology, interventionist epistemology, and value-laden etic/emic axiology, often calls for a mixed methodological approach that can enable data collection in both objective and subjective manners. The most suited method for interventionism research is longitudinal case studies based on qualitative and quantitative data collection methods (Suomala et al., 2014). However, longitudinal studies are not practical or required in this context since the aim is not to understand the history or to study a phenomenon over a period of time, but to assess the current status quo. A more current and context-dependent methodological approach is expected to furnish the current data required to develop the proposed tele-emergency framework. Also, since technology changes occur rapidly, the research aimed to understand the interoperability and scalability of the healthcare current systems with the latest technologies available worldwide and with emerging technologies that may soon find application in healthcare. For this, interviews as a research method, as opposed to conducting a longitudinal case study, to obtain information from participants that are abreast with developments within healthcare, healthcare technologies, and policy-making were found to be most appropriate.

4.5 Constructionist Perspective: Description

The constructionist perspective is opposed to the idea of singularity, or that complete objectivity is even attainable in any given situation (Holstein & Gubrium, 2013). Instead, constructionism focuses on reality as multi-dimensional and contextual, and therefore, subjective. Constructionism is, however, a broad term used to cover several research perspectives that all share similar ontology, epistemology, axiology, and methodology (Hallebone & Priest, 2008; Holstein & Gubrium, 2013). This research used the term constructionism or the constructionist perspective exclusively. The following sections discuss constructionism’s ontological, epistemological, axiological, and methodological characteristics. Table 4.3 provides a brief overview of the ontology, epistemology, axiology and methodology related to the constructionist paradigms.

Table 4.3

Constructionist Paradigm: Ontology, Epistemology, Axiology and Methodology

Constructionist Perspective	
Ontology	Subjective (The individuals' experience constructs reality and interpretations. reality is created based on people's own experiences, knowledge, and motivations)
Epistemology	Interpretivism (knowledge is collected through the sharing of experiences, reflection, and the context; there could be diverse perspectives and versions of knowledge)
Axiology	Emic (researcher is value-laden; researcher, too, is expected to bring in his or her value position into the research)
Methodology	Qualitative (interviews with open-ended questions, observations, role-playing and ethnography)

4.5.1 Constructionist ontological position.

The constructionist perspective takes the ontological position that reality is neither singular nor objective, and it cannot be independently assessed without considering the context. For a constructivist stance, the reality is created or constructed by the individual's experience and interpretations, which is highly contingent on the stakeholder's own experiences, knowledge, and motivations. This view of reality makes it more dynamic and changing, and stakeholders are likely to vary depending on the context, and so would their interpretation or construction of reality (Ter Bogt et al., 2012).

4.5.2 Constructionist epistemological position.

The subjective ontological position of constructionism makes it imperative that the dynamic, changeable, and in-construction reality be captured through means that can tolerate and work with the complexity involved in the situation. The positivistic perspective would entail a static reality that could be obtained simply by measuring specific aspects of it in isolation. Still, the constructionist perspective maintains that measuring reality is more of an interpretation activity (Ter Bogt et al., 2012). However, the interpretivist epistemology dictates that knowledge can be collected through sharing experiences and reflection and factoring in the contextual variables (Mkansi & Acheampong, 2012). Such an approach to understanding reality involves an exploration of the diversity of perceptions rather than developing a singular and unified law (Holstein & Gubrium, 2013).

4.5.3 Constructionist axiological position.

The emic axiology follows from the subjective ontological stance of the constructionist perspective, as the researcher, too, is expected to include their value research position. Since the constructionist view maintains that reality is constructed by the stakeholders involved in the situation, the researcher or the observer, too, becomes a part of the process of building and interpreting reality through interaction with the participants and situation. However, such an emic axiological stance should be guarded against researcher bias, so that, while the researcher is aware of their own value set, the researcher is still able to acknowledge such value positioning as a plausible source of bias in interpretation (Ter Bogt et al., 2012). The idea here is to ensure that all the perspectives are presented with minimum bias, to understand and explore the given situation from a diverse perspective, rather than establish a direct cause-and-effect relationship between a few attributes.

4.5.4 Constructionist methodological position.

A qualitative methodological approach is preferred with the subjective ontology of constructionism. It offers various research methods, including interviews with open-ended or semi-structured questions, observations, role-playing, and ethnography. The qualitative methodology allows the researcher to capture detailed, in-depth, and contextually rich information that allows for the idea of reality as the construction of experiences, reflection, and interaction. More specifically, these methods enable data collection in the form of texts, which the researcher can analyse in a value-laden manner to generate the participants' perspectives and interpret reality in a collaborative manner (Holstein & Gubrium, 2013).

4.6 Selection of the Research Paradigm

This section will discuss the outcomes of the simulation[1] and discuss how adopting a constructionist perspective is aligned with the correct understanding of the research problem, research design, and the values and skills of the researcher, while using other perspectives such as the realist and interventionist may not be adequate for this study.

The simulation results indicated that adopting a constructionist perspective would imply that the research topic, developing "a technology-enabled tele-emergency framework for the UAE," has emerged from a background that allows for a subjective ontology, or that the reality is not singular but context-dependent and conditional (Moses & Knutsen, 2012). This translated into meaning that 'framework' is not a singular objective construct, nor was the process of developing a 'framework' standardised or law-based. Instead, a *framework* was a conceptual idea that can be manifested in diverse ways, depending on the location, stakeholders involved, and the researcher. Developing a tele-emergency framework was likely to depend on many factors, including human knowledge base, technology, local sensibilities, and how people understand medicine and technology or conceptualise the role of their healthcare systems. The research problem was, therefore, not one of finding the right attributes to put in the right places, but of taking the perspectives of stakeholders involved in the situation, to factor in the ground

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1 See Appendix A for simulation details

realities, and developing a tele-emergency framework that was the best fit for the context of the UAE.

The research rationale and purpose were explained through the lens of the constructionist perspective by understanding that it was the stakeholders that are instrumental in developing policies, implementation, and the delivery of technology-enabled tele-emergency framework, which was the focus of defining and interpreting their own specific needs related to the technology and its use. The role of the researcher was to combine these diverse perspectives to develop a framework that sufficed the stakeholders and delivered value to the country. As a result, the conceptual framework included a multi-stakeholder perspective. The framework was developed using an eclectic mix of existing operational and hypothetical technology-based frameworks for tele-emergency, but with the scope of iterative refinement and with the help of the perspectives and knowledge gathered from the stakeholders involved in the study.

A constructionist stance called for an inductive research process to enable the 'construction of reality' and a research design that allowed for an iterative collection and interpretation of data (Easterby-Smith et al., 2012). Such a research design was most suited to open-ended or semi-structured interview methods, where the researcher can explore the participants' perspectives in detail and amend and modify questions to encourage participants to reflect and construct upon their narratives. An interview method also allowed for the emic stance of the researcher to play out since the researcher's interpretation of the interview responses was to be considered. Therefore, the researcher played an active role as a receiver of the verbal information and an observer of the non-verbal and body language cues and contextual information. The researcher's values were considered, as his personal past experiences, education, and situation perspectives were expected to impact his contribution as an observer and interpreter of reality. It is also here that the researcher's skills were also called for, where the researcher needed to be aware of their values and account for them to ensure that undue bias is not introduced in the interpretation of the study findings (Creswell & Creswell, 2017). While the constructionist paradigm allows for the researcher's subjectivity, it also requires the researcher to guard against personal biases or preconceived notions that may distort the interpretation of the data (Souto et al., 2015). The researcher should also be skilled in conducting interviews and using thematic content analysis techniques to capture a complete and comprehensive picture of the situation under study. The researcher's skills were also required in the form of the ability to be sensitive and empathic towards the participants and not to intimidate or undermine the data collection process.

4.7 Research Methods

The study adopted a constructionist paradigm based on the presumption that reality is constructed through the interaction of diverse perspectives of the stakeholders within a situation. The most suited research method for a telemedicine study was the constructionism paradigm utilising a qualitative method (Harper, 2011), since there was a scarcity in finding quantitative telemedicine research because such a field was at its nascent stages where exploratory research using qualitative methods was more prevalent (Subramaniam, Singhal, & Hopkinson, 2019). Further justifications are presented for choosing qualitative methods for this study in the following sections.

4.7.1 Quantitative methods.

Quantitative research methods are widely used in natural sciences since such methods yield data that can be quantified and analysed using statistical techniques. Quantitative data is also comparable and aids predictions regarding correlations or the nature and direction of relationships between variables under study (Bruce, Pope, & Stanistreet, 2017). Quantitative methods provide objective information that can be generalised to different populations (Kan & Gero, 2017). Additionally, the quality of quantitative data obtained depends on the researcher's ability to design data collection instruments that account for non-relevant and non-experimental variables (Chen & Hirschheim, 2004). Nevertheless, quantitative methods provide the further advantage of time savings and ease of data collection because they are concise and require respondents to offer short answers or choose from multiple-choice type answers. These methods are widely used in both natural sciences and social sciences research because they provide objective and relevant data that can be readily quantified and analysed using statistical methods (Oates, 2006). Some useful quantitative methods include surveys, observations, and experiment designs (Chen & Hirschheim, 2004). Surveys provide the advantage of being structured and tuned to meet the research objectives and test various attitudes, behaviours, expectations, and perceptions of the respondents (Park and Park, 2016). However, the fact that these methods provide objective and quantifiable data also acts as a limitation. Data is challenging to interpret and explain when used in the context of human relationships or behaviours in the real world (Park & Park, 2016). Quantitative methods were, therefore, not employed for this study since the research aimed to obtain in-depth insights from the research participants.

4.7.2 Qualitative methods.

Qualitative methods help understand and explain the relationships between themes under study, and are used when the situation requires a holistic and context-dependent exploration. Qualitative methods also enable the study of a situation in a real-world scenario, using observations, interviews, or interactions between the participants and the researcher

(Howitt, 2019). The most commonly used qualitative method found in research, especially in the healthcare sector, has been the interview method (Weiner et al., 2010; Padgett et al., 2016) due to its ability to collect a large amount of credible and relevant information from participants (Cunningham et al., 2010). Furthermore, interviews help identify future trends and uncertainties, and explore solutions from the stakeholders' perspectives with the required knowledge and expertise.

4.8 Selection of the Research Method

This research used qualitative interviews as the method of data collection. At times, the mixed-method approach was considered in cases where some research questions may warrant data that cannot be obtained using one method (Andrew & Halcomb, 2009). For example, participants were required to provide detailed information, such as their perceptions of the effectiveness of using tele-emergency services and provide specific, quantifiable information (like the number of cases attributed to tele-emergency versus the number of cases finalised through traditional emergency services). However, since this study focused only on questions that were better explored from the participants' perspective and required rich contextual underpinnings, only qualitative methods were found to suit the research needs. Qualitative methods can ensure that the research is conducted in an open environment, allowing for the fluidity of reality and its construction (Creswell & Creswell, 2017). However, a limitation of the qualitative method was that it was time-consuming, required additional scheduling and coordination than was needed for quantitative or experimental methods, and was also cost-intensive (Smith et al., 2009). To address this matter, this study acknowledged these limitations and proposed using a judicious choice of research participants.

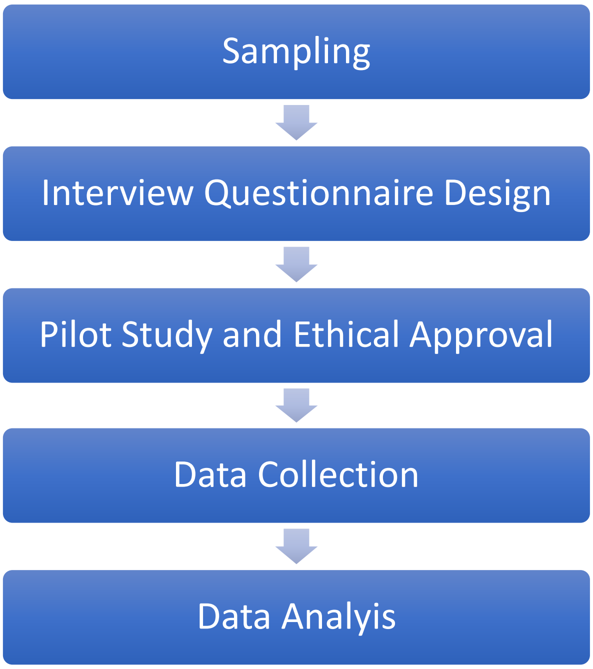
Additionally, qualitative research requires the researcher to be suitably trained in data collection methods to ensure that complete and contextually rich data is collected and accurately recorded, for which this study made adequate preparations. Qualitative methods also require that the researcher be aware of any personal biases and ward against them during the recording or analysing phases of the research (Creswell & Creswell, 2017). This limitation was overcome by reflection and critical analysis of the researcher's perceptions and past experiences within the framework of technology related to healthcare in the UAE. Despite the limitations, the qualitative method was expected to provide extensive and profound insights into the situation; and was found to be the most suitable for the research aims. This research required that data be obtained regarding the current and existing availability of medical devices, network capabilities, health information systems, and the scope and utility to integrate with a new technology-enabled tele-emergency framework. Therefore, the information was obtained from stakeholders that were profoundly involved in healthcare delivery (healthcare professionals), healthcare policymakers (government agencies), and policy-informing (institutions utilising telemedicine services).

4.9 Research Design

A research design provides a framework to research in a scheduled and controlled manner and adherence to the research rigour and ethical protocols (Howitt, 2019). A research design follows from the research questions or objectives, builds on the conceptual framework, and draws out the time and activity plan that can help answer the research questions (Kan & Gero, 2017). It includes the sampling process, designing of the research instruments, and data collection and analysis methods, as shown in the following Figure 4.2.

Figure 4.2

Research Design Process



4.10 Sampling

This section discusses the sampling technique and the attributes of the selected sample. In keeping with the constructionist nature of the research, a sample was drawn from among the key stakeholders involved in the healthcare sector of the UAE.

4.10.1 Key stakeholders.

Researcher
Government and Private Hospitals in the UAE
Healthcare Management Companies operational in the UAE
Government Healthcare Authorities/ Ministry of Health in the UAE
Healthcare Information Technology Experts in the UAE
Healthcare Consultants and Experts

4.10.2 Sample.

Since this research used the constructionist paradigm, it was useful to incorporate the perspectives of multiple stakeholders in the healthcare delivery system. This research included diverse stakeholders representing policymakers and decision-makers from MOHAP, DOH, DHA, and government and private medical institutions. Stakeholders such as health information technology and informatics experts were also included due to their unique healthcare IT and informatics expertise. Those stakeholders represented well-known international consultancy and healthcare informatics firms in the UAE. Their expertise ranged from networking, infrastructure, and telecom to healthcare digitalisation of medical records.

4.10.3 Sample size.

Since the research was based on qualitative methods, the sample size should be adequate to yield a range of perspectives that can be used complementarily and add diversity to the research findings (Marshall et al., 2013). The sample size should be practical and reasonable to interview within the time and cost constraints. According to Boddy (2016), a sample size of 20 to 30 from within a given population provides adequate diversity of information, and beyond this size, the probability of obtaining new information is substantially reduced, and the risk of saturation is high. Since the research aimed to include diverse participants, a smaller sample size was decided within each group. For this study, Table 4.4 displays the number of participants selected from each group of stakeholders, with a total of 30 participants.

Table 4.4

Types of Research Participants

Research Participants	Number
Healthcare Policy Makers	8
Healthcare Management Companies	10
Doctors and Allied health professionals from Hospitals and Clinics	4
Healthcare IT and Informatics Experts	8

4.10.4 Sampling technique.

The research used a purposive sampling technique to select participants based on specific attributes that made them most likely to provide credible and relevant data that addressed the research questions and attained the research objectives (Malterud, Siersma, & Guassora, 2016). In this study, participants were chosen based on their unique and exclusive knowledge and understanding of the topic or their interaction and familiarity with the context.

The research focused on participants from the UAE, predominantly from Dubai and Abu Dhabi, since these were the two main cities that initially implemented telemedicine. Both these cities have influential decision-makers within the healthcare industry in the country.

However, this study also included healthcare expertise from the other regions in the country to ensure that a nationwide framework captures experts' thorough and diversified opinions. To ensure that policymakers, healthcare management companies, healthcare IT experts, and healthcare professionals (medical and allied health staff) provided their unique perspectives on telemedicine in the UAE, its utility, scope, applicability, and general ease of use, a non-random approach to sampling selection was applied. Participants were selected through the researcher's healthcare network, and their availability and consent to participate in the research. Accordingly, participants were selected based on a judgemental sampling technique that empowered the researcher to select participants based on personal discretion. Using a judgemental sample was appropriate since the research goal was to develop a framework for the whole country. Therefore, focusing on both Dubai and Abu Dhabi as the main cities were vital and of significant relevance to the healthcare industry within the UAE. Similarly, since both cities were already implementing telemedicine to a certain extent and were considered healthcare hubs in the UAE (Anwar et al., 2019), focusing on these two cities was deemed appropriate.

Each set of participants was interviewed using a semi-structured interview strategy that was modified based on their domain's background and conducted until saturation had been achieved or when additional questions gained no further knowledge. Interviews lasted between 45 minutes to 1 hour.

4.10.5 Designing the interview process.

It was intended that interviews be conducted through a semi-structured questionnaire that enabled the researcher to change the order of the questions and ask additional questions or modify existing ones during the interview. This flexibility offered by semi-structured questionnaires fit well with the constructionism paradigm and helped construct reality through the interaction with the participants (Smith et al., 2009).

Policymakers' interview process.

Policymakers were included in the study to explore their perceptions regarding the need and readiness of the country's healthcare system for a large-scale, technology-enabled tele-emergency system. Since policymakers were the stakeholders that had access to accurate and dependable data on the current status of the country's ICT and networking infrastructure, the availability of medical devices, technology, and the current state of HIS; this group of participants were targeted with specific questions that helped in clarifying the current need for such a tele-emergency framework and the scope for implementing it in the coming future. More specifically, they were asked questions related to the problems faced by the population in attaining access to high-quality emergency healthcare, the availability of funding and developing a comprehensive tele-emergency framework, the policy changes that were needed for facilitating such implementation and adoption of tele-emergency framework, and any barriers and facilitators that they perceived regarding the implementation of such a framework. (see Appendix C for the interview questions).

Healthcare management companies' interview process.

Healthcare management companies were included in the study because they play a vital role in developing the country's healthcare industry. These companies are involved in the design of e-health solutions, frameworks, standards, and policies; hence, they are considered the source of relevant and valid information on the current status of technology adoption in healthcare, the healthcare needs of the country, and the future trends related to technology integration within the healthcare systems. This group of participants was asked to provide their opinion regarding the current status of the technology infrastructure and expected future trends in healthcare, the scope of telemedicine framework for emergency services, and their perspective on the current status of telemedicine, especially in the pre-and-post COVID-19 era.

Healthcare professionals' interview process.

Healthcare professionals represented doctors, nurses, senior allied health, and upper management. This group were targeted with questions that focused on the implementation and the scope of telemedicine applications that are already in use or planning to use during the current COVID-19 pandemic. Since several hospitals have already resorted to telemedicine, it was expected that insights could be obtained related to barriers to technological implementation and adoption of telemedicine from these participants. The expectation was to gain insights into integrating traditional healthcare delivery systems and HIS with telemedicine and assess the scope of using tele-emergency services on a large-scale and nationwide basis.

4.11 Data Collection Method

As discussed earlier, the researcher collected data through a semi-structured interview questionnaire. The following sections provide an overview of the interview design and data collection processes that were adopted for the research.

4.11.1 Interview design.

The interviews were designed to maintain ethical considerations such as safety, confidentiality, and participants' privacy. For this, a suitable time and location were scheduled according to participants' comfort, and precautions and safety measures were applied, as per the law, regarding the COVID 19 pandemic. Due to the pandemic, virtual interviews were scheduled for participants that felt more comfortable conducting such interviews virtually or based on the currently applied restrictions regarding social distancing within their organisations. Eight interviews were conducted physically, while 22 were conducted virtually using platforms such as Zoom and Microsoft TEAMS. Although a semi-structured interview questions approach was adopted in a virtual space, interviews were conducted formally. Where possible, direct, personal, face-to-face interviews were chosen to achieve the study's aim to obtain both knowledge and information from the participants, as well as their perceptions, opinions, and their contextual understanding of the subject at hand (Smith et al., 2009; Willig, 2013). Interviews had the advantage that the researcher could build a personal connection and rapport with participants and encouraged detailed and sincere data and opinions. As a result, the participants felt that they had space and time to think and that their inputs were deemed valuable by the researcher to communicate their perspectives fully (Palmer et al., 2010; Smith et al., 2009). Semi-structured interviews also allowed the researcher to pursue interesting themes that emerged during the conversation and enabled real-time follow-ups to clear any doubts and elaborate on specific concepts or ideas (Smith et al., 2009; Willig, 2013).

However, the interviews had a few limitations. While the purpose of the constructionism research was to obtain contextual data and construct social reality in its totality, in practice, interviews were mostly spoken conversations or text-based and did not give as much importance to the visual or spatial aspects of the situation (Willig, 2013). The observations of the researcher, while forming a part of the discussion, could not be incorporated into the findings since only the collected verbal data were considered while conducting thematic text analysis (Mason, 2002). These limitations were overcome by supplementing the interviews with personal reflections of visual and non-verbal observations such as facial expressions and body-language related cues of the participants during interviews. The researcher, therefore, generated case notes and diary entries to help in recalling and re-imagining the observations while steering the discussion and interpreting the findings. The structural alignment of the interview as a method that can facilitate and enable the construction of reality in a context-dependent manner made it appropriate to assume that a semi-structured interview method was the most suitable approach for this study.

4.11.2 Data collection process.

To conduct interviews, it was essential that planning and scheduling were planned so that participants were not inconvenienced, and interviews were conducted smoothly. Each interview lasted between 45 minutes to 60 minutes, and the entire data collection activity lasted five months.

Stage 1: The first stage consisted of pilot interviews for which one healthcare management professional, one healthcare professional, one healthcare IT expert, and one policymaker were interviewed; these participant sets fit the profile of the targeted participants for the main study. The pilot interviews were conducted to help understand any problems faced during the data collection phase and improve the interview questionnaires or the interview design. The data and experience obtained during the pilot interviews helped modify the research questionnaire and offered the researcher practical insights into the order in which the questions needed to be asked to generate maximum engagement from the participants.

Stage 2: The second stage began with selecting participants from across the healthcare network of the researcher and contacting them with an informed consent form that provided details related to the purpose of the research, the usage of the collected data, and the rights of the participants. The targeted participants were requested to sign the informed consent form (see Appendix D) exhibiting their voluntary participation in the research.

Once participants had expressed their willingness to participate, they were further contacted with details of the interview. A suitable time (in the case of virtual interviews) and location (in the case of direct physical interviews) were decided. The researcher conducted interviews by posing each question from the semi-structured questionnaire and recording the responses with permission from the participants. The interview data were analysed once all the interviews were concluded, as discussed in the next section.

4.12 Data Analysis Method - Thematic Content Analysis

The data collected from interviews were transcribed and then analysed using the NVivo software to find themes from the responses. The findings that emerged in the form of themes were then manually analysed to find patterns across the participants, and these patterns were then illustrated and discussed. The following steps were undertaken to analyse the data. These steps are based on the NVivo software manual for qualitative research. While the NVivo software supported data management, exploration, and finding patterns, the analytical skills of the researcher continued to be of prime importance. The following section provides an overview of how the analysis process was conducted using NVivo:

1. *Import*: The interviews were transcribed and imported to NVivo.
2. *Explore*: - The interviews were read with the intention of immersion with the original data. The NVivo software allowed the researcher to read the interviews several times and form an initial impression of the potential similarities or contradictions in the participants' responses. Also, at this point, the researcher developed a tentative understanding of the overall model of the presentation of the findings. This exploration of the interview transcripts was undertaken in several readings.
3. *Coding*: - Once the researcher became familiarised intimately with the original transcripts, it was possible to detect any specific mentions or thought-provoking terms relevant to the research aims being mentioned by the participants. For example, if it was discovered that one participant discussed the 'existing state of HIS in the UAE', the phrase was marked as a code. This coding helped in the next step to evaluate if other

participants also discussed the 'existing state of HIS in the UAE' and the themes under such a code.

4. _Query_: This is where the researcher ran a text search query to find out if others too have used the same phrase, such as 'existing state of HIS in the UAE'. Then, all the results from the query were pooled and reviewed in the next step.
5. _Reflect_: The review process consisted of reflecting upon what the participants mentioned around the code (to continue the example, 'existing state of HIS in the UAE') and keeping a journal or a diary to note the researcher's understanding of the participants' perceptions around this code.
6. _Visualisation_: This step helped in lending clarity to the way different participants discussed the code. Here, a word-tree was developed to see how the participants mentioned the 'existing state of HIS in the UAE'.
7. _Memo_: The researcher noted if any themes emerged from the visualisation and added any more inputs or personal reflections in the form of a memo or a note, which were used while writing the final themes that emerged from the analysis.

The above process was repeated with several codes that are relevant to the research, similar to 'existing state of HIS in the UAE', including phrases such as 'technology-enabled telemedicine framework,' 'availability of emerging technology-based medical equipment, sensors, and devices that can be enlisted as part of the tele-emergency healthcare system in the UAE,' and 'current ICT and network infrastructure of the UAE'.

Once all the codes had been segregated, data was further presented in word clouds that provided visual insights about the themes and reflected the predominant responses obtained around a given question. Word clouds provide a basic form of text analysis tools, which help explore the text before a more complex analysis can be undertaken (Kabir et al., 2018). This helped detect patterns of themes and understand how the themes may be linked with each other.

The final step was to include a discussion and interpretation of the themes. The broad themes were presented regarding the similarities or differences that emerged from the participants' perceptions regarding those themes. The themes were also analysed using the theoretical constructs and models discussed in the literature review, aligning with the recommendations of Willig (2013), and contextualising the findings within the existing literature.

4.13 Data Quality: Authenticity and Dependability

Some of the limitations of qualitative research were cited as the difficulty to overcome the inherent subjectivity of the method and ensure that research findings are valid, reliable, and generalisable (Easterby-Smith et al., 2012). It is also logical to presume that such constructs as validity, reliability, and generalisability are more suited to assess the quality of quantitative research rather than a qualitative one. Therefore, there is a need to explore additional or new approaches to establishing and evaluating quality regarding dependability and authenticity for qualitative research. This study followed the Yardley (2000) framework; it included four separate criteria that are suitable for assessing the quality of qualitative studies (Smith et al., 2009). While these criteria provide a flexible set of guidelines for qualitative researchers, the study rigorously met all the requirements and produced trustworthy, authentic, and dependable findings.

The four criteria are discussed below:

Sensitivity to context: Simply put, this can be interpreted to mean that the researcher was required to conduct a thorough review of the literature and the collected data to get immersed in both the academic and the practical context in terms of the socio-cultural, geo-political, and technological context of the research. The researcher should have had a clear understanding of the socio-cultural background of the research participants so that the researcher could interpret and discuss their responses contextually (Yardley, 2000). Therefore, this approach was followed for this study, and the researcher was well-aware of the socio-cultural background of the participants, and the historical and geo-political status of the region. This knowledge enabled an objective and accurate interpretation of the constructed reality.

Commitment to rigour: The research should be conducted with total commitment from the researcher to reflect upon personal perceptions and opinions to guard against potential bias while collecting data or during interpretation and discussion of findings (Yardley, 2000). This was accomplished through introspection, reflection, and journal keeping throughout the research. The study was conducted with a focus on ethical considerations, ensuring that participants' privacy was assured, that their responses were kept anonymous and confidential, and that they were not harmed in any way during the research. Ethical conduct during the research also includes obtaining informed consent from the participants and assuring them that they can leave the research at any point without consequences (Mason, 2002; Silverman, 2016; Wahyuni, 2012; Willig, 2013; Yardley, 2000). Hence, this was appropriately done before starting the data collection process for this study. Also, qualitative research rigour dictates that the researcher spends considerable time and resources on developing skills as a qualitative researcher, including interviewing skills, use of thematic context analysis with NVivo, and analytical and reasoning skills (Creswell & Creswell, 2017), and the researcher invested both time and resources to learn interview skills and NVivo software during the early stages of the study.

Transparency and coherence: This criterion entails that the research is conducted transparently and that the findings are coherent and easy to comprehend (Yardley, 2000). To ensure transparency, the researcher kept a detailed account of the steps taken and maintained a timeline detailing the activities undertaken and the resources consumed. It is further advisable to seek assistance from an independent reviewer. The researcher enlisted the support of a qualified qualitative research expert to crosscheck the data analysis and presentation, so that issues related to the researcher's bias are overcome. To ensure that the findings were discussed coherently, the researcher also undertook a short academic writing course and developed the skills needed to discuss complex findings using the literature background and observations. Finally, under the requirement of coherence, the thesis should be written with the reader in mind (Yardley, 2000). Therefore, the researcher used appropriately suited sentence structure, vocabulary, and embedded context.

Impact and importance: Creswell and Creswell (2017), Silverman (2016), and Gentles (2016) contend that any research, including a qualitative one, can only expect to be considered valid if it yields substantial or unique insights into a given situation. This study is expected to have immense implications, both in terms of filling gaps in the existing research in the UAE and practical utility to the UAE government's initiative of the digital transformation of healthcare services. It provides insights about developing a technological framework that is scalable, secure and safe, and has inbuilt interoperability; a theme, at the moment of this study, has not been fully explored in the existing literature. In practical terms, this study provides a deliverable in the form of a blueprint of the tele-emergency framework that can be used as a starting point for the implementation initiative leading to a revolution in emergency care services in the UAE.

4.14 Generalisation

Generally, the perception regarding qualitative research is that it is employed to conduct an in-depth exploration of a given situation. Hence, its findings may not be generalisable to other contexts (Kvale & Brinkmann, 2009). However, there has been precedent where qualitative research findings are used within analytical generalisation - or when an assessment is made regarding the extent to which the findings from one qualitative study can apply to the other context based on the similarity of the contexts and the social setting, stakeholders, and location (Trochim, 2005; Leung, 2015).

Therefore, it can be postulated that the findings from the thematic content analysis are relevant to the context of the tele-emergency framework for the UAE. Hence, the findings can be generalised to other countries with similar ICT, HIS, and networking infrastructure as the UAE, and share similar socio-cultural makeup and geological similarities.

4.15 Ethical Considerations

The research used guidance from the Principles and Procedures framework of the University of Gloucestershire by the British Educational Research Association (BERA) and the British Sociological Association (BSA). The research followed ethical guidelines and considerations related to informed consent, participant confidentiality, safety, privacy and physical, and social and psychological well-being, as per the University of Gloucestershire Research Ethics Handbook, 2014. Before the data collection process, the research participants were asked to sign an informed consent form that indicated that they had fully understood the purpose and scope of the research and gave their voluntary consent to participate. The participants were made aware that they were free to leave the research at any point, and that they did not need to answer a question if they did not feel comfortable with it. The participants' names were never linked with their responses, which were kept confidential and used only for inclusion in the thematic content analysis to generate common themes and insights. Even in the original transcripts, the participants were referred to by codes and not their names, thus ensuring complete anonymity. Only a single-copy list of the names and corresponding codes was kept with the researcher in a locked file, for research references.

The participants' names and personal contact details were not shared to ensure their privacy. Participants were only segregated as healthcare management company professionals, healthcare professionals (doctors and allied health senior staff), and policymakers. The demographic profiling of the participants was based on their experience, age, and gender. This was done only to give context to their responses and factor in any sources of biases or learnt behaviours or values. Finally, interview responses provided by the participants were stored safely with the researcher and not shared with any third party, and disposed of after one year of the research to ensure complete confidentiality.

4.16 Limitations of the Qualitative Method

A limitation of the qualitative method is that it is time-consuming and may require extra scheduling and coordination efforts than quantitative or experimental methods (Smith et al., 2009). Since most research participants of this study were professionals, the time constraint was a significant factor, so getting participants' to spend about an hour was challenging due to their professional commitments.

Qualitative research may also be cost-intensive (Smith et al., 2009), as costs related to travel or subscription costs for online video-call applications may be required to be included. Qualitative methods are often criticised for being subjective and limited in scope since generalisation to new contexts may be difficult. However, as mentioned earlier, it is possible to generalise findings from this qualitative research to other countries, provided their socio-cultural, geo-political, and healthcare systems match the UAE's (Trochim, 2005; Leung, 2015).

Besides, due to the COVID-19 pandemic, most of the interviews were conducted virtually, thus missing out on the body language, contextual cues, and personal rapport that direct personal interviews usually generate. As such, this approach probably did not result in the subliminal indicates associated with body language, which can act as contextual clues, enable personal rapport to be established quickly, and help generate more relevant data.

4.17 Chapter Summary

The chapter presented an overview of the three different research perspectives, namely, realist, interventionist, and constructionist paradigms, and provided a rationale for using the constructionist method for this study. The constructionist paradigm was better aligned with the researcher’s value-laden yet limited contribution to the development of the sought knowledge. The constructionist approach was also found to suit the practical conceptualisation of reality, where there are multiple perspectives and multiple contributors in the form of research participants and their contexts, to the development of reality. The chapter also supported the selection of the constructionist paradigm by using the simulation results, which found the constructionist approach to be most suited for this study’s rationale and purpose, and with the researcher’s values and skills. The chapter then discussed selecting qualitative research methods, more specifically, the interview method, as the most appropriate method for data collection within the constructionist paradigm. Qualitative interviews adequately supported the constructionist paradigm and helped collect contextual data from participants that were used to construct reality and understand the current situation. A judgmental sampling method was more appropriate because it allowed for the purposive selection of participants with extensive knowledge and familiarity with the research context to provide relevant information. The sample size was decided upon, primarily following from the literature that has indicated saturation of new information would be about a sample size of 30. It was expected that the 30 participants would provide adequate and complementary information, and the number of interviews could be well within a manageable time frame and resources available to the researcher. The chapter further presented a brief overview of the development of the semi-structured questionnaire contextualised within the existing literature and previous studies undertaken in the context of telemedicine. The questionnaire was customised for the three sets of participants to include the most relevant questions and are presented in Appendix C. Questions to policymakers were related to their perceptions regarding the development of policy related to the scope and possibility of developing and implementing a nationwide tele-emergency framework. The questions for healthcare professionals (medical upper management reps, doctors and senior allied health professionals) focused on understanding the current ICT and networking architecture and protocols that they were using and the scope of integrating them within a large-scale nationwide tele-emergency framework. Health management organisations were questioned on their understanding of the scope of deploying technology for tele-emergency services in the country and seeking suggestions.

A pilot study consisting of one participant from each set was conducted. The pilot study assisted in further developing the questionnaire, confirming the interview format and structure. The chapter also discussed the interview process and provided details of the data collection mechanism through a semi-structured questionnaire. The data was analysed using thematic content analysis software, NVivo, and the chapter also presented a brief overview of the steps involved in the analysis. Then, the chapter discussed the four criteria of academic rigour, transparency, coherence, sensitivity to context, and impact and importance that the researcher followed. The generalisability of the research, especially in the context of the research being qualitative, and hence subject to several criticisms regarding rigour, was indicated with caution. The chapter also presented the ethical considerations in the form of protocols followed to ensure privacy, confidentiality, anonymity and security of the participants, and study limitations. Finally, limitations were discussed that prevented conducting physical and personal interviews.

CHAPTER FIVE: FINDINGS

5.1 Introduction

This chapter presents the results of the interviews conducted with 30 participants across the UAE. More specifically, the interviews were conducted with healthcare policymakers in the UAE government, representatives of healthcare management organisations operant in the country, and healthcare professionals from different hospitals and clinics within the UAE. The research participants were selected by a purposive sampling method, and interviews were scheduled between December 2020 and April 2021. While initially all interviews were expected to be conducted physically, due to the onset of the COVID-19 pandemic, most of the interviews were conducted virtually, utilising video conference platforms discussed in chapter four. This chapter's structure is aligned with the six broad thematic questions asked in the interviews, namely: ICT related status of the country's healthcare system, existing telecommunications systems in the UAE, the role of medical equipment in this proposed framework, the importance of first responders in such a framework, EMR, HIS, and HIE systems, and availability (or lack) of resources for supporting a tele-emergency framework. The findings are reported and segregated based on categories formed using the NVivo software under each question. The results are initially developed into word clouds that offer a simplistic yet insightful way to visualise data from interviews (Heimerl et al., 2014). Word clouds automatically display the most commonly used words by enlarging them in the proportion mentioned by the interview participants (Henderson & Segal, 2013). Word clouds have also been used as a supplemental tool in qualitative studies to visually present data and provide a starting point for further in-depth analysis (McNaught & Lam, 2010). Additionally, word clouds have been extensively used in studies based on text analysis in diverse fields, including education (Jayashankar & Sridaran, 2017; Zan, Zan, & Morgil, 2015), marketing (Cherapanukorn & Charoenkwan, 2017; Kabir, Ahmed, & Karim, 2020; Wang al., 2020), technology adoption studies (Jemison et al., 2018); and more recently in evaluating media content and sentiment (Gupta et al., 2020). Word clouds then supplemented findings that are segregated based on categories formed using the NVivo software under each question; see Appendix B for details of the questions and their relationship with the themes presented in this chapter.

5.2 Information and Communications Technology (ICT)

The first two interview questions were about the current status of ICT in the country to obtain the participants' perceptions on whether the current ICT provision could support the proposed tele-emergency framework (Q1 in Appendix B) and what policy changes may be needed to support the development of a nationwide tele-emergency framework (Q2 in Appendix B). Three categories emerged that paralleled the two interview questions related to ICT, and these are discussed below as ICT standardisation, ICT law, and ICT security.

5.2.1 ICT standardisation.

When considering the standardisation and availability of ICT in the UAE for supporting a wide-scale national-level telemedicine framework, participants seem to differ in their perceptions. However, phrases or words that the participants prominently used are first illustrated through the word cloud pattern to show the usage of specific codes/phrases related to ICT.

Figure 5.1

Word Cloud Pattern for ICT Standardization

According to some of the participants, ICT was adequate for initiating connectivity between hospitals, ambulances, and first responders, as can be seen from the following response of one of the participants, P2:

"*Technically, I believe we have all the needed infrastructure to go through this, especially after the implementation of Salama System in 2017 in DHA and with EPIC in Cleveland Clinic Abu Dhabi and HAAD Abu Dhabi Health Authority, and the Ministry of Health. So they are all linked. Two weeks ago on the news, they were discussing linking the public and the private (health medical records).*"

Another participant, P15, mentioned the Network & Analysis Backbone for Integrated Dubai Health (NABIDH), which connects Dubai's private and public hospitals. Additionally, the participant said, "*MOHAP has NUMR (National Unified Medical Records) initiative.*"

However, other participants did not share such optimism, and believed that communications and connectivity were lacking at various points in the healthcare delivery chain in the case of emergencies. For example, one of the participants, P3, stated:

"So as you'd expect, I mean, we write up the medical report. It's a digitised medical report, which is physically signed by the doctor, and it is scanned or faxed. You know, old school or emailed, most of the time it's sent on WhatsApp actually, to the admitting party in the hospital, and there is no direct integration. There is no specific system in place, and there's relatively little ability to track what's going on."

