A Prospective Observational Study on Factors that Influence Survival or Non-survival for the Patient Suffering Out-of-hospital Cardiac Arrest within Abu Dhabi Emergency Medical Services

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ABSTRACT

Introduction: Out-of-hospital cardiac arrest (OHCA) is a global health concern and one of the leading causes of death. Each year, three thousand patients in Scotland suffer OHCA while only 6% survive to hospital discharge. Only one out of ten OHCA cases in England survive OHCA every year. In total, 37,054 OHCA were reported from 28 European countries in 2017, with only 8% surviving. Death and disabilities from OHCA can be avoided (Graham et al. 2015). Immediate comprehensive strategies to improve patient's survival is critical to saving lives.

In the United Arab Emirates, strategies to improve OHCA survival do not exist in the capital city of Abu Dhabi. The OHCA survival rate within pre-hospital care has yet to be investigated. Lack of OHCA status knowledge impacts examining the survival rate adversely and may prevent any potential improvement in Abu Dhabi. Factors such as unique demographics, cultural aspects, patient characteristics, and policies may influence patient survival; however, the apparent lack of research in the Abu Dhabi context is a significant concern. Thus, the purpose of this thesis is to identify the survival rate and factors that may influence survival or non-survival for an OHCA by Abu Dhabi emergency medical services (EMS).

Method: A descriptive cross-sectional approach based on a quantitative prospective data set was undertaken. A cardiac-arrest registry was created to record OHCA data prospectively in 2019 and was utilised for this thesis project.

Result: Three hundred and thirty patients with OHCA (79 females, 250 males, 1 unknown) were included in this research between January and December 2019. Most patients recorded for this study were witnessed (72%), male (75%), of younger age 56.93 ± 18.67 years. Most OHCAs happened at patients' homes (60%) to individuals who have a history of cardiovascular diseases (76%). The EMS arrival at the patient's side was 10.15 ± 4.92 minutes and the average time from patient collapse to EMS arrival was 14.7 minutes. The majority of resuscitation was initiated by the EMS staff (82.4%). First ECG rhythm and pre-hospital return of spontaneous circulation (ROSC) were predictors of survival status, while no significant prediction was determined for age, response time, and bystander CPR (X2 (5) = 31.61, p< 0.000, Nagelkerke R2 = 0.58). The current study found that Abu Dhabi EMS interventions (epinephrine injection, advanced airway management, and mechanical CPR device) do not yet significantly affect patient survival (X^2 (3) = 8.50, p= 0.04, Nagelkerke R^2 = 0.18). This study defines one key factor that influences survival for OHCA treated by Abu Dhabi EMS, being that the patient was more likely to survive if basic life support is started within seven minutes or less from when the patient collapsed (p = 0.02). Pre-hospital ROSC was observed in only 56 individuals with OHCA (17%). Of 330 patients, only 16 with OHCA (5%) (6 females, 10 males) survived to discharge from the hospital.

Conclusion: A critical factor to emerge from this study is that scientific research is now recognised by the Abu Dhabi EMS for the first time since its inception in 2001. The findings shed light on current Abu Dhabi EMS abilities concerning critical patients' care. My original contribution to knowledge is identifying opportunities for a patient's survival following OHCA and suggesting high-priority actions in Abu Dhabi pre-hospital care.

DEDICATION

This thesis is dedicated to my wife Salwa, and our four children Rawdah, Dana, Ali, and Muhammed-Ali

With Love

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List of abbreviations

AED	Automated External Defibrillator
ACS	Acute Cardiac Syndrome
ALS	Advanced Life Support
AHA	American Heart Association
BLS	Basic Life Support
BVM	Bag Valve Mask
CAR	Cardiac Arrest Registry
CPR	Cardiopulmonary Resuscitation
CCI	Charlson Comorbidity Index
CPC	Cerebral Performance Category
CI	Confidence Interval
CHD	Coronary Heart Disease
CQI	Continual Quality Improvement
COVID-19	Coronavirus Disease-19
DEPP	Developing and Evaluating Professional Practice
ECG	Electrocardiogram
EMS	Emergency Medical Services
EPCR	Electronic Patient Care Report
ETI	Endotracheal Intubation
ERC	European Resuscitation Council
ILCOR	International Liaison Committee on Resuscitation
ICU	Intensive Care Unit
IOM	Institute of Medicine
GRA	Global Resuscitation Alliance
MI	Myocardial Infarction
OHCA	Out-of-Hospital Cardiac Arrest
OR	Odds Ratio
PAD	Public Access Defibrillation
ROSC	Return of Spontaneous Circulation
RCT	Randomised Controlled Trials
TTM	Targeted Temperature Management
UAE	United Arab Emirates
USA	United States of America
VF	Ventricular Fibrillation
PMH	Past Medical History
pVF	Pulseless Ventricular Tachycardia
WHO	World Health Organization

1. Chapter one: Introduction

1.1 Introduction to the thesis

Out of hospital cardiac arrest (OHCA) is a debilitating, unexpected, and unscheduled medical condition that often results in the patient's death (Graham et al. 2015, Sawyer et al. 2020). The successful treatment of OHCA necessitates an optimal level of healthcare intervention. The most significant challenge for emergency medical services (EMS) in pre-hospital care is patient survival following OHCA. The EMS provider's complete success results in seeing an OHCA patient survive to hospital discharge with fully intact neurological faculties. However, this is a complex situation that necessitates immediate identification of the event at the scene and prompt resuscitation. The EMS provider intervenes at a unique moment when the patient starts the process of death. For patients whose circulation ceases abruptly outside the hospital, such as at home or in public places, their hearts must be restarted within minutes. Unfortunately, despite advances in pre-hospital health care, not all cardiac-arrest patients survive to discharge. As a result, OHCA could have dire effects on patients and their families.

OHCA has become a significant global health concern. The cardiac-arrest survival rate has gradually improved over the past 40 years, yet it remains unacceptably low (Yan et al. 2020, Waldmann et al. 2021). Only one in ten OHCA patients survive in England (Hawkes et al. 2017b), and only 6% out of 3,000 OHCA patients in Scotland survive each year (Halbesma et al. 2019). If the patient is to have a chance of survival after an OHCA, multiple vital procedures must be performed quickly in pre-hospital care. Due to social/cultural influences and unique features in local pre-hospital care, some OHCA patients' characteristics and survival factors may differ widely. (Patients' survival predictions are discussed in chapter three.) The impact of pre-hospital medical interventions on OHCA has not been examined in Abu Dhabi, United Arab Emirates (UAE). This thesis contributes to knowledge by identifying the factors that influence patients' survival for an OHCA in Abu Dhabi EMS.

1.2 Background

The first documented resuscitation in 1732 by surgeon William Tossach in Alloa, Scotland, is considered the first experimental use of mouth-to-mouth therapy in cardiac arrest (Tossach 1744). The research recognized sudden cardiac death in operating rooms in the 1930s (Hyman 1932)—followed by reports and experiments to find necessary cardiac arrest treatment (Safar et al. 1958, Jude et al. 1961). Hence, cardiac arrest is not a novel concept in medicine. Nevertheless, it is essential to analyse the distinctions between patient death and cardiac arrest. Patient death is arguably an inevitable termination of heart and brain activity (Lamb 2020). When a patient dies in the home or public, the EMS may be initiated to confirm the patient's death, especially if collapse is not witnessed or remains unseen for more than 20 minutes. Due to human physiological changes, the cessation of patient heart peak at night or early morning (Baert et al. 2021). The patient confirmed death when pupils are dilated and fixed, no palpable pulses, and absent effort of breathing. EMS in Abu Dhabi can begin resuscitation in these patients due to family insistence. However, there is no benefit in starting resuscitation in these patients due to prolonged cessation of patient heart or sometimes the onset of *Rigor Mortis*. The rigidity and stiffness of the human body are called *Rigor Mortis*, which occur after a few hours of death (Kori 2018). This thesis does not include the formal investigation that occurs following patient death.

This study focuses on out-of-hospital resuscitation, which is used on patients who have collapsed before or within 15 minutes of EMS activation. OHCA leads to a loss of consciousness and the cessation of breathing and heartbeat, caused by an abrupt termination of the mechanical heart output (McNally et al. 2011, Roger et al. 2011, Perkins et al. 2015a). If the cardiac arrest is reversed and the patient breathing and pulse restarts, there is a chance of patient survival. However, this is only possible with resuscitation beginning in the first few minutes after the event. Without immediate action, the OHCA patient starts to die. The prolonged time between patient pulse termination and the start of treatment is the leading cause of decreased survival chances (Yin et al. 2021).

The termination of the pulse may be cardiac or traumatic (Chen et al. 2018). Cardiac arrest is predominantly due to cardiac issues. Hemodynamic failure and loss of heart and brain function resulting from the cessation of the pulse can be caused by thrombus formation and myocardial infarction (MI). When this is sudden, cells within multiple organs begin to die of hypoxia. Cardiac arrest could result from a previous MI, after which the patient was successfully resuscitated (Corrado et al. 2020). A scar in the myocardium develops in cardiac-arrest patients with a past medical history (PMH) of MI, leading to an arrhythmogenic substrate which, based on the location of the infarct, may account for ventricular fibrillation (VF) (Di Diego and Antzelevitch 2011). As a result, neurological cells cannot survive due to a lack of oxygen. Healthcare workers worldwide believe that a person dies when the brain dies (Sherrington and Smith 2012). Unfortunately, in cardiac arrest, brain cells start to die within three to five minutes. Brain death will result in disabilities if the heart is not restarted immediately, such as if an EMS response time is too long. Therefore, successful resuscitation is crucial for reviving organs, neurological function, and restoring life.

Resuscitation is the "attempt to maintain or regain life by establishing and/or maintaining the airway, breathing, and circulation through Cardiopulmonary Resuscitation (CPR), defibrillation, and other related emergency care techniques" (Jacobs et al. 2004, Goyal et al. 2019). CPR is the most crucial part of resuscitation, defined as an attempt to restore spontaneous circulation by performing chest compressions (Jacobs et al. 2004). Resuscitation must be initiated immediately as the patient collapses for it to be successful. Modern CPR developed by William Kouwenhoven et al. in 1960 offers the advantage that resuscitation can be performed anywhere other than the open-chest CPR in a hospital setting (Kouwenhoven et al. 1960). With prompt CPR, there is a significant chance of survival. The implication is that if closed-chest CPR was shown to be effective, resuscitation might begin immediately. CPR treatment is aligned with closed-chest defibrillation for patients presenting with VF, also, as recognised by Kouwenhoven et al. (1957), who established the resuscitation's primary form. Resuscitation in out-of-hospital care aims to achieve an early return of spontaneous circulation (ROSC) to ensure the restoration of spontaneous perfusion at any time (Jacobs et al. 2004). Whereas EMS can provide advanced life support (ALS), the general public can begin basic life support (BLS) earlier using these simple CPR techniques.

Resuscitation generally originates either from EMS or bystander CPR. In this thesis, the term "bystander CPR" refers to CPR conducted by a community member outside of a healthcare facility that EMS does not orchestrate. As part of BLS, current resuscitation protocols emphasise bystander participation (Panchal et al. 2020a). Bystander CPR practice involves a public member who first recognises a cardiac arrest, calls for help, and begins chest compressions. Since a bystander prompts the intervention and calls for help, it may be critical for patient survival. Overall, starting early CPR enhances the chance of ROSC (Park et al. 2017). However, additional interventions must follow to maximise the probability of saving a patient's life. Early defibrillations care for patients with a shockable rhythm, and early advanced emergency medical services may enhance patient survival. These are detailed in the literature review in Chapter three.