The same respondent (P3) also added, *"so we spend a lot of time running around chasing up, following up, individually calling Masafi wherever, Khorfakan hospital, and the only way we can really get somebody transferred, is if my head of ICU calls their head of ICU and they're both Egyptian, and they happen to know each other, and they're buddies, and it works, but that type of system does not exist."*

These findings indicate a lack of a systematic process for dealing with patients that may need specialists during emergencies. While there may not be a lack of adequate ICT availability, there may be a lack of an understanding of how to deploy the available ICT systems more effectively.

However, the reason why more hospitals were not offering tele-emergency care was the lack of investment in purchasing the technology, and according to P1:

"... organisations may not have seen a financial benefit or had a financial model justifying such advanced care delivery systems. Otherwise, we would already see them commonly in place, and your research would reflect their existence. But, definitely, we are positioned to offer these services."

The lack of connectivity between different ambulances and monitors was also attributed to the fact that different service providers followed different chains of command. For example, P23 reported, "*some of them report to the police like the aviation, others report to Dubai Health Authority and the Ambulance Department. So you don't have one health authority to control all of this*."

When considering the phrases related to the standardisation or interoperability of ICT systems in the UAE, concern was expressed by the participants, as put forward by P1, "(*what is) required is modifications and standardisations of the hardware, software, and other platform connections between the ambulance services, the Dubai Health Authority (DHA), DOH, formerly HAAD, and/ or the other Emirates' Regulatory bodies (e.g., MOHAP), and the receiving healthcare providers like hospitals and their clinical teams.*"

It was also evident that different functions and departments were often operating with different ICT systems within the same hospital, sometimes with legacy systems that were difficult to integrate, such as Systems Applications and Products (SAP), which is a widely-used Enterprise Resource Planning (ERP) software. This point was evident from the remarks of one of the participants (P8), who mentioned that,

"*... we have SAP... Because we are part of a head office group, and we run on SAP. The hospital, I think, started on SAP, and the group has SAP in their head office. So, all of the financial reporting and all of the back-end stuff, the ERP system is all SAP. The front end also is SAP. I think it's (the front-end system) some legacy system from some other operator, but ultimately, it's based on SAP. For radiology and all that sort of stuff, it really depends on the equipment, but we have an installed base with Phillips. So the majority of the radiology stuff is run by true Phillips risc pacs system, but again that's integrated into the back end with SAP, and the Lab and the LIS again is a vendor-based solution, and the lab information system is also from an administration perspective and data is integrated with SAP, so we're pretty much SAP.*"

The overarching theme that seems to be emerging from the interviews was that ICT was not standardised. Instead, fragmentation and interoperability issues could threaten the ICT ecosystem's scalability and usability for any large-scale technology-based tele-emergency system. The following response from P9 clearly articulated this:

"*So I would say that it's evolving. Now my three comments are it's one evolving, two, it's fragmented and three every Emirate as we know (is) the different story, Malaffi in Abu Dhabi will be regulated by DOH, in Dubai DHA, and I think they have a different approach on their data trying to run through into the healthcare with the Northern Emirates. A lot of the drive from the government, from the regulation respective, is to keep data local from a national security perspective, and so it's not hosted outside, and they have control over it.*"

While there appears to be scope for further standardisation in ICT, the participants also laid out particular concerns regarding the legal aspects of ICT, as discussed below.

5.2.2 ICT law.

In response to the question about the adequacy of rules and regulations concerning ICT in the country (Q2 in Appendix B), the participants revealed multiple laws and jurisdictional problems regarding ICT management. The phrases or words that predominantly came up are shown through the word cloud pattern to show the usage of specific codes/phrases related to ICT Law.

Figure 5.2

Word Cloud Pattern for ICT Law

A trend in responses observed was that all the participants appeared to accept that ICT must fall within a regulatory framework that must be standardised across the Emirates to ensure seamless connectivity and functions. One of the respondents (P25) mentioned that new laws were getting enacted toward achieving such connectivity and the seamless transfer of information and knowledge across the Emirates,

"*We have a new law, I think 2016, about the Health Informatics (Federal Health Informatics Law 2 of 2019).*"

However, the participants also acknowledged the complications with implementing ICT laws across the Emirates and mentioned the importance of both the Ministry of Health and the Ministry of Internal Affairs in this regard. Moreover, besides the differences between the Emirates, there were also differences between the private and public sectors, which may cause barriers to any standardisation or attempts to integrate the two hospital systems for a nationwide tele-emergency service. For example, participant P3 stated that:

"*I don't think you need my EMR to be integrated with the government's EMR. That's going to be almost an impossible task because you can't force private sector hospitals to unify their IT systems with the public sector; it's just impossible. Because nobody is going to agree with it. But if there can be a unified system whereby when I need to transfer out, it can be relatively simple.*"

Similarly, another participant, P6, stated: "*there are always conflicting regulations, I mean if we think about regulators, Department of Health Abu Dhabi regulation conflicts with a regulation of the DHA, and that conflicts with the MOHAP regulations, for example*."

In addition to the above conflicting regulations or jurisdictional issues, one of the participants, P10, mentioned that there was another law related to data residency that may cause further barriers to full-scale implementation of a tele-emergency framework in the country:

"*We know from an ICT perspective and based on the UAE Federal data law; every single medical detail has to stay within the boundaries of the country; we know it's a given.*"

A related issue to ICT laws was ICT security, and the findings related to it are mentioned in the following section.

5.2.3 ICT security.

In response to the question related to the adequacy of rules and regulations concerning ICT in the country (Q2 in Appendix B), the following phrases or words were found to be predominantly used by the participants and are shown through the word cloud pattern to show the usage of specific codes/phrases related to ICT security.

Figure 5.3

Word Cloud Pattern for ICT Security

ICT security-related phrases found in the interviews indicated that there were concerns regarding this aspect of ICT, especially in the context of data residency, as seen from the following two excerpts, by P9 and P28, respectively:

"There's *a lot of rules and regulations around data residency, and cloud... So cloud is a big issue. The rules are trying to keep them local. When you keep them local, you have to keep them on in local data centers. AWS are not here; they're in Bahrain; Microsoft opened data centers, one in Dubai and one in Abu Dhabi recently summer 2019, so that's one option. Alibaba has data center services here as well, but that's another option.*"

"*However, in G42, there's a couple of cloud computing companies that have a dedicated healthcare division. In that sense, they understand the ins and outs of hosting patient data. Telecos are really actually trying really hard to help the healthcare industry, but I think their healthcare experts....they don't have too many people; they don't have doctors on board. So, I really don't think telecos are ready to provide that infrastructure.*"

The lack of a generalised framework introduces a lack of interoperability and acts as a barrier to connectivity. The above findings reveal that it also leads to security concerns for both the healthcare industry and patients' privacy.

5.3 Telecommunications

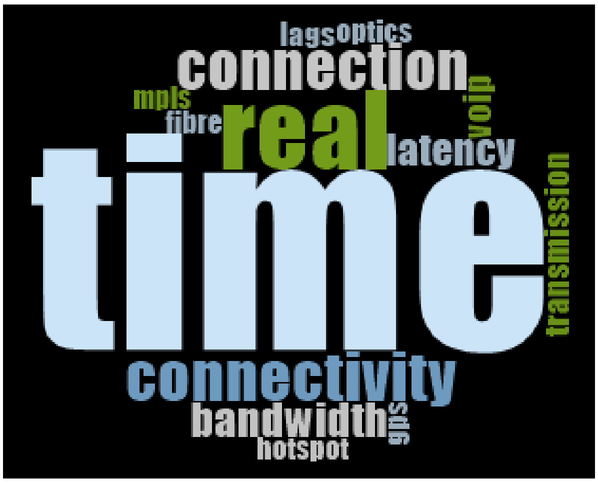
The questions related to telecommunications asked the participants about their perceptions regarding the current status of the telecom infrastructure and network (Q4 in Appendix B) and their suggestions on making the telecom infrastructure adequate for a tele-emergency framework for the country (Q5 in Appendix B). The responses put forth categories like speed and availability of broadband, platforms, data reliability and standardisation of telecom platforms.

5.3.1 Speed and availability of broadband.

In response to question 4, which is related to the current status of the telecom infrastructure in the country, the following phrases or words came up predominantly in the responses). These depict the usage of specific codes/phrases related to the speed and availability of broadband.

Figure 5.4

Word Cloud Pattern for Speed and Availability of Broadband



When considering the responses attained regarding the status of the existing speed and broadband in the country, some mixed perceptions were expressed by the participants. Some of the participants mentioned the availability of cloud-based systems, 5G connectivity, and independent hospital chains' cloud-based health information management systems that are already in use in the country. For example, P1 mentioned:

"I would say from the telecommunications standpoint, from having the availability of the cloud-based system enhanced by 5G connectivity, along with all the cloud-based healthcare information management systems companies that have major offices here, further bolstered by all the big healthcare information management companies having either proposed to do

business here or actually done business here; these technologies and system availability prepare the UAE well for advances in telemedicine, and, in particular, this tele-emergency care."

Similarly, another participant, P8, commented on the connectivity available in terms of mobile networks in the country, "s*ee if you look at the mobile penetration, this (country) probably has the highest mobile penetration in the world. If I remember, I was, at one point in time, advising (Du – UAE telecom company) and I remember that the connectivity in Dubai was that there were three connections per capita, so if there are three million people in Dubai, there were 10 million connections in Dubai. The availability of communication conduit in terms of telecom I think is very well available in Dubai. You look at the data speeds that we get at our home or the 4G or the 5G connectivity that we get."*

Other participants shared similar opinions about the country's readiness in terms of its telecom infrastructure. However, they mentioned some reservations about deploying it for a large-scale framework in emergency healthcare, as seen from the following excerpt from P5:

"*...the telecom, the ISP's, the internet service providers in the UAE have recently launched the 5G network. The latency in the 5G is 0.000001%, so it is really real-time. It has been tested in open-heart surgery as well as in other industries other than healthcare. It proved to be real-time, so from an infrastructure perspective and readiness for the country for the ICT, I believe the ISPs are ready, I believe the country is ready, and it could happen. But the healthcare industry should be ready for such a thing and to do the right investment to be able to do such a thing.*"

Similarly, one of the participants, P6, gave the example of the DCAS system in Dubai, enumerating the current status of a telecommunications system in the UAE, "*...seeing the DCAS system, their integration with DHA, telecommunications, telecommunications providers, infrastructure setup is solid enough to handle that capacity and manage it and everything. So I don't think that would be an issue."*

However, P1 also mentioned that hospitals (private) have only basic telecommunication systems, connecting ERs to the emergency services, "*I think in the ER, we do have some system, which is National Ambulance. They have this bat phone type of system. We have that installed only because we are receiving patients from the national ambulance. But other than that, our telecom is primarily just marketing and communications*."

Similarly, P30 mentioned the use of short-dialling numbers for internal connectivity, "*there's a single short dial number which is like 9932 whatever, and even for mobile phones for doctors, we have a short dial system. So rather than you have to phone the doctor on their mobile, you phone the short dial and that automatically gets routed to their mobile phone.*"

Participant P30 also mentioned the EMR as a basic system used and mentioned the continued use of telephones only in some hospitals, "*so, I mean, obviously, EMR is our main communication theme or across the hospital. And then obviously, telephone conversations, consultation is also another very important mean to communicate. Almost what's not written, what's not documented is not done. So that's why EMR (Arabic) to us is very, very important. (Arabic) But still, for example, in some procedures, there is some manual documentation. Still, we're trying to go electronic and digital, (Arabic) for example, you have a store protocol, or you have a checklist that is for stroke that you have to fill, (Arabic) even if you have an EMR, we are still required to fill it manually.*"

A new insight that was gained was that, according to one participant, tele-emergency is supposed to have different tiers of emergency, and the readiness for each level of emergency is different in the country, with the patient or critical care facilities available, but less availability of such services for the mildly sick.

Further, the participants also mentioned that the UAE hospitals were mostly telecom ready and capable of providing tele-emergency care to remote patients. One participant cited Cleveland Clinic's example in Abu Dhabi or Sheikh Shakhboot Hospital, which are likely considering launching tele-emergency programs.

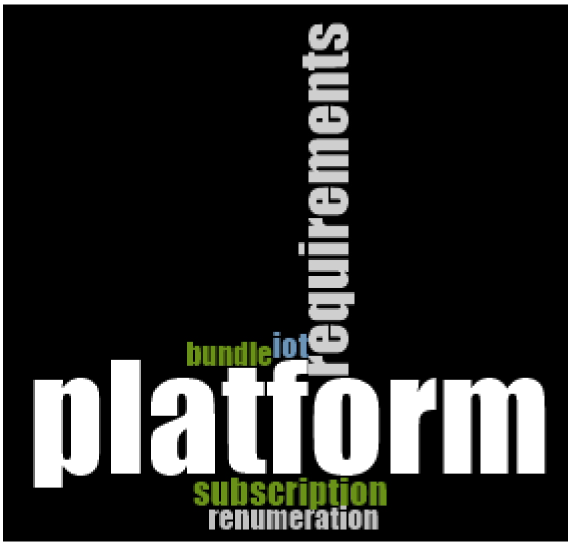
In addition to the impact of speed and broadband on any technology-enabled telemedicine framework, a topic discussed extensively in the interviews was related to the diversity of platforms and their utility for the purpose.

5.3.2 Platforms.

In response to question 4 related to the current status of the telecom infrastructure in the country and question 5 on gaps that need to be filled, the following phrases or words were found that could be categorised under telecommunications platforms.

Figure 5.5

Word Cloud Pattern for Platforms



The phrases that were found in response to question 4 (Appendix B) on the current status as it relates to the availability and adequacy of telecommunications platforms for supporting a large-scale tele-emergency framework were evident from the interviews that hospitals within the same chain used different platforms for managing their data, which caused issues related to integration and information sharing. For example, one participant, P4, stated that "*the (hospitals have) different systems, different tools, different records.*"

The participant also added that manual data or patient file extraction was done by sending someone over to the second hospital and collecting the needed information.

Within a single hospital, no unified platform is often used to streamline the workflow and manage patients' data and processes. This meant that multiple sources needed to be accessed to retrieve different information. According to one participant, their hospital used a patient interface that allowed booking appointments or scheduling video consultations through an app. However, these were rooted in legacy systems that did not allow speed or connectivity. Additionally, it was also reported by P4 that some hospitals had wiring or Internet access issues,

"*I know that, for example, there are areas where no Internet reaches. For example, no connection reaches certain areas of certain hospitals. It's pretty bad. Even in the newer hospitals, we've had connection issues in certain areas of the hospital.*"

The phrases related to standardisation and connectivity of networks indicated that there appeared to be a lack of interoperability between networks or devices, while there was substantial connectivity for individual networks and platforms.

For example, participant P14 mentioned: "*you need to build an IoT platform where it can start connecting different devices, and you can use the same platform to connect ambulances. And today, I believe DHA have something, and I think the National Emergency Services, too. But again, going back into the connectivity and what to connect, that's going to be a challenge. You have to work with the hospitals; you have to integrate with EMRs; you have to integrate with multiple systems. So, today any hospital, you have tens and maybe hundreds of different small solutions up and running together. When you talk about integration, you need to keep all this in mind.*"

The problem is probably further complicated by the differences in regulations and requirements of multiple approvals for using servers and other infrastructure, as enumerated by participant, P9:

"you need to work on their networks, with which I'm sure that the ambulances are already connected from that perspective, and they need to have their infrastructure open to any software that you are utilising, especially with web-based. If it's hosted on a DHA server or SEHA servers and then you're utilising in the ambulance, the laptop with the infrastructure connected, it won't be problematic, but that in itself is a complicated journey. I'm going to have

to deal with approvals, CIOs, MOPA (Ministry of Presidential Affairs), they have a willingness, but it's a lot of complications, especially in healthcare."

Also, the same participant revealed the problems that were being faced in the country due to the blocked VoIP services, as noted in the following excerpt from P9:

"I can tell you from the experience I had; the challenges are not about having the infrastructure. The challenges are about cloud, data residency, regulatory re-alignment across the Emirates, cybersecurity, data security, and firewalls with the operators. And then Lastly, which is a very relevant topic, has been around the blocking of IP ports for VoIP services. These are the five challenges which I face at length."

The participants also expressed concerns about data security and reliability, which is taken up in the next section.

5.3.3 Data security and reliability.

The responses to question 4 focused on concerns regarding the current status of the telecom infrastructure in the country, and question 5 asked the respondents to explore the gaps in existing policies on the issue; the following phrases or words were found that could be categorised under telecommunications related data reliability and security.

Figure 5.6

Word Cloud Pattern for Data Reliability

In the responses to question 4 related to data reliability, the participants provided insights into how this is currently managed and challenges and barriers that may need to be overcome. Data reliability, be it business-related or patient-related data, was one of the issues highlighted by several participants, as can be seen from the following excerpt from participant P4:

"*We have business intelligence tools that we can access, for example, things like revenue, patient numbers, things that are more business-related. We do have those, but they're also not reliable. The data has been the biggest issue, and the reliability of it.*"

Additionally, the telecom sector's lack of regulations was also cited as challenging for developing an effective telecommunications system in the country. As P6 mentioned: *"I know there are some questions on regulations with TRA, video calling, VoIP, and all that type of stuff."*

However, a pressing issue that was brought forth was related to data latency, especially in the context of tele-emergency situations, as mentioned by P9:

"latency is going to be very important because if you're doing an emergent case, if it's an elective case, elective consultation, and for whatever reason, the network goes down, or there are latency issues, or the hardware stalls, it's not life-threatening. The challenge you have with an emergency, it can be life-threatening, and there's a lot of legalities, and there's a lot of personal culpability around this. So we were very hesitant, both us and the providers to use it in an emergency setting because of the medical liability risk and the risk of the patient obviously, whereas you remove all the elements when it's scheduled, when it's a consultation, it's not ideal, but it's OK. So, you have to really think very carefully about this element as well."

The above issues related to telecom highlighted a critical need to develop integrated and interoperable telecom networks in the country. However, a closely related theme to the availability of telecom infrastructure is the availability and status of medical equipment and sensing devices that are essential to any tele-emergency system. These are discussed next in the chapter.

5.4 Medical Equipment

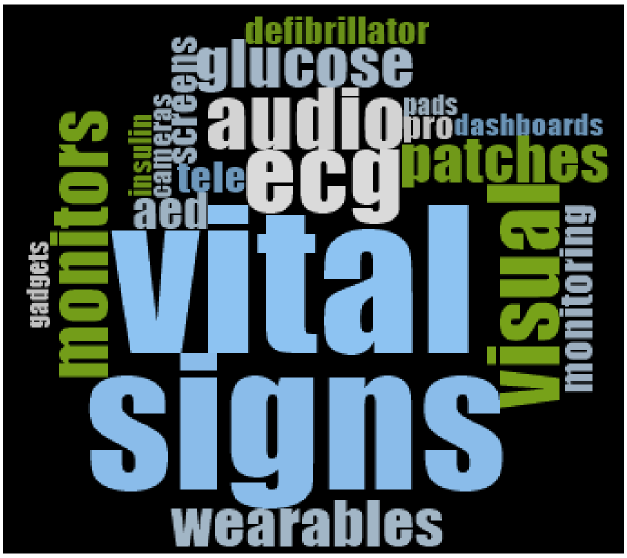
The question related to the gaps in availability and interoperability of medical equipment that could help develop a tele-emergency framework for the UAE (Question 5 in Appendix B), and gaps in policies (Question 3 in Appendix B) yielded phrases that were categorised under wearable and monitoring devices, governance, and usability.

5.4.1 Wearable and monitoring devices.

In response to question 5 related to the gaps in the current medical devices that could support a wide-scale telecommunications network and any gaps in supporting and regulating policies (Q3 in Appendix B), the following phrases or words were found that could be categorised under wearable and monitoring devices.

Figure 5.7

Word Cloud Pattern for Availability of Wearable and Monitoring Devices



The phrases related to questions about the medical equipment, more specifically medical devices that could aid in tele-emergency, led to the theme around wearable technology and its application. The participants noted that wearable technology was already a norm in the UAE. Most people were already wearing some form of wearable personal fitness tracker device, which gives scope for monitoring and tracking patients, as suggested by P1:

"*One of the service initiatives of the endocrinology department at Valiant Clinic, that they had back in 2017 was to offer the real-time blood glucose monitoring for certain patients. Since some patients with poorly managed diabetes were more likely to have a medical emergency, they qualified for sophisticated monitoring devices. So, we already have ways of tracking patients who are well, like ostensibly you, or mildly sick, like someone with well-managed diabetes who might have other co-morbidities before the patient even gets to the emergent level of care*."

Additionally, participant P6 mentioned that there was already a program in place for the UAE nationals, called the Tele-Home service, for remote patient monitoring; however, such a program was not fully functional in the country. Nevertheless, the participants provided several ideas and scenarios where wearable technology and remote monitoring can become a reality, as seen in the following excerpts from P6, P10 and P23, respectively:

"*You can put a simple Bluetooth enabled blood pressure monitor, glucose monitor, and things can be monitored in real-time, and the command center can see when sugar levels or insulin spiking or dropping and so on and intervene. I think the bigger challenge will be integrating those systems and getting everyone on the same page as far as the emergency response, the ambulance, and the hospitals.*" P6

"*In the US, they have an Alaris IV pump, or it was an HP monitor that monitored your heart rate, vital signs, they had apps where you can link up and transfer that medical record and that IV to another if you're transporting a patient from one place to another and you just hook it up, and it feeds into that. It was 12 years ago. So there are apps and medical equipment if you're going with advanced medical technologies like GE, like HP*" P10

"*Drone technology...the potential to take defibrillators, ECGs, and that kind of equipment, to the patient in order to save those valuable minutes.*" P23

However, some participants also revealed that many hospitals' monitoring devices were not connected to any automated recording system. Instead, all monitoring data was entered manually into the system for generating the patient's record, as mentioned by P4.

"*I would say it relies a lot on the doctor, and the technology just doesn't exist at that kind of high level, where you have access to patients' vitals remotely, for example, as they're coming in from the ambulance; we're nowhere near that.*"

Any medical equipment, including wearable or monitoring gadgets, must be regulated and operated within the legal and regulatory environment. The current issues related to the governance of medical equipment, and related issues of standardisation, are presented below.

5.4.2 Governance.

Question 5 (Appendix B) also explored the gaps in the current governance of medical devices and in supporting and regulating policies (Question 3 in Appendix B). The following phrases or words were found that could be categorised under governance-related issues.

Figure 5.8

Word Cloud Pattern for Governance related to Medical Devices

The interview responses related to questions regarding the availability and interoperability of medical equipment also revealed phrases that mentioned the impact of governance, regulations, and standardisations. For example, an underlying theme that could be detected was related to the lack of standardisation across the different hospitals and regions, as seen from the following response of P27:

"*Now, we do also face certain challenges when it comes to standardisation. Standardisation, and if I talk specifically about HIE, you have interoperability standardisation, so the ability of different equipment to speak with each other and to exchange information in an agreed protocol, but also even talk about this semantic or syntax standardisation, so coding standards. Can we understand each other? We all speak, and we have communication, but do you speak the same language, and can we easily exchange records?*"

There was also a concern regarding differences between the government and private hospitals, where government hospitals were already using the latest technology-based systems and devices, while other hospitals may still struggle with legacy systems. The following excerpt from P22 highlights this:

"*If I talk specifically about Abu Dhabi…the government hospitals, for example, they have very mature electronic medical record systems, very mature medical devices; hospitals are top-notch hospitals.*"

In addition to being standardised and governed in a structured manner, medical equipment and devices also need to have adequate usability for a technology-enabled tele-emergency system as proposed by this research. The following section provides insights from the findings regarding the usability aspects of medical equipment.

5.4.3 Usability.

Question 5 addressed the usability of existing medical devices. The following phrases or words were mentioned that could be categorised under usability of wearable and monitoring devices.

Figure 5.9

Word Cloud Pattern for Governance related to Usability of Medical Devices

The phrases related to questions about the usability of medical equipment and medical devices for supporting tele-emergency, a theme emerged that there was an increasing number of devices that can be deployed and which are getting tested for their utility for emergency services. For example, one of the participants, P1, mentioned: *"Devices like the Apple Watch or other AI-based gadgets that can measure EKG, cardiac arrhythmias etc., can be connected to the central database and deliver data at the doctors' desktop, as and when needed."*

Another participant, P26, also mentioned the upcoming initiatives that may enhance the usability of such devices and remote monitoring: *"So, there are actually a number of POC (proof of concept) trials running in Abu Dhabi. So, these companies have included Massimo, Jawbone, Cherish... G42 has devices, and we hooked them up with Level, who has the platform but not the devices; they're Bluetooth enabled. G42 is also looking at Massimo, I believe."*

However, in addition to the benefits and utility of remote monitoring devices, their usability was also to be determined by their costs and perceived benefits, as suggested by the following excerpt from P28:

"*The million-dollar question that most hospitals or people ask is, who's going to pay for these devices? So, can insurance introduce the policy that says we will cover the expenses of the devices? Given that you use it religiously and your data has been inputted and sent via the cloud to hospitals or whomever your caretaker or caregiver is? So, I think that's the million-dollar question that needs to be addressed by a policy, who's going to really pay for these devices and who's going to religiously use it?"*

The medical equipment findings indicated a need for more interoperability, standardisation, uniform regulation, and enhanced usability of medical devices to potentially support a large-scale tele-emergency framework. Similar issues were observable in the context of medical records systems currently existing in the country and their scope for supporting tele-emergency. This forms the theme for the following section.

5.5 Unified Medical Records

Question 12, related to medical records, asked participants about their perceptions of HIE, Patient Identification Systems (PIS) in the UAE, standards, legality, and interoperability issues related to medical records.

5.5.1 Health Information Exchange (HIE).

Question 12 explored the existing medical record processes, protocols and systems. The following phrases or words were discussed that could be categorised under HIE (see Figure 5.10).

Figure 5.10

Word Cloud Pattern for Health Information Exchange (HIE)

The phrases concerning HIE revealed that the UAE already has several HIEs. The participants mentioned Malaffi, an HIE in Abu Dhabi that links SEHA hospitals and Mubadala facilities and allows transferring of medical records across Abu Dhabi. Another similar HIE project was developed by the DHA, NABIDH HIE system, to link private and public hospitals' health records together. Also, participants reported that Dubai Healthcare Authority went live with all its hospitals using the Epic HIS, and DOH went up and running with all of their HISs in hospitals using the Cerner HIS, and Abu Dhabi and the Ministry of Health for the Northern Emirates, both are using the Cerner HIS. However, other HIE systems are functioning in the country, too; as mentioned by the participant, P4:

"*Health Information Exchange of the Department of Health in Abu Dhabi, with Orion as a vendor, the second one, which was launched three weeks ago in November or end of October, you can check the news, is DHA with Epic and as per the plan, the Ministry of Health will launch it in March 2021 with Intersystems. When you have the three HIEs within the three governorates, you'll have a unified medical platform, unified medical records across the UAE*."

However, there was a gap when it came to any national-level database, as mentioned by the same participant, P4 "*so we have an internal build one that unfortunately and this is the issue we have that the HIS isn't speaking to or between one hospital to the other, so there is a big disconnect between what you can share between the hospitals.*"

Similarly, all the Emirates did not seem to be covered by HIE according to P2: "*Yeah. So that is, I think, limited. It's new now, because like I said, in Abu Dhabi, Malaffi is considered to be the cloud Health Information Exchange, where there will be a unified health record of the nationals and residents. And in Dubai, NABIDH is just being rolled out. So that is available. Apart from that, if you take the other regions Fujairah and the other parts of UAE, that's yet to come.*"

Another participant, P17, asked a relevant question regarding the existence of different systems within the country, "*why are Dubai and Abu Dhabi building separate HIEs...and you* *have two different HIE vendors, you have Orion for Malaffi, and you have Epic for NABIDH (Network & Analysis Backbone for Integrated Dubai Health)*."

Also, participant P25 further elucidated the theme in the following words, "*You have the DHA, that has an HIE, NABIDH. And then you have DOH that has Malaffi, and then you have MOH that has Riayati. There's a decree that was issued in 2015 that says MOH through Riayati is supposed to capture both NABIDH and Malaffi. One, what are the benefits of you having one HIE for the whole country? Two, how can we make that happen if it is not already happening?*"

One of the participants, P2, believed that a central database may not be required. However, the participant suggested enabling access to the patient database located anywhere across the Emirate on a need basis, and according to this participant, "*going back to the Medical Liability Law (Medical Liability Law 4 of 2016), I don't have to proceed with the access. I mean, it has to be like limited access to some certain specialities. If the patient has been to an IVF center, I don't have to go through that. That's fine. So it has to be like the general information that helps me to stabilise the patient. The trauma department specialised people; they can tell us what access we need.*"

There was also a disconnect between patient information exchange between private and public sector hospitals. However, private sector hospitals had their own HIS, as seen in the following response from P25: "*you mentioned three things, you mentioned, DOH, MOH, and DHA. You didn't really mention all of the private clinics and all of the private hospitals that are within those Emirates. So right now, the government is mandating interoperability, but they're not forcing any of the clinics to any type of standard or medical record to be able to communicate that information. So, you need to force the clinics countrywide to adopt the standard or some type of EMR at a minimum, whether the government develops that, or contracts with a company to provide that, and forces them to accept the cost.*"

Also, there was a lack of communication and connectivity between private and government hospitals, which was not just technology-related, as revealed by the following two participants, P3 and P5, respectively:

"*There needs to be a nationwide policy, and it should be unified amongst the Emirates, which I know is always a challenge between the different regulators, between what the private sector can and cannot accept, in an emergency basis and each hospital, there needs to be a body, as far as I'm concerned, with people that actually know what they're doing. They can, on a regular basis, on a periodic basis, assess each of the private hospital providers and say, OK, your scope, as determined by us, is this, that's it. And we will bring you patients from the national ambulance if we need to.*" (P3)

"*From a governance perspective, there needs to be an authority, a higher power authority that regulates the healthcare industry in the UAE from a regulation and legislation* *perspectives. And to make sure that DHA, DOH, and the Ministry of Health align fully on the Health Information Exchange, and they allow each other to read the data from different patients.*" (P5)

It is clear from the above findings that there was a lack of connectivity, knowledge sharing, and data sharing between different healthcare institutions in the country regarding patient records. The lack of a uniform PIS may further aggravate the issue, as found in the interview responses presented next.

5.5.2 Patient identification systems (PIS).

Question 12 encouraged the participants to discuss the current status of the PIS in the country. The following phrases or words were mentioned and categorised under patient identification systems (PIS).

Figure 5.11

Word Cloud Pattern for Patient Identification Systems

The phrases related to PIS in supporting tele-emergency, where a theme emerged that the PIS was still in developmental stages. P7 described the existing system in the following way: "*We have what's called the EPCR Electronic Patient Care Record. It's a type of EMR, which is specifically designed for pre-hospital, so in comparison with other systems like, let's say, Epic or Cerner, which take care of what's within the health facility, the EPCR is more modified to fit the needs of the field. So, this EPCR is hosted here in our buildings and the DR (disaster recovery) in our other data center for disaster recovery. In this system, on the field and at the scene, the paramedics they enter all the information they need or if they take from the patient past medical history, the personal information the DHA insurance, location, all the incident information at the scene.*"

The same participant (P7) further described the process of using medical records in case of emergencies in the following: "*Let's say it's a trauma case and they're taking him to Rashid hospital. So if they just push a button on their handheld devices (Windows Mobiles), Tough band, they use these Windows Mobile devices with this Caremonix or EPCR system on it, whatever the information that they log into this case or incident will be made available to*

Rashid hospital before the case reaches there. Rashid Hospital has a full view of the case that's coming, and knows about the vitals, so they can allocate the needed resources before the patient is there."

However, the EPCR was available within specific hospitals in Dubai, and this leaves scope for a nationwide system for patient identification to be developed. Some of the ways patient identification could be addressed, proposed by the participants, were using the driver's license, UAE Pass, temporary tourist card, fingerprinting, and the National Emirates ID. Furthermore, for the first responders to identify the patients, they must have a handheld device that can read the cards or fingerprints; thus, the ambulances should have such equipment, according to P1. *"The emergency teams should have the ability to match the identification information to the medical record, automatically triggering a simultaneous response from a care team that's going to receive the patient."*

However, privacy invasion is one issue that the participants mentioned when using fingerprints or health data linked with Emirates ID. Nevertheless, these could be overcome by ensuring that data residency is secure, data resides in the country, and follows the data security law of the UAE. Additionally, an idea was put forward by P3 where the patients' past data resided within his or her phone and which could be accessed using a QR code in times of emergencies:

"*...having a QR code on my iPhone or an app and the app can work, and I can allow the access to the app, like on my iPhone, I can open my camera without having to use the fingerprint, there are a few companies who develop this QR code, which contains your essential information, configure it into a QR code, which is available on your phone, which can be accessed without having to have my fingerprint and for instance, the crew could have a QR reader, which would then allow us to pull information from that app.*"

Further, there does not appear to be any existing system that links tourists' data to any local HIS system or accesses their historical medical records. The lack of a unified medical record management system that enables emergency care personnel to identify patients and access their medical history is a prerequisite for the tele-emergency framework. Lack of integration of the systems due to the continued use of redundant technology and legacy systems in different healthcare institutions contributes to this problem further, as presented in the following section.

5.5.3 Standards.

Question 12 also focused on the standards of any existing medical record systems. It yielded the phrases or words that could be categorised under standards.

Figure 5.12

Word Cloud Pattern for Standards for Medical Record Systems

It was mentioned by P1 that owing to the disparate nature of the UAE, "*the whole UAE is at the same place. It's divided amongst Emirates because of the nature of the divisions in the regulatory environment.*"

Individual chain hospitals like MediClinic and hospitals under the DHA (Al Jalila Hospital or Al Baraha Hospital, and Rashid Hospital) were mentioned as having similar Health Information Systems platforms for sharing medical records internally. However, according to the same participant (P1), "*there may be some legacy systems that still exist within Health Systems, those need to be upgraded in order to have a better transfer of exact information that's relevant and useful in the care of patients right then and there.*"

Furthermore, due to the different HIE systems developed by different Emirates, there was a lack of communication and interoperability between the identification systems wherever they were available, as mentioned by P14; "*that's the same thing with integration. It takes a lot of work because Epic sends out data in a different way. Cerner sends out data in a different way. HL7 feeds do standardize that a little bit. They do. And then HL7 is not the only integration standard, there is CCDs, which are basically compacted, all the dump of an information about a patient, you can put in one file. And then there's other fire FHIR (Fast Health Interoperability Resources) protocols, that are essentially, you can think about it as HL7 on steroids. It's standardized globally. However, you still have to, what the phrase is called, massage the data. You have to massage the data to fit a certain mould where it's going to be kept eventually. And where it's going to be kept, is where it's going to be read from for the HIE. This is not an impossible task.*"

The above theme related to the country's medical record keeping has pointed out several areas of improvement before a tele-emergency framework can be implemented in the country. The participants pointed out an essential aspect of tele-emergency care in the form of the first responders, their suitability for the task, and their support systems. This is discussed in more detail in the following section.

5.6 First Responders

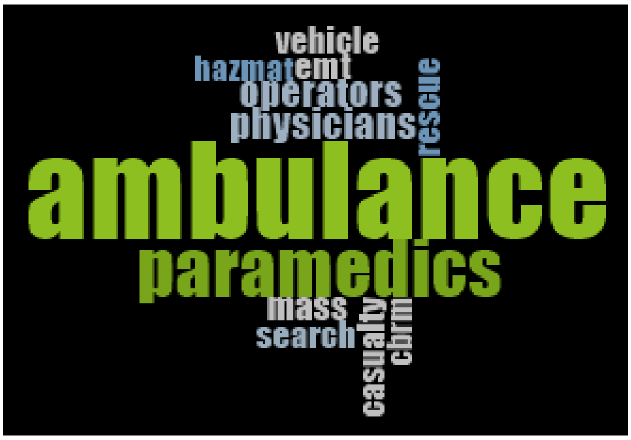
Questions 6, 7, 8 and 9 (Appendix B) focused on first responders. Hence, an analysis of phrases related to first responders led to the development of categories such as the types of first responders, management of first responders, and their supporting systems in the UAE.

5.6.1 Types of first responders.

Questions related to the contribution of emergency services such as ambulances (Q6 Appendix B) and the training status of paramedics (Q9 Appendix B), and first responders in general, yielded phrases that could be categorised as types of first responders in the UAE. The following word cloud visually represents the participants' most prominent phrases or words in the context.

Figure 5.13

Word Cloud Pattern for Types of First Responders



According to the participants, the UAE suffered from a lack of first responders or "physical extenders" trained to provide adequate or stabilising skills on the spot for emergency care. This shortage not only costs delays in emergency service delivery but also costs heavily as first responders can provide stabilisation and appropriate first aid at costs less than what a specialist may warrant for dealing with such emergencies.

First responders in the country were restricted to paramedics and Emergency Medical Technicians (EMTs); as one participant mentioned, P7: "*...paramedics, we have advanced paramedics, and we have ER physicians. So all these levels are in the field. The majority of our responders are EMTs*."

According to another participant, P1, "We've *been very risk-averse in the country in terms of licensing physician extenders. We don't have nurse practitioners in this country except for maybe at CCAD. We don't have physician assistants like we do in the United States. So this spectrum, this differentiation, and these care teams' availability are important. We've been* *very basic in terms of EMT license, and then consultant physician, specialist physician, and nurses.*"

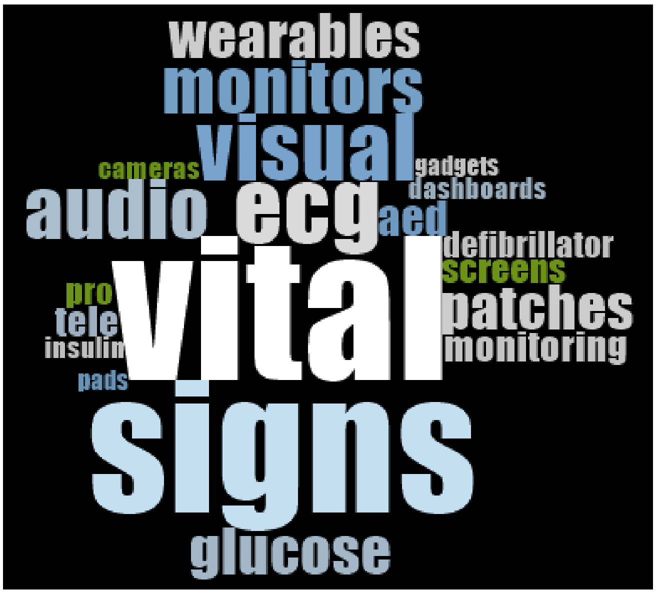
While it is evident from the finding that the UAE may need to re-think the first responders' job profile and training, there is also a need to restructure the chain of command and management systems used for the country's first responders.

5.6.2 Management of first responders.

Questions related to the operational aspect of first responders and their scope (Q8 Appendix B) led to the phrases categorised as management of first responders in the UAE. Figure 5.14 presents a visual representation of the participants' most prominent phrases or words.

Figure 5.14

Word Cloud Pattern for Management of First Responders



The phrases related to the management of first responders revealed some conflict related to their chain of command and communication barriers. The following excerpts from P7 detail the current process of managing emergencies in the UAE.

"Usually this is what happens if I call 999 or 998, the call would get to one of the call takers in the Dubai police OCC (Operations Command Centre), the call taker is a police officer, he's not a paramedic or a dispatcher, most of them speak many languages, so they would take a brief history of what's happening, and if you're calling for a health related issue, they identify the case based on experience and I would say that again there is no written procedure, there is no certain algorithm that they follow, it's based on personal experience, so it varies. So if you decide that I should take more information. Maybe I don't and I just sent him the ambulance without verifying if they need the fire department or police at the same time. It's all based on human experience."