1.2.1 Prevalence of OHCA

The high mortality from OHCA is common across nations and causes a global health concern (Kiguchi et al. 2020). According to the American Heart Association (AHA), 379,133 cardiac arrests occurred in the United States, accounting for 13.5% of death in 2017 (Virani et al. 2020), with a prevalence of 110 per 100,000 population (95% CI, 108.9–112.6) (Benjamin et al. 2019). Of these, fewer than 10% survived. Elsewhere by Gräsner et al. (2020), 37,054 OHCAs were reported from 28 European countries, with only 8% surviving in 2017. Finally, Pan Asian Resuscitation Outcomes Study (PAROS) reported 66,780 OHCAs in 7 countries of Asia (Ong et al. 2015a). The patient's survival chances varied from 0.5% to 8.5%. The statistics of all three reports conclude that the chances of survival are less than 10%. Table 1-1 summarises the survival outcome from OHCA in Middle Eastern countries.

Despite the prominent Middle East population that suffered from cardiovascular diseases, OHCA is under-reported. That is because OHCA is poorly studied, even though non-communicable diseases are a significant issue in the Middle East. It might be related to low research capacity in the Middle East (Chaabna et al. 2021). Notwithstanding, the current reports estimate a concerningly low survival rate in the countries with registered OHCA. The lack of cardiac arrest investigations in Middle East countries might negatively impact the economy and society because the economic burden of cardiac arrest is great due to high mortality (Paratz et al. 2021). The global survival rate cannot be investigated and explained in general since the patient's survival may be affected by various factors that vary across the nation. For example, the lack of cardiac arrest investigation in the Middle East may affect the local EMS systems. In the local context, the EMS organisational factors may act as either facilitators or barriers to patient survival (Dehghan-Nayeri et al. 2021). The facilitators or barriers should be defined in the local context to patient survival. A key barrier is the limited research investigation in health care in certain regions such as the Middle East.

Table 1-1 The current prevalence and outcome of OHCA reported in the Middle East.

Author	Country	Prevalence	Survival rate
(Alqahtani et al. 2019)	Northern Emirates UAE	Not reported	Reported 9% ROSC
(Al Hasan et al. 2020)	Kuwait	13.5 per 100,000	0.3%
(Irfan et al. 2016)	Qatar	23.5 per 100,000	8.1%
(El Sayed et al. 2017)	Beirut, Lebanon	Not reported	4.8%

Concerning the variation in the race, region, and cultural factors among the studies in Europe, the US, and the Middle East, the survival rate should not be taken as the global average due to differences in individual healthcare systems potentially affecting treatment outcomes. Lifestyles and the burden of comorbidities vary across nations. For example, the high level of diabetes, high body mass index, older age, and low education were all factors associated with cardiovascular diseases (CVD) in the Gulf region (Morgan et al. 2019). The predominant underlying factor for the prevalence of OHCA is CVD among most patients with underlying cardiac arrest susceptibility (Hayashi et al. 2015). Approximately 80% of cardiac arrests have a CVD aetiology (Gräsner and Bossaert 2013). It implies that the UAE has a high prevalence of one of the most high-risk factors, hypertension. (This prevalence in the UAE is discussed in depth in chapter two.) Overall, OHCA is a concern because it suggests an ever-increasing threat of a cardiac event. In addition to diabetes and high body mass index, a systematic review of the global burden of diseases shows a high risk of cardiac factors, such as hypertension and coronary heart disease (CHD), affects the rate of OHCA (Murray et al. 2020). With the globally rising death prevalence from cardiac disease over time (Virani et al. 2020), public health systems all need to address the issue of CVD and mortality (Murray et al. 2020). Cardiac conditions are likely exacerbating the high incidence of cardiac arrest.

1.3 The rationale for the out-of-hospital cardiac arrest study

OHCA and major trauma are two of the most critical cases that EMS treats in the pre-hospital setting (Zhu and Han 2021). However, much less is known about OHCA than other critical pre-hospital conditions (Soar et al. 2019, Hajian et al. 2021). In 2018, the International Liaison Committee on Resuscitation (ILCOR) released a consensus statement that listed significant information gaps in resuscitation (Kleinman et al. 2018). The enormity of knowledge gaps obstructs improved patient survival after cardiac arrest, necessitating urgent action at the science, professional, and community levels (Narayan et al. 2019). Knowledge gaps in the resuscitation process are partly due to research challenges, given the cardiac arrest event's uncertain location, patient condition severity, and ethical concerns. Experimental studies on cardiac-arrest patients are rare; hence, most reported studies are based on observations and insufficient evidence standards. As a result, limited studies reflecting a higher set of criteria impede empirical progress.

Many Out of Hospital Cardiac Arrest studies have been reported retrospectively, and results should be approached with caution when considering their implications for practice. Among the few reported OHCA studies, there was a significant variation in survival rates globally due to variations in community culture, EMS systems, and quality of care (Dyson et al. 2019, Kiguchi et al. 2020). Firstly, the cultural and EMS system variations add an extra challenge to finding the best treatment protocol for OHCA. Specifically, the cultural aspect of the community when it comes to treating OHCA. That is because community members need to participate in early CPR. In UAE, the cultural effect depends on people's education which they come from various backgrounds. In the UAE, 88% of the population are an expat from 200 nationalities, making the culture of act in time of cardiac arrest may not be expected.

Additionally, the EMS system in Abu Dhabi is dynamically changing in terms of structural management and leadership. The culture of improving cardiac arrest outcomes is challenging when this occurs in changing environments. The extended issue is that the system to treat OHCA is complicated. The care system is designed on a multidisciplinary treatment link between pre-hospital care and hospital treatment protocols, which adds to the research's complexity. Figure 1-1 depicts the difficulty of the care system. With the EMS system's systemic heterogeneity, it is difficult to enforce traditional clinical care that is "one size fits all." Therefore, OHCA must be investigated in the local context.

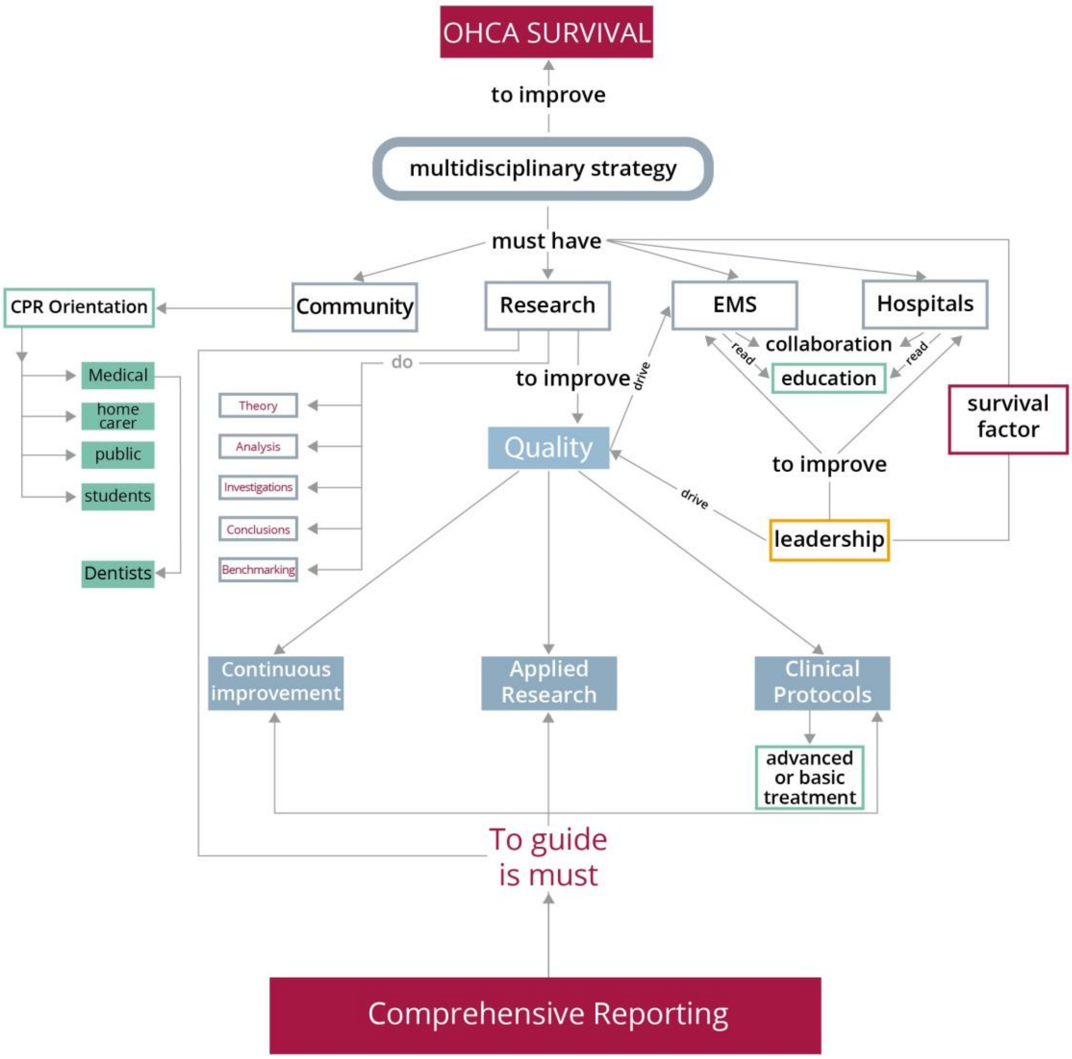


Figure 1-1 The multidisciplinary treatment linkage. This structure of various institutions and the public is needed to improve OHCA outcomes. It demonstrates the complexity faced by the institution to collaborate and produce the best evidence-based decisions and the challenges when this evidence-based practice is put in the clinical practice. The biggest challenge here is that the public may not train to participate in these complex interventions to save patient lives.

A key issue among those reporting OHCA is low survival rates (Lim et al. 2020, Gräsner et al. 2020, Majewski et al. 2020). However, the most recent research reported in the Northern Emirates is of particular concern that could not examine OHCA survival rates (Alqahtani et al. 2019). The major problem is that survival rates, and factors in the Emirate of Abu Dhabi, need rigorous investigation. There was extremely little data on this subject before this research. For example, a ROSC figure of 19% in Abu Dhabi was recently reported. While this percentage is not published, it does not imply that the patient survived (de Graaf et al. 2020). Before conducting this thesis, the researchers could not find neither valid and reliable data sources nor information about OHCA survival in Abu Dhabi. However, based on the ROSC percentage, it can be concluded that patient survival is likely to be insufficient. The primary health concern that prompted the current research programme is the high mortality rate from OHCA.

1.4 Research problem

In chapter two, in describing the EMS in the Abu Dhabi context, the EMS responds to about 45,000 calls in 2019, increasing 20% each year. In particular, cardiac arrest cases rise in Abu Dhabi due to the fast-growing population, as stated in chapter two. The increases in cardiac arrest events are followed by an increase in mortality rate in the country, which is an issue in society and depletes the economy. The EMS in Abu Dhabi has not tackled the high mortality rate issues before, and no study to date has recognised the problem in the EMS system. In this thesis, I aim to collect data to investigate the problem of high mortality from cardiac arrest cases in Abu Dhabi. Lack of OHCA status knowledge adversely impacts the low survival rate and may prevent any potential improvement in Abu Dhabi EMS. It is significant to declare that the issue that is not recognised cannot be solved (Mărăşoiu 2020). Due to a lack of knowledge within EMS, the dilemma or the contributing factors have been identified. Significantly, this influences the ability of the Abu Dhabi EMS to track and improve patient care adversely. Hence, research must address the knowledge gap because a robust system is required in Abu Dhabi to collect and report valid and reliable healthcare data.

Before this thesis, I could not rely on the local ambulance reports due to data reliability issues; there is no procedure for testing data and the limited variables used. Also, EMS services are promoted in the local context due to a lack of evidence-based planning (Letaief et al. 2021). Given these obstacles, and in the absence of high-quality literature in Abu Dhabi, this research sought to describe and investigate OHCA to educate policymakers and develop or refine strategies to tackle OHCA-related mortality in the Abu Dhabi community. Hence, this study aims to estimate the incidence, characteristics, and outcomes of OHCA in Abu Dhabi.

1.4.1 Demographic challenges

When reviewing OHCA in the Gulf region, factors such as unique demographics, cultural aspects, patient characteristics, and policies may be blamed. Also, only last year UAE Ministry of Health escalated the Good Samaritan Law to the cabinet for approval to allow bystanders to offer chest compression for cardiac arrest patients without fear of legal punishments (Ghany and Qazi 2018). However, the apparent gap in research in this area is a significant concern (Batt et al. 2020). This lack of local research evidence has influenced the Abu Dhabi EMS to adopt treatment guidelines from Western countries. However, recognizing some of the Middle East's unique demographic and patient characteristics has exposed considerable difficulties in adopting OHCA care strategies developed by non-local programmes. In addition, the multiple nationalities living in this context create unique demographic characteristics and cause fundamental challenges in promoting health care. The demographic characteristics are explored in greater depth in Chapter two, study context section 2.2, page 16.

Implementing the "chain of survival" policy is a significant problem in the Middle East (Cummins et al. 1991). The chain of survival outlines the process needed for OHCA patient survival. Community involvement, the EMS system, and hospital treatments are all necessary components of the survival chain. However, due to legal and cultural problems in Abu Dhabi, community involvement in cardiac arrest is low. The legal concerns are related to medical intervention performed by non-medical professionals if the patient is injured. Therefore, the local pre-hospital response may need to customise the treatment guideline to fit within the specific system (Batt et al.

2020). Abu Dhabi EMS needs such research to outline challenges. Additionally, little is known about Abu Dhabi EMS's quality of care (Moafa et al. 2019). Other studies by Batt et al. (2016) and Alqahtani et al. (2019) did not investigate the survival rates in other similar contexts, emphasizing an existing knowledge gap.

1.5 Study significance

EMS plays a fundamental role in pre-hospital emergency response (Ong et al. 2018). OHCA research is becoming increasingly relevant in EMS systems to indicate care quality results (El Sayed 2012, Pap et al. 2018). This study is significant for three reasons. First, I urged the Abu Dhabi EMS organisation to establish a branch for research into service quality due to the high demand for EMS. The dramatic rise in the number of calls requesting EMS demonstrates this trend. Also, the shortage of OHCA data is a source of concern and hinders support decision-making (Bashiri et al. 2019). Lack of OHCA knowledge is a healthcare problem. Since there is no current EMS level investigation, any implemented advances and strategies may not improve the services. The lack of investigations may not facilitate robust studies to be performed similarly to the nursing specialty in UAE (Al-Yateem et al. 2019). Before this research, there was no published research agenda and a lack of capability, as Abu Dhabi EMS lacked the ability and research skills to investigate.

For example, Abu Dhabi EMS policymakers allocated additional resources to enhance the EMS's organisational capability and reduce response time to the patient. In 2016, it was part of the pre-hospital enhancement program. Given the complexities and dynamics of pre-hospital care, recent studies on the OHCA area have not addressed fundamental strategic advances. So, the impact of specific EMS advances may be inadequate and fail to tackle pre-hospital care's fundamental issues. Most importantly, further innovations lack planning and evidence-based decisions. Creating evidence-based procedures in practice is significant (Dagliana et al. 2021), but not tackled in Abu Dhabi EMS. In critiques by Blair and Sharif (2013), it was evident that the UAE provision of extra resources raised the cost of health services without improving patient outcomes. This significant expenditure diverted funds away from planning and analysis. Finally, research is required to inform decision-makers about aspects of the

EMS system that are working well and which areas in the EMS system need improvement.

Second, public reporting of OHCA is critical for defining the issue and recognising contributing factors. For example, the USA Institute of Medicine (IOM) released an article arguing publicly reporting cardiac arrest through appropriate mechanisms to enable comparisons and increase public awareness about the EMS system's incidence and accountability (Neumar et al. 2015). While the IOM report is based on the USA context, similarly, the Global Resuscitation Alliance (GRA), supported by the World Health Organization (WHO), recommends that collecting and reporting OHCA data is the first step to improving survival rates (Nadarajan et al. 2018b). As a result, other researchers have investigated OHCA to address the issue's low survival rate. Overall, there are no alternative strategies to define OHCA rates other than collecting and reporting data, identifying survival factors, and appearing to be a successful strategy for saving lives.

Third, investigating and reporting OHCA survival variability is the first step to overall EMS improvement. Comparing local EMS systems provides an opportunity to understand why specific ones have achieved substantial OHCA survival rates. Comparison between EMS systems is achievable in OHCA research when similar concepts and variables surrounding OHCA are reported across multiple countries. ILCOR defines those variables and allows for comparison of the systems (Perkins et al. 2015b). According to Van Diepen et al. (2017a), research should determine successful OHCA characteristics that can be cultivated through more EMS systems to enhance OHCA survival. Furthermore, El Sayed et al. (2017) argued that the OHCA survival rate reflects the overall EMS system level. As a result, the OHCA investigation will offer a valuable account of Abu Dhabi's pre-hospital care.

1.6 Author introduction

I have served as an advanced paramedic in the Abu Dhabi ambulance department since 2007. As an advanced paramedic, it is always a thrill to respond to medical emergencies in pre-hospital care. I have received multiple recognitions, including medals to provide high-quality care treatment and save lives. In 2017, I was transferred to the clinical governance section to oversee the EMS performance. Resuscitation science is a passion as saving lives from cardiac arrest is the primary goal in ambulance services. My enthusiasm led me to dig into Abu Dhabi's low cardiac-arrest survival rate compared to other countries. I embarked on this professional doctorate to address the issue. The professional doctorate programme is based on modules that allow contextualising and evaluating enhancement strategies, which also allowed me to develop as a researcher. This doctorate has enabled me to see the problem from a broad view. I initiated a cardiac-arrest registry to collect data and start networking in the local and international context. The data collection project and professional doctorate initiation have allowed me to investigate the low survival rate issue. Ultimately this doctoral thesis has added new knowledge about OHCA cases attended by the EMS and provides a foundation for the ongoing development of the Abu Dhabi EMS.

1.7 Thesis structure

Chapter one of this thesis provides an overview of out-of-hospital cardiac arrest (OHCA), the thesis's central investigation theme. I have presented the background of Abu Dhabi having a low OHCA survival rate and the reasons for conducting this research study.

Chapter two is an overview of the United Arab Emirates in general and the Emirate of Abu Dhabi in the research context. Finally, I outline vital information concerning the current EMS in Abu Dhabi, including information about the demographic characteristics and health care system and critical details about the EMS system concerning OHCA.

In chapter three, I undertake a critical review of predictors of OHCA survival via a "chain of survival" concept. It reveals that Abu Dhabi EMS did not investigate OHCA, and my research is the first in the context.

Chapter four presents the methodological approach of this research. It outlines how the research design was formed and identifies the best approach to data analysis. Finally, the rationale for the method adopted is explained, including research philosophy, ontology, and epistemology. In short, this project embodied positivist philosophy and a deductive approach that allows for objective evaluation of variables that may influence patient outcomes.

Chapter five shares the result of this research; it describes OHCA demographics and characteristics. That includes sample size, patient characteristics, and findings in each chain of survival links.

Chapter six discusses the knowledge contribution to the possibility of patient survival following OHCA. First, I discuss the probability of a patient surviving OHCA in Abu Dhabi and the significant gap in Abu Dhabi EMS.

Chapter seven presents the project conclusion. Finally, I addressed how this research project brings new insight into the local and regional context and its recommendation and potential expansion.

2. Chapter two: Study context – Emirate of Abu Dhabi

This chapter provides an overview of the study context and outlines key information regarding current EMS in Abu Dhabi, including information about the demographic characteristics and healthcare system, followed by key information about the EMS system concerning OHCA. The general healthcare issue is undiagnosed CVD and increases in sudden cardiac arrest rates among younger persons, which are a significant problem for Abu Dhabi health services. A particular issue in pre-hospital care is when EMS dispatchers do not recognise cardiac arrest when prioritising critical patients.

2.1 Background

The Emirate of Abu Dhabi is the capital city of the United Arab Emirates (UAE), a high-income developed country located in the Arabian Peninsula (Paulo et al. 2017). Abu Dhabi is the largest emirate in the UAE, covering 87% of its total land. Abu Dhabi has undergone massive economic changes since the formation of the UAE in 1971. There has been a remarkable improvement in the quality of life in Abu Dhabi in recent decades (Elessawy 2021), following the discovery of oil reserves in the 1960s. The availability of oil reserves stimulated economic expansion from foreign investment and brought about societal changes and the provision of healthcare services (Al Sadik 2001). The rapid growth in UAE created demographic disparities in Abu Dhabi, which may affect healthcare conditions as described below.

Figure 2-1 Map of United Arab Emirates

2.2 Demographic characteristics and healthcare

2.2.1 Age and gender

In 2016, it was estimated that the population of Abu Dhabi was 2.9 million residents, comprising 19% local citizens and 81% non-citizens. The high non-citizen percentage is due to mass recruitment of expats to work in industrial districts. Furthermore, this caused a gender disparity in the population (Loney et al. 2013), where 64% are male (Figure 2-2).

Additionally, adults in Abu Dhabi are younger than in Western countries (16% age 0 to 14, 83% age 15 to 64, and less than 1% over 65). Consequently, most residents are between 20 to 59 years old. This demographic information is relevant to this thesis project, as a previous study showed that age and gender are essential factors in cardiopulmonary diseases (Choi et al. 2013). For example, an OHCA report in the northern emirates stated that 50 years old is the mean age of patients (Batt et al. 2016).