The participant (P7) further enumerated this by detailing a hypothetical best-case scenario: "*Actually, the perfect scenario would be to have an MPDS, medical priority dispatch system. That would tell us in a systematic and scientific way based on an algorithm, a verified algorithm that this patient needs an ER physician; for this patient an EMT would be enough, and this patient does not need transportation at all. We don't have this system as of now. Actually, the workflow is a little bit complex because we don't handle the OCC ourselves which is run by the Dubai Police.*"

Additionally, first responders were not authorised to make decisions that could save lives, as can be seen from the following response from P8:

"*An EMT cannot give certain medicines in the field. He cannot perform certain procedures, and intubation is only done by an advanced paramedic. Controlled drugs are only administered by ER physicians. Certain manoeuvres are only allowed after you take the advice of a senior. Let's say you are an EMT in the field and you need to do this procedure or manoeuver. Unless you have the acceptance and approval of a higher rank professional you cannot perform.*"

As mentioned by several participants mentioned, including P8, first responders were not technology savvy: "they're *really paramedics, so that's all. Their training is very paramedic lead training, they are not technology lead people, so their education has to have a very high component of technology.*"

Furthermore, paramedics were also not expected to administer procedures such as intubation or administering controlled medication such as morphine. One of the participants enunciated the issue in detail in the following words of P3:

"I mean, look, the difference between the UK and here in the UAE, I'm telling you the paramedics here, are not paramedics, my friend. They're not. They are glorified porters. I mean, they have a degree of medical training, but I've seen the limitation the paramedics have here; it's crazy. I mean, as an example, if we take MIs. Paramedics are not allowed to initiate Streptokinase, for instance, or any of the antiplatelet medications, so if you're having a heart attack and you have a coronary atheroma, then if you can't be treated in the ambulance on the way to the hospital..."

The findings, therefore, indicate that the first responders' management may need to be aligned with the practical and ground-level operational needs of emergency care delivery. Hence, there should be a well-developed support system enabling first responders to perform their jobs effectively.

5.6.3 Supporting systems for first responders.

Questions related to the availability of technologies and support for first responders (Question 7 Appendix B) and their current training status (Question 9 Appendix B) led to the phrases depicted in Figure 5.15, categorised as a support system for first responders in the UAE.

Figure 5.15

Word Cloud Pattern for Supporting System for First Responders

The phrases related to first responders' questions also revealed a category that could come under the available supporting systems for first responders in the UAE.

As discussed earlier, it was found that the paramedics were not authorised to conduct emergency procedures or make decisions on the spot, but were expected to transport patients to the nearest hospitals. The support system for paramedics seems to consist mainly of ambulance and dispatchers, as described in the following manner by P11: "*Let's talk about the ambulance. You have the driver and you have the paramedics and you have the team that is behind, that we call the dispatchers. The ones that dispatch and communicate, and all of that with the call center. And the call center is not an agent that is just dispatching an ambulance. It's actually healthcare professionals, because they understand the case, they are the ones that get contacted by the patient or from the families and they try to have some questions, to try to understand the case from a quick call, because usually in that call, the patients are not in a normal situation.*"

The interviews also discussed the scope of a large-scale tele-emergency framework from the participants' opinions. They explored the availability of additional resources with the potential to support a technology-enabled tele-emergency framework in the UAE. These are presented next.

5.7 Resources

Questions 2, 3, 10 and 11 (Appendix B) related to the participants' opinions regarding the availability of resources (or lack of it) for supporting a nationwide tele-emergency framework for the UAE. Phrases related to pre-alerts, decision making, and specialisations in EDs were obtained from the participants' perceptions.

5.7.1 Pre-alert systems.

Questions 2 and 10 explored the diverse resources, including the existence of infrastructure or policies that could enable pre-alert systems, and the following words emerged, as shown in Figure 5.16.

Figure 5.16

Word Cloud Pattern for Pre-Alert Systems in the UAE

The phrases around the questions focusing on pre-hospitalisation or pre-alert systems indicated that the participants were not content with such a system's adequacy in the UAE. Two of the participants, P3 and P20, emphasised that there is almost no pre-alert system in the UAE, "*the pre-alert system is more or less non-existent, which is a problem*" P3.

However, P20 did mention the existence of a pre-alert system, although in a rudimentary form as of now, but expected to develop further, as seen from the following two excerpts:

"*They have, as far as EPCR, which is the electronic patient care record. (Arabic) That's basically what I saw, which is what most of the developed systems or EMS systems use; it shows you real-time, it transmits the patient information into a tablet that is transmitted to the hospital, and me being in the hospital, I can open it, (Arabic) for example, so and so is coming, pre-alert, so I can see it. (Arabic) However, the system in some places, not majorly implemented, (Arabic) for example, they invested here in Abu Dhabi, but no one comes to check on the monitors, the machines, there are no good alarm system and so on, like someone who has a television but has not tuned it properly. So, do we have the infrastructure? Yes, we do, it's there, and it can be boosted.*"

"*We have three sectors, in the pre-hospital sector, all the three ambulances, the Abu Dhabi Ambulance is connected to DCAS (Dubai Corporation for Ambulance Services) in Dubai, and DCAS is connected to the National Ambulance in the Northern Emirates. (Arabic) You can see them, until today, I want to sit in a room that I see all the screens, three services on one screen, got it. That's a dream day.*"

According to the participants, an effective and functional pre-alert system seems to be lacking in the country. Additional resources like decision-making support and systems at each stage of emergency care were analysed and discussed with the participants.

5.7.2 Decision-making.

Question 3 (Appendix B) addressed the process of decision-making that existed for tele-emergency services (including the purchase of equipment, data management, and coordination of the physical effort) and the gaps that may be required to be filled before a nationwide tele-emergency framework could be implemented.

Figure 5.17

Word Cloud Pattern for Decision-Making Systems for Tele-emergency in the UAE

In the phrases related to questions about the decision-making process supporting tele-emergency, the theme that emerged was that in the context of ER emergencies, the decision-making was undertaken manually, as the nurses made the decisions at the triage. Later the doctors made their decisions based on the nurse's initial assessment and their own assessment. There was a lack of a technology-backed decision support system, where no Early Warning Score (EWS) or severity score was calculated. There was no vital sign-based cardiovascular risk or stroke risk calculation system that could auto-detect and save time. This finding was made evident by the participant P3 in the following way,

"*they first go to triage desk, the triage nurse, and she obviously uses the standard system, but we use technology for inputting data. There's not a huge amount of algorithms. And there's not like the EWS score, severity score, for how acute the patient is... it's not automatically calculated by SAP for instance. It doesn't like which I'm used to where it shows an alert, it says based on these vital signs, this patient is sick and it's up to the operator to do that, so the nurse will take the vital signs, she puts them into the system but it's up to the nurse to triage the* *patient manually, then it comes to the doctor and then the doctor can see the initial triage information.*"

Also, decision-making was often not smooth since there could be conflicts between doctors and paramedics, as seen from the following from P6: "*...the ambulance to the hospital. They'll give them a brief on their view; there tend to be clashes between a doctor and a paramedic's view because one is the doctor and they always have egos, and paramedics are not fully trained, although they're capable of handling trauma on scene."*

Further, participant P12 also provided another reason for issues with the decision-making process, especially in the context of tele-emergency, where the patient and the physicians could be in separate Emirates: "*Physicians licensed in one Emirate are not allowed to practice in another, so, even if telemedicine is employed, there could be some regulatory or legal complications.*"

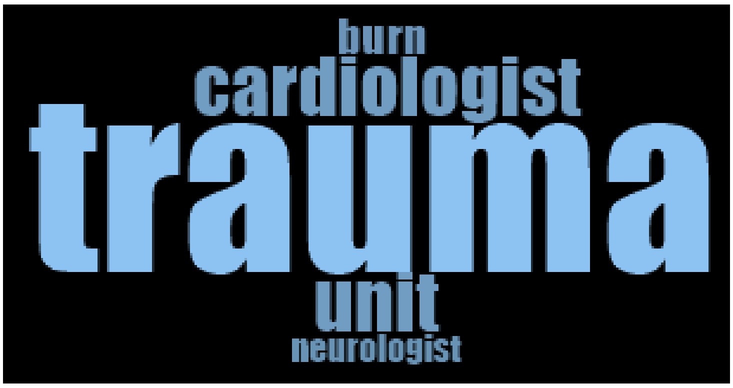
Further, there appears to be a concern regarding the access and availability of specialist services in emergency healthcare, which is presented next.

5.7.3 Specialisations in EDs.

Questions 10 and 11 (Appendix B) asked the participants to share more about the available resources, including the availability of specialisations in EDs. The following words emerged, as shown in Figure 5.18.

Figure 5.18

Word Cloud Pattern for the availability of Specialisations in EDs



Most of the participants stated that large clinics and hospitals have affiliations with international hospitals and are equipped to provide speciality tele-emergency services if they want to. Nevertheless, the barrier is a lack of financial reimbursement model.

However, some participants also mentioned that their EDs did not have facilities for certain specialities that prevented them from receiving patients. For example, according to one participant, P30, there were several deficiencies in critical care specialities: "*For example, toxicology. (Arabic) It's one of the major sub-specialities that we have deficiencies in the region is toxicology...Some physicians who specialise in trauma. And it's very important, ED critical* *care, so someone who did emergency medicine... Another one is burn units, which is very important. Usually, in burn centers, (Arabic) and of course, burn centers are very sub-specialised, and their access is very very hard. So same thing with trauma."*

The findings indicate that there may be sufficient resources available in the country; however, there is a need to better coordinate and structure the resources if a large-scale nationwide tele-emergency framework is implemented. Further, a tele-emergency framework needs to be supported by the medical equipment and the interoperability and connectivity within the telecommunications platforms available in the country.

5.8 Summary

This chapter presented the findings from the thematic content analysis of interview transcripts from 30 participants across the healthcare sector in the UAE. The chapter illustrated the responses and further classified them within meaningful categories that were consolidated to reflect emerging themes. The findings indicated six broad themes in the context of a nationwide technology-enabled tele-emergency framework for the UAE: ICT, telecom, medical equipment and devices, medical record systems, first responders, and healthcare resources.

The findings reveal that while the country has sufficient ICT and telecom infrastructure in terms of physical coverage, but lack of standardisation and interoperability continues to be an issue that would need to be addressed in any future nationwide tele-emergency framework. Different Emirates appear to have different ICT and telecom architectures, operating different healthcare institutions, often with legacy systems that are difficult to integrate with any nationwide latest technology-enabled tele-emergency framework. Further, the lack of standardisation is also apparent in terms of emergency protocols, laws and practices, and even in the management of services in different Emirates. Additionally, there is no nationwide consensus around data residency laws and ICT security solutions.

A similar lack of interoperability and connectivity between diverse healthcare institutions was evident when comparing their telecom infrastructure. The research revealed that the country had solid and established telecom services with 4G and 5G connectivity and high penetration of the internet, there were differences between public and private healthcare institutions, and at times technology adoption varied within institutions as some areas of the organisation continued to rely on legacy systems and technologies while others were updated. Additionally, the participants expressed concerns about data reliability, latency, and lack of standardised regulations in the telecom sector.

The research also indicated that medical devices and gadgets are readily available, although their adoption by the current healthcare system is low. It is unclear if the existing devices can be used seamlessly within a new system or suffer from interoperability issues. Their usage in healthcare to date has not been tested in any nationwide study. The participants further pointed out a lack of clarity in terms of governance and legalities associated with patient privacy and confidentiality and data storage and sharing with wearable devices. This gap was emphasised as substantial and needed serious consideration for such a framework to succeed or even be considered viable.

The interviews provided insights regarding the current status of health information management systems in the country. It was evident that different Emirates had taken expansive initiatives toward digitalising healthcare records. However, there was substantial duplication, redundancy, and lack of connectivity due to jurisdictional issues and a lack of coordination and cooperation between different authorities managing healthcare records. There were hesitations and long pauses in the interviews when the discussion leaned towards comparing authorities and considering developing a unified medical record system for the country. Also, it was evident that both lack of standardisation in technology architecture, and lack of willingness to share, led to a lack of sharing of data between different healthcare institutions.

Nevertheless, the interviewees expressed hope about the unified PIS, which currently exists in the form of an EPCR. However, they could be used to enrol UAE citizens in one massive database. Alternatively, the interviewees also suggested expansion of the Emirate ID to include individuals' health records to serve as a unified patient identification card on a need basis.

Another area of concern highlighted was the status, training, and empowerment of the first responders, who are the frontline service providers in any tele-emergency framework. It was evident from the interviews that the country lacked well-trained and equipped first responder systems. Most healthcare professionals acting as first responders were simply playing the part of couriers. Paramedics did not have the adequate authority or training to deal with emergencies on the spot or connect through tele-emergency tools (even mobile or an ambulance communication device) to deliver any substantial or crucial emergency care. It also revealed that different first responders operated through different chains of command, and there was a lack of coordination of effort and streamlined communications during fieldwork.

Finally, the chapter discussed resources related to the rudimentary existence of a pre-alert system, a non-structured chain of command for managing integrated emergency services leading to a lack of effective decision-making, and the need for adding more specialities in EDs to make them more relevant for a nationwide tele-emergency service. The participants indicated that there was scope for improving the pre-alert systems, which are only at a rudimentary level at the moment. Additionally, emergency services command and leading structures need to be modified to ensure that operations are undertaken to provide the patient with the fastest and most appropriate emergency care instead of facing bureaucratic hurdles and delays. Also, decision-making processes need to focus on delivering care at the point of emergency, and technology can be used to ensure that real-time patient data is credibly collected through monitoring devices and transmitted seamlessly to the specialists over an integrated ICT and telecom structure, and first responders are empowered to provide the required aid to patients.

The next chapter will further build on the six themes and discuss their implications for the proposed tele-emergency framework. It will explore the shortcomings in ICT, telecom, medical devices, unified medical records, PIS, first responders, and the availability of resources in the UAE. These will be discussed with a view to putting forward plausible and practical solutions, which will then refine the tele-emergency framework already mentioned in chapter three.

CHAPTER SIX: ANALYSIS

6.1 Introduction

The research findings presented in chapter five, based on the interviews of diverse healthcare professionals, are discussed, collated, and analysed in the form of themes in this chapter. As depicted in the previous chapter, the findings were clustered around six broad areas related to ICT, telecom, medical devices, HIE, first responders, and resources to support a tele-emergency framework in the UAE. The literature review presented in chapter two indicated that telemedicine frameworks need to be supported by numerous technical and infrastructure-related aspects (Yilmaz et al., 2019). This study evaluates the current state of the UAE in terms of its technical potential to support a large-scale nationwide tele-emergency framework. The following sections analyse and discuss the findings.

6.2 Theme one: ICT

The study explores the current status of ICT in the UAE healthcare industry, with the underlying aim of evaluating its scope to support a nationwide tele-emergency framework. The interviews were directed toward extracting information about the ICT infrastructure, its compatibility and scope for interoperability and integration with the latest healthcare technology systems, and the legal provisions regarding data residency and privacy. The following insights were gained from the analysis of the findings.

6.2.1 Lack of standardisation in ICT infrastructure.

The interviews evidenced that the country already possessed state-of-the-art ICT infrastructure, connecting different hospitals, ambulance systems, emergency first responders, and remote monitoring devices. However, problems were identified at two broad levels: first, the ICT infrastructure was uncoordinated across the country and restricted by jurisdictional issues. Second, there was variation in the quality and adequacy of ICT systems within individual hospitals or networks of hospitals. For example, while the country has different systems such as the Salama System (DHA), the EPIC system (Cleveland Clinic Abu Dhabi) and the DOH system and MOHAP using Cerner (an electronic health record platform used by hospitals), these were disconnected, built on different specifications from each other, and did not have provision for sharing information and data seamlessly. Then, there is NABIDH, which aims to connect public and private hospitals and clinics; Malaffi, an initiative by the DOH that connects Abu Dhabi's private and public hospitals and clinics; and the National Unified Medical Record (NUMR) initiative by MOHAP called Riayati, that allows for some unified record-keeping across the Northern Emirates. However, none of these HIEs was built to provide a standardised, connected, coordinated, and interoperable system for healthcare delivery across the country. There are hardly any provisions for connecting ambulances and first responders with ERs or hospital control rooms that can deliver emergency care at the location. From the analysis of the interviews, it was evident that the country needed modifications and standardisations of platforms, hardware, and software so that there is seamless connectivity between health authorities that monitor and oversee emergency healthcare services, EDs, first responders and ambulances, and the clinical teams.

In the context of the second issue (variation in the quality and adequacy of ICT systems within individual hospitals or networks of hospitals), it was found that different departments or branches within a hospital network were often operating with varying ICT systems. Most hospitals continued to use legacy systems in some processes, while upgrading with the latest versions of SAP in only a few functions - making it difficult to share information or keep track of a patient's case progression over time.

The interviews suggested that while the problem may be related to a lack of technical integration and interoperability, the more significant issue may be the lack of a shared vision between different Emirates and difficulties accepting that a common ICT infrastructure is urgently required. This is a unique insight from the research, where most previous studies have focused on developing and assessing the technological feasibility of large-scale networks (for example, the Gansu Province framework, where the researchers first installed a province-wide tele-emergency framework from scratch and then assessed its efficacy (Cai et al., 2016). However, none of the studies had targeted exploration of the nationwide feasibility of the framework. Due to a lack of precedent regarding any attempts to develop a large-scale nationwide tele-emergency framework using an existing ICT framework of the country, this study cannot compare its findings to previous studies. Instead, it highlights the lack of standardisation in ICT infrastructure in the UAE, leading to the reduced scope of interoperability and integration of systems into one unified tele-emergency delivery framework.

6.2.2 Lack of uniformity and/or compatibility between ICT governance laws.

As pointed out earlier, it was also found that the lack of technological standardisation was related to the lack of a common regulatory framework to monitor and guide ICT. Different Emirates follow different regulatory laws for ICT operations and healthcare, although the country has introduced some common laws such as Federal Health Informatics Law 2 of 2019. Different authorities, such as MOHP and the Ministry of Internal Affairs, were involved in law-making. There were differences in public and private hospitals' laws and legal frameworks. The problem was further aggravated by the contradictions between regulations and authorities, such as between DOH, DHA, and MOHAP. These differences and contradictions were not restricted to the healthcare area alone; instead, the country had certain regional contradictions regarding data sharing laws. For example, while the UAE federal data law requires that all medical information resides within the country, different Emirates have different versions of inter-Emirate data sharing between private and public hospitals. Currently, the country's laws do not ensure that private hospitals must share their data on a unified network with government hospitals.

This lack of standardised governance of ICT stems from the geopolitical nature of the country. However, it needs to be addressed in order to support a nationwide streamlined tele-emergency framework. In other countries, where such a large-scale tele-emergency system may be attempted, similar problems may not be faced due to uniformity in their legal systems governing ICT. Previous literature has not focused on evaluating the issue from this perspective. Some large-scale frameworks, such as that put forward by Yellowlees et al. (2010), studied in a federal system, have not reported jurisdictional issues or incompatibilities between laws of different states. As such, there is little previous information about reconciling the lack of standardisation between ICT laws or their impact on developing a large-scale tele-emergency framework. There is, nevertheless, the scope of using Health Insurance Portability and Accounting Act (HIPPA) laws that hold the access-holder accountable for any breach of privacy or security. Accountability can be enforced by ensuring that the system flags any access to patient data and even requires the authorised personnel to justify data access by providing valid justifications.

6.2.3 Lack of clarity on data residency and privacy-related aspects.

Privacy laws emphasise the ICT security-related concerns when developing a large-scale tele-emergency law. Participants expressed some confusion regarding laws governing cloud data. At the same time, they were aware that cloud data centres had immense utility for such a tele-emergency framework. There are companies providing cloud data storage, such as Microsoft, AWS, and Alibaba. However, there were, again, different data privacy laws applicable, which led to a lack of seamless interoperability between systems and a lack of clarity on how and where data was being stored. While there is a global debate regarding data privacy laws, and data sharing and storage often fall within a legal grey area, a similar contradiction could be reduced in the UAE by developing a unified system of cloud storage that ensures data residency within the country. Towards this end, some telecom companies have already started working on new initiatives. The technological infrastructure to develop a large-scale data centre within the country is a feasible solution to the above privacy-related issues. Also, such an infrastructure can solve some of the problems related to ICT capability and support the proposed tele-emergency framework.

6.3 Theme Two: Telecom

Another aim of the study was to evaluate the current status of telecom in the UAE healthcare industry and assess if it was adequate to support the proposed tele-emergency framework for the UAE. Research participants were asked questions about the scope and suitability of broadband and telecom platforms' current speed and availability, whether they could be integrated in an interoperable manner with the proposed tele-emergency framework, and issues concerning data reliability.

The following sections contain insights gained from analysing the findings from the literature review and interviews.

6.3.1 Readiness and availability of high broadband speeds.

An underlying theme emerged: the UAE had an adequate broadband network in terms of 4G and 5G connectivity. The 5G connectivity having an extremely low latency rate of 0.000001% could ensure real-time healthcare delivery in emergencies. Also, since the mobile network penetration is almost 100% in the country, the availability of the network to service a nationwide tele-emergency system is sufficient. This is why there are a growing number of cloud-based health information management system organisations in the country. The current telecom system can support the Dubai Corporation for Ambulance Services (DCAS) operations by integrating telecommunications with DHA and enabling the healthcare infrastructure. The UAE does not seem to lack the telecom infrastructure, which is an achievement since many countries face inadequate telecom infrastructure. Cai et al. (2016) and Mbunge et al. (2022) reported that telemedicine's implementation and capacity utilisation are often limited due to a lack of information technology infrastructures such as high-speed Internet or other network services, which is not the case in the UAE.

Another fact highlighted was that telecommunications systems were not adequately or correctly utilised. For example, while private hospitals often take National Ambulance patients (from the Northern Emirates), they do not have a modern telecom system to support their operations. Instead, they rely on a single device. So, while the country does not suffer from inadequate or insufficient penetration of network services in fibre optic cables or satellite coverage, there seems to be a lack of initiative or will in deploying the available resources toward making emergency services more efficient. There may be many reasons behind the inadequate deployment of telecom in the different hospital settings, ranging from the lack of alignment of the hospital's agenda with the national level or regional level emergency healthcare services' strategy, the lack of financial incentives to invest in the deployment of telecom resources toward remote emergency services, or bureaucratic issues - which are beyond the scope of this research, but which still need to be addressed for a successful implementation of any nationwide tele-emergency framework.

Most hospitals continue to use legacy telecom systems in their departments, which are not integrated across their hospitals or other branches. The lack of integration of systems, which falls within the technology-related aspects of tele-emergency and hence falls within the purview of this research, is further discussed in the next section regarding the diversity of platforms and their utility in the current healthcare system.

6.3.2 Lack of standardisation, integration, and connectivity.

A prominent theme from the interviews was a lack of standardisation and interoperability between platforms. Hospitals, even those within the same chain, were using different platforms for managing their data. This caused disconnection and issues related to integrating records and information sharing. The situation appears to be ironic because, on the one hand, the country seems to have among the highest penetration levels of telecom technology and the Internet and has been committed to digital transformation. On the other hand, our hospitals continue to manually extract patients' files by sending their staff long distances (across hospital wings or different cities) and retrieving the data physically. Even more critical is that hospitals often do not have a streamlined flow of data across various departments, and managing patients' information becomes a mammoth task. Multiple sources access is required to get and collect patients' information, causing confusion, duplication, and delay in reports and data sharing. In some cases, it is also reported that an entire section of the hospital does not even have an Internet connection. This state of affairs can only be explained in terms of a lack of focus on developing an integrated platform, which in turn, could be rooted in the absence of any perceived direct financial benefits from such an investment. So, while some departments or branches may have acquired state of the art telecommunications platforms or unique stand-alone solutions to support their workflows, hospitals may not have been able to see the value of changing their existing legacy systems in other departments. The problem is further exacerbated by the differences in regulations between the Emirates and public and private healthcare institutions, and the requirement of multiple approvals for using any servers or other infrastructural investments.

Whatever the underlying causes of such outcomes are, the fact remains that a lack of standardisation and connectivity of networks leads to a lack of interoperability between networks or devices, reducing the overall scope of implementing any large-scale tele-emergency framework for the entire country. The issue is further complicated because the country has blocked IP ports for VoIP services, and is still struggling with regulatory alignment across the Emirates related to data security, data residency, firewalls, and overall cyber-security. However, since the pandemic, this blockage has been relaxed, suggesting a more optimistic future in the telecom parameter of this tele-emergency framework.

6.3.3 Policies for data security and reliability.

There were concerns regarding data security and reliability. Data reliability, be it business-related or patient-related data, was one of the major issues causing hesitancy in deploying technology for data management. A prominent concern related to data reliability was data latency, where the participants mentioned that they could not rely on data since it was not available in real-time. Latency of data, or other problems that may stall the network, were a cause of concern, especially in emergency care, where such issues could be life-threatening and expose healthcare providers to lawsuits. For example, in emergency cases, it is usually a matter of life or death. Any delays in transmitting critical information, compiled with low internet speeds, lack of connectivity, router malfunction, or communication failure, may prove fatal. Data security was also an issue closely related to aspects such as data residency. The current laws in the UAE are neither consolidated yet nor made to focus on delivering tele-emergency services. The above issues highlight a critical need to develop an integrated, interoperable, and standardised telecom network under one jurisdictional authority in the country, forming the backbone for the tele-emergency framework proposed for the country.

A closely related theme to the availability and adequacy of telecom or ICT infrastructure is the availability of medical equipment and sensing devices that can be connected and utilised with the proposed tele-emergency system. These are discussed next in the chapter.

6.4 Theme Three: Medical Devices

6.4.1 Lack of integration, interoperability, and/or seamless connectivity.

A theme that emerged from the interviews was that wearable technology was already a norm in the UAE. According to most research participants, the UAE population already embraces wearable personal fitness tracker devices, even if they were not actively involved in fitness training or health management. This indicates that the country already has access to technology, and there is a growing culture of accepting health informatics as part of daily life. This gives scope for monitoring and tracking people's health and vital signs as a precautionary measure or monitoring patients at home. One such initiative in Dubai was by Valiant clinic's endocrinology department in 2017, where patients were monitored remotely in real-time for blood glucose through sophisticated monitoring devices. Another similar initiative was available in the form of Tele-Home services for remote patient monitoring. It is evident from the findings that the country has the availability of medical devices, and similar programs have already found acceptance. However, there has not been an attempt to connect citizens nationwide with a large-scale tele-service home-monitoring framework to date.

The findings emphasise the potential and scope for developing a nationwide tele-emergency service framework with monitoring and tracking devices as an essential component.

The challenge that continues to limit any such endeavour is again related to the connectivity of medical devices with ambulances, EDs, and HIE in real-time and without latency. Also, IoT remains an area that needs to be fully exploited to ensure seamless connectivity and data sharing, even in programs and examples like the Valiant Clinic's diabetes monitoring program. As a result, data entry almost always requires human intervention, introducing errors or latency into the entire process. This is an issue in many hospitals, where monitoring devices are not connected to any automated recording system. Instead, all monitoring data was entered manually into the system and included in the patient's record, leading to delays and often duplication and redundancy issues. In addition to the IoT, the latest technology, such as drone technology, can be integrated into a tele-emergency framework for quick and accurate delivery of medical devices such as defibrillators and ECGs at emergency scenes. The findings also indicated a need to standardise regulations and streamline the governance of such technologies and health informatics data, which are discussed in the following section.

6.4.2 Lack of standardisation in the governance structure.

One of the themes highlighted in the interviews, closely related to the scope and utility of medical equipment, is the need to regulate these devices appropriately. Several issues concerning the legal and regulatory environment of the country surfaced. For example, while medical devices were available, interoperability was not established; because monitoring devices were not used in healthcare applications. Most monitoring devices and wearables, such as the Apple Watch, Garmin bands, or Fitbit bands, are used individually to track fitness performance. Their governance is covered by individual data sharing or privacy norms. The scope of connecting monitoring devices to collect healthcare information, feed a central database, or make medical decisions, would come with its own regulatory and legal challenges, which currently have neither been identified nor dealt with in the UAE or any other country. The findings pointed out the current lack of standardisation across hospitals and regions, where technological incompatibility between platforms and ICT infrastructure across hospitals and departments within hospitals is likely to be a barrier to interoperability. The lack of technological interoperability is further complicated due to a lack of agreement regarding how the different devices should be communicating, the semantic and syntax differences that are likely to be encountered due to the differences in underlying technology used, and the coding standards employed. Therefore, it is evident from the findings that a uniform governance structure should cover medical equipment and medical devices to be potentially used seamlessly, while delivering tele-emergency services across the different parts of the country.

Further, medical equipment and devices are also required to have adequate usability before being deployed in a wide-scale technology-enabled tele-emergency system. The following section discusses insights obtained from the findings regarding the usability aspects of medical devices.

6.4.3 A need for enhanced technological usability of medical devices.

The findings related to questions regarding the usability of medical equipment and medical devices for supporting a tele-emergency framework revealed that, according to the participants, many already existing fitness monitoring devices could be deployed and tested for their utility for emergency services. In fact, various companies, such as Apple and Fitbit, worked with AI-based systems to measure vitals and were already connected to central databases of their companies, which emphasises the scope to deploy similar devices for medical monitoring purposes. What is needed is to ensure that a similar system is available to deliver data at the doctors' desktops, as and when required. Such devices and systems are already in various stages of development, and companies like Massimo, Jawbone, and Cherish were in trial phases to come up with solutions that could use the Bluetooth technology to collect patient data, send it to a central database, and allow it to be shared with relevant healthcare points of contacts.

An additional criterion decides the usability of medical devices, and it is related to the financial cost-benefits aspects of investments. Business decision-making is often driven by financial returns on investments rather than delivering the most relevant or practical services. Unfortunately, a similar logic applies to healthcare services in general and the UAE. The interviewees raised questions about the financial aspects of developing a network of technologically adequate and relevant devices and if healthcare companies and hospitals would find such an investment lucrative. The question about the financial attractiveness of the framework is beyond the scope of this study. However, it can define whether a large-scale tele-emergency framework that deploys medical devices and health informatics on a national scale is acceptable financially. Although technically, all the evidence indicates that it is feasible and possible.

There is a need for further interoperability, standardisation, uniform regulation, and enhanced technological usability of medical devices to potentially support a large-scale tele-emergency framework. The following section discusses medical records systems currently existing in the country and their scope for supporting the tele-emergency framework.

6.5 Theme Four: Health Information Exchange (HIE)

This study assessed the HIS and HIE status, PIS, and standardisation protocols related to data collection, recording, sharing, and storage; using the information obtained from the participants' interviews. These aspects are crucial in operating tele-emergency services; they allow for effective, accurate, and timely delivery of care to emergency patients at the specified location in real-time, which would save lives. The following is a discussion of the insights gained from the research findings.

6.5.1 Deploy medical devices and health informatics on a national scale.

The interview findings suggest that the country is slowly approaching or evolving into one central system for health records. There is scope for integrating the diverse health record systems (Malaffi and NABIDH) already operational in the UAE. These HIE systems are currently diverse and non-aligned, namely: the Malaffi of DOH (links SEHA hospitals and Mubadala healthcare facilities, and allows for the transfer of medical records across Abu Dhabi) and NABIDH by DHA (links private and public hospitals' health records). These are large-scale networks that use the Epic HIS (NABIDH system) or the Orion based Cerner HIS (Malaffi System). However, they do not exchange information between them.

Similarly, another system is coming to light, the NUMR system by MOHAP, which as per the ministerial decree in 2015, is supposed to capture both NABIDH and Malaffi, including the Northern Emirates hospitals and clinics. The better approach would have been if all three authorities had one unified health information system to tap into, which should have included all of the medical facilities' patients' health data. Since NABIDH and Malaffi are in the advanced stages of unifying their respective citys' medical records of private and public medical institutions, another investment to build a larger HIE would not be logical. Therefore, one way forward is to have an HIE or exchange capability between the three HIEs and have MOHAP as a regulating authority and the lead agency over the exchange.

The technological aspects of connecting private hospitals, which often still operate using legacy systems, may prove to be complicated. Other issues not related to the technology perspective also need to be resolved, such as concerns regarding medical liability, only granting authorised or need-based access to patient records, lack of unified policy among different Emirates on data sharing, and differences among the health regulatory authorities. It is evident that there is currently a lack of technological connectivity and interoperability regarding knowledge and data sharing between different healthcare institutions regarding patients' record keeping.

All in all, the country does not have a uniform or centralised HIE that could be accessed by medical professionals across the country, making it even more complex to serve and treat emergency patients through tele-emergency services. In the absence of access to patients' past medical history, delivering appropriate emergency care may be challenging or even fatal. This problem is further intensified by the lack of a uniform PIS in the country, discussed in the following section.

6.5.2 Lack of a unified Patient Identification System (PIS).

The findings indicated that PIS already exists in the country but in a rudimentary format at best and needed considerable developmental work to become suitable for a nationwide tele-emergency framework. The existing system relies on using the patients' health insurance cards. However, there is scope for using any of the identity cards (such as the Emirates ID, driver's license, UAE Pass, and temporary tourist card – if tourist) for patient identification. Fingerprinting technology or other biometrics can also be employed for patient identification. However, the mere identification of the patient is not sufficient. What is needed is that the patient could be connected with his or her health records stored in a centralised database and available to paramedics or first responders and tele-emergency specialists back at the hospital - which is still not a reality in the UAE. Currently, some hospitals use the EPCR system that allows first responders to manually log patient details, which are then shared with affiliated hospitals that await the arrival of the emergency patient. The EPCR system was only available in Dubai and specific areas of Abu Dhabi, and thus there was a need for a nationwide system for patient identification to be developed.

Additionally, there is a need to ensure that patient identification can be undertaken quickly, accurately, and even when the patient is non-responsive. This could only be done using already stored or historic biometric data, or a card that would hold patients' past medical history and identity and connect to the tele-emergency response team. The technical dynamics of developing such a system that allows for automatic retrieval and sharing of patient data using PIS can be worked out easily. However, privacy and data sharing issues still need to be resolved to ensure accountability and responsible data sharing without violating patients' privacy. There are available technologically-enabled solutions for privacy and security matters that ensure that data residency is secure, data resides in the country, and systems operate within the framework of data security laws of the UAE.

It is also feasible to store patients' data on their smartphones and access it using QR codes in emergencies. However, patient identification can be complicated if there is no system to link tourists' data into any local HIS system or access their historical medical records. This is a considerable gap in the current system since the country harbours numerous tourists, and their healthcare records may not be available in emergencies.

The lack of a unified medical record management system, which could enable emergency care personnel to identify patients and access their medical history on the spot, can limit the proposed tele-emergency framework development. The problem is as much related to privacy and data residency issues, as it is due to the lack of integration of existing health information systems, redundant and legacy systems in use for patient identification, and the lack of standardisation in records.

6.5.3 Lack of standardisation in HIE platforms and PIS.

The lack of interoperability between diverse HIE platforms and patient identification methods stems from the lack of standardisation in different hospitals' technical specifications and platforms, limiting connectivity and seamless data sharing. Due to the continued existence of legacy systems that are difficult to integrate, the technological incompatibility between different systems is further complicated by jurisdictional and regulatory differences between the Emirates. Therefore, the ultimate impact is felt by providing adequate and timely emergency care to patients across the country. Thus, developing a unified and standardised recording, storing, and sharing of patients' health records becomes essential.

The above theme regarding the country's medical record keeping has pointed out several critical areas for improvement before a tele-emergency framework can be implemented in the country. The participants pointed out an essential aspect of tele-emergency care: first responders, their suitability for the task, and their support systems. This is discussed in more detail in the following section.

6.6 Theme Five: First Responders

Initially, the research had not explicitly aimed to evaluate first responders' current status. However, the interviews revealed numerous insights around them, which were found suitable for this study's current scope, and hence included. The research participants mentioned their views concerning availability, training adequacy, management, and authority granted to first responders in the current emergency care delivery system. These insights from the discussion on whether first responders' existing structure and availability could be integrated into the proposed tele-emergency framework are analysed.

6.6.1 Lack of adequate quality and well-trained first responders.

Findings regarding first responders highlighted the need for revising the structure and training approaches for these professionals. For example, first responders and paramedics in the UAE were simply employed to transfer emergency patients from the emergency scene to the hospital. The staff were not trained to provide adequate or stabilising skills on the spot, which resulted in costly delays and complications. Moreover, first responders were either paramedics trained in transporting patients, or EMTs. The country lacked licensed nurse practitioners or physician assistants that could be trained to save lives in EDs or at emergency scenes without involving costly resources such as specialist doctors' time. As reported by the participants, first responders in the country were also not well-trained in using healthcare technologies, which could further act as a barrier to the functioning of a tele-emergency system.

The lack of training and probably the lack of understanding of first responders' importance makes saving patients in the required time and location impossible. As a result, in the UAE, first responders cannot administer crucial procedures such as intubation, administer controlled medications such as morphine, initiate streptokinase, or administer antiplatelet medications. These are crucial gaps in the delivery system of emergency care that must be resolved before proposing a large-scale tele-emergency framework and expecting it to succeed.

There appears to be a serious lack in the structure of operations and work processes for front-line emergency professionals. Consequently, any tele-emergency system with the technical sophistication envisaged and proposed in this research cannot work optimally without trained and equipped first responders. It is evident from the interview findings that the UAE should re-evaluate first responders' job profiles and training needs.

The findings indicated a need to restructure the chain of command and management systems used for first responders in the country. The impact of the chain of command and how technology can resolve it is discussed next.

6.6.2 Lack of structure and framework for the operations of first responders.

The research revealed that the management of first responders brought forth some structural and communication-related contradictions in the system. In the UAE, an emergency was serviced by various emergency service providers, following diverse regulatory and operational frameworks, and any emergency or rescue operation may be mired with confusion related to different chains of command that conflicted with each other. The situation, while functional, was not conducive to supporting any large-scale nationwide and integrated tele-emergency framework. This issue is not directly related to the technological aspects of a tele-emergency framework. Yet, it is a significant drawback to the smooth functioning of the framework that is intended to be proposed by this research. Currently, all emergency calls are received by the police department rather than by emergency command centres. Calls are responded to in a non-structured manner since there are no systems to record data systematically. Such issues can be readily resolved by developing a centralised call centre to receive emergency calls and deploying trained dispatchers to direct calls to the appropriate units - be it the police department, ambulance services, different first responders, or the fire department. The country also needs a medical priority dispatch system to help decision-making regarding the kind of intervention an emergency warrants.

It is evident from the research that there is a need to provide a better structure and management of first responders to align with the practical and ground-level operational needs of emergency care delivery. Additionally, it is indicated that EDs often fail to provide a supporting system to first responders in the form of effective connectivity with ambulances, hospitals, central records, or patient identification, which are discussed next.

6.6.3 Lack of adequate support systems for first responders.

A theme emerged in the interviews regarding the availability of supporting systems for first responders in the UAE. It revealed that medical liability issues or lack of training prevented first responders from conducting most emergency procedures, which led to delays. First responders were not backed by a centralised dispatch centre that harbours trained representatives capable of connecting them with the required specialists or directing them through the operations. This lack of support was also evident because first responders, in most cases, did not have adequate equipment or authorisation to access the medical records of patients, which could help provide targeted and appropriate care at the incident location.