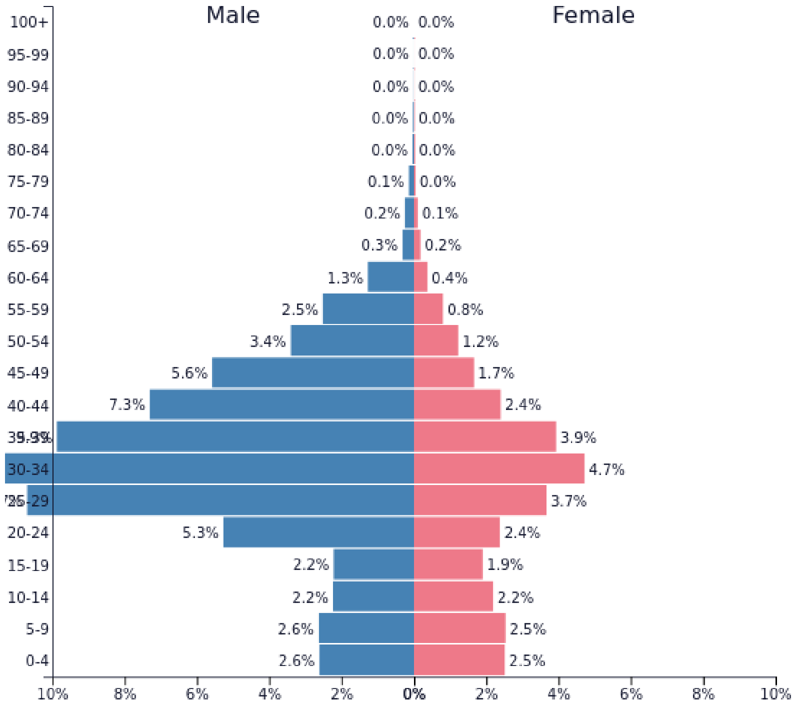


Figure 2-1 Population pyramid in UAE showing the high percentage of populations at the age 20 to 59 years old

2.2.1.1 Cardiac risk factors

Figure 2-3 shows the general cardiac risk factors and facts about CVD in UAE. It might be that the local UAE nationals have a low level of health literacy (Kazim et al. 2021), which may influence the incidence of cardiac arrest due to the prevalence of high-risk factors for CVD. The low health literacy may also be due to the high number of uneducated expatriates. Chief among these is a high prevalence of obesity and diabetes amongst people with low health literacy (Cheng et al. 2018), specifically those who are illiterate. A national cross-sectional diabetes and lifestyle study by Sulaiman et al. (2017) that surveyed adult expatriates living in the UAE found that 32% of expatriates are obese and 43% are overweight. This influences the health status in UAE, giving a high percentage of the population risk factors for CVD and other chronic diseases (Loney et al. 2013, Paulo et al. 2019). It must be said that the World Health Organization (WHO) recognises obesity as a global epidemic affecting most areas of the world, leading to an overall risk of CVD.

Figure 2-2 The risks and facts concerning CVD within UAE. These figures are nearly consistent with CVD and lifestyle issues in other countries like UK and USA. It starts by the fact that WHO declared obesity is epidemic, but it can occur in younger people, which leads to diabetes/CVD and may lead to lowering life expectancy

2.2.1.2 Diabetes, obesity and hypertension

In UAE, CVD is the leading cause of death at 74% in 2019 (Ministry of health and prevention 2021). Studies show that a vital issue in UAE health status is the high percentage of cardiac risk factors among younger people. An observational study that included 33,327 national UAE males aged 18 to 29 attending an obligatory standardised medical examination showed that 24.4% were overweight and 28% were obese (Alzaabi et al. 2019). Furthermore, this study demonstrated that obese patients were more likely to have cardiac risk factors in younger age groups, potentially due to low health literacy, as explained before in (section 2.2.1.1). Moreover, it is not only a problem in UAE. Using routinely collected data, a cross-sectional study in England demonstrated a high prevalence of CVD, including hypertension among males over age 50 (Hinton et al. 2018). Also, in the USA, obesity is correlated with the risk of

CVD complications and cardiac dysfunction (Powell-Wiley et al. 2021). The USA case demonstrates that obesity is a risk factor for CVD.

Obesity may be a factor in the high incidence of diabetes (Fiteni 2021), as one-third of the UAE population is either is diabetic or prediabetic (Hamoudi et al. 2019). Diabetes mellitus is a risk factor for CVD, leading to heart failure and cardiac arrest at later stages. An analysis of the Scottish diabetes mellitus registry showed that heart failure from CVD was two-times higher in patients with diabetes, causing morbidity and mortality (McAllister et al. 2018). Therefore, CVD is a common issue and leading cause of death across multiple countries needing immediate intervention to reduce mortality (Bhatnagar et al. 2015). The American Diabetes Association's latest recommendation is that cardiovascular risk factors should be systematically assessed at least annually in all patients with diabetes (American Diabetes Association 2020). A possible explanation for this might be that the CVD has increased in USA over two decades, accounting for increased spending and economic burden (Birger et al. 2021).

However, cardiac risk factors among young UAE patients include undiagnosed CVD (Al-Shamsi et al. 2019). Patients with undiagnosed CVD risk factors may develop additional issues, leading to cardiac arrest at a younger age. Increased CVD in Abu Dhabi also has long-term ramifications. For example, the life expectancy in Abu Dhabi in 2019 was 76 years for males and 81.5 years for female citizens. This is substantially lower than the average life expectancies in other high-income countries (84.4 years for females, 79.7 years for males) (Ho and Hendi 2018). These lower life expectancies may be caused by the high prevalence of CVD among adults, especially men. This is reflected by the findings that suggested the high prevalence in Abu Dhabi was linked to hypertension, diabetes, and cardiac failure (Razzak et al. 2018). Knowledge of this population health data is important for predicting and planning for future EMS dispatch and OHCA response.

2.3 Abu Dhabi EMS

The police administer the EMS in Abu Dhabi. Figure 2-3 demonstrates the pyramid administration of EMS in Abu Dhabi. The administration pyramid is significantly different in its management compared to other countries. These may affect the provision and allocation of EMS and pre-hospital care for critical patients. Also, the differences in OHCA survival are likely due to the EMS structure, leadership style, cultural aspects, and expenditure allocated to health care. To facilitate an improvement in EMS quality in Abu Dhabi, it is important to examine all these multiple variables. Although EMS is crucial for Abu Dhabi health integration, relatively little research exists to measure the services' quality. Abu Dhabi EMS measures performance based on ambulance response time. however, such measurement is not a key indicator of EMS quality (Lucchese 2020), because response time measurement is not sufficient to inform decision-makers on how to manage the use of resources. Therefore, it is crucial to examine other performance indicators, including clinical and non-clinical data. However, some barriers may hold the development of an improved EMS system back as described below.

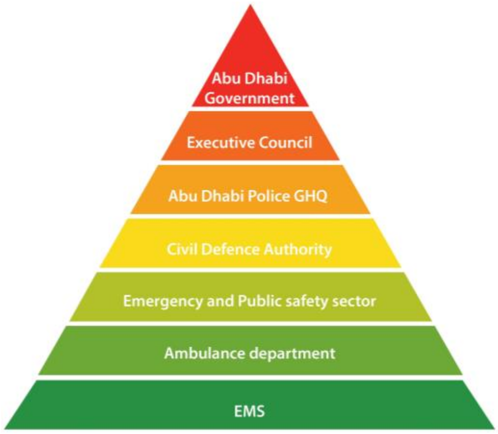


Figure 2-4 Pyramid administration of EMS in Abu Dhabi. This figure shows the foundation of the EMS services in Abu Dhabi. However, the legislation and regulation enforced into EMS are mixed between the Department of health and Abu Dhabi police

2.3.1 EMS background

In Abu Dhabi, the EMS is managed by the Abu Dhabi police general headquarters. Abu Dhabi police are the primary government organisation delivering various security subspecialties, including EMS, fire defence, traffic, and law enforcement. Abu Dhabi police formed EMS in 2001, although there is no clear record of why. It is likely a result of high numbers of fatal car accidents in the late 1990s. In the early 2000s, EMS only provided transportation for patients who were injured in vehicle accidents, although no previous literature was available for corroboration, and so this interpretation must be taken with caution.

Currently, EMS provides basic, intermediate, and advanced levels of service in the entire emirate. There are 72 sub-stations distributed throughout the emirate to reach patients in a time-efficient manner. Figure 2-5 shows the top 10 presenting complaints treated by Abu Dhabi EMS during the years 2015 to 2020, where chest pain may be categorized as 'generally unwell' or 'pain'. However, there are no set standards on how these sub-stations are distributed or how provider levels are organised. This is likely due to the lack of federal EMS legislation and policies, which may hamper the improvement of the EMS (Shah 2006).

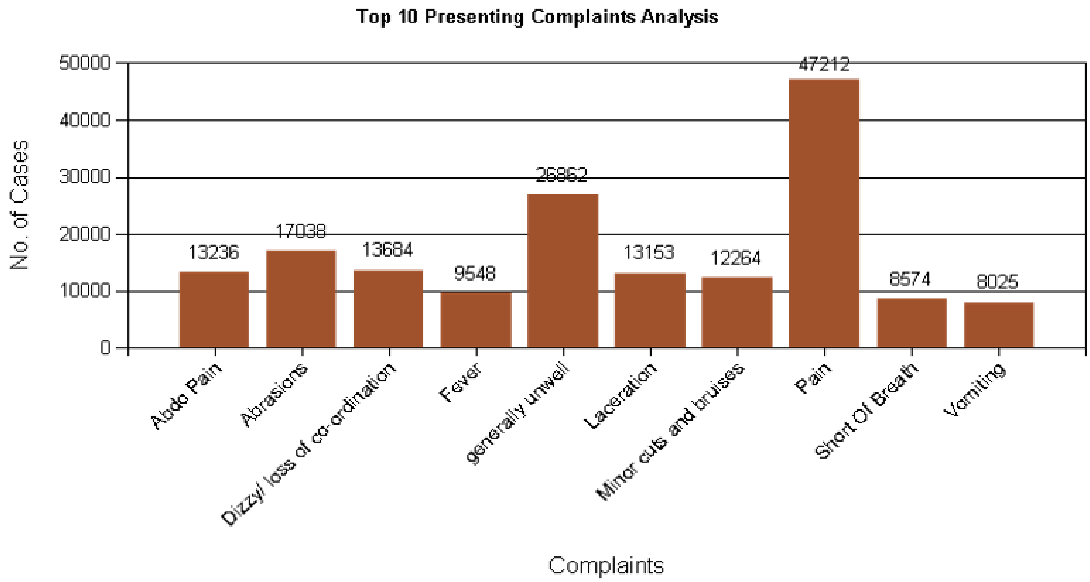


Figure 2-6 The most common cases within Abu Dhabi EMS shows calling the EMS because of pain is the most

2.3.2 Dispatcher centre

The current EMS dispatching process is illustrated in Figure 2-6. Most people use smartphones to activate the EMS in an emergency so there is a significant acceleration in response time than before (Weinlich et al. 2018). The use of smartphones in the UAE may enhance response times, especially when the patients experience language barriers. However, there is no system currently utilised to locate the patient effectively. People must call the universal 999 number to activate any emergency needs, such as police, ambulance, or fire defence. The incoming emergency call must pass through a police operation centre before being sent to the ambulance crew. This creates the issue that there is no clinical assessment or triage system available (Sasser et al. 2004), which limits the ability of the dispatcher to identify patient's chief complaint. Thus, the EMS units are dispatched to all calls equally with no call screening, clinical priorities, or pre-ambulance arrival instructions. Therefore, the speed of the medical response is not prioritised based on the health condition. The average distance from the EMS to anywhere in the locality involves a 10- to 30-minute journey. Transport of the patient to a medical facility takes place in less than 15 minutes after the EMS arrival. However, the survival of an OHCA patient has been previously demonstrated to be linked to dispatcher identification (Wissenberg et al. 2013). If the dispatcher does not recognise the signs of cardiac arrest, the high priority patients, such as those with OHCA, will receive the same response time as someone with a minor illness. Cardiac arrest identification is simple if the patient is unconscious and has abnormal or no breathing, which means that he/she is in critical condition (Bohm and Kurland 2018). While previous studies show positive relationships between early OHCA identification and patient survival (Hasan et al. 2019, Siman-Tov et al. 2020), some barriers to identification of OHCA by the dispatcher have also been identified (Michiels et al. 2020). One of the obstacles is the structural challenge when a different public agency is responsible for EMS dispatch to deal with a case of OHCA (Kurz et al. 2020).

Figure 2-7 The current Dispatching process in Abu Dhabi EMS. This figure notes the extra steps and time lost for the advanced unit to reach the patients. Some steps must be waived to reduce response time, like locating the patient by the dispatcher and EMS crew, also, using smart technologies to locate the patient

For example, in Abu Dhabi, the dispatch centre is controlled by the police department. Therefore, the dispatcher may have a non-medical background and is likely to misidentify or not recognise cardiac arrest symptoms. That may limit the EMS' ability to intervene more quickly for the most critical patients, leading to higher mortality rates (Moller et al. 2017, Mapp et al. 2019). In some countries, barriers to identifying OHCA are associated with a longer delay before CPR begins (Ho et al. 2016). If a trained dispatcher is present on the call, they can guide the assisting person through the procedure prior to EMS arriving on scene. Due to a lack of identification of critical patients in Abu Dhabi, it is possible to hypothesise that a delay in CPR likely leads to increased mortality. In short, Abu Dhabi EMS have an issue with early identification of OHCA and no medical advice/dispatcher-assisted CPR is provided before the ambulance arrives. The only information the EMS get during the call are the classification of the case as shown in (figure 2-7).

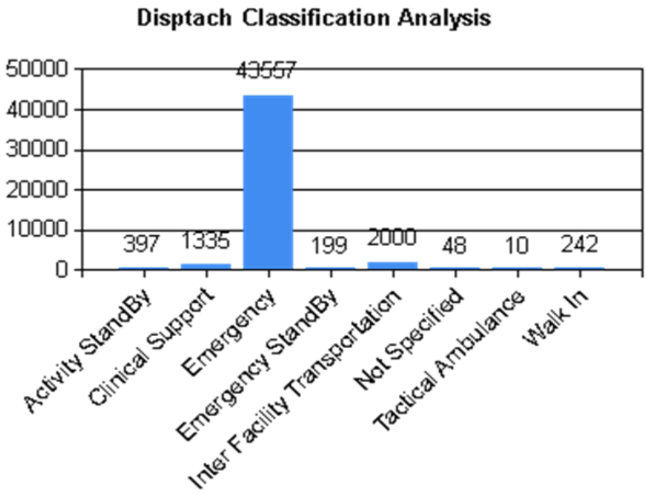


Figure 2-8 Classification of 2019 EMS calls by the dispatchers in Abu Dhabi

2.3.3 OHCA interventions

As explained above, EMS crews in Abu Dhabi consist of three levels: basic, intermediate, and advanced paramedics, each with different functions (Table 2-1). Abu Dhabi EMS follows the AHA guidelines for cardiac arrest resuscitation. AHA produced the policies based on recommendations from the ILCOR. However, the approach of using AHA guidelines in Abu Dhabi is questionable. Although the AHA quality of evidence was categorised based on the study methodologies and risk of bias (Link et al. 2015), AHA treatment recommendations for OHCA require further investigation. Critics of the AHA guidelines assert that most evidence was based on expert opinion, and a mere 1% of the 2015 treatment guidelines were based on clinical trials, the highest level of evidence (Morrison et al. 2015).

Another significant weakness is the contextual validity of AHA evidence for use in Abu Dhabi. Because all the cited studies are biased toward a Western context like the USA and Europe, study selection is a concern because of differences between Western and Abu Dhabi cultures, health equity, ethnicity, and pre-hospital systems, which may affect the response to OHCA. This is not only a concern in Abu Dhabi, but in other nations as well. An observational study conducted in New Zealand using cardiac-arrest registry data showed significant health equity disparities by race and OHCA (Dicker et al. 2019a). These highlights the continuing uncertainty about many of the interventions (Kleinman et al. 2018). It is not clear if the low level of evidence affects the outcome in Abu Dhabi. The local EMS should address the gap in AHA recommendations., and only then may they introduce a local treatment guideline for OHCA.

Table 2-1 EMS provider skills

Basic	Intermediate	Advanced
• Use AED • Perform defibrillation • CPR	• Use AED • Perform manual defibrillation • Administer drugs (epinephrine and amiodarone)	• CPR • Perform manual defibrillation • Perform manual shock • Administer drugs (epinephrine, amiodarone, sodium bicarbonate) • Perform endotracheal intubation

3. Chapter three: A critical review of predictors of OHCA survival

3.1 Clinical conceptual framework: The Chain of Survival

AHA illustrated the "chain of survival" concept is a dominant feature used to treat OHCA (Cummins et al. 1991). Since being published, the chain of survival concept has been used in numerous clinical guideline protocols (Committee members et al. 1995, American Heart Association 2000, American Heart Association 2005, Travers et al. 2010, Neumar et al. 2015, Soar et al. 2018). The concept includes the five following links: early access, early CPR, early defibrillation, early EMS/advanced cardiac life support (ACLS), and hospitalisation management (Cummins 1992, Rao and Kern 2018). The AHA partnered with ILCOR in 2020 to update the recovery chain guidelines to maximise the chance of patient survival (Merchant et al. 2020). To increase the chances of OHCA patients surviving, these connections must occur quickly in sequence or in parallel (Andrusiek et al. 2017). The existence of the chain of survival in all resuscitation process guidelines indicate that treating OHCA in EMS systems is of major focus. As presented in Figure 3-1, the first four links refer to actions within the community and EMS before the hospital.

Figure 3-1 Chain of Survival by (CUMMINS et al. 1991) page number 1833.

Studies in Western countries have demonstrated a substantial increase in OHCA survival due to the "chain of survival" implementation (May et al. 2018, Berg et al. 2019, de Visser et al. 2019). Over the past decade, there has been substantial growth in community CPR education and EMS response. Furthermore, there has been an escalating focus on developing strategies to improve OHCA survival using a chain of survival principle (Wei et al. 2020, Pepe et al. 2020). However, the UAE has a low OHCA ROSC rate, suggesting that further research is required to refine or enforce chain of survival strategies (Batt et al. 2017, Alqahtani et al. 2019). It is for this reason that I feel compelled to clarify the chain of survival concept. The data on the first four connections linked to pre-hospital treatment will be reviewed and addressed in this critical analysis. The aim is to explore and identify what is already known about OHCA survival predictors. The main review question is: What factors predict patient survival in OHCA?

3.2 The review objectives:

1. To critically analyse relevant international evidence of the "chain of survival" concept.
2. To identify the predictors of OHCA survival rates reported in the international research literature. The primary emphasis is to detail the factors that influence OHCA survival for patients resuscitated in the pre-hospital setting.
3. To critically examine research studies that have similar contexts and conditions to those present in Abu Dhabi.

3.3 Method

This is a narrative review of the relevant literature. The initial review was completed as part of the XD025 module in 2018, updated in January 2020 and again recently for this thesis purpose (Appendix 1 and 2 is the previous search strategy). In January 2021, the reviewed studies were selected from CINAHL Plus and Science Direct electronic databases. The quest was limited to English-language studies and articles regarding OHCA patients. Other research selection requirements included the "chain of survival" links to be carried out as an intervention. With the patients remaining neurologically healthy, ROSC or survival had to be the result.

The measure for the analysis review was as follows. Initially, all duplicated results were removed using RefWorks. All study titles were reviewed and any irrelevant publications were excluded. Following that, all remaining abstracts were reviewed and articles that did not fulfil the inclusion criteria in the Table 3-1 were eliminated. A review of the remaining papers' full text was performed to assess inclusion and final analysis. All retrieved studies were evaluated for methodological quality and risk of bias.

Table 3-1 Inclusion criteria for the study

Inclusion Criteria	
Studies	• Publication date 2015 (inclusive) - present. To focus the review on the most recent literature related to the OHCA. The earlier literature review was from 2017 and before. • Studies from any geographical location. • English language. • Studies using quantitative or mixed methods of analysis. • Quantitative published report. • Cardiac arrest registry annually published report. • Research papers study the benefit of the chain of survival.
Participants	• Adults (>18 yrs.). • Participant of non-traumatic cardiac arrest. • Being treated in out of hospital setting.
Intervention	• Early recognition. • Dispatcher recognition. • Bystander CPR in an out of hospital setting. • Automatic external defibrillator use. • EMS management.
Outcome measures	Primary outcome measure: • The survival rate from OHCA. • ROSC. Secondary outcome measure: • Neurological outcome at hospital discharge. • Discharged from hospital with long or short-term survival. • Quality of life.

Table3-2 Exclusion criteria for the study

Exclusion Criteria	
Studies	• Non-English language but not Arabic. However, no studies were found in Arabic language. • Published pre–2015. • Grey literature. • Abstracts. • Studies without a sampling procedure.

	• Qualitative studies using questionnaires or other methods that do not involve direct contact or observation of participants. • Treatment guidelines documents or chapter books.
Participants	• Children (<18 yrs.). • No OHCA diagnosis. • Traumatic patients.
Intervention	• In medical facilities witnessed patients.

3.3.1 Search strategy

The electronic database search strategy was used and the final search reported here was conducted in January 2021. Table 3-3 presents the research strategy.

Table 3-3 Search strategy used for the study

Search terms		Combinations
Condition	1. MH "Heart Arrest" 2. "OHCA" 3. "Cardiac arrest" 4. "sudden OHCA" 5. MH "sudden cardiac arrest" 6. MH "sudden cardiac death" 7. MH "Out-of-hospital cardiac arrest" 8. MH "out of hospital cardiac arrest"	9. #1 OR #3 10. #2 OR #4 OR #5 OR #6 OR #7 OR #8
Intervention	11. MH "pre-hospital CPR" 12. MH "early AED" 13. MH "EMS management" 14. MH "automatic external defibrillate" 15. MH "community CPR" 16. MH "chain of survival" 17. MH "bystander CPR" 18. "cardiopulmonary resuscitation" 19. "CPR" 20. MH "pre-hospital resuscitation" 21. "resuscitation" 22. "early access" 23. "early recognition"	24. #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23
Outcome	25. "ROSC" 26. "return of spontaneous circulation" 27. "survive" 28. "cardiac arrest survival" 29. Survival 30. "long term survival" 31. "short term survival"	32. #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31
Combination		33. #9 OR #10

	34. #32 AND #24 AND #33

3.3.2 Study selection

The selection was made in January 2020 and again updated in January 2021. Titles and abstracts were initially screened to exclude irrelevant papers from the criteria or to meet one or more of the exclusion criteria. The relevant articles were then found by reading the manuscripts. Also, the complete manuscripts were carefully examined for inclusion criteria. To evaluate the study's goals, processes, strengths, and weaknesses, an MS Excel matrix (Microsoft, Redmond, WA) was used. Additionally, the national institutes of health (NIH) quality assessment tool used to assess the quality of the studies methods and risk of bias (Ma et al. 2020). In January 2021, a total of 14 publications were retrieved and included.