The interviewees also discussed the scope of a large-scale tele-emergency framework. They explored the availability of additional resources to potentially support a technology-enabled tele-emergency framework in the UAE. These are presented next.

6.7 Theme Six: Resources

The fundamental aim of the research was to evaluate not only the competence and strength of the available technology, in terms of ICT, telecom, medical devices, and HIE, but also to understand the availability of technology-based supporting systems such as pre-alert systems, access to specialists, and decision-making systems in the country. Therefore, this section discusses the themes that emerged around the supporting resources for a nationwide tele-emergency system.

6.7.1 Lack of adequate and relevant pre-alert system infrastructure.

A theme that emerged regarding the availability of resources for supporting a large-scale tele-emergency framework in the country was in the context of pre-alert systems. The literature review revealed that pre-alert systems and pre-hospital care are essential parts of any tele-emergency process and are often crucial for saving patients' lives. However, as pointed out by the participants, a pre-alert system was inadequate and insufficient to support even the current level of emergency services in the UAE. This is a vital issue that needs resolving if a new tele-emergency framework functions effectively. As discussed earlier, the country has the EPCR system, but it is based on a manual data entry process and restricted to government hospitals in Dubai. In Abu Dhabi, a similar system is set up. However, it is not functional, and there are also little or no alarm systems to alert hospitals regarding potential emergency admissions beforehand. Even ambulance services are disparate and managed by different authorities, making it challenging to connect them with relevant hospitals in real-time. It is evident from the findings that while the country has the infrastructure and the capacity to build further on the pre-alert infrastructure, this has not been the focus of healthcare policies. This has resulted in an ineffective and dysfunctional pre-alert system, which must be part of a nationwide framework for effectively delivering tele-emergency services.

A related theme emerged concerning the issues revolving around resources, access, and availability of specialised services in EDs, which is presented next.

6.7.2 Lack of access and availability of specialisations in EDs.

From the interview findings, it was noted that in many EDs, patients could not be supported due to a lack of specialists, although some hospitals and clinics had direct connectivity with remote specialists across the globe and could take in a variety of emergency cases. However, such connectivity was not fully utilised due to financial reasons. An exploration of this issue or a proposal for resolving it is beyond the scope of this research. It can be considered a plus point that hospitals could technically connect with specialists and potentially work well with a large-scale tele-emergency system. Remote connectivity with specialists is an area that has been expansively explored in the literature on telemedicine frameworks, and most authors have found that EDs can serve remote areas by utilising such specialists efficiently (Tsou et al., 2020). Similar success can be achieved in the UAE with certain changes in healthcare policies.

The country has sufficient resources available, but there is a lack of coordination and structuring of resources, which must be addressed before a large-scale nationwide tele-emergency framework is implemented. An area highlighted concerning resources was decision making systems in the delivery of tele-emergency healthcare, which is discussed further in the following section.

6.7.3 Lack of technology-supported decision making.

Decision-making for tele-emergency services includes equipment purchase, data management, and coordination of physical efforts. Several gaps were identified that might require addressing before a nationwide tele-emergency framework could be developed. Based on the findings, different stakeholders were involved in decision-making at different levels of ER emergencies, which made the process subjective and open to human error. For example, at triage, nurses decided within seconds of the manual checkup of the patient, and later, doctors provided their assessments, which were primarily impacted by the nurses' initial report. The entire decision-making process was prone to communication errors because there was little involvement of an automated technology-backed decision support system. For example, no EWS or severity score was calculated automatically, and no vital sign-based cardiovascular risk or stroke risk calculation system was used that could auto-detect possible complications. Vitals data were collected manually and input into the system using the data entry process, which again led to delays and scope for errors. The lack of automation in the decision-making process can lead to improper diagnosis or loss of valuable time for the patient and the doctor.

Due to the problems related to the chain of command and management of first responders discussed earlier, manual decision-making often caused conflicts between first responders and doctors. A suitable solution would be to use a sophisticated tele-emergency centre that receives patients' vital signs data and provides appropriate alternative decisions to guide healthcare professionals at different stages. However, unless such technology-backed decision-making is included in emergency care, it is likely to undermine the potential scope of any large-scale tele-emergency framework.

6.8 Summary

This chapter discussed themes that emerged from the thematic content analysis of the interviews and categorised them as ICT, telecom, medical devices, HIE, first responders, and resources. Analysis of the ICT theme revealed that while the country has modern and latest ICT capabilities and infrastructure, due to lack of coordination or federal oversight, most Emirates are using their unique approaches to ICT development, which leads to a limited scope for integration between them. Lack of standardisation leads to a lack of interoperability, a barrier to any large-scale tele-emergency framework initiative.

A similar theme was identified for telecom, where different Emirates operated with diverse telecom architecture for their healthcare institutions. As a result, there are mismatches between various departments and divisions' telecom systems within the healthcare institutions, with some sections still dependent on legacy systems, while other sections within the same groups get upgrades. On the one hand, the irony is that the country boasts state-of-the-art telecom ecosystems. On the other hand, a lack of seamless connectivity prevents data sharing in real-time across healthcare institutions in different Emirates. This state of affairs requires upgrades, integration of telecom platforms, and standardised protocols for data sharing and storage across the different Emirates, such as HL7 and FHIR standards.

A prominent issue regarding the telecom theme was that data residency and data privacy-related laws need to be more explicit and need federal enforcement for a nationwide tele-emergency system to be developed and successfully implemented. A similar theme developed around data latency and reliability - both due to the lack of technological integration and interoperability issues; due to errors inherent in the manual process of data input and retrieval that is currently implemented. The standardisation for ICT laws and security was identified as a prerequisite for connecting and integrating ICT across the country to support a new tele-emergency framework. Findings also indicated that the country had availability and access to the latest health informatics devices and medical gadgets, and citizens were open to using them. However, it is evident from the research that several individual companies have created such devices for personal fitness monitoring or sports performance, and a similar penetration of medical monitoring devices for proper healthcare management was mostly not planned for. The interviews evidenced the existence of monitoring experiments for diabetes or cardiovascular patients, but the mainstream usage of such healthcare monitoring was minimal. One reason for the low penetration of medical mobile monitoring technology is the lack of interoperability and clarity in the governance and legal aspects of data storage and information sharing related to their usage. These issues should be addressed before a tele-emergency framework can be developed.

A related issue around information and data sharing was highlighted by analysing the HIS and HIE theme findings. A similar pattern of stand-alone disparate and unconnected HISs was observed in diverse healthcare institutions. While there were widescale HIE systems at the individual Emirate level in the process of development or already operational, a large-scale nationwide tele-emergency system would require authorisation-based access to databases and data sharing across the country. At the moment, the individual HIEs are not integrated seamlessly, and often records have to be retrieved manually, consuming precious time during emergencies. There were also jurisdictional issues that hindered serving emergency patients across Emirates borders. It was evident that considerable effort was required to develop a technology-integrated architecture that could share and integrate the existing HIEs across the country. Before this, additional efforts are required to align the legal and jurisdictional issues. A uniform medical record system can only provide optimum efficiency if it is paired with a uniform PIS, which at the moment, is not available in the country.

The country has successfully implemented one of the most critical tasks in issuing all residents a unified Emirates ID card. Such an initiative can either be replicated for medical records, or even better, to include the residents' complete health records on the existing Emirates ID card. This will allow such medical records to be accessible to authorised medical personnel as and when needed. Currently, only the EPCR, and only in selective locations, allows first responders to manually enter patients' identifications and medical condition and share it with hospitals' EDs. Therefore, the EPCR system would not support a tele-emergency framework that aspires to serve people across the country, and considerable efforts are needed to unify and automate access to patient information.

First responders formed an essential part of tele-emergency services; currently, their training and authority are insufficient to deliver the level of service that a technology-enabled tele-emergency framework demands, which is another emerging theme from the findings. There is a lack of connectivity between ambulances, first responders, and EDs, which can prevent delivering effective tele-emergency care. Finally, although the country's hospitals possess the highest and best medical equipment with high internet speeds and connectivity, there is still a reluctance to deploy such resources for tele-emergency services. It is evident that while it is easy to understand the gaps in technology and suggest remedies for technical integration (which are discussed in detail in the next chapter), the issues in the policymaking process and legal environment may be more challenging to address, because of the required involvement of diverse Emirates and both public and private healthcare institutions. The policymaking process and the legal environments are not within the scope of this study; therefore, they will not be discussed further. Instead, the next chapter will refine the proposed tele-emergency framework based on the themes highlighted in this chapter.

CHAPTER SEVEN: TECHNOLOGY FRAMEWORK

7.1 Introduction

This chapter will develop the blueprint for the tele-emergency framework (Figure 7.11), using the Heeks (2002) technology deployment model, as evidenced in the provisional conceptual framework presented in chapter three (Table 3.1). This conceptual framework is further developed using interview material and elements from the telemedicine frameworks (Table 7.1). To this end, the three dimensions of change (processes, technology, and people), following the Heeks (2002) model, will be evaluated in the context of the regulatory and the operational environments within the UAE, and shortcomings and weaknesses highlighted that could limit the implementation of a large-scale tele-emergency framework for the UAE. The chapter is structured to deliver a detailed assessment of each change dimension, first within the regulatory environment of the UAE and then within the context of the operational environment. This assessment provides the basis for identifying the blueprint elements in detail and presenting the final blueprint in a diagrammatic model at the end of the chapter.

7.2 Heeks (2002) Technology Deployment Model

The Heeks (2002) technology deployment model proposes four dimensions of change: technology, processes, people, and structures. As mentioned earlier in the conceptual framework discussed in chapter three, this study will only consider the processes, technology, and people dimensions, with a greater focus on technology. The dimensions of processes and people are maintained within the scope of this research, as these influence and define the technology that must be in place for a successful tele-emergency framework to function. Also, as indicated in Table 7.1 below, the framework will be developed using the context of the regulatory and operational environments. The regulatory environment includes laws associated with procedural processes, technologies to be deployed, and the need for managing people, thus including medical laws, technology-related laws, and human resource management laws in the country. More specifically, this encompasses laws governing medical data storage, data sharing, accountability and medical liability, ICT and telecom, legal use of medical devices, and laws related to managing personnel and professionals involved in delivering care. The operational environment consists of management, control, and structural systems that determine the usage of resources, people, technology, or processes. This study will not focus on specific management systems (management styles, recruitment and promotion policies) or control systems (performance management and appraisals), since these systems are not within the scope of this research. However, it is deemed essential that the operational environment within which processes, technology, and people function must be studied in terms of aspects such as the communication flows, chain of commands, and organisational structures to manage the tele-emergency framework. The existing operational environment can be enhanced, modified, or changed to serve the needs of a nationwide tele-emergency framework.

The following Table 7.1 provides an overview of the scope of this research and provides a structure for the following sections in this chapter.

Table 7.1

Change Dimension and Environments

Change Dimensions	**Environments**	
	Regulatory	**Operational**
Processes	**Process Related Laws** – Process documentation and standardisation. – Process Audits and Service-Level Agreements. – Medical liability.	**Process flow** – Emirate Health Emergency Control and Management Processes – CCC-Hospital ED Communications – Ambulance Services Processes – First responder processes – Hospital processes
Technology	– ICT Laws – Telecom Laws – Medical Devices governing laws – HIE Laws	– ICT infrastructure – Telecom infrastructure – HIE and Medical devices
People	– Coordination and management of emergency personnel – Licensing – Hiring and training governing laws – Unified Performance Standards	– First responders' management and role enhancement – Skill Gaps and Training – Other Healthcare Professionals

The following section will discuss change dimensions within the regulatory and operational environments, identifying issues that need to be addressed to successfully implement the proposed nationwide tele-emergency framework.

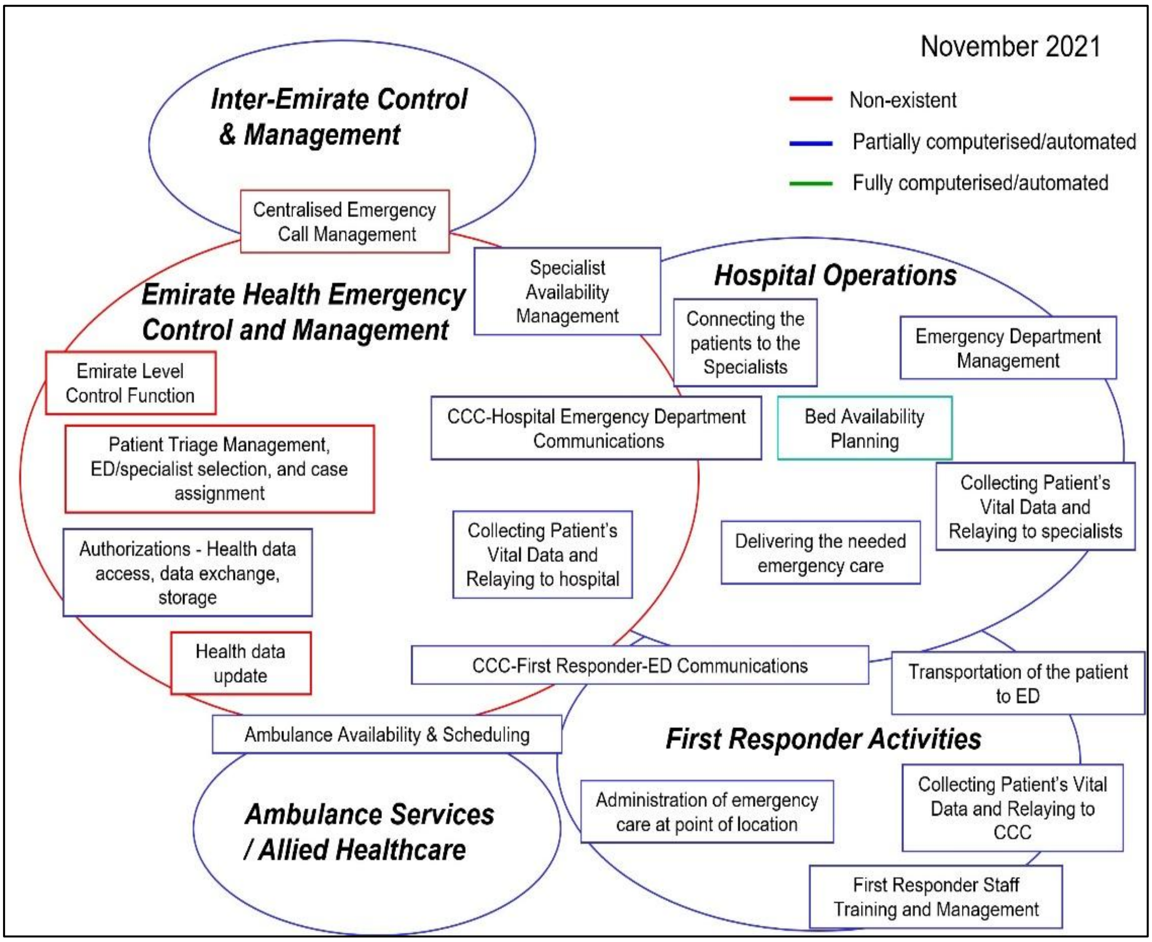
7.3 Processes

To be effective, a nationwide tele-emergency framework requires extensive and complex processes that support the structural and communication connectivity between different elements of the tele-emergency care delivery system and stakeholders. The processes related to the tele-emergency framework are integrally linked with their regulatory and operational environments, which are discussed in detail in this section. The current status of tele-emergency operations in the UAE is evaluated to point out gaps in the regulatory and operational contexts, as revealed in the interviews.

Suggestions are made to improve the operational framework and develop laws and regulations to support tele-emergency processes. The following Figure 7.1 outlines the process map for the tele-emergency framework and illustrates the processes and sub-processes involved. The diagram is presented with a colour-coded distinction made in terms of the current status of each process and sub-process, where red denotes the absence of the process (and hence a need to include it in the final blueprint), blue highlights a partially automated process, and green denotes a fully automated process.

Figure 7.1

UAE Tele-Emergency Main Processes and Sub-Processes



The following Table 7.2 summarises the key points discussed in the following sections within the processes dimension.

Table 7.2

Process Dimension: Themes

Change Dimensions	Environments	
	Regulatory	**Operational**
Processes	**Process Related Laws** – Process documentation and standardisation. – Process Audits and Service-Level Agreements. – Medical liability.	**Process flow** – Emirate Health Emergency Control and Management Processes – CCC-Hospital ED Communications – Ambulance Services Processes – First responder processes – Hospital processes

7.3.1 Regulatory environment.

The processes involved in the blueprint broadly relate to a centralised command centre that carries out the sub-processes of emergency call management, Emirate-level control of the overall emergency operations, patient triage, EHR/EMR access, and authorisations. The sub-processes also include communications with first responders, EDs, specialists, ambulance operations, hospital-level operations, and first responders' operations (Figure 7.1). These processes are an essential part of any large-scale framework. However, none of the frameworks considered in the literature review dealt with the issue of the regulatory aspects of the processes involved in centrally handling emergencies and connecting patients, first-responders, EDs, specialists, and HIE; probably because the countries studied already had unified emergency protocols in place, which is an aspect that needs to be explored in greater depth in the context of the UAE.

Process documentation and standardisation.

Based on the insights of the interviews, the desired integration level in the processes involved in the delivery of emergency care through the Central Command Centre (CCC), as outlined in the section below (Section 7.3.2), should be supported by unified emergency protocols and process documentation, which the country is currently lacking. Currently, the UAE has Federal Law No. 2 of 2011, which has been amended several times through Federal Decrees - for instance, the Federal Decree-Law No. 2 of 2011 in Respect of the Establishment of the National Emergency, Crisis and Disaster Management Authority (NCEMA), the Federal Decree-Law No. 6 of 2013, and the Federal Decree-Law No. 8 of 2015. This Law defines an emergency as "a major incident or sets of incidents which: bring serious damages to individuals or property or threaten public order, continued functioning of the government, human health, environment, or economy. Incidents as such require special mobilization and coordination between several entities" (NCEMA, 2011). The scope of the Law is predominantly leaning toward large-scale emergencies rather than individual accidents or emergencies, as will be covered by the proposed blueprint of the tele-emergency framework. Therefore, there is a need to develop laws supporting the CCC processes for national-level crises and individual emergencies.

Process audits and service-level agreements.

Process audits or Service Level Agreement(s) (SLA) are not mentioned in any healthcare delivery laws, specifically tele-emergency. For example, Federal Law No. 2 of 2011 provides only a general overview of emergency protocols without providing a framework for auditing performance or establishing SLAs. Likewise, the Federal Law No. 5 of 2019 on the Regulation of the Practice of the Human Medicine Profession (Ministry of Health and Prevention, 2019c) defines obligations, code of ethics, and cases for licence revocation. However, it does not stipulate procedures for auditing care delivery.

The above situation leads to a recommendation for assimilating and integrating the best practices from across the UAE and internationally regarding first responders' response times, procedures and protocols, EDs' response times regarding accommodating and stabilising patients, and procedures for obtaining access to remote specialists (which may involve additional jurisdictional issues related to medical practice licensing). Such laws are required for facilitating the ambulance services processes, first responders' processes, and hospital-level processes, as outlined in Figure 7.1 above. Then, uniform protocols are required concerning follow up and discharge procedures. Most countries follow paramedic or first responder competencies and best practice protocols (Horrocks et al., 2019), which should be emulated for the UAE for process audits and developing SLAs.

Medical liability.

The interviews emphasised that a significant concern related to healthcare delivery processes has always been the fear of malpractice suits and medical liabilities. Malpractice concerns and medical liabilities are also cited in the literature as barriers or limitations to implementing new medical protocols or healthcare technology and limiting factors in delivering tele-emergency (Chakraborty et al., 2014; Zulkipli et al., 2022). As such, tele-emergency care delivery related medical practice laws and liabilities need to be fully developed, and laws governing the code of conduct of first responders, specialists, and ED physicians need to be determined in the context of this proposed nationwide tele-emergency framework. Such laws are required to facilitate the essential first responder processes, specialists management sub-processes, and hospital management processes, as shown in Figure 7.1 above. The UAE already has Federal Law No. 4 of 2016 on Medical Liability and the Cabinet Resolution No. 40 of 2019 concerning the Executive Decree for Federal Law No. 4 of 2016 on Medical Liability (Ministry of Health and Prevention, 2019a). However, most provisions pertain to healthcare institutes and professionals' ethical codes of conduct and desired professionalism. An annexe to the Executive Decree covers some regulations and conditions for telehealth services. However, there is no specific mention or framework for regulating the delivery of tele-emergency services or the scope of malpractice concerning the delivery of tele-emergency.

7.3.2 Operational environment.

The tele-emergency framework processes predominantly consist of the Emirate health emergency control and management processes, hospital operations, ambulance services, first responder activities, and inter-Emirate control and management, with numerous inter-linked and overlapping sub-processes.

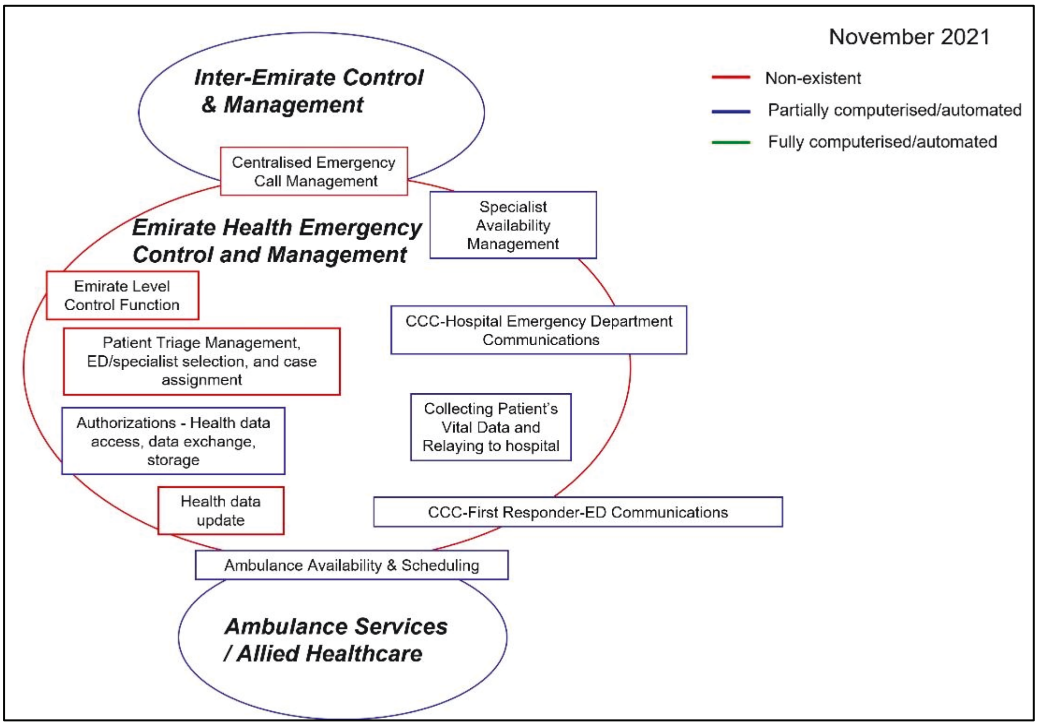
Emirate health emergency control and management processes.

As indicated in the diverse tele-emergency frameworks reviewed in the literature, there is a need for having an Emirate-level Central Command Centre (CCC) or a central hub that acts as the control centre for all tele-emergency operations. In order to perform this function of monitoring and controlling tele-emergency operations, there are several sub-processes such as the Emirate-level control process (which includes the operations of the CCC) and additional sub-processes such as the centralised call management, patient triage, establishing and relaying communications between first-responders and EDs, establishing direct communications with hospital EDs for preparation, managing the availability of specialists, managing and overseeing the ambulance scheduling and communications, and access authorisation and update of the medical database.

Emirate-level control process: A CCC is suggested based on the works of Lu, Lin, and Shen (2013) and Lee et al. (2013). However, further refinement is suggested based on the insights and suggestions obtained from the interviews. Instead of installing just one centralised hub, Emirate-level hubs or CCCs should be positioned to serve a specific geographical area; yet, have access and interoperability with each others' databases, devices, and authorised healthcare specialists. Therefore, the need for a cloud-based platform uniformly used by all healthcare institutions across the country is critical, as discussed later in the technology section. Such multiple CCC-based structures with cloud connectivity will enhance the management of the tele-emergency delivery locally. At the same time, CCCs should connect with each other to reach out to remote locations and access data across different Emirates. By using Emirate-level CCCs, the federal and jurisdictional issues could be overcome, leading to efficient operations of tele-emergency delivery. However, the operations of these connected CCCs are mainly dependent upon the country having a suitable cloud-based healthcare platform and the latest decision-making support systems. Therefore, a uniform cloud platform that allows the CCCs to access and connect with various hospitals, first responders, and specialists in real-time, forms the core of this large-scale tele-emergency operation. So, the CCC undertakes and supports the following sub-processes to facilitate the control function.

Figure 7.2

CCC Processes and Sub-Processes



Inter-Emirate control and management processes.

Inter-Emirate control and management is an essential prerequisite through which the later processes can be performed seamlessly across the different Emirates while preserving the federal nature of jurisdictions. The Emirate-level CCCs will be connected seamlessly. This connectivity will allow the CCC to handle the emergency case, directing the case to an ED in a different Emirate (as necessary). Similarly, such connectivity enables CCCs to request the assistance of specialists from different Emirates without licensing and jurisdictional issues. Finally, the inter-Emirate connectivity can ensure that the centralised HIE is utilised effectively, and data is accessed by specialists and EDs from anywhere in the country as and when necessary.

Centralised emergency call management: The Emirate-level CCC will operate as a central hub for receiving and processing emergency calls. Currently, emergency calls are directed to different departments - fire department or police, which causes a delay in the actual medical care delivery at emergency scenes. Therefore, the CCC will trace incoming emergency calls (through a central emergency call centre) and be directed to the nearest CCC through geo-location technology and connect with the nearest first responder station.

Patient triage management: The Emirate-level CCC will process data and information, whose primary task is to take or provide real-time triage decisions regarding delivering accurate tele-emergency care. Therefore, the requirements are processes and protocols that can deliver precise triage suggestions in real-time; unfortunately, such a system does not exist in the country currently. The CCC will establish processes to consider location proximity, type of emergency, patients' current vitals data, and past medical records (that will be accessed through the patients' Emirates IDs or various PIS means discussed later) and then match the specialist or physician credentials, and assign the case to these identified specialists. Additionally, the CCC can establish further support to the first responder teams by contacting other specialised departments that can help rescue operations, such as air ambulances, police, and the fire department.

Collection and relay patient data: The Emirate-level CCC will connect with first responders, who had already connected the patient with monitoring devices, and upload the patient data directly to the CCC. The CCC will use this data to triage the patient and then share the vitals data with the selected ED and the specialists. Consequently, the CCC authorises EDs or specialists to access patients' medical records from the centralised HIE. This process enables specialists to access health records, provide guided instructions to the ED or first responders, and deliver timely emergency care.

Ambulance availability and scheduling: While connecting with first responders, a pre-requisite is to schedule and dispatch ambulances, a function that the Emirate-level CCC will perform while coordinating with ambulance services. For this, communication between the CCC, ambulance services, and first responders' dispatchers must be maintained uninterruptedly.

CCC-hospital ED communications: In addition to managing first responders' operational network and communication, the Emirate-level CCC will be connected with hospitals within the Emirate. Therefore, the nearest ED is located and pre-alerted about the patient's Estimated Time of Arrival (ETA). With the above backdrop, it is possible to suggest that the Emirate-level CCC be directly connected to hospitals via their pre-alert systems.

Emirate-level CCC, specialist, ED, and first responders availability, communication and management: Part of the Emirate-level CCC's function is to monitor, be informed, and know the capacities of EDs regarding specialist capabilities, specialities, and availability. Part of the CCC's processes and mandate is to find the required specialist and connect the specialist to other specialities within the country or internationally. Should the need arise to connect the specialist to a cross-border (an international) specialist, the CCC will lead the process of sharing the patient's medical records and current vitals within the established confidentiality and security measures. While the CCC continues to stay connected and facilitate the transfer of the patient to the ED, such connectivity allows the first responders, ED specialists, and other healthcare staff to maintain a steady flow of data and information to aid in stabilising the patient at the scene or in transit.

Health data management processes (access, authorisation, collection): The Emirate-level CCC acts as the hub in the proposed framework and provides connectivity between EDs, first responders, and remote specialists, by facilitating health data retrieval from the patient's records and directly from the patient's condition in real-time. For security, transparency, and accountability reasons, the communications between hospitals (the ED with the patient and the hospital with the specialist) will be through the intranet or a dedicated internal application suited to the local networking and security needs. Specialists are provided access to the patients' records and current vital signs through the CCC; therefore, they deliver tele-intervention as guided instructions to the point-of-care paramedic to intervene. For the HIE access and data sharing between the EDs, specialists, and first responders, process-wise, the CCC will take charge of issuing authorisation based on the information provided by the decision-support system that considers the designation and connection of the requesting medical staff to the case and the medical condition of the patient.

Ambulance services processes.

Ambulance services are essential for emergency care and are included in the tele-emergency processes blueprint. In most of the reviewed tele-emergency frameworks, ambulance services are not discussed explicitly because they are already considered an essential aspect of any emergency care system. However, it is vital to understand the current practices associated with ambulance services in the UAE context and then propose the required changes in the processes. According to the interviews, the current process of first responders operates with the hospitals receiving direct emergency calls and dispatching their paramedics, or the police department getting the emergency calls and then connecting with the nearest hospitals and emergency services to reach the caller's location. This caused delays due to multiple chains of commands and a lack of a structured approach to delivering tele-emergency care at the emergency scene. For example, the interviews revealed that different ambulance systems were connected to different authorities. For instance, the National Ambulance operates both in Abu Dhabi and the Northern Emirates under the umbrella of the Ministry of Interior (MOI), MOHAP, and NCEMA (National Ambulance, 2021). However, DCAS is an independent entity linked to the authorities in Dubai, such as DHA and Dubai Police. This translated into dealing with multiple CIOs and the Ministry of Presidential Affairs (MOPA) when transporting data and patients across different regions.

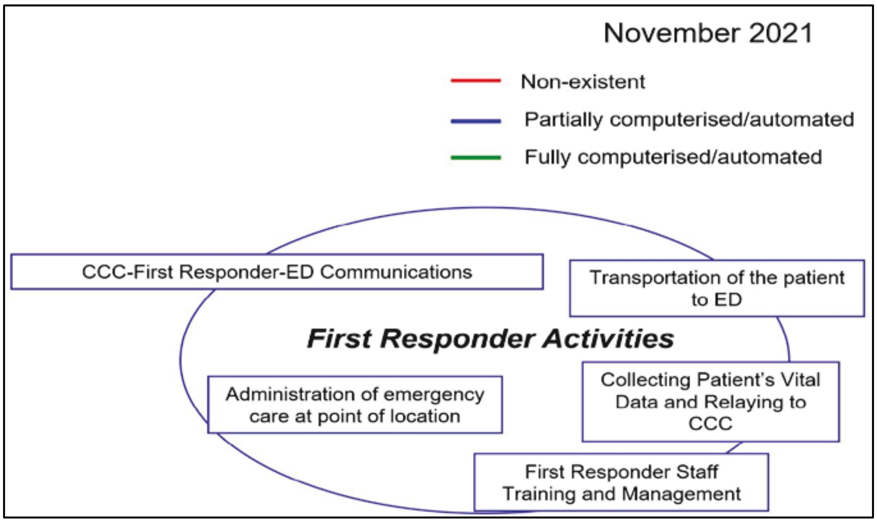
The communication lines should include a direct link between the Emirate-level CCC and the first responder ambulances, so that the dispatched ambulance is in constant contact with the command centre. Such connectivity is evident in the literature review, where the dispatched ambulances were connected to the emergency services in a centralised manner (Cooney et al., 2011; Davis et al., 2020).

First responder processes.

The literature review indicated that almost all the tele-emergency frameworks employed a range of healthcare professionals, including first responders and nurse practitioners, who played vital roles in the care delivery process. However, in the context of the UAE, and as revealed during the interviews, the country seems to lack a centralised management and communication system for first responders. First responders were neither authorised nor required to perform emergency procedures, to save lives. First responders are the first line of medical professionals that reach the emergency scene and have the potential to save lives, and as such, the following sub-processes relate to first responder activities.

Figure 7.3

First Responders Processes and Sub-Processes



First responders management and training: The proposed blueprint calls for a centralised command for first responders under the Emirate-level CCC. There can be national level accreditations and educational programs. Once first responders are certified, they can be assigned jobs based on the national registry and affiliated with the Emirate-level ambulance services. Therefore, in tele-emergency operations, first responders will adhere to the CCC processes and work within the CCC's communications framework. As a result, the CCC will manage first responders' appropriate training and develop authorisations to deliver the necessary care at emergency scenes.

Emirate-level CCC-first responders-ED communications: As mentioned in the Emirate health emergency control and management processes, first responders will stay connected with the ED and the CCC throughout the emergency operations. The Emirate-level CCC will connect first responders to the CCC-identified ED and establish direct communications to share the patient's identity and vital signs or receive any on-the-location guidance from the remote specialists. With adequate authorisations, as suggested earlier, first responders will use this connectivity with the ED/specialists to get guidance on administering on-the-spot protocols to stabilise and even save lives.

Collecting and relaying the patients' vitals to Emirate-level CCC: Once first responders connect monitoring devices to patients, vital signs data will be directly relayed to the CCC and the ED/specialist. Interview participants suggested using IoT technology to connect ambulances with patient monitoring devices and then relaying the data back to the CCC. This data sharing process will ensure that first responders do not have to manually measure and input data into the system, reducing human errors. First responders will use patients' identity cards and relay the data through the system to the CCC to retrieve medical records and share the data with the ED and specialists.

Administration of emergency care at the point of location: First responders will be fully trained and authorised to perform emergency procedures on the spot as and when needed. There is a need to conduct a skill gap analysis, then provide responders with adequate training and facilitate authorisations to deliver effective emergency care.

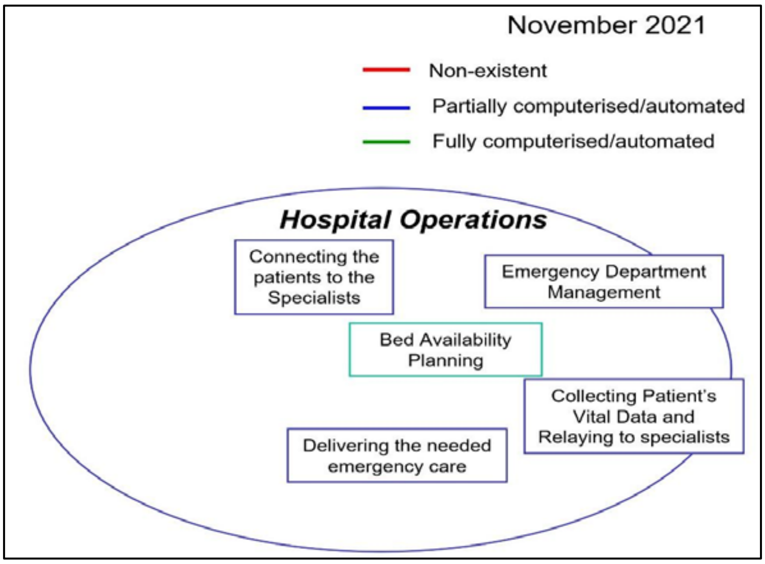
Transport the patient to the ED: First responders are primarily associated with the ambulance services or hospitals in the UAE and predominantly act as transporters of patients in cases of emergencies. In the proposed framework, first responders will also be required to perform medical procedures under the guidance of specialists so that patients are stabilised and get essential care timely.

Hospital processes.

Tele-emergency frameworks reviewed in the literature were related to a single ED in a hospital or a chain of hospitals under single ownership and management. However, in the context of the UAE, due to the federal nature of the country and the presence of numerous government and private hospitals, tele-emergency-related hospital processes should be managed in a centralised manner. The following are the sub-processes as envisaged in the blueprint.

Figure 7.4

Hospital Operations Processes and Sub-Processes



ED management: Emergency Department (ED) of hospitals will be ready to receive patients and, to succeed, EDs will be connected with the Emirate-level CCC to receive an alert. EDs will also be aware and alerted of the type of emergency expected. Toward this, EDs will be in direct communication with the first responders. EDs will be equipped with additional resources, as discussed in the following sections. Overall, EDs will be a part of the central database available to the CCC to enable decision-making regarding selecting the most suitable ED in an emergency.

Beds and resources management: In addition to the technological gaps that need to be addressed, concerns were voiced during the interviews regarding the lack of resources, such as bed availability, qualified specialists, and medical staff. Such concerns could hinder the smooth operations and processes of the tele-emergency framework (Wang et al., 2018). The interviewees explained the underlying rationale for the lack of beds. The hospitals' management cannot see the benefits of equipping their EDs with extra beds because, under normal conditions, EDs do not perform at their ultimate or maximum capacities in the UAE.

Connecting patients with specialists and relaying data: In maintaining the tele-emergency framework requirements, EDs will have monitoring devices, video-conferencing, scanning facilities, robotics, and data sharing platforms to enable smooth interaction between the physician, first responders at the emergency scene, and remote ER specialists. However, the interviews revealed that EDs in the UAE were not equipped with adequate and qualified ER specialists in different specialities and did not have the capabilities to connect through video-conferencing (audio-visual) or platforms with such specialists across the country. It is also interesting to note that several research participants mentioned that hospitals in the UAE had the infrastructure and technological potential to allow connectivity with specialists across the globe. However, such potential was never harnessed, stating that financial considerations were the ultimate motive. Regarding data sharing detailed earlier, most hospitals in the UAE have advanced communications and telecom infrastructure, although there does not seem to be a dedicated line of communication between the EDs/hospitals, which would enhance healthcare delivery.

Delivering the needed emergency care: Hospitals should have the means to deliver emergency care under the guidance of remote specialists or in-house specialists. For this, hospitals must have adequate equipment, staff, professionals, and technicians available. Unfortunately, as discussed earlier, many EDs in the UAE do not operate at capacity and hence lack investment in beds, equipment, staff, and resources. Such limiting capacity may hamper the effective delivery of tele-emergency. Further, regarding first responders processes discussed earlier, the country lacks nurse practitioners, which means that most emergent procedures, even those undertaken by general physicians or nursing assistants, are only performed by specialists who, otherwise, can focus their attention and skills on critical cases. Therefore, EDs in the UAE will have more varied medical staff to optimise the delivery costs of emergency care.

In conclusion, the above sections provided a basic understanding of the processes and sub-processes and their interdependence and emphasised the requirements of connectivity and communications networks and platforms. The following section discusses the technology aspect that will effectively enable the performance of the above processes.

7.4 Technology

This section discusses the current status of technology in the country, pointing out the gaps in the regulatory and operational environments revealed through the interview findings. This section will provide suggestions and scope for upgrades and improvements to support the tele-emergency framework using the insights gained from the literature review and the interviewees' suggestions. The following Table 7.3 highlights the themes related to technology that are discussed below.

Table 7.3

Technology Dimension: Themes

Change Dimensions	Environments	
	Regulatory	**Operational**
Technology	– ICT Laws – Telecom Laws – Medical Devices governing laws – HIE Laws	– ICT infrastructure – Telecom infrastructure – Medical devices – HIE

7.4.1 Regulatory environment.

The country's regulatory environment frames and controls the scope of the operational environment. As such, the regulatory environment of the healthcare sector in the UAE, including any recommended changes to support effective technology deployment of the tele-emergency framework, are discussed first. The following section focuses on how the current regulatory environment would impact the performance of tele-emergency care and provides suggestions on modifying and creating laws and regulations to become more supportive and facilitate efficient tele-emergency care delivery in the country.

ICT laws.

As indicated in Figure 7.1, communications and data sharing underline the processes and sub-processes of tele-emergency care delivery. The interviewees emphasised that the government regulations needed to be strengthened around data sharing, storage, access, and transfer norms in the UAE. The country has ICT and telecom laws that are more local than federal. This issue would impact connectivity and seamless integration of tele-emergency processes related to the CCC, first-responders, ambulance services, and hospital processes across the country. Federal Law No. 2 of 2019 concerning the use of ICT in health fields, which guides the use of ICT in healthcare, applies to all UAE, including free zones (Tithecott & Jhala, 2019). This law discusses the optimal use of ICT in the healthcare field. It requires that all the principles, standards, and practices of deployment of ICT be comparable to international standards (Ministry of Health and Prevention, 2019b). While this is a welcome move toward standardisation, the law's provisions regarding data storage, transfer, and sharing are unclear. Instead, appear to be generic guidelines for the different Emirates. For example, in Federal Law No. 2, Article 3, the country requires that all health-related data reside in the State-Level (Ministry of Health and Prevention, 2019b), and all sharing of data be controlled through authorisations, the process of which is not explained sufficiently. As such, data localisation within the individual Emirates would limit opportunities to access crucial data by first responders, EDs, or specialists in different locations and hamper the effective delivery of tele-emergency care.

Each Emirate has its own ICT policies, strategies, and implementation approaches, and the Federal Law provides general guidance on objectives and controls. For example, DHA has published Guidelines for Managing Health Records (Dubai Health Authority, 2019), and DOH has the Abu Dhabi Healthcare ICT Strategy (Department of Health - Abu Dhabi, 2020a). The situation calls for the Federal Law to ensure that it is direct, explicit, and supportive of the flow of medical information across the different Emirates and create a data-sharing culture that will enable optimum performance of a centralised HIE that will enable data sharing across the Emirate-level CCC processes and facilitate first responders and hospital ED processes.

Telecom laws.

The UAE has a well-developed federal telecommunication law initiated by the TRA that licenses telecommunication networks. However, the country's telecommunication sector is currently a duopoly, with only two major operators. Ideally, a more competitive market could ensure that quality telecommunications services are available at affordable prices (Rashidirad et al., 2017), but, at this stage, it is not possible to suggest altering the country's market dynamics. Instead, it is recommended that the existing telecommunication companies adopt a quality approach and ensure that they deliver consistent, real-time, and zero latency services that can support tele-emergency operations, which is obtainable through the introduction of the 5G network technology. Such laws will ensure that the specialists' communications with EDs or first responders are uninterrupted and that the specialists' delivery of crucial healthcare instructions is possible.

Federal Law No. 5 of 2012 (amended by Federal Law No. 12/2016) concerning Combatting Information Technology Crimes and the UAE Penal Code (Global Legal Group, 2019) are the main laws that ensure the cybersecurity and privacy of telecommunications platforms in the country. However, numerous Emirate-level cabinet resolutions and policies (for example, the Cabinet Resolution No. 21 of 2013, applicable in Dubai) determine the local interpretation and implementation of the laws (Global Legal Group, 2019). The differences between the regional policies on cybersecurity can lead to miscommunication and delays in granting authorisation and access to medical data. Therefore, an overarching Federal Law on cybersecurity must be developed to be uniformly adopted across the country, which will help the CCC better facilitate medical data access in real-time to specialists and EDs.

Medical devices governing laws.

Another area of concern is the lack of relevant laws related to the usage of medical devices, especially personal analytics and personal data tracking medical devices, which are restrictive of the first responders' and ED processes related to transferring and relaying patient data to specialists. Currently, Federal Law No. 4 of 2019 guides the registration of all medical devices with MOHAP. However, the law is not explicit and is amenable to interpretation, making it possible to flexibly register devices under different categories (WHO, 2020). The law does not refer to any type of monitoring device used for data transfer over the internet; therefore, it needs to be amended to explicitly address the issues around data storage, data transfer, and data access. Nevertheless, a National Strategy for AI 2031 exists in the country, although it does not explicitly mention AI deployment for medical monitoring devices. The National Strategy for AI 2031 considers healthcare as an emerging sector for possible AI deployment, especially in developing the human genome and combating congenital diseases (UAE Government, 2018). As such, it can be inferred that AI laws regarding the use of medical devices connected by IoT technology and suggested in this blueprint of the tele-emergency framework, should be developed to explicitly cover standards of operations, testing, and registration requirements.

HIE laws.

CCC processes related to retrieving and sharing patients' health records and identification requires that the CCC has uninterrupted access to medical databases. Federal Law No. 2, Article 5 (Ministry of Health and Prevention, 2019b) states establishing a Central System in collaboration with the Health Authority and Competent Authorities, which is expected to oversee authorisations of data access, data sharing, and use. However, again, the law falls short in explicitly providing for the roles of this Central System and does not clarify if this Central System is to act as a hub for all ICT related coordination, act as an HIE, or be a centralised authority from which all permissions and authorisations are granted. At the Emirate levels, there are individual information exchange laws that may apply in the context of healthcare data, for instance, the DOH Policy on the Abu Dhabi Health Information Exchange (Department of Health - Abu Dhabi, 2020b) and DHA's Guidelines for Managing Health Records (Dubai Health Authority, 2019). There appears to be duplication around the central authority that oversees ICT and health data exchange. While Federal Law No. 2 of 2011 positions NCEMA as the central authority based on Federal Decree-Law No. 2, 2011, Federal Law No. 2 of 2019, Article 5, based on Federal Law No. 2, 2019, states a Central System to oversee ICT operations and health information exchange. The above discussion indicates specific policy and legal framework gaps and recommends making the framework more explicit and robust to protect service users and healthcare professionals.

Implementing a large-scale technology-based framework will reduce malpractice and medical liability, but only if there are appropriate regulations and standardisation regarding the deployment and technology usage in the emergency care delivery processes and sub-processes. Technology enables greater transparency and traceability of processes, leading to greater accountability and monitoring (Yiannas, 2018). Additionally, technology enables limiting access to authorised purposes only, hence reducing the chances of malpractice. So, since digitalisation leads to electronic record-keeping and footprints of all activities undertaken during the care delivery process, simultaneously recorded in real-time, establishing accountability becomes easier to support the electronic health exchange sub-process, as shown in Figure 7.1 (Holeman, Cookson, & Pagliari, 2016; Mukhiya et al., 2019). The traceability and accountability offered through technological record-keeping are not possible through manual record-keeping systems (Saifudin et al., 2021). As seen in the above sections, there are no uniform Federal level laws in the UAE governing ICT or information exchange. This calls for change if the inter-Emirate level CCC processes are established and successful.

7.4.2 Operational environment.

ICT infrastructure.

The operational environment of technology is related to the operations of the ICT infrastructure, telecom, HIE, and medical devices. Different, often incompatible ICT systems are used in different Emirates and regions, making it challenging to get seamless connectivity and interoperability between systems and making it difficult for the CCC processes to run smoothly when the emergency case involves connecting with first responders in one Emirate, locating the patient's records in another Emirate's HIS, and finding a specialist in yet another. Numerous jurisdictional issues were highlighted during the interviews, and were cited as the reason for the current non-integrated state of technology platforms and ICT networks in different Emirates. While the jurisdictional issues need to be resolved at the policymaking level, it is suggested that the nation should adopt both a strategic and a tactical level outlook on the operational aspects of the tele-emergency care delivery process.

One solution proposed in the interviews and supported by examples in the literature on large-scale tele-emergency systems (Ghansu example) (Cai et al., 2016) was developing a single cloud-based platform for the entire country. A large-scale tele-emergency system should be supported by a cloud-based platform that can retrieve information from different hospitals and clinics, irrespective of their geographical location. Such a system can facilitate several tele-emergency processes by connecting EDs, first responders, and specialists across the Emirates or even abroad. The system can aid first responders at the emergency site and help them stay connected with the backend EDs or specialists. The large-scale tele-emergency frameworks studied in the literature had pointed out the presence of a cloud-based system to support tele-emergency care (Pang et al., 2018); however, none of them had been developed on a nationwide scale, as suggested here. According to the interview findings, a single cloud platform is essential for emergency care services to access information such as the availability of beds, nurses, required medical equipment, and specialists. Such a uniform cloud platform can also help retrieve and share patient data, leading to patient identification and linking to the patient's health records, thus leading to real-time and accurate delivery of emergency care. Furthermore, a cloud-based database of specialists and their availability based on their geographical location or licensing jurisdictions will prevent delays in assigning appropriate and necessary specialists in real-time to deliver tele-emergency care. A cloud-based platform will also reduce duplication and redundancies, where storing data on the cloud is accessed and updated from anywhere without the need to keep and manage databases at multiple physical points. There is substantial evidence affirming that using cloud-based platforms lead to better time management, reduces efforts, and allows healthcare professionals to focus on the essence of healthcare delivery (Cherrayil, 2018; Kaur & Chana, 2014). ICT also needs to deploy integrated and interoperable frameworks, where all the authorised hospitals and associated agencies can connect in real-time to access records and resources (Lo'ai & Habeeb, 2018).

With this contextual understanding of the importance of cloud-based systems, it is appropriate to review the UAE systems' current status. In the UAE, while Microsoft and Google are providing cloud-based services, there are still issues related to data residency, preventing the country from utilising the full benefits of these services. However, a Blockchain-cloud-based platform has already been explored as an alternative due to the transparency, accountability, and security it provides to healthcare services (Esposito et al., 2018). Such a platform is suggested for the proposed framework.

A related aspect of connectivity is to deploy software vendors and platforms that work in an interoperable manner and enable connections between hospitals, healthcare institutions, and governmental authorities. The interviews revealed that different Emirates deployed different healthcare software, which could be a challenge or barrier to connectivity and communications needed for a nationwide tele-emergency operation. Different departments functioned on different software platforms within the same hospital or chain of hospitals, thus limiting the hospital's tele-emergency management processes. For example, it was revealed that some of the hospital labs had a local vendor-based Laboratory Information System (LIS), while their front-end operations were upgraded with the latest SAP software. The issue highlighted in the interviews was the lack of interoperability of health record systems, lack of transparency as data sharing was limited and discordant, and overall delays in effective healthcare delivery. The literature review revealed that small-scale tele-emergency frameworks and some large-scale ones had used simple AI-based algorithms and integrated software that provided real-time connectivity and enabled data sharing across the framework (Panesar, 2019). While none of the studies had revealed the specific names of the integrated software packages or AI apps, a similar solution, including integrated SAP software and applications, can be suggested for the UAE healthcare system. AI-based algorithms should be developed using big data and machine learning processes to enable access to information and support decision-making (Kumar & Prabaharan, 2021) by calculating the availability of beds, specialists, medical equipment, and Priority Codes (PC) for patient triage. Technology can, therefore, provide decision support by analysing large amounts of diverse data and providing valuable reports for making quality decisions (Mabillard, Demartines, & Joliat, 2021). A suggestion here is to explore the currently emerging AI technologies from Google and IBM developed specifically for application in healthcare.

Two examples can be explored further in this regard, from the Mayo Clinic (USA) (Bahl et al., 2018) and the National Health Service (NHS) (UK) (Bloch-Budzier, 2016). These two medical institutions built a customised AI-based monitoring and healthcare management system for their departments. Using a uniform and interoperable software platform is vital, specifically in tele-emergency services, where decisions regarding triage and assignment of EDs may be required in real-time to guide first responders at the emergency scenes. This concept is further discussed in the first responders' section and the pre-alert systems that hospitals need to instal if they are to be made active participants in the nationwide tele-emergency system, for which they also need to be connected with the Emirate-level CCC (discussed earlier in Section 7.3). Nevertheless, the CCC processes are essential to the delivery and operations of a nationwide tele-emergency framework. CCC processes include acting as a hub for gathering and collating data through the Multi-Sources Healthcare Architecture (MSHA) network, generating the PC codes using the AI-based algorithms, sending pre-alerts across the network to the patient-receiving hospitals, and connecting first responders with EDs or specialists for data sharing, through the 5G or Wi-Fi networks. At the emergency location, using technology such as the IoT can ensure that human data collection and sharing errors are avoided, thus furnishing high-quality data in real-time for accurate decision-making.

Currently, as revealed in the interviews, this hospital pre-alert system consists of a single phone, rarely operated by anyone. Therefore, this area can improve, and hospitals across the country need a dedicated line for the CCC operations. Most advanced countries such as the UK, USA, and Canada already employ a well-developed pre-alert system built into their ambulances, directly connected with the dispatching of first responders and EDs over telecommunication platforms (Booth & Bloch, 2013).

However, since the focus of this study is a centralised and nationwide tele-emergency framework, a pre-alert system can work efficiently when first responders/ambulances at the scene are connected to the CCC (which is in a better position to make decisions regarding hospital selection) and send the pre-alert to the assigned ED, based on the priority code/triage decision generated by the CCC (Lo'ai & Habeeb, 2018). The interviews also suggested that a tele-emergency app can support the overall operations.

Some hospitals in the UAE currently use an EPCR system that allows ambulances to connect to EDs. However, the EPCR system is not used across all the hospitals, and it also does not connect with any centralised authority such as the CCC that could assign the most suitable, based on the AI-based algorithm and PC, hospital for the patient. Therefore, the proposed framework suggests including a pre-alert system similar to the Emergency Medical Services (EMS) used in the USA, allowing seamless connectivity between first responders and hospitals (Faudere et al., 2018).

In addition to having a dedicated line for a pre-alert system, hospitals should have dedicated audio-visual resources - computer systems, mobiles, and video-conferencing resources - enabling and connecting EDs in real-time to first responders and specialists. Such connectivity requires telecommunications infrastructure to be relied upon for real-time data transfer and encryption to ensure privacy and confidentiality. Based on the interview findings, the UAE already has a 5G infrastructure network (which can reduce data latency and ensure real-time data sharing, and VoIP that allows for encryption and privacy). However, the coverage is patchy in some remote areas. This gap needs to be addressed before a large-scale nationwide tele-emergency framework can be implemented.

Telecom infrastructure.

Telecom and ICT are closely associated and should be considered holistically because they complement each other. A country cannot have an extensively upgraded ICT infrastructure without having a suitable and compatible telecommunications infrastructure (Thapa, 2012). The availability of high-speed telecom in terms of mobile connectivity, broadband speed, and connectivity is essential for real-time data sharing, facilitating first responders, ambulances, EDs, CCC processes, and healthcare-related operations (Aziz et al., 2016). The country already has 4G and 5G networks, providing greater security, connectivity, speed, bandwidth, and encryption for data sharing in real-time. However, such connectivity needs to be available uniformly across all regions of the UAE to be effective for the proposed tele-emergency framework, especially in remote and rural regions. This area was pointed out during the interviews, warranting immediate attention if a nationwide and integrated tele-emergency framework is operational.

Related issues that may hinder effective tele-emergency delivery concern data security and latency, which are closely related to the speed and bandwidth of the telecommunication systems (Ma et al., 2017). A telecom system with high speed and bandwidth, which provides encrypted and real-time data transfer, is required to support the communication and data-sharing processes of the proposed tele-emergency systems (Mahmeen et al., 2021). The literature indicated that most tele-emergency frameworks, either large-scale or single-ED based, were developed in the context of countries that already had well-developed telecommunications frameworks. There were no issues revealed during the interviews regarding the status of telecommunications in the UAE, indicating that the UAE already acquires solid and advanced telecom systems in general.

Finally, it is evident that the desired level of connectivity and data sharing are ensured for the proposed tele-emergency framework to be functional. A closely related aspect to the availability of hardware and software underpinning ICT and telecom operations is the availability of single Health Information Systems (HIS) in the country and an HIE that could provide a seamless transfer of patient records across the country. This is further discussed in the next section.

HIE and medical devices.

There are already three large-scale HIEs available in the UAE: Malaffi in Abu Dhabi, operated by DOH; NABIDH in Dubai, operated by DHA; and Riayati for the Northern Emirates, operated by MOHAP. However, as per the interview findings, these three HIEs are bound to their geographic regions and do not connect, which defeats the purpose of having an HIE that serves the entire nation and can support CCC's processes related to accessing and sharing patients' data across EDs and remote specialists in real-time. The tele-emergency frameworks that were studied (Appendix E) were restricted to a single province - the Gansu Province in China (Cai et al., 2016), a single State - California, USA (Petter & Fruhling, 2011), and small regions within countries such as Greece (Nikolaidis, Efthymiadis, & Angelidis, 2019) or Guatemala (Martínez-Fernández et al., 2015) that did not have a federal system, and hence did not face jurisdictional issues related to data sharing. In the context of the UAE, a standardised and interoperable HIE is suggested for the UAE nationwide, where medical records can be retrieved in real-time from any hospital at any time by CCC-authorised personnel. Although the technicalities of interoperability are not the focus of this study, it is appropriate to mention that interoperability standards are a necessity for data sharing, seamless flow, consistency, quality, and efficiency (Garza et al., 2021). Standards such as HL7 (Health Level Seven), FHIR (Fast Healthcare Interoperability Resources), and GraphQL combined, have proven to be efficient, cost-effective, scalable, and flexible to meet web and mobile requirements (Mukhiya et al., 2019). HL7 and FHIR support the REST (Representational State Transfer) architecture and SOA (Service-oriented Architecture) for seamless information exchange and are the international healthcare information exchange standard (Garza et al., 2021; Mukhiya et al., 2019). GraphQL is a query language developed by Facebook that provides promising techniques to overcome issues associated with REST (Mukhiya et al., 2019).

Therefore, in this proposed tele-emergency framework and operations, the CCC can connect to the HIE to retrieve patients' records from any hospital (government or private) across any Emirate, based on the patient-identification data input from the emergency scene medical responders. Having access to patient records across the Emirates would enable the CCC to use relevant or specific details to develop the PC and triage to enable better decision-making. Besides, such a unified and standardised HIE can also allow remote specialists to access and update patient records with current incident details, prescriptions, and follow-up data. This seamless exchange of medical data is necessary for the successful functioning of the proposed tele-emergency framework.

It is suggested that a uniform and standardised platform be used for a nationwide HIE to ensure connectivity and interoperability (Mukhiya et al., 2019; Yaraghi, 2015). For example, the UAE can develop a federated database system, a meta-database management system that allows exchanging records maintained individually by different hospitals, consequently providing virtual access to information to authorised personnel. The interviews also suggested capturing, updating, and uploading data into a consolidated HIS directly through the IoT connected patient monitors (Kashani et al., 2021), thus effectively enabling first responders and ED processes. IoT is a network where physical devices and gadgets are connected through sensors, medical equipment, and software applications. These devices can exchange data over the internet without human input (Mavrogiorgouet al., 2019). IoT is already operational in several industries, and it is expected to grow to a network of 22 billion devices by 2025 (Moustafa et al., 2016). Therefore, IoT has a transformational potential in healthcare, where remote monitoring of patients can be undertaken through medical monitoring devices connected to hospital servers over IoT (Amira et al., 2019).

In addition to the directly captured vital signs data, the current condition of the patient, the patient's symptoms, and any procedures administered by first responders or ER physicians are added manually to update the medical records in the HIS. At this point, provisions should be made so that data can be automatically and continuously captured from various touchpoints - from the patient's physician, the diagnostic reports, any tests undertaken (directly from the lab), procedures conducted, drugs administered, or prescriptions by ER staff.

An app may be suitable for the first responders to connect with the CCC to enable data collection and communication. This app can be used in parallel to the IoT-enabled connectivity between the medical monitoring devices and the ambulances, which can directly relay patient data to the CCC, independent of the first responder app. However, the first responder app would act as a backup device and enable responders to ask additional questions or connect directly with assigned EDs or remote specialists. It is also possible that a version of the app can be used directly by the end consumer (pre-emergency patient) to connect with the CCC and request the aid of a first responder or be connected to specialists. This app should have a user-friendly interface that allows patients to get assistance and pre-emergency care. Such an app has been studied in the literature as a Therap-e app (Ambroise et al., 2019), allowing the public (potential patients) to connect to EDs directly. Therefore, a similar app is recommended for the proposed framework but refined. Based on the interview insights, it is suggested that the CCC oversees and manages all the tele-emergency operations.

For security, transparency, and accountability reasons, the communications through an app between hospitals (the ED with the patient and the hospital with the specialist) should be conducted through the intranet or a dedicated internal application suited to the local networking and security needs. The specialists are to be provided with access to the patients' records, current vital signs through the app, and conduct tele-intervention as guided instructions to the point-of-care paramedic to intervene, possibly even through robotic interventions, if applicable.

This app will be functional on mobile and desktop devices and connected with video-conferencing tools. The technology is already available to develop such an app, but it must be connected to a single cloud-based healthcare platform. The suggested app will facilitate communications and information sharing between the stakeholders, subject to the CCC providing the decision-making support and assigning the ED or the specialist to the case. Several app-based telemedicine programs are available and operational in the UAE, notably during and post-COVID era. However, these apps offer extremely limited services and do not provide the type of access to and from the HIE that is envisaged for the proposed tele-emergency framework. Nonetheless, the literature review presented the e-Rés@MONT platform in the Italian healthcare setting, which allowed nurses in high altitude locations to transfer patient data back to hospitals in Aosta, which was diagnosed by medical experts and formed the basis for further action, for instance, point-of-care treatment or transportation to the hospital (Martinelli et al., 2020). A similar communication platform between the first responders and the CCC, which can be operable by trained first respondents, should be developed for the UAE.

Additionally, from the literature review, an MSHA-based tele-monitoring system using body-sensor devices (Salman et al., 2014) was found to be suitable for this proposed framework. This could include a basic monitoring device, a simple fitness tracker or a particular monitor for pre-existing condition patients. The collected data will then be used with the data retrieved from the HIE before making decisions or developing the PC, a basic sub-process associated with the CCC's triage operations. This combined influx of information, directly from the sensors and complemented by the patient's chronological medical records, will aid in better decision-making inputs for the CCC, which can then use the algorithm-supported decision-support system to guide the processes of the first responders or the remote ER specialists (Salman et al., 2014). This will form the decision-support system for the CCC, where triage decisions are delivered, and further courses of action are directed. Still, the interviews revealed extensive usage of fitness trackers among the UAE population. There appears to be scope for utilising such routine fitness trackers for medical monitoring (provided the data storage and sharing protocols are standardised and devices are interoperable with the first responder systems and the EDs' ICT and platforms). Therefore, the proposed tele-emergency framework recommends integrating personal fitness tracking and analytic devices within emergency care services. However, patients with pre-existing chronic conditions can wear specialist monitoring devices.

Much of these processes, of retrieval of records through the HIE and collection of live data from sensors, need to be funnelled through algorithms to generate PC and triage-related information. This has already been successfully implemented in simulated tele-emergency frameworks by Salman et al. (2014), and the current framework should emulate the machine learning and AI-based algorithm platforms. Therefore, with triage decisions, creating the PC, and assigning EDs and ER specialists, algorithms with minimum human involvement will function efficiently.

Such an MSHA-based tele-monitoring system that directly draws data from the patient and connects to health records from the unified HIE should be operated within strict privacy and confidentiality protocols. The HIE should have an in-built mechanism to safeguard patient records and ensure only authorised access for approved purposes. To ensure technical security of data, protocols such as encryption, firewalls, control access, user ID/passwords, use of Privacy Enhancing Technology (PET) will be considered for this proposed framework (Kruse et al., 2017).

Finally, the CCC must maintain complete transparency regarding the accessing personnel, the purpose of access, and the location of access. This level of transparency will be assured by using the Blockchain technology within the platform, which is increasingly finding applications in healthcare technologies. Blockchain is a record or a chain of transactions that are immutable, tamper-proof, and stored in shared ledgers that are accessible to all (Nofer et al., 2017). This basic conceptualisation of Blockchain manifests in advantages such as the impossibility of tampering with records, a transparent chain of command and accountability, and complete transparency in operations. Blockchain technology also ensures verification and authentication for EHR/HIE access, thus protecting the privacy and confidentiality of patient data (Nofer et al., 2017).

The above section provided a greater understanding of technology's role in implementing a nationwide tele-emergency framework in the UAE. Taking the Heeks (2002) model forward, the next section will discuss changes in people skills and competencies.

7.5 People

A large-scale nationwide tele-emergency framework involving coordination between CCCs across different Emirates and operations that span the country's boundaries will have extensive and diverse staffing requirements. From hiring to training and performance management, the management of people will be bound by applicable laws and involve a conducive operational environment. This section is focused on discussing the regulations (or the lack of them) around the management of first responders, specialists, and other professionals involved in the tele-emergency framework. The section will then discuss the new requirements and provide recommendations to improve the operational framework for the effective and efficient performance of human resources involved in delivering emergency care.

Table 7.4

People Dimension: Themes

Change Dimensions	**Environments**	
	Regulatory	**Operational**
People	– Coordination and management of emergency personnel – Licensing – Hiring and training governing laws – Unified Performance Standards	– First responders' management and role enhancement – Skill Gaps and Training – Other Healthcare Professionals

7.5.1 Regulatory environment.

The regulatory environment for managing human resources (People – healthcare professionals) involved in the tele-emergency delivery should consider the labour laws and their applicability in the healthcare sector within the UAE. Essentially, the processes related to first responders, ED physicians, nurses, and specialists can only be undertaken within a regulatory framework that defines the standards for hiring and training, the scope of their jobs, authorisations for the performance of procedures, and standards of performance.

Coordination and management of emergency personnel.

NCEMA is positioned centrally as the coordinator and manager of any emergency, disaster, or crisis. Although the role is defined generically in the UAE, no systematic course of action or steps is mentioned for tele-emergency care. For a nationwide tele-emergency framework to be operational, explicit regulations, process documentation, and protocols are required to guide the assignment of roles and responsibilities during an emergency, as well as ensure that a structured chain of command is followed to deliver emergency care effectively. There are no explicit federal-level regulations for hiring, certifying, or training healthcare professionals such as first responders and allied health professionals. A lack of such laws makes it challenging to perform the first responders, hospital, and specialist management processes effectively.

Licensing.

The interviews revealed differences in the licensing requirements in different Emirates, making it challenging for healthcare professionals (specialists, first responders, and nurses) to provide services online or otherwise in the Emirate other than where their licenses were issued. Federal Law No. 5 of 2019 on the Regulation of the Practice of the Human Medicine Profession (Ministry of Health and Prevention, 2019c) does not cover healthcare professionals' licensing other than physicians. A nationwide uniformity of licensing healthcare professionals is a prerequisite for this proposed tele-emergency framework.

Hiring and training governing laws.

Laws governing the hiring and training of healthcare professionals, specifically for technology-enabled tele-emergency care delivery, need to be revised and expanded since no such framework exists in the country. In the context of first responders, the interviews revealed that their role was limited due to a lack of authorisation to administer medication and a lack of standardised emergency protocols. However, the UAE has various certifications and short courses that can qualify candidates as first responders, and a few colleges offer a diploma or a graduate course for paramedics. For example, Dubai Women College offers a 4-year Paramedic Course in the UAE that only intakes female students (HCT - Dubai Women's College, 2021), and Khawarizmi International College offers a Bachelor of Science in Emergency Medical Care (Khawarizmi International College, 2021). The National Ambulance Services in Abu Dhabi provides training and certification for first responders in collaboration with the University of Sharjah (Sebugwaawo, 2017). While DCAS provides their paramedics' certification and training, DHA provides their own training and certifications (Dubai Health Authority, 2017). This is where further process documentation and procedures need to be developed to provide first responders with adequate training and authorisation to perform their duties adequately. Currently, there appears to be no federal law that defines the rules or responsibilities of first responders, resulting in, as highlighted in the interviews, first responders being relegated to the task of being transporters of patients. Further enhancements are still required to develop standard operating procedures and define training needs for first responders.

Unified performance standards.

Regarding performance standards, the CCC should monitor the first responders' response time as a performance objective. The time taken from the first call to providing the first response should be calculated, along with the time taken to deliver the necessary emergency care, either at the scene or after transfer to the suitable ED. Finally, specific first responder performance standards and benchmarks need to be developed using variables such as the patient's location, the distance between the ED and the patient's location, the patient's condition, and the necessary time to stabilise the patient for transportation.

Currently, the country has one generic code of conduct that applies to all healthcare professionals and is regulated by MOHAP (Ministry of Health and Prevention, 2019c). Yet, each Emirate or region is regulated by their own healthcare regulations. For example, DHA has their health regulation confined to Dubai and DOH has their health regulations confined within the Emirate of Abu Dhabi (Department of Health - Abu Dhabi, 2020b; Dubai Health Authority, 2017). Therefore, explicit codes of conduct, best practices, and benchmarks must be formulated that relate to first responders and other healthcare professionals involved in delivering emergency healthcare.

Similarly, the participants highlighted that since many different agencies were currently involved in the emergency operations (police department, fire department, ambulance services, and/or first responders), which led to conflicts in the chain of command and probably costly delays, there is a need to develop specific protocols guiding the chain of command in emergency operations by having the Emirate-level CCC as the central authority that could coordinate and effectively direct first responders, ambulance services, firefighters, and police departments.

With standardised laws supporting the hiring, training, and overall management of staff and roles and responsibilities, the operational aspects related to people can be well-developed, which are discussed next in the following section.

7.5.2 Operational environment.

One of the themes that emerged from the interviews was the importance of first responders, their roles and contribution to tele-emergency services in the UAE and the barriers or challenges faced. While this study focused on the scope of technology-enablement of first responders, additional related insights were obtained around the training of first responders and their management. This section highlights the insights obtained from the interviews that are applicable in refining and suggesting a tele-emergency framework for the UAE while at the same time maintaining the technological perspective.

First responders' management and role enhancement.

Paramedics or first responders are the front-line healthcare professionals that form the first contact with the patient at the emergency scene. In this respect, it is suggested that first responders' command be placed in control of the CCC within that Emirate or region. Further, it is recommended that first responders have a direct line of communication with the CCC. The interviews indicated that in the UAE, while first responders are trained paramedics, they are primarily considered transporters of emergency cases from the emergency scene to the nearest ED. This understanding of first responders' role in tele-emergency delivery is limiting. This research suggests an expanded and more contributing role of first responders in the proposed tele-emergency framework. There is a need to expand first responders' roles beyond mere transporters of patients by having first responders trained and equipped to take decisions at emergency locations.

Skill gaps and training.

First responders must be qualified and trained to intervene and stabilise the patient's condition immediately. An essential part of the tele-emergency front-line protocols is identifying patients and retrieving their medical records. First responders can use devices that read the patient's Emirates Identity (EID) cards, conduct retinal scans, facial recognition, and/or fingerprint scanning (if the patient is not carrying their EID, unconscious, or unable to communicate). While a part of this enablement plan is necessary to provide first responders with the authorisation to administer medication and implement emergency protocols (discussed above in the regulatory section), this study suggests providing technology-related training for first responders. Therefore, further training in effectively utilising and applying medical monitoring devices, IoT, and ambulance communication systems is needed. Additional training is also necessary for first responders to accurately obtain, document, and communicate patient data to the CCC through the effective use of technology to establish communication lines with remote specialists or EDs. Therefore, first responders should have the technological and technical capability to effectively use audio-visual, scanning, and medical devices to communicate during operations. Nonetheless, first responders should be trained to follow the PC-based recommendations for medical interventions through the guidance of the connected remote specialist or transporting patients to EDs. Toward this, first responders must be certified, trained, and qualified to administer first aid adequately.

Other healthcare professionals.

A discussion regarding a nationwide tele-emergency framework would be incomplete without analysing the required specialist human resources to support such a large-scale framework. While the literature review did not specifically mention any study that explored or evaluated resources to support tele-emergency services, a summary of such resources could be established based on their references in studies regarding the theme of tele-emergency frameworks and interview evidence. For example, most of the literature reviewed frameworks focused on emergency specialities such as emergency maxillofacial surgery (Ambroise et al., 2019), psychiatric emergencies (Southard, Neufeld, & Laws, 2014), and strokes and cardiology (Bagot et al., 2018). Some of the frameworks also mentioned the importance of trained nurses and other healthcare professionals and the need to support tele-emergency operations with policies and protocols that provide legal protection to hospitals while conforming to the privacy and confidentiality regulations of the land (Cai et al., 2016; Nikolaidis et al., 2019) (Appendix E).

Similar findings came from the interviews within the context of the UAE. For example, the interviewees mentioned that EDs often shied away from accepting patients due to the non-availability of specialists. This meant that the patients were forced to travel long distances to reach the required specialists. EDs in the UAE do not get traffic regularly because patients do not attend EDs unless an emergency arises. According to the interviewees, hospitals do not provide more than the basic resources since EDs remain mostly idle. This tendency of patients not presenting to EDs, instead of going directly to the specialists if they can expend the time and cost, means that the EDs do not operate at their optimum capacity and resources are not utilised cost-effectively. The situation reduces the motivation of the hospitals' management to invest additional resources into their EDs (Natafgi et al., 2018), which may backfire when there is a severe emergency or a pandemic breakout, which overwhelms EDs that are ill-prepared to receive the load. This proposed tele-emergency framework suggests that EDs act as hubs for pre-empting traumas and emergencies, where patients can be presented even before an absolute life-threatening emergency occurs, and where patients can get connected or directed to specialists. In this proposed tele-emergency framework, EDs are not required to have resident specialists in all specialities; instead, they need to be connected to specialists from across the UAE or even internationally through the CCC.

Similarly, the UAE does not have enough nurses or nurse practitioners to perform simple procedures and deliver minor emergency care at a much lower cost compared to trained physicians. More specifically, and according to the interviews conducted, the UAE currently does not have a position for nurse practitioners or physician assistants, the reason being both social and financial. Both social and financial parameters that can impede or facilitate a successful implementation of such a proposed framework are beyond the scope of this research. However, for a large-scale tele-emergency framework to be operational with the desired level of integration and connectivity, the contribution of additional healthcare professionals is required. In addition to having basic medical training, these healthcare professionals should also be trained in decision-making, operating medical devices, managing ICT, and utilising communications and data sharing equipment.

7.6 Blueprint for the Tele-Emergency Framework

This section builds upon and consolidates the research findings to develop a framework based on the literature review and interview findings. The success of any large-scale nationwide technology-based tele-emergency framework will depend substantially on the availability of ICT and telecom infrastructure. The framework will also require modern medical equipment and devices to provide interoperability and monitoring capabilities connected to the health record systems through a uniform HIE. Such a framework will be dependent on the availability of skilled, fully trained, and empowered first responders, and will require the healthcare system to be equipped with additional resources such as, but not limited to, a variety of specialists and hospitals with functional pre-alert systems. The main recommendations are summarised below in Table 7.5.

Table 7.5

Blueprint for Tele-emergency Framework: Recommended Actions

Change Dimensions	Environments	
	Regulatory	**Operational**
Processes	– Licensing of specialists extended across the Emirates to participate in tele-emergency services. – Laws governing the allocation of roles and responsibilities at each stage of the tele-emergency delivery framework need to be developed. – Process documentation and standardisation need to be developed, and protocols for Process Audits enacted. – Service Level Agreements and related documentations need to be prepared to support the functioning of the tele-emergency framework.	– An Emirate-level CCC acts as a hub for data and information sharing and communications between all stakeholders (first responders, EDs, specialists, and authorities). – CCC receives the first information call, and coordinates the dispatch of emergency services. – First responders use Emirates ID cards, medical monitoring devices, and personal observations to feed the CCC, which receives the data through the MSHA network. – CCC uses AI-based algorithms to generate a PC, which leads to selecting the ED and a pre-alert sent to the designated ED. – The CCC connects first responders to EDs or remote specialists throughout the patient transfer process over an app, enabling continuous monitoring and real-time data sharing on the patients' condition.

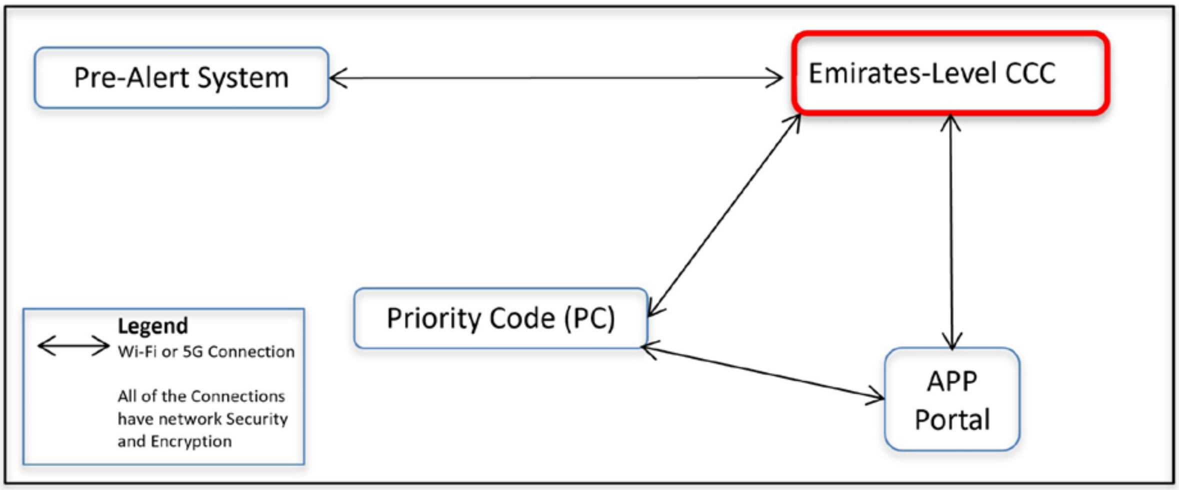
Technology	– Federal Law No. 2 of 2019 that guides ICT Laws must be updated to ensure seamless connectivity. – Telecom Laws, enabling encryption of data and ensuring zero latency. – Federal Laws, not Local Laws. – Explicit and well-defined Laws governing the categorisation and use of Medical Devices. Federal Law No. 4 needs to be updated with adequate provisions for IoT connected devices and MSHA networks. – Emirate-level Federal and Uniform Laws for HIE, data transfer, data storage. – Laws that allow data sharing within different Emirates and with offshore specialists.	– Integrated cloud-based platforms, preferably blockchain-based, providing real-time connectivity, continuity, interoperability, and scalability for a uniform ICT network in the country. – AI-based decision support systems for triage and assigning cases to EDs. – High-speed broadband with zero latency and complete encryption. – More sophisticated medical devices that can operate with IoT and integrate with data analytics systems and MSHA networks. – Central HIE that connects with any HIS across any Emirate.
People	– Nationwide uniform laws governing licensing, hiring, and training of healthcare professionals. – Laws to provide authorisation to first responders to administer medication at emergency scenes. – Laws to hire and manage nurse practitioners and other allied health practitioners.	– Provide training and authorisation to First Responders to deliver emergency services. – Additional specialities added to EDs. – Roles created for allied health practitioners, assistant doctors, and nurses. – Training in operating technology, using IoT, ICT, and medical devices provided to first responders and allied health practitioners.