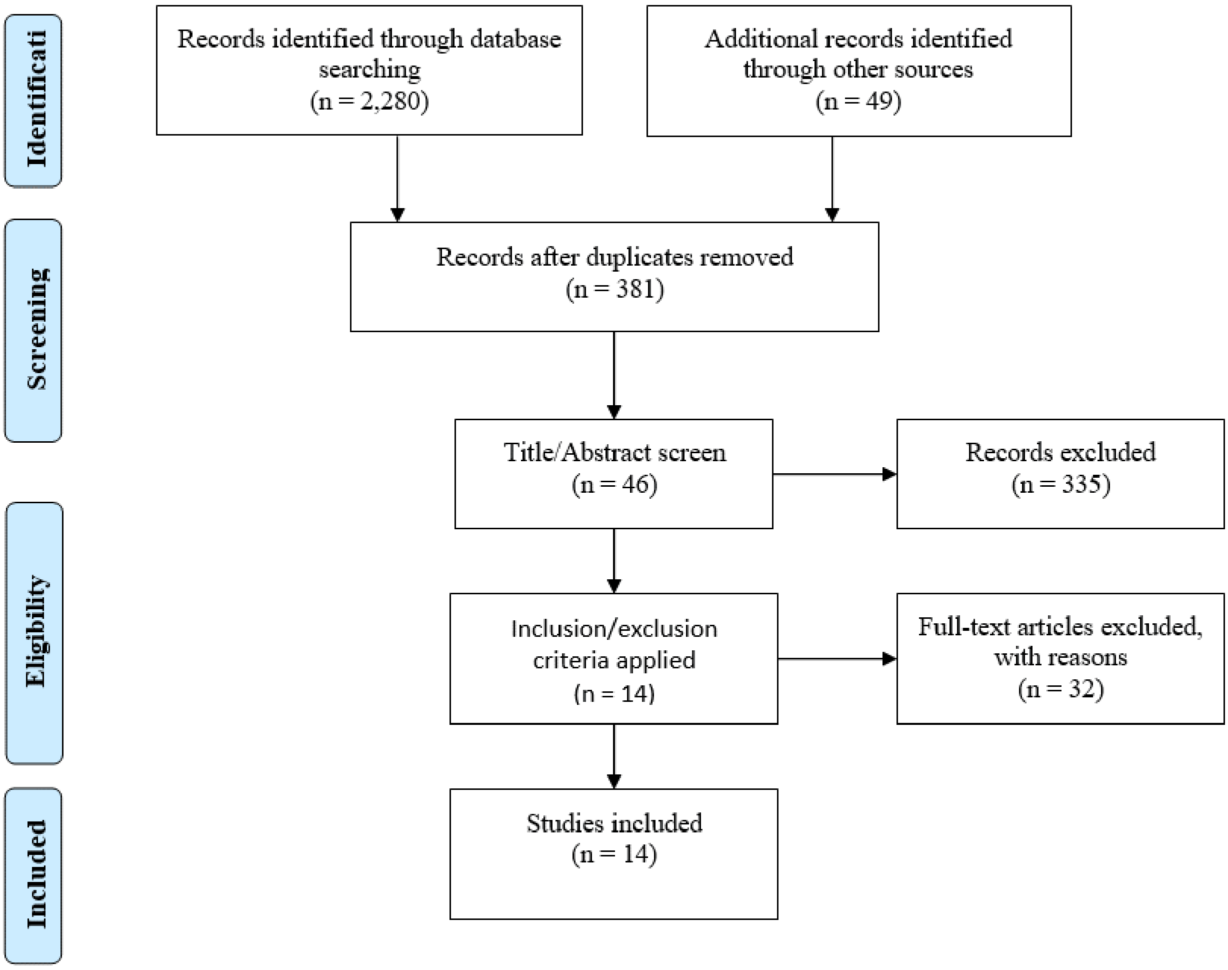


Figure 3-2 Flow diagram for selected studies in the literature review

Table3-4 Details of included studies in January 2021

Author	Study Aim	Method	Relevant findings
Al-Dury et al. (2020)	To investigate the importance of 16 well-recognised factors in OHCA to predicting survival	examined 45,000 cases of OHCA between 2008 and 2016 using a machine learning algorithm	The most important predictor of survival in OHCA is initial rhythm, followed by age, time to start of CPR, EMS response time, and place of OHCA
Kumpol et al. (2020)	to identify OHCA ROSC predictors	a prospective observational study evaluated possible ROSC in 347 patients	The factors including witnessed arrest, time from arrest to chest compression predicting ROSC, and patient discharge from hospital
Michael et al. (2020)	to compare the survival outcomes of EMS witnessed to bystander witnessed and unwitnessed OHCA in Singapore	a retrospective analysis of 8,394 OHCA from 2011 to 2015	Survival to discharge was higher in EMS-witnessed arrests compared to bystander-witnessed and unwitnessed arrests
Chocron et al. (2019)	assessing the association between allocated ambulance resources and outcomes in OHCA patients	prospectively collected 8754 nontraumatic OHCA occurred in the Greater Paris area	a higher density of advanced ambulances was associated with a significant survival rate
Christensen et al. (2019)	investigate the association between bystander CPR and survival in OHCA of presumed non-cardiac origin	identified 10,761 OHCAs through the Danish Cardiac Arrest Registry	Bystander CPR was associated with a significantly higher 30-day survival chance of 3.4% (95% confidence interval [CI]: 2.9-3.9) versus 1.8% (95% CI: 1.4-2.2) without bystander CPR
Czapla et al. (2020)	identify factors associated with ROSC in Poland	Analyse recorded 2,137 EMS responses to OHCA between July 2017 and June 2018	The rate of ROSC was significantly higher when CPR was initiated by bystanders ($p < 0.001$)
de Visser et al. (2019)	To evaluate the impact of the chain of survival on OHCA	Observational study of the 433 OHCA cases in the mid-western part of the Netherlands	Optimised' chain of survival' was significant for the 1-year-survival rate of 27%
Doan et al. (2019)	To investigate the bystander interventions on OHCA on survival	Respective analysis of 23,510 OHCA patients in Queensland Ambulance Service, Australia between January 2000 and December 2018	The odds of event survival, survival to discharge, and survival to 30-days were 1.16 (95% confidence interval 1.05–1.28), 1.20 (1.06–1.37), and 1.21 (1.06–1.38) times higher, respectively, in patients receiving bystander intervention compared to without the intervention
Grunu et al. (2019)	To determine if the ALS response interval was associated with patient outcomes.	Secondary analysis of 12,722 ALS-treated OHCAs between (2006–2016) in British Columbia, Canada	ALS response interval (per minute) was associated with decreased survival (adjusted OR 0.98, 95% CI 0.96–0.99)
Kishimori et al. (2020)	to evaluate the effect of public-access AED use for OHCA	A prospective registry of 1,743 OHCA	survival with favourable neurological outcome was higher in the AED pad application group than in the non-AED pad application group (29.8% [100/336] vs 9.7% [137/1407]; adjusted OR, 2.85; 95% CI, 1.73–4.68)
Kobayashi et al. (2020)	assessed public-access defibrillation (PAD) by laypersons and the OHCA outcomes	Enrolled 20,970 bystander witnessed OHCAs from the nationwide registry in Japan	Earlier PAD initiated by bystanders before EMS arrival was associated with better outcomes after OHCA
Luc et al. (2019)	to describe the incidence and immediate OHCA survival in France.	Data were extracted from the French national cardiac arrest registry	Survival rates were 4.9% [4.4; 5.4] and increased to 10.4 when bystander CPR was immediately performed
Michell et al. (2020)	to evaluate the association between early ALS and good neurological outcomes in non-traumatic OHCA patients.	A retrospective cohort study of 20,804 OHCA using data from the French cardiac arrest registry	Early ALS arrival was associated with a decreased occurrence of the good neurological outcome at 30 days
Perkins et al. (2019)	to assess the effect of adrenaline compared with placebo according to whether the initial cardiac arrest rhythm was shockable or non-shockable	survival and neurological outcomes according to the initial arrest rhythm were compared amongst 8,014 patients enrolled in the PARAMEDIC-2 randomised, placebo-controlled trial reported in (2018)	odds of the favourable neurological outcome at discharge suggested insufficient evidence of better neurological outcome with adrenaline compared to placebo in those with shockable rhythms (adjusted OR: 1.09, 95%CI: 0.77–1.53) and non-shockable rhythms (adjusted OR: 1.91, 95%CI: 0.87–4.22)

3.4 Results

OHCA research has increased dramatically in the last two decades (Figure 3-3). However, most retrieved articles were based on retrospective observations, with only two randomised controlled trials (RCT). This reflects the challenges of conducting well-designed resuscitation studies.

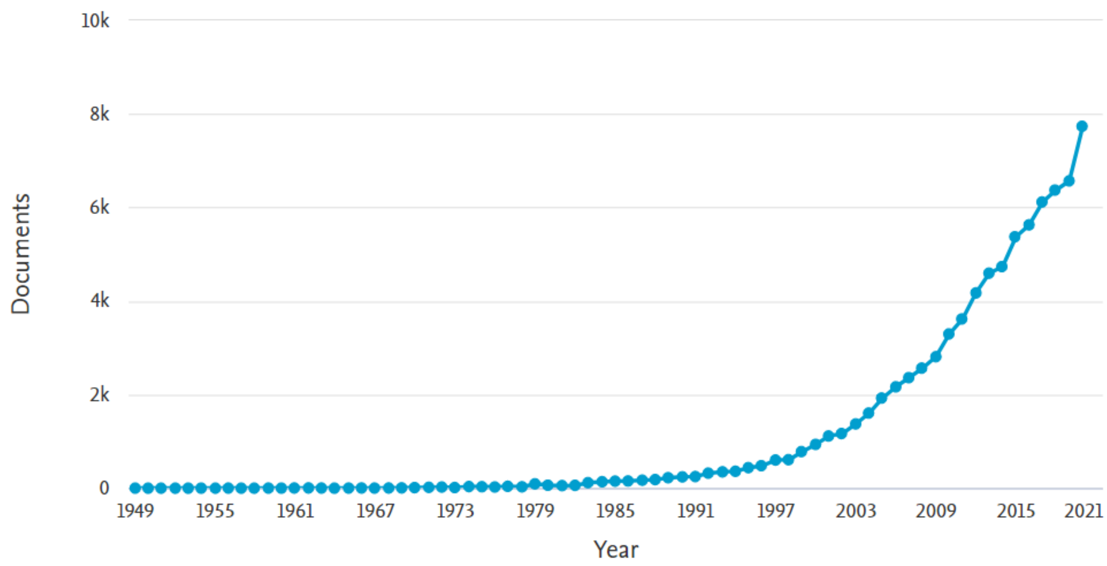


Figure 3-3 Number of studies by the same search strategy identified in the Scopus search engine

3.5 Result - Critical Analysis and Synthesis of Research Results

The aim was to examine the chain of survival links as pre-hospital care, clarify their influence on OHCA patients' outcomes, and identify any related studies conducted within the UAE. OHCA is poorly studied and no effort has been made to collect and analyse data in Abu Dhabi, despite the significant mortality rate for this condition in the UAE. This is a critical issue and the focus of this exploration.