The critical components of the framework are developed based on the themes drawn from the findings and consolidated with the insights gained from the literature review. Further, the Heeks (2002) technology deployment model-based analysis of the change dimensions of processes, technology, and people within the regulatory and operational environments enabled the conceptualisation of essential technology-enabled elements of the blueprint, namely, CCC, HIE, hospitals and HIS, first responders, healthcare professionals, medical devices and software, and infrastructure. These elements are discussed in-depth in the following sections and are later combined to deliver the diagrammatic representation of the complete blueprint of the tele-emergency framework for the UAE presented in Figure 7.11. The following figures, 7.5 to 7.10, represent the main elements of the tele-emergency framework. The connections in the figures represent secured Wi-Fi and 5G connections that allow for encrypted data exchange. Each element is briefly illustrated with its connections and finally combined to present the main framework depicted in Figure 7.11, which is the ultimate aim of this research.

7.6.1 Emirate-level Central Command Centre (CCC).

Figure 7.5

Central Command Centre (CCC) Connections within the Macro-Framework



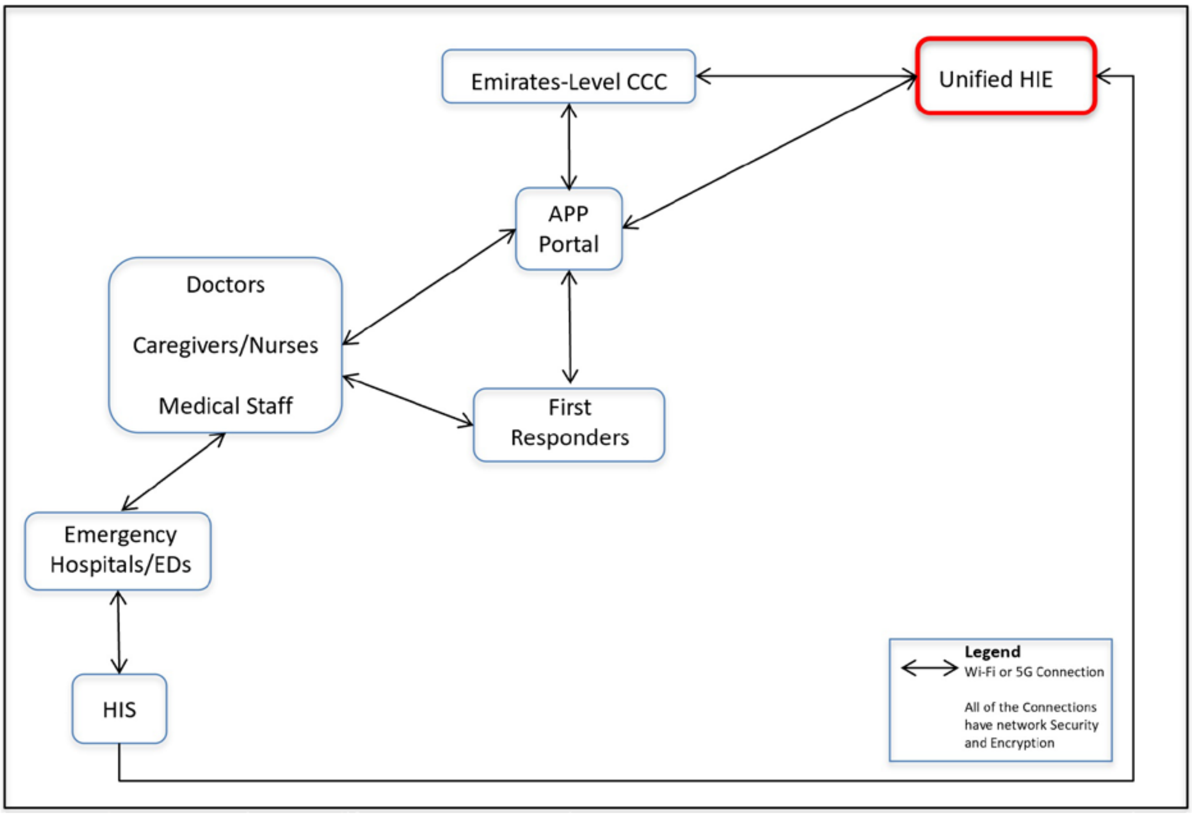
A central hub is proposed in this framework based on Lu et al. (2013) and Lee et al. (2013). To enable the enhanced functioning of the entire framework, not one CCC but multiple CCCs, located in different Emirates are deployed and connected. Establishing connected CCCs at the Emirate levels can help implement a strategic outlook for the nationwide tele-emergency care delivery process. Such CCCs will continue to reflect the federal nature of the country, while ensuring complete transparency and connectivity across the nation. These individual CCCs will have interoperable systems that have access to each other's databases, connected monitoring devices, EDs, and specialists.

Emirate-level CCCs will reduce bureaucratic barriers and ensure better management of the tele-emergency care delivery within each Emirate. These CCCs will be connected to facilitate data sharing and medical records retrieval, as and when needed. The Emirate-level CCCs will be similar in most aspects, except being more contextually located while retaining the healthcare system's federal nature while providing seamless connectivity. The emergency calls are directed to the local CCC to determine the future course of action and direct the required emergency procedures. For example, at the CCC level, algorithm-based decision-making will develop the Priority Code (PC), considering the location proximity, type of emergency, bed and specialist availability, patients' current condition, and patient's medical records (that can be accessed through their Emirates ID primarily, or with the multiple PIS means discussed earlier). The PC recommends guidance to the first responders, either to administer intervention at the scene or transport to the ED that is already alerted through the pre-alert system by the CCC.

7.6.2 HIE.

Figure 7.6

Unified HIE Connections within the Macro-Framework

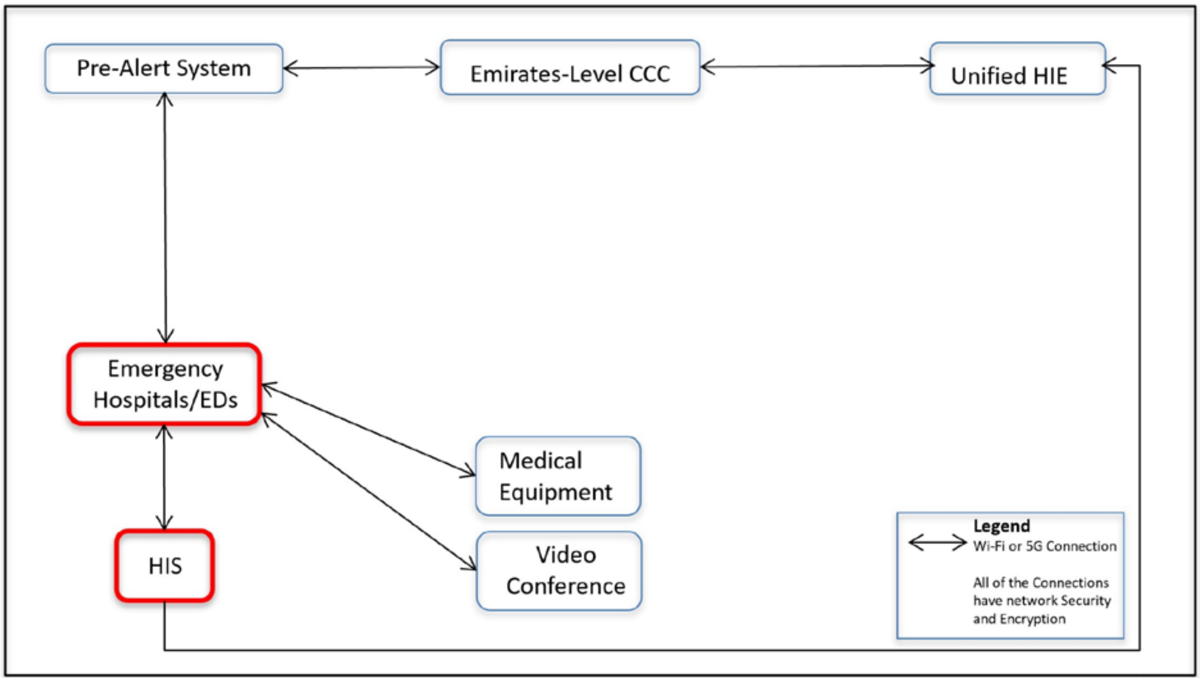


The country will have a central HIE, and for all emergency-care related operations, the CCC will facilitate access to the HIE to the concerned stakeholders such as first responders, ER physicians, specialists, and medical staff. The HIE will be constructed to allow the CCC in one Emirate to access the health records stored in the Health Information System (HIS) of any hospital in any Emirate. Such connectivity offered by a centralised HIE will facilitate efficient tele-emergency operations across the country. Also, the authorisation caveat built in the technology and managed at the CCC level will ensure the traceability of all exchanges and prevent any data breach or confidentiality issues. Further, the identification of patients and retrieval of their medical history will be made in real-time, resulting in more targeted and accurate delivery of emergency care.

7.6.3 Hospitals and HIS.

Figure 7.7

Emergency Hospitals and HIS Connections within the Macro-Framework

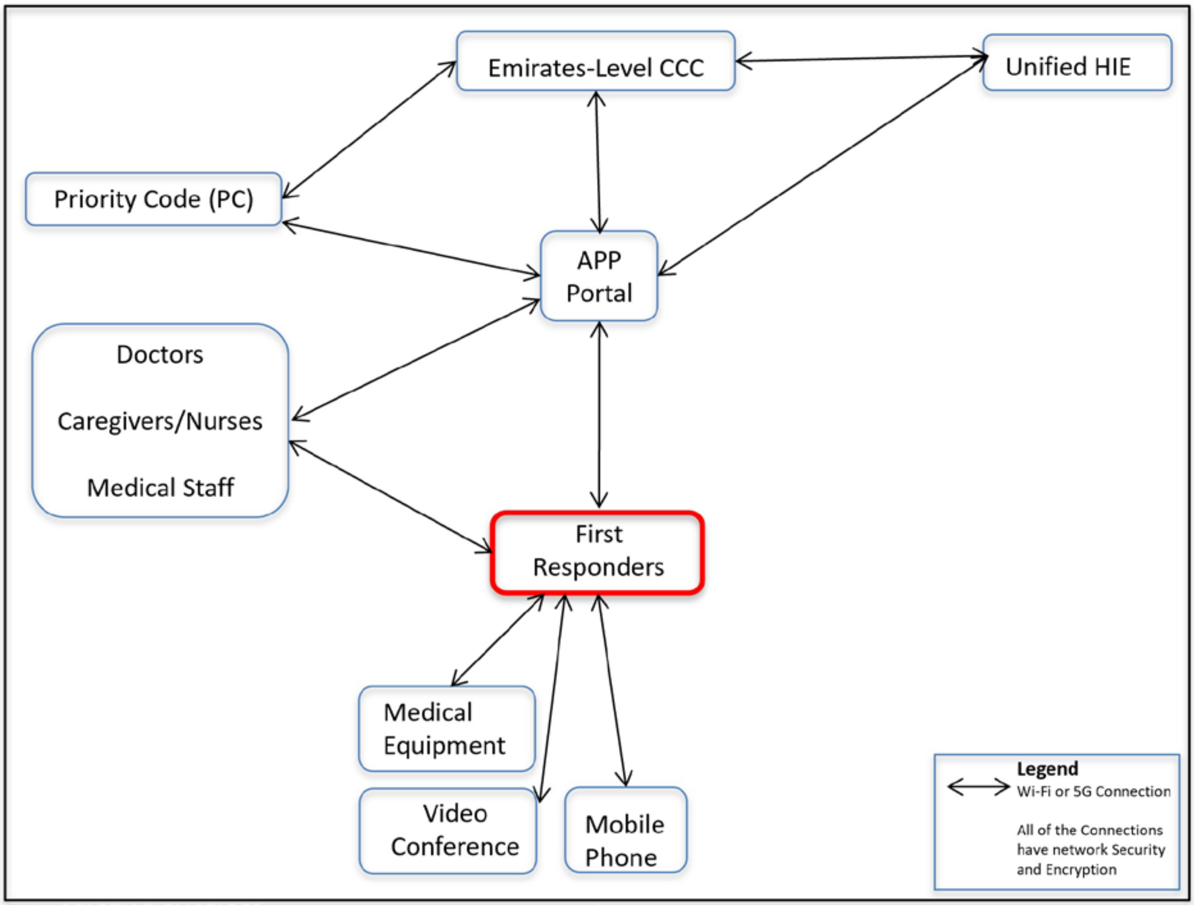


Hospitals in the UAE do not have well-functioning pre-alert systems that could efficiently enable tele-emergency services, which is a gap in the country's current emergency healthcare delivery system. Therefore, the proposed framework will upgrade and provide separate telecommunications bandwidths between hospitals and CCCs to ensure better and uninterrupted connectivity. Additionally, hospitals will have adequate resources represented by beds, medical equipment, audio-video capabilities, and connect their HIS to the centralised HIE.

7.6.4 First responders.

Figure 7.8

First Responders Connections within the Macro-Framework

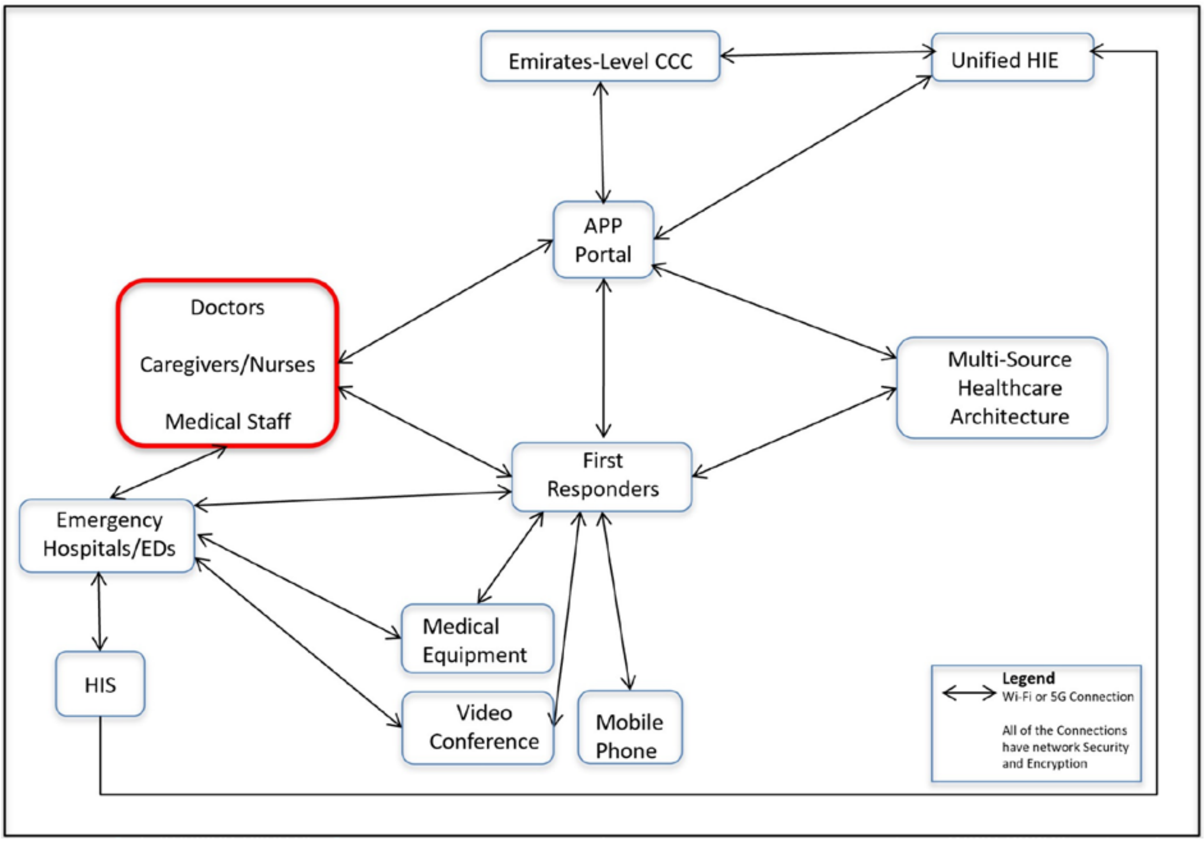


At the point-of-care, which is often a remote location only accessed by first responders, the role of the first responders becomes crucial. Most of the frameworks studied in the literature review did not highlight the importance of first responders. Yet, the interview findings emphasised their roles as front-line emergency care providers in the UAE. While some literature is dedicated to the specific functions of first responders in emergencies (but not in the context of large-scale tele-emergency frameworks), such literature or knowledge is not available regarding the UAE healthcare services. The interviews revealed that first responders or paramedics in the UAE are predominantly seen as transporters rather than first-line caregivers. Therefore, first responders will be integrated into this proposed tele-emergency framework due to their importance. Nonetheless, first responders will be fully trained and equipped with monitoring and medical devices that are interoperable with ambulances (cars, vans, and helicopters) and connected to servers at the CCCs. Finally, first responders will be empowered and have the authority to administer first-aid procedures at the point of care, with the guidance and permission of remote ED physicians or connected specialists.

7.6.5 Healthcare professionals.

Figure 7.9

Medical Staff Connections within the Macro-Framework

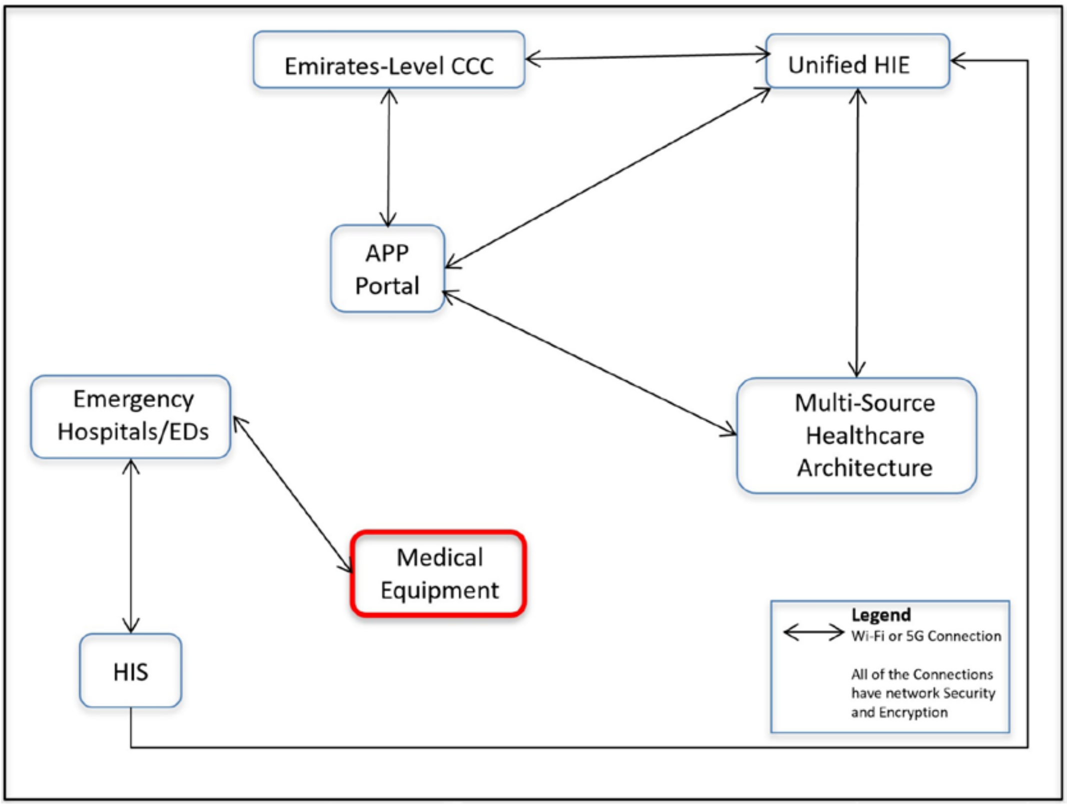


The interviews indicated a lack of specialists at EDs, which will be overcome by connecting EDs with specialists externally. Consequently, specialists will be authorised to access patients' medical records through the HIE, subject to approvals from the CCC and receive real-time data on the current vital signals captured through medical devices and relayed by first responders and ER physicians. Therefore, specialists can provide tele-intervention in the form of guided instructions to the point-of-care first responders or ER physicians.

7.6.6 Medical devices.

Figure 7.10

Medical Equipment Connections within the Macro-Framework



The literature review assessed simulation-tested theoretical frameworks (Salman et al., 2014) that provided insights concerning micro-monitoring patients and pooling data from mobile patients outside of hospitals or EDs, and even in pre-emergency conditions. This aspect will continue to be included in this blueprint, where monitoring is undertaken only through specialist monitoring devices for patients with pre-conditions. This blueprint of the framework uses simpler tracking devices, such as regular fitness trackers or specialist trackers for patients with known risks and pre-conditions, which continuously records vital signs. According to the interview findings, such fitness trackers are already extensively used in the country, and there is scope for deploying such data from trackers in the healthcare system in a more formal capacity. However, there is a need to enforce, strengthen, and standardise regulations related to data storage and sharing protocols; plus, the devices are interoperable with ambulances, hospital HISs, and platforms. Therefore, this tele-emergency framework will integrate personal fitness tracking and analytic devices within emergency care services and platforms, subject to medical protocols and laws initiated through this framework.

7.6.7 Software and infrastructure.

Monitoring and medical devices, body sensors, and fitness trackers will be integrated into the first responders' platforms by retrieving and collating data to and from the unified HIE. These devices will be connected through the IoT to ambulances to facilitate a seamless data transfer and retrieval between tracking/monitoring devices and the first responder platform. Consequently, as suggested earlier, PIS will retrieve patient records stored in the HIS to support decision-making. Patient identification is facilitated through automatic card readers or biometric identification devices that first responders possess. This level of identification requires seamless connectivity to the HIS from different regions and Emirates, facilitated through independent CCCs. Therefore, this framework suggests that unified, standardised, and enforced protocols and laws should be developed for the UAE regarding sharing medical information across private and public hospitals. Nevertheless, physical and software upgrades are essential to ensure that databases are connected, and systems are integrated and interoperable.

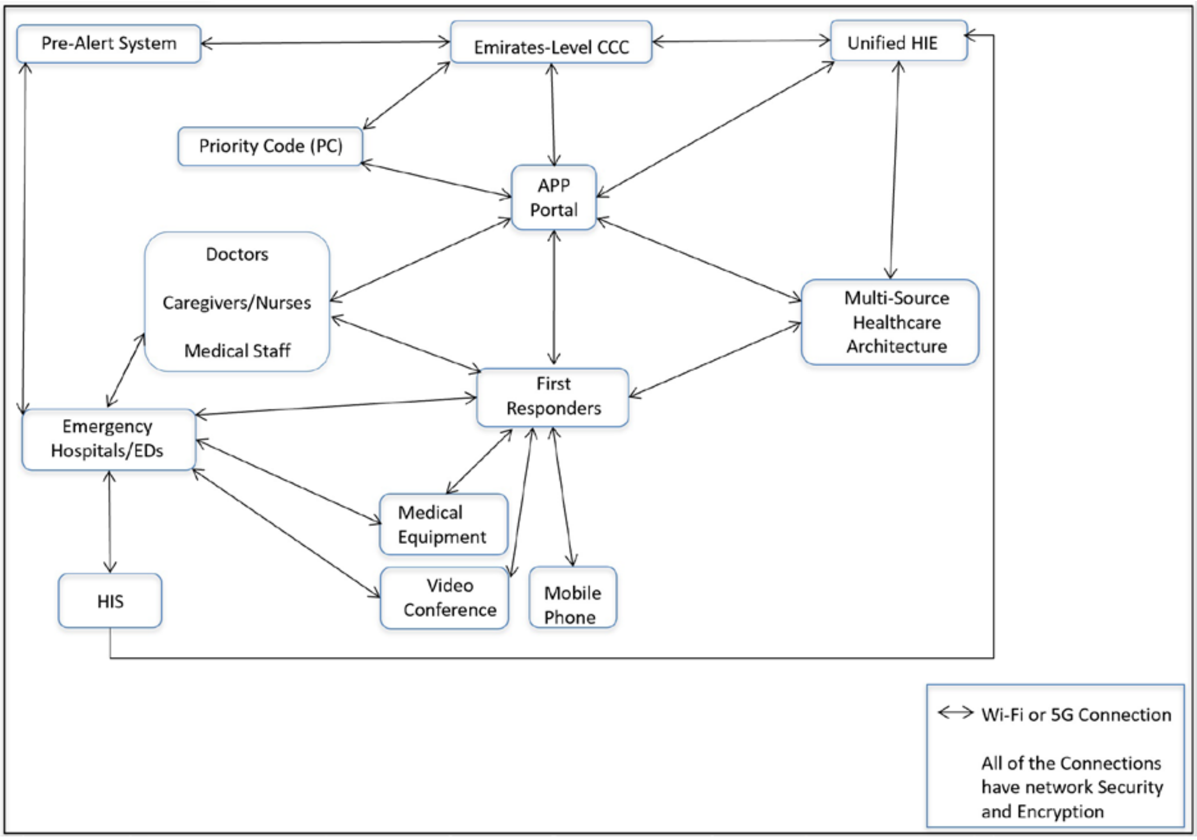
The software will establish connectivity between CCCs and hospitals; and between specialists, EDs, and first responders. To this end, this study initially suggested using an app similar to the Therap-e (Ambroise et al., 2019); however, the app was confined to managing the connectivity between remote specialists and patients only. Therefore, in addition to an app similar to the Therap-e app, direct communication lines will be established between the concerned parties (ED with the patient and the hospital with the specialist). These communication lines are based on an intranet connection or a dedicated application that hospitals will utilise. At this point, data is automatically and continuously captured from various touchpoints - from sensors, diagnosis reports, tests conducted (from the lab), procedures performed (at the emergency scene), drugs administered, and prescriptions. This diverse and rich data source is captured and streamed into the patients' updated HIS using an MSHA that enables pooling and collating real-time gathered data and integrating such data into the patient's health records. Such an architecture will collect data consisting of, but not limited to, vital signs, inputs by first responders, and the patient's medical records through the HIE into a single stream. This combined influx of information - directly from the sensors and complemented by the patient's medical records, is utilised by the CCCs to develop the PC, aiding accurate decision-making. Then, the CCC issues directions to first responders, send alerts to the identified ED, and shares information with the appropriate specialist (Salman et al., 2014). This amalgamation of data will enable decision-making and aid the tele-emergency service delivery process (tele-triage, an offshoot from tele-emergency) by identifying the type of emergency and the specific specialities required to deliver the appropriate care.

Lastly, the country already possesses state-of-the-art ICT and telecommunications technologies but requires integration to establish connectivity and interoperability across the Emirates. Technology must retain network security, encryption, and data protection through authorised access for such seamless integration. While the 5G network provides real-time data transmission and reduces any latency concerns related to medical errors in the delivery of tele-emergency care, encryption will ensure that patients' personal and medical data are protected and not accessible to any third party. Additional network security will also lead to traceability and enhanced accountability, thus reducing the chances of malpractice or medical liability.

Figure 7.11 combines all of the essential technology-enabled elements of the blueprint, discussed in Figures 7.5 to 7.10, namely, CCC, HIE, hospitals and HIS, first responders, healthcare professionals, medical devices, and software and infrastructure. This diagram represents the ultimate aim of this research of presenting a complete blueprint of the tele-emergency framework for the UAE, represented by Figure 7.11.

Figure 7.11

Technology-based Tele-Emergency Framework

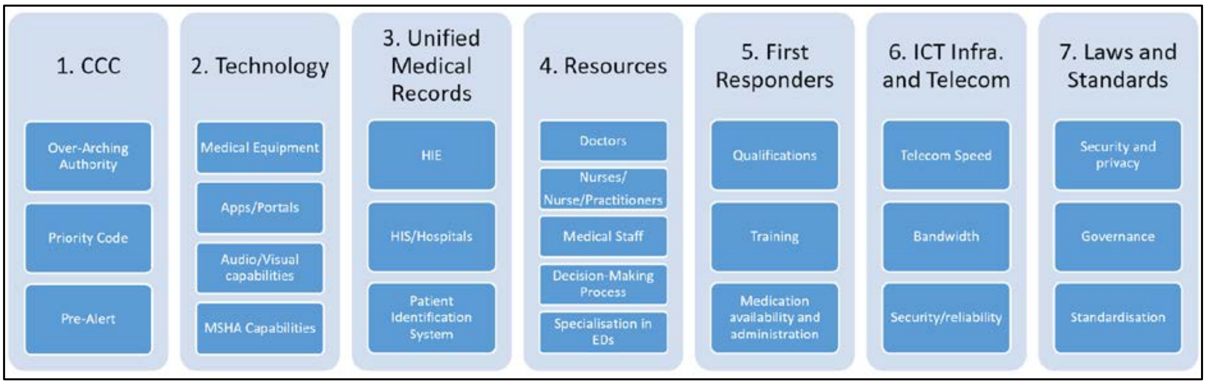


7.7 Outcomes

This section discusses the research outcomes based on the literature review, interviews conducted, and application of the Heeks (2002) technology deployment model. The main outcomes identified seven blueprint elements of tele-emergency, which form the basis of the proposed blueprint framework presented in Figure 7.12 below:

Figure 7.12

Tele-Emergency Blueprint Elements



After conducting an extensive literature review and interviews with healthcare professionals within the UAE, the outcomes suggest that a CCC will be a critical central element in this new tele-emergency framework, supporting operations in the form of monitoring medical devices and equipment, audio-visual capabilities, data streaming architecture such as MSHA, and medical apps. Two of the other blueprint elements have technology infrastructure capabilities regarding ICT and telecom, and unified medical records. These capabilities are prerequisites for real-time data capturing, sharing, processing, and decision-making capabilities. The research indicated the importance of resources represented by specialists, nurses, doctors, and first responders, which are also vital for the tele-emergency blueprint proposed by this research. Finally, the research emphasised the importance of laws and standards as the final element for supporting the nationwide tele-emergency framework.

However, there are limitations regarding connectivity, interoperability, and technology integration across the Emirates, which creates a barrier to implementing a unified tele-emergency framework. More specifically, the UAE’s current ICT and network infrastructure lacks interoperability, which makes it challenging to scale up and implement a unified tele-emergency operations framework for the entire country. The current ICT technology can provide benefits such as privacy, security, and traceability, but lacks connectivity due to the different platforms and resources used by other Emirates, including jurisdictional and policy-level challenges. The current ICT and network infrastructure of the UAE need to be re-aligned, focusing on harnessing the potential to support a scalable, private and secure, traceable, and interoperable system of tele-emergency healthcare.

It is also evident that although the UAE population already uses fitness trackers extensively, these fitness trackers are not used for medical purposes. However, the data can be utilised for medical monitoring purposes, especially for patients with pre-conditions. The interviewees cited confidentiality and privacy issues as barriers to adopting such medical sensors, which this new framework addresses. The lack of integration of patients’ medical records in a unified standard or unified HIE system leads to further limitations, such as the reduced utility and scope of monitoring devices. If required, the data relayed from monitoring devices may be recorded and stored within a specific geographic jurisdiction to share across the Emirates. There is already an availability of emerging technology-based medical equipment, sensors, and devices that can be enlisted as part of the tele-emergency healthcare system in the UAE.

The proposed tele-emergency framework encourages the process of policy-making and the development of a regulatory framework; hence, medical devices, sensors, and monitoring devices can have enhanced connectivity, interoperability, and access to a uniform HIE. The framework encourages the UAE population to participate in this nationwide health monitoring program. The public (end-user) would receive official and authenticated medical alerts and timely recommendations regarding pre-emergency care and general medical guidance through their fitness trackers.

Finally, as discussed earlier, the UAE had three separate HIE databases that integrated and exchanged medical records within confined geographical and jurisdictional limitations. A unified HIE is required (one of the three HIEs can become the focal point) to support the complex routing (ED selection, location proximity, generating priority codes, bed availability, availability of specialities/specialists, and resources requirements) and data-sharing requirements; to ensure patient identification and medical-records retrieval is performed in real-time. This proposed tele-emergency framework emphasises the integration of technology platforms to enable a unified HIE system for the nation. It is hoped that the framework will enforce policy changes to overcome jurisdictional issues that would otherwise limit the full integration of the nation's medical record management system.

7.8 Summary

This chapter presented a blueprint for a new nationwide tele-emergency framework, using insights gained from the interviews and the context provided by the literature review. The Heeks (2002) technology deployment model was used to develop the blueprint, using three dimensions of change – processes, technology, and people, and assessing and evaluating these dimensions within the context of the regulatory and operational environments of the UAE as it relates to the healthcare sector. The chapter presented each dimension of change and recommended the changes required in the regulatory and operational environments to facilitate the implementation and adoption of the tele-emergency framework. The chapter ended by presenting a detailed overview of the elements included in the final blueprint, their interplay with each other, and the overall functioning of the tele-emergency system proposed by this research.

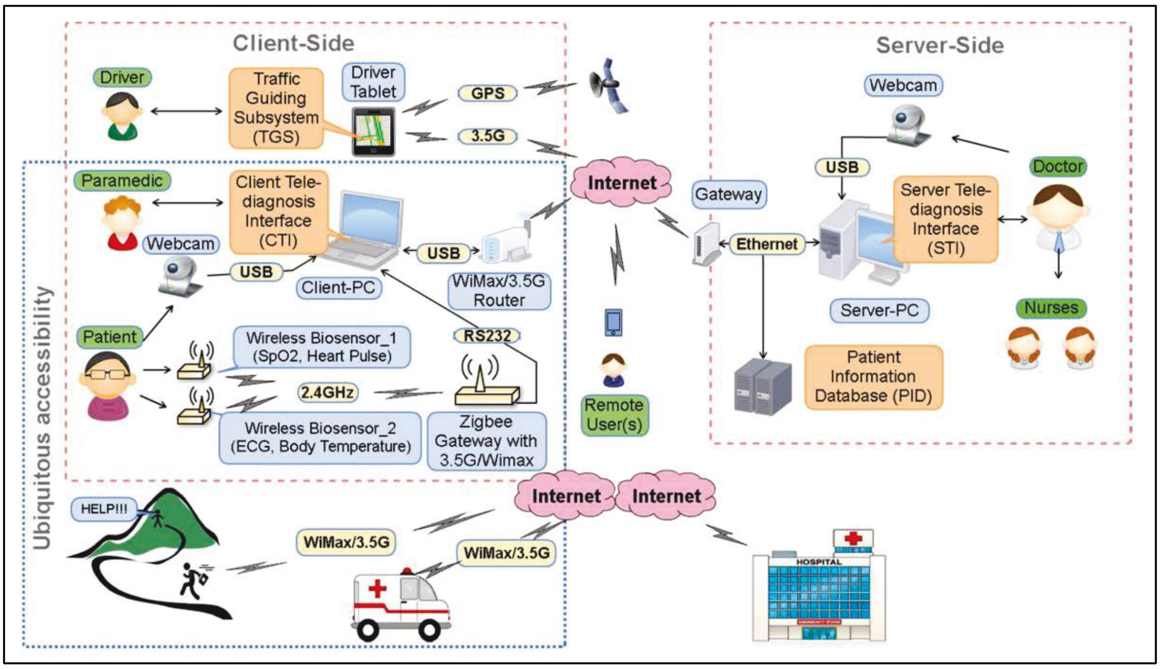
CHAPTER EIGHT: EVALUATION OF THE FRAMEWORK

8.1 Introduction

This chapter evaluates the technology-based tele-emergency framework presented in chapter 7 (Figure 7.11), henceforth called the UAE framework, against the frameworks detailed in Appendix E. In particular, this chapter uses the Ubiquitous Emergency Medical Service (UEMS) system (Tan et al., 2017) and the Telemedicine Framework for EMS and 911 organizations (Federal Interagency Committee on EMS, 2021) to analyse the UAE framework. The development of the UAE framework blueprint elements are also mapped back to the interview findings to illustrate how the UAE framework builds upon the interviewed stakeholders' suggestions and ideas. Finally, the UAE framework cannot be implemented without the recommended action list in Table 7.5 (chapter 7). Therefore, the main actions are also mapped against the Telemedicine Framework for EMS and 911 organizations and suggestions from the interview material. The chapter comprises three main mapping and comparison exercises contained in the following three chapter sections. The first two sections focus on alignment with the UEMS framework: Client-side operations and Server-side operations. The third section concerns the main elements of the recommended actions list (Table 7.5 in chapter 7); which focuses on laws and policies and is the implementation catalyst for the successful implementation of the proposed UAE framework.

Figure 8.1

Ubiquitous Emergency Medical Service System



Note. From "Ubiquitous Emergency Medical Service System Based on Wireless Biosensors, Traffic Information, and Wireless Communication Technologies: Development and Evaluation," by Tan, T., Gochoo, M., Chen, Y., Hu, J., Chiang, J., Chang, C., Lee, M., Hsu, Y., Hsu, J. *Sensors* 17(12): 202.

The UEMS system by Tan et al. (2017) is based upon a tele-emergency framework that is predominantly developed for reducing response times of ambulances and paramedics in emergencies, ultimately increasing the first aid quality, resulting in better outcomes and lives saved. The UEMS framework deploys WiMax technology to retrieve patient data from health records, relay patients' vital statistics, and connect remotely with healthcare specialists in ERs. The UEMS framework is similar in several aspects to the UAE framework in terms of the Client-side operations and the Server-side operations. Additionally, many features incorporated in the UAE framework are aligned with the suggestions made by the Federal Interagency Committee on Emergency Medical Services (FICEMS) framework. These are discussed in more detail below.

8.2 Client-side Operations

8.2.1 Emergency calls and pre-alert systems.

The Client-side operations evidenced within the UEMS framework begin with an emergency call to the hospital, dispatching an ambulance with paramedics, biosensors, and WiMax technology or facilitating direct communications between the doctors at the hospital and the paramedics in the ambulance. A similar approach is suggested for the UAE framework, except that the calls are routed through the CCC (discussed further in the Server-side operations section), an operational requirement supported by the interview participants. For example, P7 had mentioned the need to unify emergency operations so that a central call centre could handle all incoming emergency calls, and then direct them to the relevant agencies, "*basically, it was ERs from Dubai Ambulance and from DHA, were located in an operation room, OCC Operation Command Center in DHA and they could actually visually communicate with the ambulance vehicle.*" Also, P3 stated, "*Right now the pre-alert system in the UAE, I don't know how it works with national ambulance and government facilities, but the pre-alert system is more or less nonexistent, which is a problem.*" This suggests using a pre-alert system at the hospitals to ensure that the nearest hospital can be alerted over a dedicated line or pre-alert platform. As such, the UAE framework proposed a pre-alert system within the hospitals to prepare for receiving patients with their updated medical conditions.

8.2.2 Ambulances, sensors and first responders.

The UEMS framework proposes using wireless biosensors for retrieving patient information on the Client-side. Similarly, the UAE framework also used similar monitoring and sensing devices, based on the work of Salman et al. (2014), which suggested body sensor data is transmitted using the MSHA architecture and Chakraborty et al. (2013), who suggested using Wireless Body Area Network (WBAN) to transfer data to the telemedicine hub. Additionally, the UEMS framework allows for the connection and communication between the healthcare providers at the ER and the paramedics, facilitating emergency healthcare delivery while the patient is in transit. Although the UAE framework also allows such connectivity, it goes beyond simple monitoring and delivery of tele-emergency first aid; the UAE framework added Priority Codes (PC), also proposed by Salman et al. (2014), which uses AI and Machine Learning to generate PCs. Further, MSHA is used within the UAE framework to pool data from multiple sources. This data is then used to generate information on the necessary course of action for the patient in the form of a PC. Although Salman et al. (2014) used PCs to support the delivery of emergency care, their framework did not discuss the algorithm that may be used for generating and assigning PCs. This gap was addressed in the interview findings, when P7 stated, "*having this decision, an algorithm in the framework, we could actually allocate our resources in a more efficient way*", suggesting using an algorithm-based initial diagnostics and planning of a further course of action and more efficient resource allocation. Consequently, the UAE framework proposed using an algorithm for generating PCs. The use of PCs ensures that preliminary triage can be performed at the emergency scene (where first responders attend to the patient). Therefore, EDs and specialists can be set in motion while the patient is in transit and have a severity score as suggested by P3 "*as I said, I would like to see more algorithms, automated process, for instance for an EWS score, severity score, for how acute the patient is.*" The UEMS framework proposes a similar mechanism for providing relevant data to doctors for decision-making while the patients are in transit, but without any algorithm-based PC generation. Also, in the literature, some tele-emergency frameworks have suggested triage once the patient arrives at the ED (for example, Greenwald et al., 2017a; Greenwald et al., 2017b; Sharma et al., 2017; see Appendix E), or through a nurse stationed remotely (Bhandari et al., 2011). However, by using PC codes generated automatically much earlier on, the UAE framework can save time and become crucial in delivering the optimum emergency care to patients.

Tan et al. (2017) highlighted the role of first responders and the need to equip them with adequate training to deliver pre-hospital treatment, which is also highlighted in the UAE framework. The idea of Community Facilitators (CFs) from Martínez-Fernández et al. (2015), where the CFs used cell phones, solar panels, batteries, and external microphones and speakers for audio-conferencing to connect to the remote telemedicine centre and log patient information, was deployed in the UAE Framework. However, the UAE framework suggested an expanded role of first responders equipped with the requisite skills to use biosensors and transmit and retrieve data accurately. Most reviewed frameworks did not explicitly cite the first responders' role. So, most of the suggestions regarding the scope and role of first responders for the UAE framework were derived from the interview findings. For example, the UAE lacked adequately trained first responders. The first responders' role was fairly limited to patient transportation; as stated by P3, "*they are glorified porters. They have a degree of medical training, but I've seen the limitation of the paramedics here*". Additionally, P8 stated that "*frankly speaking, they're not technologists. They're really paramedics, so that's all. Their training is very paramedic lead training, they are not technology lead people, so their education has to have a very high component of technology.*" Therefore, based on the experience and suggestions provided by the participants, the UAE framework provides for an expanded scope for first responders, ensures their proficiency in ICT usage and communications, and that they are skilled and authorised to provide the necessary and optimum care on the spot.

Furthermore, Tan et al. (2017) used a Client Tele-diagnosis Interface (CTI) installed on a portable client portable laptop that displays the patient's bio-signals, and real-time video is transmitted to the doctors, guiding first responders during the emergency care delivery. Similarly, the UAE framework provides a more dynamic application that operates as an interface for all stakeholders to send and receive information. This application is based on the Therap-e app from Ambroise et al. (2019), which provides an interface between patients and remote physicians. The Therap-e app had the additional characteristic of being linked to the EHR and updating the patient's records as the diagnosis and treatment progressed. The UAE framework added a specification to the app - to access patient records from the HIE (discussed in the Server-side operations section), allowing only authorised access to data on a need basis through the CCC. In addition, P11 noted "*so for the patient to be transferred it takes time, so we should have a big triage unit that basically the paramedics and emergency response staff as soon as that patient is put in a transfer vehicle, a physician or a medical team are already accessing their data and telling the paramedics what should happen in real-time. It has to be in real-time*". Therefore, in the UAE framework, the app allowed first responders to provide their inputs and observations while enabling the monitoring devices to relay data to remote healthcare providers through the interface. Finally, the remote specialists and the ED staff could access patients' data and records; and communicate over the proposed app.

8.2.3 EDs and remote specialists.

The UEMS framework connects emergency room doctors with patients through webcams and apps, with the primary objective of guiding point-of-care emergency responders. A similar approach was found in the frameworks reviewed (Appendix E). Emergency care support was delivered from doctors at the backend to first responders (Martínez-Fernández et al., 2015), or where ER physicians guided physicians in rural EDs (Cai et al., 2016). In other frameworks, patients in ERs were also connected with specialists in the same hospital or from remote locations (Ambroise et al., 2019; Greenwald et al., 2017a; Greenwald, Stern, Clark, Hsu, & Sharma, 2017b; Sharma et al., 2017; Izzo et al., 2018; Southard, Neufeld, & Laws, 2014). A similar approach was adopted for the UAE framework but with further enhancements based on the suggestions of this research's participants. For example, P30 stated that there was a need for more specialities in EDs in the UAE, "f*or example, toxicology. It's one of the major sub-specialities that we have deficiencies in the region,*" and P1 elaborated on the request of "*emergency care clinical expertise, expert advice in real-time from remotely available sub-specialists internationally*". The UAE framework proposed this solution but with caution. The UAE framework proposed this connection through the CCC as a command centre, providing connections to specialists from across the globe to EDs and first responders, should the need arise for such specialities.

8.3 Server-side Operations

On the Server-side of operations, the UEMS framework suggests operations such as accessing patient records, utilising a diagnostic decision-making system, and delivering healthcare online (Tan et al., 2017). While these operations are proposed in the UAE framework, additional provisions are developed using the participants' suggestions as guidelines due to the complexities of the context of the UAE, and the aim of this research of developing nationwide operations through the UAE framework.

8.3.1 HIE.

The UEMS framework provides access to patient records to physicians and first responders through a patient information database for decision-making (Tan et al., 2017). Similarly, the FICEMS framework proposes the integration of EHRs and electronic Patient Care Records (ePCR) and collaboration with HIEs (Federal Interagency Committee on EMS, 2021). A similar process is suggested in many of the reviewed frameworks (Appendix E). For example, Tchao et al.'s (2017) framework for the city of Kumasi under Ghana's Millennium Villages Project (MVP) employed a centralised HIS, while Bagot et al. (2008) used the Victorian Stroke Telemedicine (VST) program that allowed using connected HIS to get access to the health records in the framework that they used. Both these frameworks suggested using a system that could provide real-time access to patient records. However, several interviews suggested having a central HIE that can access data from diverse regions and simultaneously ensure that the data storage is kept at the local HIS level. P10 stated, "*when you talk about HIE health information exchange, … it should be at the national level, because you want to integrate everybody's electronic medical records, …, we need a central unified data models to be able to evaluate various things, whether it's emergency health for that particular person to be able to triage, or to analyse the health of the population overall.*" Similarly, P13 suggested having a centralised HIE that allows first responders and the medical staff to retrieve patient data, "*they (first responders) should be connected in the sense that they already have 'Wareed' (an* *electronic healthcare information system - HIS) and they would be able to deploy in these emergency departments under one dashboard or pipeline of Data Lake to allow emergency Departments to share and get data from and to the HIE.*"

8.3.2 Emirate-level CCCs.

The interview participants emphasised the need to manage emergency care operations in a centralised manner. Several diverse agencies were involved, and often there was a lack of clarity on the chain of command and workflow of rescue operations. For example, P7 stated that the first call was often made to the police department, "a*ctually, the workflow is a little bit complex because we don't handle the OCC (Operation Command Center) ourselves which is run by the Dubai police. And usually this is what happens if I call 999 or 998, the call would get to one of the call takers in the Dubai police OCC, the call taker is a police officer, he's not a paramedic or a dispatcher*". P7 further elaborated on the need for a central command centre where all emergency calls are received, and decisions are made based on embedded algorithms within the CCC platforms, "*actually, the perfect scenario would be to have an MPDS medical priority dispatch system. That would tell us in a systematic and scientific way based on an algorithm, a verified algorithm... We don't have this system as of now*". This request is aligned with the concept of telemedicine centres mentioned in Martínez-Fernández et al. (2015) and Cai et al. (2016), where all emergency care operations were facilitated through a central hub. Building upon the participants' suggestions, the concept of a Central Command Center (CCC) was introduced in the UAE framework. However, as highlighted by the majority of participants, there were several jurisdictional issues due to the federal nature of the country; and being mindful of these issues, the UAE framework suggests Emirate-level CCCs. The Emirate-level CCC would ideally be within the jurisdictions of the three health authorities of the UAE: MOHAP, DOH, and DHA. This results in three separate CCCs equipped with seamless connectivity amongst each other and connected to the central HIE proposed by the UAE framework. Additionally, the Emirate-level CCCs would be connected to all of the EDs within their jurisdiction to facilitate emergency care to patients.

8.4 Mapping the Main Recommended Actions

In addition to the operational elements, the UAE framework also needed to consider the legal and regulatory aspects of emergency healthcare delivery. The participants provided useful insights and suggestions that helped develop the suggestions listed in Table 7.5 in chapter 7. For example, according to the participants, specialists licensed in one Emirate were not currently allowed to operate in other Emirates, and this was rectified in the proposed blueprint that recommends using a country-wide licensing system for all healthcare professionals. According to P1, "*...the only thing that's available to us today, without having our US based* *doctors licensed in the UAE, the only thing that's available is to have gatekeeper positions in Dubai, who will accept the second opinions, or the expert advice that are rendered and they can share that with a patient here on the ground in the UAE.*"

Further, based on the interview findings, the country deployed diverse agencies in times of emergencies; laws must be enacted to specify and establish the specific chain of command, inter-agency communication and guidance, and direct the workflow during operations. According to P19*, "there's often a communication breakdown… the communication between them should be better… there may be an interim solution developed for emergency medicine, or other things we've talked about, bed numbers or ambulance availability, the staff availability, and which hospitals to transfer to… And it could be very useful if it was deployed to the right people and in the right location, to the right staff. To the people, it' so important that information is going to be available in the Eds, in the ICUs."* Additionally, P29 stated, *"the benefit of this one framework and comes together to form this framework, the standards and one system, because that will allow the resources to be used in a much more efficient way rather than duplicating for each different entity or Emirates or whatever.That will be a challenging task. But in terms of recommendations, I would say, one framework, one set of standards, one command, or one leadership, is what will be the key for this."* P2 complimented the idea, "*there should be a federal law, so through that law, it's should mention that you should have all access, the patients information, in order to treat him".* Such insights led to the development of the CCC, which could have the legal status of acting as the central authority in times of medical emergencies.

Regarding standards, the participants suggested developing process documentation and standard protocols, as well as service level agreements to support the UAE framework, as the current processes and procedures were found to be lacking in this aspect. According to P30, "*almost what's not written, what's not documented is not done. So that's why EMR (Arabic) to us is very, very important. (Arabic) But still, for example, in some procedures, there is some manual documentation. Still, we're trying to go electronic and digital, (Arabic) for example you have a store protocol, or you have - 3 - a checklist that is for stroke that you have to fill, (Arabic) even if you have an EMR, we are still required to fill it manually.*" This aspect was incorporated in the UAE framework and is also suggested by the FICEMS framework, where processes for changing standard operating procedures and clinical protocols (p. 16) must be initiated for telemedicine implementations. Equally important, in the context of technology, it is suggested that Federal Law No. 2 of 2019 is updated (in the recommended action list Table 7.5), based on the views of the majority of participants, so that the UAE framework can operate with complete connectivity and interoperability. Similarly, to improve telecom laws to support encryption and ensure that there is no latency in data transfer, P26 stated that there was a need to improve laws and develop a new entity to oversee the implementation, *"while today DOH had a lot of successes, that linkage among all four that sits above, and it's kind of like the States, we have federal laws but then we have state laws. But if you had that federal and if it's MOH, maybe it's about revamping what that sounds like. And you take talented people across from DHA, from DOH, all of whom you've selected because they had successes in the bits and pieces you're trying to put together for the country. So, for sure, MOH in the northern Emirates with MOPA, will have, what was great for MOPA for that area, Dubai with the economy, for them it's been about tourism, but everybody's got a little piece of what they're really good at and putting that together in a new entity.*" Based on the suggestions offered by the participants, the UAE framework proposes the development of a unified and strengthened Federal Law to govern the tele-emergency health care system in the country.

Also, since the UAE framework includes an extensive usage of medical equipment and devices, concerns around device efficacy and patient safety also need to be addressed. According to P12, "*OK, so the good news about equipment that we have only sole owner of the certification or compliance of medical devices, so it's not the DHA, not DOH, it's only MOH. So we have one focal point for this and I believe the challenge with that is mostly is that we don't have the calibre of people who really can vet those machines and making sure they are certified only from being faulty or non-faulty, but even from the security perspective for example. This is becoming very important because if you are attaching devices to people, those people will be vulnerable even for attacks or for cybersecurity attacks or whatever, so we have to make sure that whatever system we do, we need to vet it from the patient safety side, quality, and also from the security and privacy respect. So this maybe or could be one of the challenges and even also those applications that are controlling this, they also need to be vet from these angles; from security, privacy, and accuracy, and quality, but this requires processes policies, but even more important, people who are capable of doing that.*" Suggestions like the above led to the recommendation of explicit and well-defined Laws governing the categorisation and use of Medical Devices in the UAE framework. Similarly, according to P9, "*the challenge you have with emergency, this stuff can be life-threatening and there's a lot of legality, and there's a lot of personal culpability around this. So we were very hesitant, both us and the providers, to use it in an emergency setting because of the medical liability risk and the risk of the patient obviously, whereas you remove all the elements when it's scheduled, when it's a consultation, it's not ideal, but it's OK. So, you have to really think very carefully about this element as well.*"

Based on the arguments put forth in the interviews, the UAE framework is suggested to be accompanied by changes in Federal Law No. 4 with adequate provisions for IoT connected devices and MSHA networks and uniform laws to be developed to guide the sharing of data across HIE and data storage. For example, P16 opined "*IoT would require a completely* *different platform. So, you need to build an IoT platform where it can start connecting, maybe it's different devices, and you can use the same platform to connect ambulances moving around, …Then you talk about, what do I need to integrate with the medical equipment? Like those monitors that can transmit, the vitals, etc. And then you talk about the IoT, do you want to connect the cars as well? That's a different thing. That's beyond the connected car, the speed of the car, the emergency, the geolocation, there are many things that could be added.*"

Further, the UAE framework also requires laws to be developed to guide sharing of patient data with offshore specialists, "*so, I think the country wide, there needs to be policies in terms of storing and sharing patient health data. There needs to be standard, regardless of whether the information is collected in a hospital in Fujairah, or a clinic in Al Ain, or a hospital in Abu Dhabi, or Dubai, data,*" P29 and P22 added, "*the law is almost adjustable, (Arabic) I mean it's not written there forever, I'm sure it can be adaptable and adjustable over time, depending on the demands. How can we work around this ICT law is the challenge, how we can, (Arabic) I mean move telehealth beyond the borders. I actually had a talk a week ago with this regard, and how we can break through this ICT law and provide services to patients over the whole of Dubai, to the UAE, and extend beyond the walls of the UAE around the world…a lot of the facilities in general find this ICT law very challenging, because everybody wants to get out of that box. They want to broaden their perspectives of telehealth (Arabic) in the UAE.*"

Moreover, the interview participants mentioned the need to update the current status of hiring and licensing for healthcare professionals. For example, P1 stated that "w*e've been very basic in terms of EMT license, and then consultant physician, specialist physician, nurses: these are all major, general categories. Some providers, especially physicians, might be specialised, but their designation, their licenses are granted in essentially the same ways. We need a better spectrum, more differentiated spectrum, when it comes to these providers in order to achieve what you're talking about, which is those people having the right advanced skills. The knowledge and skillsets, not to mention the ICT and equipment, to take care of my heart attack right then and there in the air ambulance or in the mobile ambulance,so we're missing that*." A similar need is expressed in the FICEMS framework that suggests developing "*licensing, including recognition of specialised credentials (i.e., Community Paramedic-Certified (CP-C))*" (Federal Interagency Committee on EMS, 2021), for the effective performance of the telemedicine framework.

Consequently, the UAE framework recommends the introduction of those nationwide uniform laws governing licensing, hiring, and training of healthcare professionals be used. Also, since the participants had mentioned that the UAE lacked nurse practitioners, it is suggested by P26 that "*laws to hire and manage nurse practitioners and other allied health"* practitioners be enacted to support the UAE framework "*because they can do really great* *fundamental care and then you save your consultants for the really high acuity stuff*". Further, as mentioned earlier in this chapter, the first responders' role was reported to be limited, and suggestions were made to expand the scope of their contribution. To support this, additional laws were suggested by P29 to authorise first responders to administer medication at the point of location "*so, this comes into two things, the expertise of the paramedics is one and liability is another, but can he/she administer the medication if he gets authorised prescription to administer from a doctor through the telemedicine services*". P7 also emphasised the issue of administering medication by first responders by stating "*usually some of them are allowed to give very limited number of medications on site. It varies from Panadol injection, paracetamol to painkillers, stuff like that. But in general, all the controlled drugs are only administered by the ER.*"

8.5 Summary

This chapter compared the UAE framework developed in chapter 7, to the existing frameworks detailed in Appendix E, and in particular the UEMS framework, and the FICEMS framework. In addition, the UAE framework was also reviewed in the light of interview findings and mapped back to specific perspectives put forward by interviewees. The chapter discussed the main elements of the UAE framework and explained how the sources mentioned earlier helped develop a unique framework for the UAE in the context of tele-emergency, focusing on the technological implementation of the framework. This evaluation looked at the UAE framework from three analytical perspectives, the first two aligning with the UEMS framework by Tan et al. (2017): the Client-side of operations and the Server side of the operations. The last perspective involved mapping the FICEMS framework and the interview findings with the recommended action list presented in Table 7.5 in chapter 7. As a result, the output of the UAE framework was a distillation of existing frameworks (Appendix E) and interview evidence. The evaluation process involved a comparison of the UAE framework against two recently published frameworks of similar ilk, and a backward mapping to pertinent extracts from the interview material. It is believed and considered that this represents a viable and effective evaluation and validation process for the UAE framework.

CHAPTER NINE: CONCLUSION

9.1 Introduction

This study examined the status of the tele-emergency care system in the UAE and established a blueprint for developing and implementing a nationwide technology-based tele-emergency care delivery framework. The study is the first of its kind in the UAE because not only does this study employ an extensive review of the literature, but it also uses a constructionist paradigm to explore the current status of ICT, telecom, HIS and HIE, medical devices, healthcare professionals, resources, and laws and standards in the country. Additionally, the perspectives of healthcare professionals involved in healthcare delivery and policy framework development are considered to develop a roadmap for a technology-based nationwide tele-emergency framework. This chapter presents the conclusions drawn from this research and summarises the key themes that emerged in response to the research aims. Then, the chapter presents an overview of the study's contributions to knowledge and academic literature, and the managerial implications. Finally, the chapter discusses the limitations of the research and provides recommendations for future studies in this field.

Generally, this research has demonstrated numerous beneficial outcomes expected from implementing this proposed technology-based tele-emergency framework. In addition to enabling greater transparency and accountability in instilling higher efficiency in emergency care, this tele-emergency framework offers and encourages a preventative rather than a reactive approach to emergency management. By taking a proactive approach, the framework encourages EDs to invest in adequate resources such as equipment and beds; and will enable patients to connect with EDs for preliminary assessment or triage rather than turning directly to specialists. This technology-based framework will also ensure faster and more secure data sharing to specialists from emergency scenes and allow patients' EHR retrieval with faster and more efficient patient data processing, leading to more accurate data-driven decision-making. Such a technological framework will lead to the delivery of emergency care without loss of time, thus preventing the loss of lives. Since this proposed tele-emergency framework brings about complete digitalisation of all record-keeping and data management processes, it will enable research and analysis, and allow policymakers to develop more effective, evidence-based emergency protocols. Also, as a hopeful consequence, the technology-based tele-emergency framework will lead to greater effectiveness in healthcare management, leading to higher returns for insurance companies with enhanced premiums.

More importantly, a large-scale nationwide tele-emergency framework will be welcomed because such a framework will facilitate providing efficient care to patients across the country. This proposed framework will also benefit healthcare management professionals, empowering them to efficiently utilise triage resources, develop priority codes, and assign EDs and specialists cost-effectively. Furthermore, the remote nature of the service delivery, connecting online between medical professionals and patients, will reduce the costs of commuting involved in healthcare delivery (Natafgi et al., 2018). EDs' capability of connecting remotely with specialists can save costs of hiring specialists, and instead, utilise their services on a need basis.

By improving accountability and transparency, this technology-based tele-emergency framework will reduce risks related to medical liabilities. Consequently, the in-built provisions of traceability and accountability are expected to encourage healthcare professionals to perform at their optimum levels, with enhanced vigilance to reduce errors. Then again, using AI-based algorithms to support decisions will enhance the quality and effectiveness of medical decisions throughout the emergency care delivery process.

While the research had focused on the three objectives, the interviews revealed additional insights regarding first responders and the resources required. The proposed tele-emergency framework demands an enhanced role of first responders and requires further training and development. This leads to policy changes, where first responders are granted the authority to make decisions at emergency scenes, administer medications, and apply the approved protocols and procedures required to deliver care. Finally, in terms of resources, the framework will lead to an overhaul of pre-alert systems in hospitals, and improve the availability and allocation of beds, equipment, medical devices, telecommunication devices, and specialists.

9.2 Addressing the Research Objectives

This section focuses on addressing the specific objectives of this research and discusses the additional insights gained. This research developed a blueprint for a technology-based tele-emergency framework for improving access to emergency healthcare in the UAE. This overriding goal of the research was attained by exploring the current ICT, telecom, HIS and HIE, availability of medical devices, first responders and other resources, and the state of the overall emergency operations in the UAE. Finally, assessing any technology-related gaps that need to be addressed when developing a blueprint for a nationwide technology-based tele-emergency system. Therefore, the following research objectives guided the study and provided valuable insights to build the tele-emergency blueprint.

Objective 1: To explore the availability of emerging technology-based medical equipment, sensors, and devices that can be enlisted as part of the tele-emergency healthcare system in the UAE.

The overall aim of the research was to evaluate the scope and provide recommendations for the development of a nationwide technology-based tele-emergency framework for emergency healthcare provision in the UAE. One of the guiding aims was to assess the medical equipment, sensors, and devices that can form a part of the framework. The literature review indicated that IoT connected body sensors had been tested in simulated tele-emergency settings, which allowed patients to stay mobile while still connected to the backend monitoring databases. Such a framework, as yet, has not been developed or deployed in active healthcare systems. However, there is an increasing trend of collecting medical data through personal analytics devices such as Fitbit bracelets, Garmin watches, Apple watches, Galaxy watches, and Samsung watches.

The literature includes many frameworks showing how monitors and sensors are deployed in an emergency, either by first responders at emergency scenes or at EDs and healthcare facilities. It can be presumed that connected medical equipment and devices need to be an essential aspect of any framework blueprint proposed by this research. The interview findings confirmed this presumption, and a theme emerged that personal analytics devices were extensive in the country. However, those devices mainly were utilised for sports or recreational purposes rather than for health record keeping. This leaves scope for encouraging users and the public to start adopting personal monitoring devices connected to their health records in a central database, which can signal a warning to the CCC and EDs/specialists in emergencies. Nevertheless, first responders must be equipped with such devices to apply them to patients at emergency scenes and start relaying data through the CCC to EDs and specialists. To operate monitoring devices that are interactive and connected with a central HIE and patients' records, the country must have standardised and uniform laws and regulations regarding the functioning of such devices and equipment. Therefore, a theme related to the use of medical devices emerged involving the training of first responders and laws governing the management and practice to adequately use medical monitoring devices and relay the data accurately to the backend CCC and the EDs.

Objective 2: To evaluate the current Information and Communications Technology (ICT) and network infrastructure of the UAE, focusing on assessing its potential to support a scalable, private and secure, traceable, and interoperable system of tele-emergency healthcare.

The second aim of the research was to evaluate the country's ICT and telecom network infrastructure. These ICT and telecom infrastructure aspects are crucial and integral parts of tele-emergency frameworks reviewed in the literature and hence, were presumed to be important in the UAE context. The UAE already has an efficient and latest ICT infrastructure supporting the telecommunications infrastructure, equipped with high bandwidth internet and 5G connectivity. The UAE ICT infrastructure was secure, private, and traceable. However, a theme emerged from the interviews that the ICT infrastructure currently suffered from a lack of interoperability and was prone to loss of scalability, leading to a restricted operational environment. The underlying reasons for the current state were revealed in the interviews as operational, jurisdictional, and regulatory issues. Different hospitals and healthcare institutions adhered to different ICT platforms, which were secure but did not connect smoothly with other ICT systems in the country, leading to data sharing issues.

Similarly, independent decision-making processes regarding adopting different technology platforms were followed in different Emirates, making it challenging to have a single seamless ICT infrastructure. Hence, different Emirates adopted different ICT networking capabilities and followed different regulations and legal requirements. Thus there was a lack of technological interoperability between ICT infrastructures of hospitals across the Emirates. As a result, even within the individual Emirates, different hospitals, governmental and private, did not have interoperability within their ICT systems. This is a critical limitation pointed out by interview participants and should be rectified to ensure that nationwide emergency services can deliver tele-emergency services. Toward this, a standardised cloud-based ICT platform and telecom infrastructure are suggested in this proposed blueprint at the operational level, supported by uniform regulatory requirements throughout the country. Likewise, such a conceptualisation of a single, uniform, standardised, cloud-based ICT infrastructure would support the essential CCC and its operations, as proposed in this blueprint, to deliver emergency care to every corner of the country. CCCs require such a level of connectivity to collect data from EDs' resources databases (availability of beds, specialists, equipment, and other resources), first responders, MSHA (patient monitors, patient IDs, sensors), and HIE (to retrieve patient medical records). Such a complex influx of data can be collated to generate priority codes and provide directions to all stakeholders.

Objective 3: To explore the existing technology used for Healthcare Information Systems (HIS) and Health Information Exchanges (HIE)s in the UAE, focusing on evaluating them for integration across ERs (Emergency Rooms) in the country to create a comprehensive blueprint for a new tele-emergency framework for the UAE.

The literature reviewed on tele-emergency frameworks (Appendix E) showed several instances where a standardised and central HIE system connecting various hospitals in the network, supported large-scale tele-emergency frameworks. It is appropriate to presume that any large-scale tele-emergency framework that services a geographically diverse area should be supported by an HIE system that allows accessing and updating medical records in real-time. However, interview findings revealed a theme for the UAE, where hospitals had their own independent HIS, often not connected to other hospitals under the same chain of ownership or within the same Emirate. As a result, different hospitals lacked connectivity or interoperability across the Emirates due to a lack of technological compatibility of platforms and bureaucratic and jurisdictional issues. It was also found that there was a lack of interoperability between HISs within the same Emirate or the same hospital chain, which meant that usually, there was no way that data could be exchanged in real-time using electronic sources.

Hospitals continued to have legacy HIS systems in some branches or departments while upgrading others, which further reduced the chances of interoperability. The conditions culminated in the fact that manual retrieval of data was often needed, resulting in costly delays for patients and the cost of travel to and from the database location. In addition to the technological incompatibilities, further problems were faced in real-time data transfer due to the lack of standardised regulations around health data recording, storing, and sharing, making it complicated to access and relay patient information from one location to another. A theme emerged that indicated that a large-scale nationwide tele-emergency framework cannot optimally function with the status quo unless supported by a unified HIE. In the current situation, effective care delivery may not be delivered to cases where medical records of an emergency patient are located in a hospital's HIS located in a different Emirate from the emergency scene.

PIS was a closely associated sub-theme that emerged from the interview responses. Currently, nationals and residents of the UAE have the UAE national ID card. However, those national IDs are not linked with health records, although a ministerial decree had been issued for such a purpose (in fact, a precursor condition for linking ID cards with health records would be to already have a functional and centralised HIE system that enables such data access and retrieval across the country). These findings indicated a need for operational and regulatory environment changes, which are a significant part of the research findings. As suggested by the interviews, the country needed a centralised HIE system with seamless connectivity to all hospitals and healthcare facilities across the UAE to facilitate the transfer and retrieval of medical data during emergencies.

The research was successful in attaining the main three aims. Still, the research findings went beyond just achieving the pre-defined aims and contributed additional findings presented as themes in the previous chapters. For example, a theme that emerged during interviews was the limitations of the first responders' roles during emergency care delivery. First responders were not authorised to deliver on-the-spot emergency care other than enabling the stabilisation of patients for transportation purposes. The findings call for a re-thinking of the scope of the role of first responders, providing them with adequate authorisations and training and enabling first responders technologically.

Similarly, another theme indicated that EDs in the UAE might not be equipped or prepared with specialities, beds, nursing practitioners, or equipment to meet emergency requirements. The underlying reasons were rooted in the mindset that EDs were rarely utilised in pre-emergency or preventative capacity, as patients seemed to directly connect with specialists without going through a general physician or an ED, and as such, EDs did not perform at optimum capacity. According to the healthcare management of hospitals, any investment in EDs, which were not utilised at optimum capacity, was less than cost-effective from the financial point of view. So, to rectify this issue, this research suggests that hospitals' management and EDs' management be undertaken to ensure that an adequate number of beds, professionals, and equipment are available; and CCCs would verify the availability to manage the operations of directing patients to EDs.

9.3 Research Contribution

9.3.1 Academic knowledge.

Adopting a constructionist perspective to obtain answers to the research questions led to the generation of academically and practically valuable insights. In terms of the academic contribution, the research explored relationships between new variables, such as the background of healthcare professionals and the ease of using technology exhibited by them and their acceptance and adoption of a technology-based tele-emergency or telemedicine framework. The study yielded a rich source of primary data and information regarding the existing technology, the scope of scalability, traceability, security, privacy, and interoperability, which can be used as a starting point for numerous complementary and supplementary studies on the topic. The research also opened up the scope for further iterative research to refine the tele-emergency framework that this study proposed. In terms of managerial implications, practitioners in other countries or regions can adopt the research findings as a starting point for developing their own technology-enabled tele-emergency frameworks.

The literature review indicated that no previous research was conducted to propose a technology-based large-scale tele-emergency framework for the UAE. However, a paper proposes a tele-emergency framework from the policy and process perspective (Alloghani et al., 2015). While this research has benefited and derived conceptually from global tele-emergency frameworks, this research produces and presents a unique and eclectic amalgamation of literature to propose a blueprint adequately suited to the UAE.

Most of the previous work on tele-emergency frameworks has only focused on the operational perspective, without reference to technology models such as TOE or TAM – since these models are expected to inform only at the implementation and adoption phases of technology projects, not at the developmental phase. However, this research has used the Heeks

(2002) technology deployment model to provide a detailed analysis as the basis for the blueprint, using three dimensions of change: processes, technology, and people within the operational and regulatory environments of the UAE. The blueprint proposed in this study is adequately grounded and structured, providing substantive guidance for addressing gaps in the regulatory and operational environments to support the development of a nationwide technology-based tele-emergency framework for the UAE. This research provides an example for other scholars to adopt a similarly structured healthcare framework for developing technological solutions in other contexts. Finally, earlier studies have worked on organisational level technological implementations in healthcare, and this study is unique in providing a nationwide perspective on a technology-based tele-emergency framework.

9.3.2 Managerial practice.

While this research focused on developing and proposing a technology-based blueprint for a practically functioning and implementable tele-emergency framework that can deliver emergency care nationwide, it also discussed processes and people as integral elements of success in technology implementation. As a result, this research provides insights into the organisational structures, command structures related to first responders, and communication structures related to data sharing for tele-emergency delivery, which need to be developed and fine-tuned to support the proposed large-scale technological changes. Additionally, this research provides insights concerning first responders' training and enhances the scope of their roles in the tele-emergency delivery system. Finally, this research revealed gaps in the country's regulatory environment that need to be addressed; this has provided valuable insights and guidance for policymakers to enable a more facilitating regulatory and legal environment for the tele-emergency care framework.

9.4 Research Limitations

The research was undertaken within the context of the UAE, a federal country with seven distinctly different Emirates. In terms of healthcare practices, the country is divided into three segregated authorities, namely, Abu Dhabi (managed by DOH), Dubai (managed by DHA), and the Northern Emirates (managed by MOHAP and MOPA). The three distinct geographical healthcare jurisdictions differ in their medical practice laws and technological adoption of healthcare systems. The country is also socio-culturally diverse, with urban centres and rural areas. This study's findings are expected to apply to similar socio-cultural and geographically diverse countries, but with caution regarding the role performed by government structures in the healthcare system. However, since the research aimed to evaluate the existing operational and regulatory environments of the UAE to propose a blueprint for a UAE-wide tele-emergency care delivery framework, the generalisability of findings to other contexts was not the prime focus.

Another limitation of this research may have been that most interviews were conducted virtually due to the COVID-19 pandemic. So, the benefits of personal interactions and cues such as body language and other non-verbal cues were lost, which are primarily useful in qualitative research. However, the researcher recorded the interviews with the participants' consent. Hence, these interviews were meticulously transcribed without lag time to ensure that the researcher could also record and recollect any additional thoughts or impressions that may have been noticed during the interviews. Furthermore, the researcher initiated follow-ups to clarify doubts and include as much context and detail in the transcriptions. Additionally, interviewees inevitably leaned towards their experience and speciality to some extent. For example, medical professionals focused more on the medical practices and protocols that needed to be implemented than the technological solutions that could primarily improve visibility and save time regarding the patient record retrieval process. The healthcare IT experts focused on the framework's technical aspects, i.e., standardisation and data residency issues. Although this might seem restrictive, putting the views of experts and stakeholders together yielded valuable insights that contributed to the development of the proposed framework. On another note, a few participants refrained from answering what they considered sensitive topics. For example, the intricacies of the different operating models within the three major healthcare authorities within the UAE. However, the research into the central theme of HIE, which is linked to the sensitivities of the three authorities, was not compromised. Some of the discussions were very cautious and neutral. Since the target was to engage the participants and ease the discussions, the researcher probed with a different question that the participant leaned towards and was willing and comfortable to provide a more in-depth analysis for.

Finally, a further limitation of this research is that it only included healthcare professionals and policymakers within the healthcare sector and excluded end-users (patients) - nationals, residents, and visitors. The reason is that the end user's perspective is vital to developing a service delivery module, and as such, the research acknowledges that this was a limitation that can be addressed in future research.

9.5 Future Research

Recommendations for future research follow from acknowledging the limitations of the current research. Future research could usefully include the end-user perspective. End-users could be selected randomly, with an appropriate sample size representing the country's diversity. Future research could also be conducted using quantitative methods through surveys to have a more significant and representative sample of end-users of tele-emergency care.

A random sample of healthcare professionals (using a database of hospitals and healthcare management institutions from across the country) could also be used in future research. By random selection of participants from across the country, it is likely that even more diversified opinions and insights may emerge, further enriching the blueprint of the tele-emergency framework proposed in this study.

For a large-scale nationwide tele-emergency framework to be functional, additional aspects such as healthcare systems' organisation and structural frameworks, management control systems and structures, leadership and socio-cultural aspects of technology adoption, financial implications of implementing tele-emergency across the UAE – should also be explored. Future research is recommended to explore these non-technological aspects of the healthcare system to explore gaps and suggest changes that may be desirable to support the effective delivery of tele-emergency using the blueprint framework put forth in this study. Finally, the UAE is ethnically and culturally diverse, with substantial differences between regions' demographic and economic profiles. Socio-cultural focused research is needed to provide a holistic perspective on the barriers and challenges while reconciling the country to a unified and standardised system of tele-emergency healthcare delivery.

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Appendices

Appendix A - Paradigm Simulations

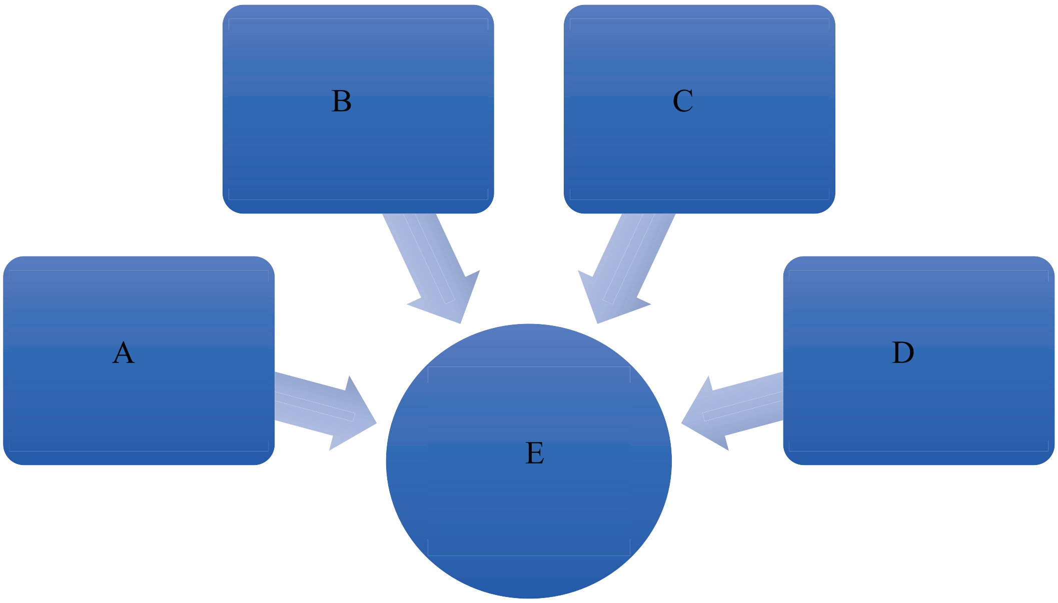
10.1 Realist Simulation

This section presents a simulation, or a step-wise development of the research process including research topic, problem, and research design by taking a realist perspective and then exploring what the simulation reveals regarding the impacts on the research problem, the research design, and the researcher's skills. Adopting a traditional realist approach would imply that the ***research topic***, "developing a technology-enabled tele-emergency framework for the UAE," is based on the presumption that the act of 'developing' is an objective reality. The researcher then should find the variables that can be put together in an identifiable manner to connect causes to effects. Consequently, by putting the variables in a definite manner, it is possible to arrive at 'the' technology-enabled framework that, too, is a singular reality and based on universal generalisations. In the post-positivism epistemological stance, it is also possible to include correlational relationships in addition to simple cause and effect relationships. Therefore, the ***research problem*** could be for the researcher to find out those crucial variables and their relationships so that an objectively constructible tele-emergency framework is likely to follow.

The underlying ***rationale*** is that such variables are already existing and measurable in an objective manner. Once those variables are identified and used within the generalised law guiding their relationships, they will yield the desired research outcome or the technology-enabled tele-emergency framework.

Figure 10.1

Simulated Research Rationale for Realism Paradigm



As depicted in Figure 10.1, if variables A, B, C, D exists, then variable E (technology-enabled tele-emergency framework) is likely to result. However, an inherent contradiction can be noted at this point, since variables A, B, C & D are unknown at this point, and any research that aims to establish a cause-effect or correlational relationship between these variables and the dependent variable E is debatable unless it is preceded by exploratory research that can first establish the existence of variables operant in the given context. This reasoning, therefore, underscores the inherent fallacy if a realist approach is used in this research. For a realist approach, it would require that A, B, C, D be pre-identified to enable a suitable measurement technique to capture their variance, and the current research does not start with a pre-identified A, B, C, and D, but instead, it aims to find out and explore the variables that impact variable E (technology-enabled tele-emergency framework); therefore, using a realist approach is not suited. However, proceeding with the simulation and using the objective ontology and post-positivist epistemology, the ***goals*** of the research will be:

- to measure factors A, B, C, and D as they operate in a given situation,
- to define the correlation between A, B, C, D, and E (technology-enabled tele-emergency framework),
- to calculate the best combination of factors A, B, C, and D that can lead to the development of a technology-enabled tele-emergency framework in the context of the UAE.