Studies in the Western world highlight the value of the chain of survival. Specifically, early bystander CPR has been demonstrated to be a critical factor in adequate resuscitation, confirming the association between early CPR and OHCA survival (Hasselqvist-Ax et al. 2015, Harjanto et al. 2016, Park et al. 2018, Riva et al. 2019). Although poorly researched, the period time of collapse to first CPR is the most critical factor. Primary research evidence also revealed the crucial function of early detection in cardiac-arrest patients, as predicted. This related to the previous argument that if a cardiac arrest is recognised immediately, CPR can begin promptly, thereby increasing the chance of patient survival.

3.5.1 Early access

The first link of early access is intertwined with public engagement and education. Early access begins when a patient collapses and encompasses a series of critical events that culminate in EMS care initiation. Studies in Western countries indicate that for early access to the EMS to be effective, the public must be trained and a uniform emergency number must be accessible to all. Subsequently, there needs to be an efficient dispatch centre and the EMS system needs to be well organised (Berg et al. 2020). Early access begins with early detection of a cardiac arrest, enabling the subsequent links to be activated (Deakin 2018a). The present literature emphasises the early recognition of OHCA and successful resuscitation by EMS.

UK ambulance services built the "NHS pathway" system to expedite the treatment for OHCA patients. Over a year, only 75% of 3,119 OHCA patients were found by dispatchers in the south-central emergency service (Deakin et al. 2017). The caller may declare the patient dead as a clear indication to the dispatcher to recognise a cardiac arrest patient (Riou et al. 2021). However, other factors may prevent early identification (Mapp et al. 2020). To minimise uncertainty and time to initial CPR, the AHA produced a dispatcher policy statement to recognise OHCA (Kurz et al. 2020). Furthermore, the AHA 2020 resuscitation guideline recommends that EMS dispatchers play a vital role in detecting cardiac arrest and alerting bystanders to perform CPR (Berg et al. 2020). For example, activating an emergency for a chest-pain patient before they collapse may increase the proportion of cases handled by the EMS, promoting OHCA patients' survival (Glass and Brady 2019). However, cardiac arrest may be sudden and without warning, resulting in a delay in EMS treatment (Ornato et al. 2021). If EMS is delayed, it falls to a community member to recognise a cardiac arrest and begin CPR instantly to fulfil the criteria of the first two chain of survival links.

Specifically, the public recognition and prompt reaction to cardiac arrest, calling for help, initiating CPR, and applying defibrillators are crucial contributors to

OHCA survival within the population (Berg and Berg 2019). Public training and education substantially increase cardiac arrest recognition and minimise time to CPR. Like Anantharaman (2017), reviewed 34 years of resuscitation training: 1983 to 2017, which is perspective-supported community-based CPR training programmes in Singapore as a likely contributor to OHCA patients' recognition and survival. However, Anantharaman (2017) appears overly ambitious in this claim and provides little information about the method used to analyse training programs' efficacy. Even though the public may be trained to perform CPR, early detection of cardiac arrest is complicated since OHCA is an unplanned, unscheduled, and rare event. For example, Blomberg et al. (2019) analysed 108,607 emergency calls in Copenhagen using machine learning to recognise OHCA calls and found only 918 (<1%) were cardiac-arrest related in 2014. Due to the event's rarity, dispatchers may not recognise cardiac arrest, as seen in the UK's south-central ambulance service results (Deakin et al. 2017). Therefore, dispatchers may require further optimisation and education to identify cardiac arrest and activate the subsequent links.

All the above studies suffer from inadequate research methods due to different communities, cultures, education, dispatchers, and pre-hospital settings (Adam et al. 2020). Consequently, the varied cultural and educational aspects across settings make it challenging to identify which element (education, community member, or dispatchers) shapes the outcomes. The difficulty in measuring the effect of early access on OHCA survival may cause any results of such studies to be unclear. Using early access to improve OHCA outcomes means introducing a specific action that causes different communities to respond in a similar manner, which might be why there is no clear association between early access and survival. The bystander must report the patient's collapse, then the dispatcher must provide further instruction to activate telephone-instructed CPR. Community education and dispatcher awareness must be optimised to improve the early access connection.

3.5.2 Early CPR

Early bystander CPR is another critical issue in the international field of out-of-hospital resuscitation, which is dependent on the detection of a cardiac arrest (Olasveengen et al. 2020). Most recent studies predict that OHCA patients may regain near-normal function if bystander CPR is attempted early (Luc et al. 2019, Doan et al. 2020a, Czapla et al. 2020). These studies are observational but with large sample size. Luc et al. (2019) investigated 6,915 patients in France and demonstrated that bystander CPR improved survival from 4.9% to 10.4%. Doan et al. (2020) analysed 23,510 patients in Queensland, Australia, and found the odds of patient survival to hospital discharge were 1.16 (95% CI). Both Luc et al. (2019) and Doan et al. (2020) show that bystander CPR must begin before EMS arrival for a cardiac arrest patient to survive. Furthermore, early CPR is directly linked to a patient's doubled survival rate (Sondergaard et al. 2019).

For example, Christensen et al. (2019) analysed 10,761 records from the Danish cardiac-arrest registry and noticed that bystander CPR was correlated with improved survival chances after 30 days of 3.4% (95% CI) versus 1.8% (95% CI) without bystander CPR. Christensen et al. (2019) used a large sample size, but the data suffers from the fact that the patients analysed with OHCA were presumed to have non-cardiac causes only. Christensen et al. (2019) would have been more effective if they had focused on CVD, a common underlying cause of cardiac arrest in the Western world; it is responsible for 75 to 80% of cases (Katritsis et al. 2016). Another retrospective observational study of 181 OHCA patients in Bologna, Italy, by Giugni et al. (2018) confirmed a reduction in patients' mortality after one year when they received early bystander CPR versus non-bystander CPR (p=0.0003). The conclusions in Christensen et al. (2019) and Giugni et al. (2018) studies showed a positive correlation between bystander CPR and patients' survival in OHCA.

Several studies have shown that early CPR is beneficial (Park et al. 2018, Tanaka et al. 2018, Barnard et al. 2019, Fukuda et al. 2019). In summary, bystanders witnessed the patient collapse and began immediate CPR before EMS arrived. This can be achieved if bystanders are qualified to administer CPR or receive instructions from the dispatcher (Riva et al. 2020). Early CPR preserves the myocardium by maintaining oxygenated blood supply throughout the heart and circulatory system (Goyal et al. 2019). Furthermore, oxygenated blood keeps brain cells alive, allowing neurological regeneration and a higher chance of OHCA survival (Kumar et al. 2020). The evidence suggests the importance of public education on CPR as an aspect of a community's ability to provide rapid intervention (Villalobos et al. 2019, Nishiyama et al. 2019). However, training the public in CPR does not indeed lead to a performance in an actual situation because some communities show fear and hesitation, believing they may cause additional harm (Becker et al. 2019).

Overall, early CPR has conclusive evidence in the chain of survival and is correlated with a better prognosis for OHCA patients. An initiative in England to optimise bystander interventions has shown better outcomes (Hawkes et al. 2017a). Bystanders activate the next link by the attempt to use defibrillators. When examining the early defibrillation link, it is crucial to reveal that early CPR maintains patients' circulation and keeps the patient in a shockable cardiac rhythm, allowing pre-hospital defibrillation and supports ROSC (Song et al. 2018, Kiyohara et al. 2019, Geri et al. 2017).

3.5.3 Early defibrillation

Early defibrillation is essential in improving OHCA survival and can be performed in the public using Automatic External Defibrillators (AEDs) (Riddersholm et al. 2017). An AED analyses a patient's heart to identify a shockable rhythm and provides precise CPR guidance. It prompts the bystander to defibrillate the patient if a shockable rhythm is present or directs them to continue CPR (Mishra and Venugopal 2016). Shockable rhythms are ventricular fibrillation (VF) and pulseless ventricular tachycardia (VT), are known to predict patient survival (Al-Dury et al. 2020b). For example, Kishimori et al. (2019) and Kobayashi et al. (2020) prospectively analysed bystander AED use in Japan and found that patients who received AED defibrillation before EMS arrived had a higher chance of survival. This is consistent with other studies which found that using an AED in OHCA cases increases patient survival dramatically (Pollack et al. 2019, Merdler et al. 2020, Krammel et al. 2020a). According to two broad RCTs, defibrillation for shockable patient rhythms can convert to normal sinus rhythm and double survival rates (Hallstrom et al. 2004, Christenson et al. 2007). There is no recognised alternative treatment to a shockable rhythm; therefore, AED must be accessible at the scene.

It has been argued that AED must be accessible and unhindered at the time of OHCA to increase the defibrillation chances (Karlsson et al. 2019). The authors concluded that when accessible AED devices were present, the chance of bystander defibrillation tripled, and 30-day survival nearly doubled. Similarly, Pollack et al. (2018) asserted that higher survival chances were achieved when AED was used before EMS arrival. Although evidence validates that accessibility of AED and early bystander defibrillation could boost patient survival probabilities (Karlsson et al. 2019, Sun et al. 2019, Wang et al. 2019), there are challenges to overcome before incorporating AEDs into routine use (Ringh et al. 2018). Literature shows that AED is rarely used in public places, despite its association with improved patient outcomes (Andersen et al. 2019). For example, a three-year survey by Nishiyama et al. (2019) in Japan investigated how many of 3,000 trained persons performed AED and found that the trained individuals rarely encountered a person needing help and therefore did not use their skills.

The current research notes that situating AEDs in public places may increase patient survival. Others Zhang et al. (2019) and Wang et al. (2019) discovered no improvement in public awareness of AED and its usability. The reason for this is unknown, but it may relate to regulations, cultural aspects, and resource availabilities (Smith et al. 2017). This is evident in a survey analysing the current knowledge about AED in Saudi Arabia, which found AED use in public places is not regulated. Further, most participants (95.2%) had not received training about AEDs (Al Haliq et al. 2020).

Furthermore, no identified studies related community education programs and responses in Abu Dhabi or the UAE. Therefore, no community education program on AED or CPR is assumed to exist in the UAE. Because of the scarcity of educational AED programmes, public initiatives can suffer (Midani et al. 2019). A study by Batt et al. (2016) in northern Emirates states found the public may not appreciate the time-sensitive importance of OHCA or recognise the patient is in critical condition, posing a cultural obstacle to using AED. However, the interpretation is unreliable as the reports supplied by ambulance crews were biased rather than taking a scientific approach. Therefore, we still do not know if or why the UAE population hesitates to assist patients. In conclusion, early defibrillation may increase the survival rate, yet these findings' implications are not optimised.

3.5.4 Early EMS/ALS

It is favourable for patients when medical providers witness a cardiac arrest. For example, survival was higher in EMS-witnessed arrests in Singapore in a retrospective analysis of 8,394 OHCA patients (Chia et al. 2019). Patient collapse witnessed by EMS staff has the tiniest time between arrest and the implementation of high-quality CPR. In addition, the current literature emphasises advanced life support (ALS). The ALS interventions in OHCA are considered equal to endotracheal intubation (ETI) and vasopressor drugs, including epinephrine and amiodarone. Hypothermia therapy post-ROSC has recently been added to the ALS guideline (Panchal et al. 2020a).

Additionally, advanced equipment – such as a mechanical chest compression device – was added to enhance resuscitation quality. Given the recent resuscitations advancements, Abu Dhabi EMS prioritised ALS intervention for OHCA patients. Advanced technology and critical care interventions may be linked with better outcomes (Parker et al. 2021). However, recent studies raise questions about EMS' clinical value when administering ALS on OHCA patients.