Subsequently, the ***research questions*** can be:

- How are variables A, B, C, and D correlated with variable E (technology-enabled tele-emergency framework)?
- How can A, B, C, and D be combined to develop a suitable technology-enabled tele-emergency framework for the UAE?

These research questions then pave the way for the ***research hypotheses*** in the following manner:

H1/2/3/4: A, B, C, and D are positively correlated with developing a technology-enabled tele-emergency framework.

H5: Combining A, B, C, and D in an optimum mix leads to the best-suited development of a technology-enabled tele-emergency framework for the UAE.

The ***research design*** ideally needs to include a research process that involves two steps, one aimed at developing the research hypothesis, and the second aimed at data collection to prove the hypothesis. The first step that is aimed at the development of the research hypothesis needs to be positioned in a literature review to determine how variables A, B, C, D engage with or impact variable E (or the development of a technology-enabled tele-emergency framework), and is expected to yield the hypothesis (Holden & Lynch, 2004; Sobh & Perry, 2006). However, again, it needs to be mentioned that the starting point of research using a realist approach is that A, B, C, and D are already known, and the literature review is undertaken to find their relationship with E (which is not the case for the current research). However, continuing with the simulation, the next step of the research process will involve testing the hypotheses using the appropriate methodology. The ***most-suited methodology*** with realism involves using ***quantitative methods*** (Easterby-Smith et al., 2012), using experimentation or surveys. The dependent variables will be used as A, B, C, & D, and the independent variable as E, an appropriate analysis method such as regression analysis or correlation analysis can be used to test the hypotheses.

The quantitative methodology follows from the realist premise that it is possible to capture an objective reality objectively, with the researcher adopting an etic stance and refraining from adding any value or contamination to the process of data collection or data analysis. Therefore, the realist approach determines that there are certain known variables (A, B, C, D and E), which can be captured objectively without taking their context of existence or considering the contribution of researchers' value position since the researcher is value-free. This etic stance of the researcher also positions them to have exceptional ***researcher skills*** and expertise to develop suitable research questions, and abilities to reduce complexities of the situation to a few, measurable variables, and to be able to conduct both data collection and data analysis in an objective manner (Bell, Bryman, & Harley, 2018).

10.1.1 Contribution to Knowledge

Adopting a realist perspective would enable the testing of the research hypotheses and add to the existing literature on 'developing a technology-enabled tele-emergency framework.' It will provide for a suitable combination of variables to employ in developing such a framework in the context of the UAE. The research would spur further similar research that can also be carried out in diverse regions to replicate the results or refine the findings and add to the literature further.

A practical implication of the research would be to inform the UAE healthcare sector and provide essential research background on which the technology-enabled tele-emergency framework can be built. However, as noted before, a realism approach is not suited for the current research because it will limit the fuller exploration of the complex situation due to realism's inability to consider the context. Developing telemedicine (tele-emergency) framework needs to consider the contextual complexity and richness of the dynamics involved between the numerous variables that may be operational within the context of the UAE.

10.2 Interventionism Simulation

This section discusses how adopting an interventionist perspective potentially impacts the understanding of the research problem, research design, and the values and skills of the researcher.

Using an interventionist perspective would mean that the research topic, “developing a technology-enabled tele-emergency framework for the UAE,” has been developed on the premise that the reality or truth is not universal or out there, but rather, it is subjective and open to interpretation by those involved in the context. Instead, it would mean that developing a technology-enabled tele-emergency framework for the UAE needs to be uniquely fitted within the context of the UAE and the stakeholders that are developing it. As opposed to the case with the realist perspective, there is no objective, standardised methodology to develop such a framework, and a unique, ongoing, and contextually relevant approach is needed, thus conforming to a subjective ontological stance.

The underlying rationale being that the process of ‘development’ is open to interpretation and intervention, and any change in the context and the researchers’ perspective is likely to warrant improvements in the process. Instead, the development process will have to be viewed as a continuous process of improvements and implementations, mostly brought about through initiating changes and implementing modifications by the researcher/developer. As such, the research focuses on using an action-research approach, where the development process is iterated to arrive at its best version. Using the interventionist approach, the conceptual framework of the research would primarily include the researcher's perspective, based on the researcher’s understanding of the factors that may be deployed for building a UAE contextualised framework. Deriving from an interventionism epistemology, the conceptual framework would be heavily weighted by the researcher’s interpretation of the situation and the changes brought about in the situation since such research is being conducted.

Taking the simulation further, the aims and goals of the research would be:

- to explore, from the researcher’s perspective, the availability of emerging technology-based medical equipment, sensors, and devices that can be enlisted as part of the tele-emergency healthcare system in the UAE,
- to evaluate the current ICT and network infrastructure of the UAE, from the researcher’s perspective, to assess its potential to support a scalable, private and secure, traceable, and interoperable system of tele-emergency healthcare,
- to develop an understanding, from the researcher’s perspective, of the existing technology that is used for HIS (Health Information System) in the UAE to evaluate them for integration across ERs in the country.

Nonetheless, the main research question may be developed as:

- what changes in the ICT, Infrastructure, HIS, and devices may lead to the development of a comprehensive technology-enabled tele-emergency framework for the UAE?

The above questions would be guided by the following questions, which should be repeated with several rounds of research:

From the researcher's perspective:

- What emerging technology-based medical equipment, sensors, and devices can be deployed for a tele-emergency healthcare framework in the UAE?
- Are the current ICT and network infrastructure of the UAE capable of supporting a scalable, private, and secure, traceable, and interoperable system for tele-emergency healthcare in the UAE?
- Can the existing HIS in the UAE be integrated across ERs in the country to support the tele-emergency framework?

Since the research aims to develop a context-dependent framework for the UAE, the nature of the interventionism paradigm dictates that this context is expected to be impacted upon or even contaminated by the presence of the researcher and their interaction with the situation. Therefore, there appears to be an inherent contradiction in the successful implementation of the research. Also, unlike the constructivism paradigm, the inputs from the experts and the stakeholders directly involved in using or adopting the framework are not included or may be included in a secondary capacity to the researcher's contribution. Therefore, the interventionism approach falsely implies that the researcher possesses the necessary competencies in the form of technological acumen, socio-cultural understanding, and healthcare delivery related expertise to be successful at developing the technology-enabled tele-emergency framework.

Nevertheless, the research process under this simulation would require an action research approach, where the four phases of Dewy's model (Kolb, 1984) can be used, namely, observation of the current situation, reflection, developing a conceptual understanding, and then drawing a generalised theory, which can be tested in the next cycle of observation, reflection, conceptualisation, refinement, and theory development. Therefore, the methodology with this action research-based interventionist perspective would require a mixed-method approach or even unique methods for data collection and analysis (Bruce, 1999; Kottkamp, 1990). Methods used in action research include journals, conversations, portfolios, mapping, case studies, reflective interviews, participant observations, shadow observations, and dialogues since these allow the researcher to obtain contextual information, and to include their perceptions during the data collection process (Gray, 2007). The researcher can conduct reflective interviews of experts, develop a conceptual understanding of the current situation, draw a generalised theory underpinning a technology-enabled framework for the UAE context, and further refine the framework in several similar iterations.

Further, the interventionism paradigm would indicate an emic position for the researcher's value, similar to the constructionist stance but with more explicit intervention and active value-addition from the researcher (Sunding & Odenrick, 2010). Such an emic stance, requiring the researcher to own up the role of a catalyst rather than just an interpreter of the situation, places a tremendous onus on the researcher's skills (Roberts & Westin, 2010), and requires the researcher to have mastery over the process of observation and reflection, as well as possess substantial social and cognitive competencies to generate data and interpret it (Suomala, Lyly-Yrjänäinen, & Lukka, 2014).

10.2.1 Contribution to Knowledge

The research is expected to lead to theory building and refinement, thus contributing to the existing literature on developing technology-enabled tele-emergency frameworks for the UAE. It is also expected to lead to further research, refine the developed theory, and subsequently develop simulated models and test their implementation in the context of the UAE (Suomala et al., 2014).

Accordingly, it is also expected to contribute to the practice by enabling the development and operation of a tele-emergency framework in the UAE. Moreover, the action research approach can be expected to provide further insights for refining and enhancing any tele-emergency framework that has already been implemented, as it would ensure a continuous and iterative process to improvement (Jönsson, 2010).

However, despite the iterative nature of the development process, the interventionism approach places the researcher in the role of a catalyst and the director of the outcomes, which means that the situational reality may get contaminated by the researcher's intervention and interpretation. A technology-enabled telemedicine framework needs to consider the complex situational variables such as the technology environment, the existing HIS, the technical expertise of the people who would be operating the framework; and should not be restricted to the researcher's interpretation alone. The interventionism paradigm is probably challenging to reconcile with the fact that the situational context may need to be given priority in constructing the framework.

10.3 Constructionist Simulation

This section discusses how adopting a constructionist perspective may impact the understanding of the research problem, research design, and the values and skills of the researcher. The constructionist perspective would imply that the **research topic**, “developing a technology-enabled tele-emergency framework for the UAE,” has emerged from a background that allows for a subjective ontology, or that the reality is not singular but context-dependent and conditional (Moses & Knutsen, 2012). This translates into meaning that 'framework' is not a singular objective construct, nor is the process of developing a 'framework' standardised or law-based. Instead, a framework is a conceptual idea that can be manifested in diverse ways, depending on the location, people involved, and the researcher. 'Developing a tele-emergency framework' is likely to be dependent upon a large variety of factors, including human knowledge base, technology, local sensibilities, and how people understand medicine and technology or conceptualise the role of their healthcare systems. The research problem is, therefore, not one of finding the right variables to put in the right places, but to take the perspectives of the people involved in the situation, to factor in the ground realities, and to develop a tele-emergency framework that is the best fit for the context of the UAE.

The research **rationale and purpose** is explained through the lens of the constructionist perspective by understanding that it is the people who will be using the technology-enabled tele-emergency framework (the stakeholders) that are likely to define and interpret their own specific needs related to the technology and its use, and the role of the researcher is to combine these diverse perspectives to develop a framework that suffices the stakeholders and delivers value to the country. Therefore, the purpose of the research is to present a framework that fits with the technology, resources, and human aspects of the context (Lee & Lings, 2008).

As a result, the **conceptual framework** would include a multi-stakeholder perspective. The framework will be developed using an eclectic mix of existing operational and hypothetical technology frameworks for tele-emergency, but with the scope of iterative refinement with the help of the perspectives and knowledge gathered from the subjects involved in the research. Further, the research aims and objectives using a constructionist stance could be:

- to explore, from the perspective of the technology experts and healthcare professionals in the UAE, the availability of emerging technology-based medical equipment, sensors, and devices that can be enlisted as part of the tele-emergency healthcare system in the UAE,
- to evaluate the current ICT and network infrastructure of the UAE from the perspective of the technology experts and healthcare professionals in the UAE, to assess its potential to support a scalable, private and secure, traceable, and interoperable system of tele-emergency healthcare,
- to develop an understanding from the perspective of the technology experts and healthcare professionals in the UAE, of the existing technology that is used for Health Information Systems (HIS) in the UAE to evaluate them for integration across ERs in the country.

Correspondingly, the research questions may be developed, according to the healthcare professionals and the technology experts, as:

- What emerging technology-based medical equipment, sensors, and devices can be deployed for a tele-emergency healthcare framework in the UAE?
- Are the current ICT and network infrastructure of the UAE capable of supporting a scalable, private, and secure, traceable, and interoperable system for tele-emergency healthcare in the UAE?
- Can the existing HIS in the UAE be integrated across ERs in the country to support the tele-emergency framework?

Also, since the constructionist stance indicates that reality is not objective and probably too complex to be captured using relationships between simple variables, the current research will refrain from posing any hypotheses at the onset. Instead, the data collection and analysis phase may likely reveal certain conditional and contextual relationships, which may be explored and reflected upon during the interpretation of the findings. This iterative aspect of the research is expected while adopting a constructionist stance, since reality is dynamic and complex, and understanding it requires keeping an open mind as well as being open to further iterations of data collection and interpretation (Lee & Lings, 2008).

Furthermore, a constructionist stance would call for an **inductive research process** to enable the 'construction of reality' and a research design that allows for an iterative collection and interpretation of the data (Easterby-Smith et al., 2012). Such a research design is most suited with open-structured or semi-structured interview **methods**, where the researcher can explore the perspectives of the subjects in detail and amend and modify questions to encourage the participants to reflect and construct upon their narratives. Further, an interview method also allows for the emic stance of the researcher to play out, as their interpretation of the interview responses is to be considered. Therefore, the researcher plays an active role as a receiver of not only the verbal information but also as an observer of the non-verbal and body language cues and contextual information. The **researcher's values** need to be taken into consideration, as the researcher's personal past experiences, education, and perspective on the situation are expected to impact their contribution as an observer and interpreter of reality. It is also here that the **researcher's skills** are also called for, as the researcher needs to be aware of their values and account for them to ensure that undue bias is not introduced in the interpretation of the research findings (Creswell & Creswell, 2017). While the constructionist paradigm allows for the researcher's subjectivity, it also requires the researcher to guard against personal biases or preconceived notions that may distort the interpretation of the data. Additionally, the researcher also needs to be skilled in conducting interviews and using thematic content analysis techniques to be able to capture the full and comprehensive picture of the situation under study.

The researcher's skills are also required in the form of the ability to be sensitive and empathic to the subject to not intimidate them or to undermine the data collection process.

10.3.1 Contribution to Knowledge

Adopting a constructionist perspective to obtain the answers for the above research questions would lead to the generation of insights that can be both academically and practically useful. In terms of the academic contribution, the research is expected to open up scope for exploring the relationships between new variables, such as the background of the healthcare professionals or the ease of using technology exhibited by them and their acceptance and adoption of a technology-based tele-emergency framework. The current research is expected to yield a rich source of primary data and information regarding the existing technology, the scope of scalability, traceability, security, privacy, and interoperability, which can be used as a starting point for numerous complimentary and supplementary studies on the topic. Further, the research also opens up scope for further iterative research to refine the tele-emergency framework that the current research expects to propose.

In terms of the managerial implications, practitioners in other countries or regions can adopt the research findings as a starting point for developing their technology-enabled tele-emergency frameworks.

Appendix B: Interview Questions and Relationship to Themes

Interview Questions	Categories	Theme
#1 What do you think about the current ICT infrastructure available to healthcare facilities in the country? #2 What policies are needed to develop the ICT and networking infrastructure to support a nationwide tele-emergency framework?	– ICT standardisation – ICT Law – ICT security	Information and Communications Technology (ICT)
#4 According to you, what is the status of the current telecommunications network employed in healthcare service delivery? #5 Please share your suggestions regarding the equipment, devices, and infrastructure that may be needed for developing and implementing a nationwide tele-emergency framework in the UAE.	– Speed and Availability of Broadband – Platforms – Data Security and Reliability	Telecom
#3 What policies may need to be developed to support the production or acquisition of medical devices like medical sensor equipment, personal wearable devices, monitoring devices, and other equipment that need to be a part of a large-scale tele-emergency delivery system for the country? #5 Please share your suggestions regarding the equipment, devices, and infrastructure that may be needed for developing and implementing a nationwide tele-emergency framework in the UAE.	– Wearable and Monitoring Devices – Governance – Usability	Medical Equipment
#12 Does the UAE have a unified healthcare database of patients, if not, what do you suggest can be done, what framework can work for the UAE?	– HIE – PIS – Standards	Unified Medical Records
#6 How do you see the Ambulance services contributing to the tele-emergency framework? #8 Can the paramedics connect to the hospital to which the patient is being transferred? #7 What technologies are currently available to paramedics, as far as you know? #9 Do the paramedics have enough training to administer medication to patients? If so, what are they, if not what do you think is needed to help facilitate such a step?	– Types of First Responders – Management of First Responders – Support Systems for First Responders	First Responders
#2 What policies are needed for developing the ICT and networking infrastructure that can support a nationwide tele-emergency framework? #3 What policies may need to be developed to support the production or acquisition of medical devices like medical sensor equipment, personal wearable devices, monitoring devices, and other equipment that need to be a part of a large-scale tele-emergency delivery system for the country? #10 What, in your opinion, is the scope for deploying a large scale nationwide tele-emergency system in the UAE? #11 Where do you see telemedicine, especially, tele-emergency, as part of the country's digital healthcare drive in the future?	– Pre-Alert Systems – Decision-Making – Specialisation in EDs	Resources

Appendix C: Interview Questions

Infrastructure

- What do you think about the current **ICT infrastructure available to healthcare facilities in the country**?

Prompt Question **What is needed to support any large-scale telemedicine operations for emergency care in the country**?

- **What policies are needed to develop the ICT and networking infrastructure to support a nationwide tele-emergency framework?**

Medical Equipment & Telecom

- **What policies may need to be developed to support the production or acquisition of medical devices like medical sensor equipment, personal wearable devices, monitoring devices, and other equipment that must be part of a large-scale tele-emergency delivery system for the country?**
- According to you, what is the status of the **current telecommunications network** employed in healthcare service delivery?

Prompt Question: How do you suggest it can be developed further for supporting any large-scale telemedicine/tele-emergency system? How **reliable do you think is the current network**?

- **Please share your suggestions regarding the equipment, devices, and infrastructure needed to develop and implement a nationwide tele-emergency framework in the UAE.**

Emergency Responders

- **How do you see the Ambulance services contributing to the tele-emergency framework?**

- **What technologies are currently available to paramedics, as far as you know?**

- **Can the paramedics connect to the hospital to which the patient is being transferred?**

- **Do the paramedics have enough training to administer medication to patients? If so, what are they, if not, what do you think is needed to help facilitate such a step?**

Framework

- **What, in your opinion, is the scope for deploying a large scale nationwide tele-emergency system in the UAE?**

- **Where do you see telemedicine, especially, tele-emergency, as part of the country's digital healthcare drive in the future?**

    Prompt Question What about since the current pandemic?

- **Does the UAE have a unified healthcare database of patients, if not, what do you suggest can be done, what framework can work for the UAE?**

Appendix D: Informed Consent

NEW TECHNOLOGY-BASED TELE-EMERGENCY FRAMEWORK FOR EMERGENCY HEALTHCARE PROVISION IN THE UNITED ARAB EMIRATES

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Introduction and Purpose of the Study

The study aims to develop an understanding of the current telemedicine structure in the UAE and to develop a comprehensive technology-based framework for a nationwide tele-emergency system.

Description of the Study

If you participate in this study, you will be asked a set of open-ended questions regarding the technology framework used for telemedicine in the UAE, the medical equipment used in ERs (Emergency Room), the (Health Information System) HIS integration across ERs, and any recommendations.

Research Commitment

The interview will be scheduled to reflect your commitments. The interview will take place at a neutral and discrete location (chosen by the participant), and will last between 45 mins to one hour.

Confidentiality

All private and contact information will be treated confidentially, stored safely, and will not be shared by any third party. Your identity and any responses during the interview will be anonymized. All the data will be aggregated and analyzed together, ensuring that individual participant identity is anonymized.

Voluntary Participation

Participating in the study is totally voluntary.

Withdrawal from the study

At the commencing, during, and up to one month after the interview, you have the right to withdraw from the interview without any repercussions.

Costs

There is no fee required for participation in the study, or any reward or remuneration is given to participants for their contribution.

Benefits for Participating

Your contribution will help in building a new national technology-based tele-emergency framework benefiting millions of citizens of the UAE.

I have read the above details and give my voluntary consent to participate in this research study

□ Yes □ No

Name of Participant:

Signature of Participant: Date:

Person Obtaining Consent:

Signature: Date:

Appendix E: Reviewed Telemedicine Frameworks

Telemedicine Frameworks by Categories, Scope, Context, Characteristics, Benefits, and Limitations

Single/Two ED-Based Operational Frameworks

Speciality Frameworks	Authors	Framework Scope	Context of the Framework	Framework Characteristics	Benefits	Limitations
1	(Ambroise et al., 2019)	ED of a University Hospital (Caen)	Emergency Maxillofacial Surgery	1. The Web-based application, Therap-e, can be downloaded on Android devices. 2. 3G/4G enabled 3. Synchronous and Asynchronous communications 4. Log-in and Password required to ensure security 5. ED physicians can create requests, upload patient data to the app and remote specialists can deliver recommendations 6. Audio, video, word documents can be shared 7. No data stored on the hard drive of the device used 8. All details converted to PDF and added to EHR.	Enhanced data security, privacy, record-keeping, greater transparency and accountability, enhanced access to information, reduced door-to-consult time, reduced length of stay, and enhanced process efficiency. Scope for scalability, traceability and national-level deployment.	Data exchanged over a website or app may be vulnerable to cyber risks, Therap-e-like app may not be scalable due to traffic management and server issues
2	(Southard, Neufeld, & Laws, 2014)	ED of 2 Rural Critical Access Hospitals (CAH), USA	Psychiatric Emergencies	1. Video-conferencing enabled remote consultation for ED 2. 3G/4G network	Reduced door-to-consult time, consultation ordered to consultation completed or treatment time, and length of stay significantly.	The process could be improved with more automation, as requests for consultation were still being placed manually

3	(Izzo et al., 2018)	ED (level 1 trauma care) of the Washington Hospital Center, USA	Triage for Psychiatric Evaluation	1. Mobile tablet at the triage enabled patients to enter their data 2. Remote physicians at an office equipped with audio-visual access to the triage area, and dual screens, which allowed doctor-patient interaction and document check patient's data simultaneously.	Better accuracy of diagnosis, higher patient satisfaction, reduced door-to-treatment time, reduced duration of stay, and overall efficiency	The study is only based on a single-centre and needs to be evaluated in the context of a multi-centre design. Remote physicians were limited to those within the premises of the hospital; thus, there is scope for expanding the access to remote physicians from other, external centres.
4	(Bowman, 2017)	ED/stroke victims	Video-conferencing with a remote neurologist	1. The patient was connected to a remote neurologist with a robot unit that allowed audio-visual exchange plus data entry through a laptop. 2. High-resolution video	Enabled administration of time-critical therapy like rt-PA, saving lives, and improving chances of rehabilitation post-stroke.	The study is only based on a single-case and needs to be evaluated in the context of a multi-centre design
General Frameworks	**Authors**	**Framework Scope**	**Context of the Framework**	**Framework Characteristics**	**Benefits**	**Limitations**
5	(Greenwald et al., 2017a)	ED of an academic medical centre	Tele-consultation for people presenting at ED	1. Video-conferencing tools 2. 2G/3G networks 3. Remote physicians were located in the same hospital	There is no difference between patient satisfaction, duration of stay, change in treatment required, and the likelihood of return within 72 hours.	The study is only based on a single-centre and needs to be evaluated in the context of a multi-centre design. Remote physicians were located in the same hospital, thus limiting the scope of expertise that could be accessed.
6	(Greenwald, Stern, Clark, Hsu, & Sharma, 2017b)	ED of an academic medical centre	Tele-consultation for the elderly	1. Video-conferencing tools 2. 2G/3G networks 3. Remote physicians were located in the same hospital	There is no difference between patient satisfaction, duration of stay, change in treatment required, and the likelihood of return within 72 hours.	The study is only based on a single-centre and needs to be evaluated in the context of a multi-centre design. The remote physicians were in-house; there is scope for involving specialists from other centres.

7	(Sharma et al., 2017)	EDs of two hospitals, elderly patients	Video-evaluation for further treatment or diagnostic tests	1. Patients presenting with low acuity complaints at the EDs were screened by a physician at the triage 2. Video-evaluation was conducted, which led to the recommendation of the future course of action. 3. The discharge slip and details were printed directly in the patient's room, reducing the need for check-out. 4. Basic video-conferencing technology-enabled physicians not located in the ED to evaluate patients.	Reduced length of stay for the patient, the smaller number of patients reporting back within 72 hours of consultation, and a lesser number of diagnostic tests and x-rays ordered, hence reducing the overall cost of healthcare and maintaining the quality of care	The study is only based on a single-centre and needs to be evaluated in the context of a multi-centre design The available specialist help was limited to the physicians within the hospital
Multiple ED Based Operational Frameworks						
Speciality Frameworks	**Authors**	**Framework Scope**	**Context of the Framework**	**Framework Characteristics**	**Benefits**	**Limitations**
8	(Bhandari, Tiessen, & Snowdon, 2011)	EDs at Chatham-Kent Health Alliance (CKHA), Sydenham Hospital, and Leamington District Memorial Hospital	Triage for Psychiatric Evaluation	1. Nurses could make decisions at triage for remote sites using the video-conferencing system. 2. Used Cisco Architecture for Voice, Video, and Integrated Data (AVVID) and secured IP-based connection for video conferencing. 3. PAR framework involves inputs from all stakeholders and uses the Kouzes and Posner (1996) leadership practices. 4. Supported by comprehensive protocols for using the telemedicine system and code of conduct 5. Training for staff.	Reduced the need to hold mentally unstable patients at non-psychiatric facilities; reduced the workload for the ED physicians as triage decisions could be made efficiently by the remote nurse.	Lack of an adequate number of cases makes it difficult to gauge the framework's impact. Does not include a comparison of outcomes of pre-and post-implementation of the project, which makes an evaluation of the efficacy difficult

9	(Martínez-Fernández, Lobos-Medina, Díaz-Molina, Chen-Cruz, & Prieto-Egido, 2015)	Rural emergency care personnel, Guatemala	Community Facilitators CFs	1. CFs provided with cell phones, solar panels, batteries, external microphones and speakers (for audio-conferencing), and an app that enables them to enter patient data and transmit it to the remote telemedicine centre and get clinical advice from specialists from across the Ministry of Health and Social Welfare hospitals. 2. CFs could get training 3. TulaSalud's Kawok Application allowed the CF input data to be captured in real-time and recorded as epidemiological data. 3. Telemedicine centre supported language translation in case the CFs or the remote specialists were unable to communicate. 4. Used 3G/4G network	Decrease in child and pregnant women mortality rates	The framework depends upon network connectivity and cell phones, which may not be adequate in rural locations or affordable in many countries
10	(Bagot et al., 2018)	ED of a Regional hospital 200km from Melbourne, Australia	Tele-consultation for stroke patients	1. Video-conferencing mobile cart to enable remote neurologists to evaluate the patient 2. Data scanning and sharing with a remote specialist 3. Regional ED connected to VST (Victorian Stroke Telemedicine) program, which connected the point-of-care physicians with remote specialists from across the state.	Timely administration of time-critical therapy like rt-PA leads to saving lives and improving chances of recovery	Focus on human aspects of telemedicine rather than technological

11	(Kyriacou et al., 2001)	Ambulances, Rural Health Centers or other remote health locations, validated in Four countries	Critical care telemetry and telemedicine home followups	The telemedicine system is a combined real-time and store and forward facility that consists of a base unit and a telemedicine (mobile) unit. The telemedicine unit (patient site) allows the transmission of vital biosignals and still images of the patient from the incident to the base unit.	The telemedicine system has a flexible architecture that can be adopted in several different application fields.	Further development is needed for integrating the system into the hospital HIS/PACS networks
General Frameworks	**Authors**	**Framework Scope**	**Context of the Framework**	**Framework Characteristics**	**Benefits**	**Limitations**
12	(Cai, Wang, Guo, & Bao, 2016)	Local and regional hospitals in Gansu Province are connected via Gansu Provincial Telemedicine Center (China)	Tele-consultation, remote diagnosis, treatment suggestions, or referrals to the provincial hospital	1. Multi-stakeholders (Government, medical facilities, technology providers, Network service providers) 2. Multi-level operations connected local facilities to county and provincial and then to the Telemedicine Center. 3. The Gansu Center is linked with 1487 regional hospitals using ADSL/VPN and 3G/4G networks. 4. The Gansu Telemedicine Centre stores all data from all communications in the form of patient records 5. Gansu Telemedicine centre is connected with the national centre for telemedicine supervision and services that facilitates remote consultations.	The telemedicine framework was able to provide timely and accurate teleconsultation, diagnostics and other services in the rural regions that are prone to natural disasters like earthquakes and mudslides as well as medical emergencies like the HIN1 outbreak and melamine milk contamination.	Missing full details of the framework, or the working of the telemedicine centre. Gives a basic understanding of how remote area clinics and hospitals can be connected through technology

13	(Petter & Fruhling, 2011)	State laboratories	Tele-diagnostics	1. STATPackTM (Secure Telecommunications Application Terminal Package) 2. Macroscopic and microscopic digital images of culture samples were transmitted over the internet to state public health laboratories, for remote experts' review	Reduced risks of exposure or contamination, facilitated the speedy investigation, and information dissemination.	Lacks technical specifications of the framework
14	(Nikolaidis, Efthymiadis, & Angelidis, 2019)	Remote physicians in multiple locations in Greece	Cell-phone for tele-consultation	1. Cell phones and internet connection 2. Medical equipment to monitor patients 3. Remote physicians monitored patients and obtained teleconsultation from the Athens Medical Center	Enhanced quality of care, patient and doctor satisfaction	Simple framework, not inclusive of technological specifics. Scheduling of consultations or emergency applications not discussed.
Hypothetical Frameworks						
Theoretical Frameworks	**Authors**	**Framework Scope**	**Context of the Framework**	**Framework Characteristics**	**Benefits**	**Limitations**
15	(Anwar & Prasad, 2018)	Nationwide e-health ecosystem	Escalation model for telemedicine implementation	1. Multiple stakeholders, including government, pharmaceutical companies, healthcare institutions, end-users, legal and ethical framework advocates and the ICT industry. 2. Latest technology using sensors, bio-sensors, AI, machine language 3. Supported by e-literacy	General framework for developing an e-health ecosystem	Lacks technical specifications of the framework
16	(Wallis et al., 2017)	Image-based diagnostic telemedicine	Integration framework for telemedicine with legacy systems	1. Multi-stakeholder involvement 2. Integration of existing health informatics with telemedicine 3. Using or upgrading existing technology 4. policy deregulation 5. inter-operability 6. user-friendly interface 7. framework that adds value to professionals	Enhanced acceptance of telemedicine by professionals and increased access to care by end-users	Problems associated with the legacy system and interoperability can be encountered. Role of different stakeholders is not clear

17	(Hwang et al., 2014)	Technology Adoption Model for Telemedicine	Ease of use based technological framework for teleconsultation	1. EMTs perceived usefulness of telemedicine depended upon the clinical factors of the patient, ease of use of technology, and recognition they expected to get. 2. EMTs' attitudes toward technology depended upon the above factors and organizational facilitation. 3. Perceived usefulness and attitudes determined EMT's intention to use telemedicine 4. The framework needs to include body sensors and the latest technology that could be effectively used to gauge PHI, and is easy to use and helps EMTs perform their jobs better.	Education of EMTs, creating of a user-friendly telemedicine interface, and enhancing the accuracy of measurement - all are expected to lead to better quality healthcare and greater adoption of telemedicine by healthcare emergency professionals	It is not a technological framework and does not give full details of the framework that EMTs can readily accept
18	(Chang, 2015)	Evaluation Framework for assessing Telemedicine frameworks	Evaluating telemedicine programs on their scalability and effectiveness	1. Logical Evaluation Framework (LEF) approach 2. Staged Model using Project Management Approach 3. Fishbone model for detailed requirements 4. Focus on multiple stakeholders and multi-dimensional factors that impact telemedicine implementation	Broad framework that gives guidance for scalable telemedicine frameworks	Theoretical model with less information on technical specifics
19	(Anwar et al., 2019)	Surveillance Model for deploying telemedicine in disaster management	Tele-consultation for field workers; coordination of disaster management effort.	1. Specialists connected to field workers for tele-monitoring or tele-consulting 2. collection of data useful for epidemiological purposes and for developing rehabilitation and prevention plans	Broad framework that gives guidance for scalable telemedicine frameworks for disaster management	Practical implementation and technological specifications are not mentioned.

20	(Tsiknakis et al., 2002)	Delivery and medical training across the island of Crete	EHR integration	1. Provide seamless access to the Electronic Health Record (EHR) during a patient-doctor encounter 2. Empower individuals and give them control to make informed choices about options available to them regarding their health 3. Improvement of efficiency and quality in the healthcare process	Relies on defining a set of standard messages that allow different healthcare information systems to exchange data via standardised messages	Does not provide an adequate solution to the problem of information integration
21	(Novillo-Ortiz, 2016)	Telemedicine Hat Model for Nation-wide Telemedicine Framework	Nation-wide, escalation model	1. Based on the alignment of multiple expected outcomes of telemedicine 2. Development of the framework is to be guided by public policy, organizational considerations and strategic considerations. 3. Framework to include interoperability and changes in organizational structure, culture and human resources.	A broad framework for developing an e-health ecosystem	Practical implementation and technological specifications are not mentioned.

Simulation Tested Frameworks	Authors	Framework Scope	Context of the Framework	Framework Characteristics	Benefits	Limitations
22	(Chakraborty, Gupta, & Ghosh, 2013)	In-hospital users monitored remotely	Body-Sensor based decision support system for remote monitoring and consultation	1. In-body and on-body sensors to collect biological data and PHIs and to create the WBAN (wireless body area network) 2. Body Area Network Co-ordinator (BANC) node collates all sensory data from WBAN through GPRS, Bluetooth, WiBro, UVB and ZigBee. 3. BANC transmitting data to the Telemedicine Hub (TMH) over a secure network using 2G/4G network 4. TMH equipped to record data to Electronic Health Record (EHR), conduct a preliminary analysis, and provide decision support to remote physicians	Real-time patient monitoring from a remote location, enhanced quality of the decision, and better record keeping. Enhanced privacy and security for data due to secure networks	There is no involvement of point-of-care professionals, and no inputs other than physical and body-sensor-based inputs. Emerging technologies are not tested or available yet. Regulatory and legal aspects are not clear.

23	(Lu, Lin, & Shen, 2013)	Mobile end users continuously connected with specialists	Body-sensor, opportunistic computing-based tele-monitoring	1. SPOC (Secure and Privacy-Preserving Opportunistic Computing) framework 2. SPOC allows a user in an emergency to access and use computing resources of other service-users in the vicinity. 3. Privacy control through ensuring that only those who have similar conditions can share their resources with the user in need 4. Privacy is managed through attribute-based access control mechanism and PPSPC (Privacy-Preserving Scalar Product Computation) 5. Body sensor nodes to collect user data, smartphones to transmit the data 6. A trusted authority or TA at the centre that could monitor users' PHI and deliver timely healthcare.	Allows users to get help from other users in the vicinity while maintaining privacy to a certain extent	Security risks, and privacy vulnerabilities need to be further explored
24	(Lee, Hsu, Lai, & Vasilakos, 2013)	Mobile end users continuously connected with specialists	Body-sensor, opportunistic computing-based tele-monitoring	1. Same specifications as Lu et al. (2013), but with two-way authentication, and login-password to ensure data privacy and security 2. TA is protected from cyber-attacks by an algorithm that protects users' identities.	Allows users to get help from other users in the vicinity while maintaining privacy to a certain extent	Security risks, and privacy vulnerabilities need to be further explored
25	(Salman, Rasid, Saripan, & Subramaniam, 2014)	Scalability of telemonitorin g systems	Body-Sensor based decision support system for remote monitoring and consultation	1. Multi-Sources Healthcare Architecture (MSHA) based telemonitoring systems 2. Medical sensors, manual texts, and images data collected and input through the user-interface 3. Data transmitted to the base station that fuses the data at the feature level - using features from each sensor, undertaking data associations and data aligning - to produce a priority code (PC). The PC code, along with Tips, is transmitted to the server over a Wi-Fi network. The server queues the requests for a specialist consultation based on a PC and provides data from the patient's EHR as well. The specialist can make an informed decision.	Improves the accuracy of decision making, and provides real-time telemonitoring and tele-consultation, improving the quality of health care. Reduces waiting times in telemedicine queues.	Only tested in simulation and needs further exploration to establish its scalability. More body sensors or manual PHI collectors can be used for added benefit.

26	(Tchao, Diawuo, & Ofosu, 2017)	Ghana 40-city telemedicine model	Teleconsultation for 40 cities across Ghana	1. WiMAX technology network connecting hospitals in major cities to Vodafone's backbone transmission network provided by the (National Communication Backbone Company) and Gigabit Ethernet or GE). 2. Five Distributed Base Stations comprising the Base Band Unit (BBU) for in-door sites and the Remote Radio Unit (RRU) for installation on poles or walls 3. BBU and RRU connected through fibre optics 4. Base Stations covering the entire region with adaptive 4 by 4 MIMO configured antennas.	Improved response time in case of medical emergencies, improved accuracy and quality of healthcare. It is a scalable model	Restricted to tele-consultation or monitoring, Technical details related to scalability are missing. Simulation-based model only
Reviewed Frameworks						
Generic Frameworks	**Authors**	**Framework Scope**	**Context of the Framework**	**Framework Characteristics**	**Benefits**	**Limitations**
27	(Doolittle and Spaulding, 2006)	A framework for defining the need for a telemedicine service	Designed to be generalizable to a variety of applications, and considers the needs of both consumers and providers	1. General model that guides the technical, economic, and clinical implementation of telemedicine 2. The framework provides a sequential, step-based approach to telemedicine	Provides a broad structure and sequence of actions necessary for telemedicine implementation	Does not provide detailed guidance on the technological implementation or cultural and personal factors in telemedicine implementation
28	(Warren et al., 1999)	Object-oriented information architecture for telemedicine systems (Plug-and-play)	Interoperable Telemedicine services architecture	1. The architecture supports standards for component interoperability so that functionality from different vendors is integrated onto the same care platform. 2. The architecture utilises standards for the exchange of medical information to allow these systems to interact with electronic patient records stored in hospital information networks with the advent of appropriate security technology.	Initiated integration and interoperability within the HIS	Dealt with 20th century technologies and could not have envisaged more complex service components this century.

29	(Mykkänen et al., 2003)	Integrate the already existing HIS with the new telemedicine system	PlugiT Project in Finland	1. Identify the data and functionality shared between the different systems. 2. Locate the integration points in the interoperable parts of the systems. 3. Developing a suitable interoperability model and supporting them with integration technologies 4. Supporting interoperability during the transition period	Enhanced the efficiency of the HIS applications through interoperability and information sharing between diverse systems.	Did not include provisions for ensuring access to data and records during downtimes in telecommunications
Recent Comparable Frameworks						
Generic Frameworks	**Authors**	**Framework Scope**	**Context of the Framework**	**Framework Characteristics**	**Benefits**	**Limitations**
30	(Tan et al., 2017)	Tele-emergency framework using WiMax	Tele-emergency framework for reducing response times of ambulances and paramedics in emergencies	UEMS framework deploys WiMax technology to retrieve patient data from health records, relay patients' vital statistics, and connect remotely with healthcare specialists in Ers.	Increasing the first aid quality, resulting in better outcomes and lives saved	Does not retrieve patient records from the HIE or HIS
31	(Federal Interagency Committee on EMS, 2021)	Telemedicine Framework for the EMS and 911 organisations	Incorporating telemedicine practices into EMS and 911 operations	1. Knowledge building 2. Integrate with existing systems 3. Initiation of assessments of existing gaps 4. Financial sustainability and growth	Provides an overview of what and how EMS and 911 organisations can benefit from a telemedicine program, emphasising the importance of financial sustainability	Does not provide operational directives