Grunau et al. (2019) compared the effect of ALS versus Basic Life Support (BLS) treatments on the outcome of 12,722 OHCA patients in Canada. The authors concluded that ALS was associated with a lower probability of survival. These outcomes are consistent with a Stiell et al. (2004) controlled clinical trial conducted in Canada that found advanced interventions did not improve survival. The limited evidence suggests that these ALS interventions may not improve survival rates (Kurz et al. 2018). Also, since the results are biased against the Western population, caution should be exercised, as the findings may not be applicable to the local population. Because the trial was designed for ALS to be a first responder to the patient, which is different from the local tier system. Therefore, the importance of advanced therapies by Abu Dhabi EMS for OHCA survival when conducted in the pre-hospital setting is debatable, and the general debate continues (Cournoyer et al. 2017, Ohashi-Fukuda et al. 2017, Morgenstern et al. 2018, Kurz et al. 2018)

Another significant aspect was the EMS response time resulting in early CPR and emergency management, which was linked to better patient outcomes. For example, Chocron et al. (2019) prospectively analysed OHCA data from the cardiac-arrest registry and demonstrated that having a higher ambulance density in Paris that can react to OHCA faster is linked to a higher patient survival rate. However, early ALS was associated with decreased neurological ability after discharge (Michelland et al. 2020). Likewise, Sun et al. (2018) conducted a similar study in Korea and found that allocating additional BLS ambulances is correlated with improved neurological function and hospital discharge after OHCA. Due to patients receiving early bystander CPR, the evidence from Sun et al. (2018) must be interpreted with caution. Lee et al. (2019) conducted a prospective observational study in Korea with a broader perspective and argued that shorter EMS response times might contribute to more frequent OHCA survival.

Conversely, El Sayed et al. (2017) reported patient outcomes for 271 OHCA and found a survival rate of only 4.8%. This figure is consistent with other OHCA studies and revealed that the survival rates for EMS patients had remained consistently low for decades (Sasson et al. 2010, Myat et al. 2018). However, it is unclear why, and more investigation is needed to gain better insight.

A potential explanation is that the patients suffering from OHCA may have co- or multi-morbidities, advanced age, or undiagnosed cardiac abnormalities, reducing the probability of survival. Also, the number of ambulances available to perform either basic or advanced interventions may affect the patients' outcomes. Also, there are wide discrepancies noted among the EMS community as to who reported OHCA. As a result, it is crucial to consider that almost every publication focusing on the EMS effect on OHCA patients' survival has a distinctive EMS design. Due to this, comparing studies and drawing broad conclusions is difficult. For example, in this review, certain studies looked at Paris EMSs (Sun et al. 2018, Chocron et al. 2019), where highly skilled medical doctors make up the ambulance crews, while other studies in Lebanon and Korea consider EMS where the crew only has basic training (El Sayed et al. 2017, Lee et al. 2019). In addition, there are noticeable differences between EMS models around the world. For example, in the Franco-German model, the patients were treated in the scene by a practitioner who brought the hospital to the patient, and if needed, they transferred to the medical award directly. On the other side, the Anglo-American model consists of paramedics trained to treat the patient on the scene or on the way to the emergency department (Al-Shaqsi, 2010).

Therefore, different competency levels among these models make the studies difficult to draw general conclusions as to whether early EMS intervention influences patient survival. As a result, these findings may not represent global OHCA patients and outcomes.

3.5.5 Abu Dhabi Context

The survival rates and factors in the Emirate of Abu Dhabi bear little resemblance to other Emirates. Two published studies demonstrate the OHCA feature of another northern emirate in the UAE, with low OHCA ROSC rates, low bystander CPR rates, and low public defibrillator usage (Batt et al. 2016a, Alqahtani et al. 2019). However, the data analysed in both studies were incomplete since no survival rate was calculated. Also, since the studies recorded the private ambulance service at a primary stage, the survival percentage might not be generalisable to Abu Dhabi. In contrast, the level of Abu Dhabi EMS includes both BLS and ALS. As demonstrated previously, the EMS level influences survival rates (Sanghavi et al. 2015, Dyson et al. 2016, Sun et al. 2018). Also, the quality of research publications in the UAE is questionable and needs significant improvement to reach excellent research output (Al Marzouqi et al. 2019).

Nevertheless, in reviewing the literature, none of the existing studies can fully relate to OHCA cases in Abu Dhabi EMS. Incorporating the “Chain of Survival” concept in the system may improve OHCA outcomes. Furthermore, there was no significant literature on OHCA in Middle Eastern countries. Hence, the limited use of research-based evidence in Western countries may display a bias toward population and cultural differences more so than the UAE. Therefore, reviewed studies’ external validity is debatable when applied to the local context, as the OHCA survival rate within the Abu Dhabi EMS has yet to be investigated. Therefore, modern research is required to record survival rates, explore bystander interventions, and investigate Abu Dhabi EMS’s influence on survival.

3.5.6 Real-world model to increase survival following OHCA

I endeavoured to find a real-world application in a similar context to Abu Dhabi in terms of a chain of survival approach. The PAROS is a clinical research network that described Dubai OHCA characteristics, revealing that the survival rate is only 3% (Ong et al. 2015b). This is one of the world's lowest survival rates for OHCA patients. Detroit, USA, has the lowest documented OHCA survival globally, with no OHCA patient surviving (Dunne et al. 2007). However, the retrospective review in that study to assess the survival rate and prevalence of survival factors is weak. Because Dunne et al. (2007) published data from 2002, it may not be applicable to this project in the time, but it is included Dunne et al. (2007) to show the increase of survival in Detroit from 2002 to 2018. The latest study of the same city's EMS published in August 2018 indicates the survival rate markedly increased to 6.4% (May et al. 2018). The observed increase in Detroit OHCA survival outcomes is reported to be due to implementing the chain of a survival approach. This implies that novel changes to enforce the chain of survival approach are an effective solution for OHCA patients. Similar findings have been witnessed in ten American EMS systems and likely the same in other populations (Pepe et al. 2021). The most significant aspect is that the survival rate has increased, indicating that the chain of survival principle will improve patient outcomes in the UAE if applied correctly.

3.6 Discussion

In recent years, the survival rates of OHCA patients have increased worldwide (Yan et al. 2020), even though they vary drastically. Differences in OHCA survival are likely due to differences in health care systems, cultural aspects, and economic issues, including the amount of GDP that countries allocate to health spending (Shuvy et al. 2019, van Nieuwenhuizen et al. 2019, Dyson et al. 2020). Multiple variables spring from combining these in different contexts (Ridic et al. 2012, Arcaya et al. 2015). Development programs that improve OHCA survival chances in the Western context may need to be customised to the local context. This is due to the inconsistencies in patient care among the EMS systems (Hill et al. 2021). Despite the successful implementation of developments in another context, further research is needed to address cultural, demographic, and other characteristics in the local context when we attempt to apply the chain of survival. Therefore, a better understanding of variables related to higher OHCA survival and awareness of the knowledge and practice gap is essential in the local context.

3.6.1 Key findings

The most obvious link in the survival chain is early CPR as it is associated with a higher survival rate and better neurological maintenance. Early CPR is significantly correlated with bystanders in a more highly educated community. The most compelling evidence is that early ALS is correlated with decreased survival rate and neurological impairment. However, EMS interventions are still controversial due to the lack of a high level of evidence. That consistent with recent review by Lotfi (2021), which the current treatment pursued may be futile. Besides the current research, no other OHCA research has been performed in Abu Dhabi.

3.6.2 Literature interpretation

Changes in pre-hospital care have the potential to enhance OHCA survival rates significantly and are primarily intended to enforce identified survival predictors. Early CPR and early defibrillation are established OHCA survival predictors. However, these predictors are related to the community or EMS context. The most powerful predictor of patient survival is when CPR began instantly after the patient collapsed. Early CPR is aimed at high-quality intervention, which the EMS personnel can perform. However, the time from patient collapse to the EMS start CPR must to be determined and documented in order to be studied. Also, even if high-quality CPR is performed, the chances of patient survival are low. Earlier experimental high-quality CPR on animals show low circulation flow to the vital organs (Ditchey et al. 1982), reducing the probability of survival. There are no other current experimental CPR studies, other than those conducted on dogs. Advanced resuscitation research faces challenges due to a lack of high-quality data. Clearly, researchers face ethical issues in experimental trials for patients who are unconscious and in out-of-hospital areas. Therefore, the highest predictor of patient survival should be further investigated.

Typically, the literature refers to early bystander CPR, which is usually not performed by a health care professional. This raises concerns about the quality of CPR delivered. None of the literature explores the CPR quality related to patient survival chances. The ability of bystander to perform high-quality CPR is questionable. Because not every patient who received bystander CPR survive; nonetheless, bystander CPR, when performed before the EMS arrival, is correlated with increased survival chances. Also, it is mainly associated with the ability to recognise patient collapse early. The probability of early cardiac arrest recognition is dependent on public awareness and education. Moreover, even though the general public is educated on cardiac arrest symptoms, witnessing a collapsing patient is rare. This leaves the higher survival chances only for the patients witnessed, and then a bystander may activate the emergency services and start high-quality CPR.

The survival chances are highly reliant on public participation and faster EMS response. However, the applicability of public involvement in the UAE is questionable, since there is no recognised public education programme in the UAE about cardiac arrest and CPR. Additionally, the association with OHCA survival within the local context demands further investigation. Interestingly, only a few EMS organisations have investigated OHCA trends. EMS organisations seem to focus on ALS intervention. Advanced technologies and interventions are assumed to reduce morbidity and mortality. However, the reported ALS on OHCA reduces the survival chances when performed in pre-hospital. The assumption that ALS lowers survival chances is based on a low level of evidence. Though most of the OHCA literature is frequently retrospective, few experimental studies have been carried out. According to the AHA, a mere 1% of the 2015 treatment guidelines were based on the highest evidence level (Neumar et al. 2015, Duff et al. 2019). This suggests the continuing uncertainty about many of the ALS interventions. All those experimental studies are biased to the Western context due to different technologies and levels of competencies. While in Abu Dhabi, EMS is believed to use the latest available technologies, such as mechanical chest compression devices, this yet to be examined. Finally, before this thesis, Abu Dhabi EMS' effects on patients' survival and whether the outcome is like other countries are unknown.

3.7 Conclusion

This review aims to identify the predictors of OHCA survival reported in the local and international literature. Early CPR is a predictor of patient survival. In the local and foreign contexts, the time interval from patient collapse to first CPR is yet to be determined. No previous work has reviewed the OHCA studies in UAE and the Middle East. This review shed light on the region's limited studies on cardiac arrest. Abu Dhabi EMS, in particular, has no existing knowledge about OHCA survival predictors. Despite the mortality caused by cardiac arrest in other countries, Abu Dhabi's community and EMS services' characteristics have not been investigated. Although, the OHCA survival patient is a predictor of successful pre-hospital treatment. However, the review suggests uncertainty about cardiac arrest treatment in Abu Dhabi. The effectiveness of Abu Dhabi EMS initiatives would require comprehensive research investigation. Given the importance of examining the treatment effectiveness, this thesis was significant contribution in examining and exploring OHCA in Abu Dhabi.

4. Chapter four: Research Methodology

4.1 Introduction

An essential stage of this research is the dissemination of information to policymakers and researchers, figure 4-1. Translating new knowledge into action is a challenge for Abu Dhabi public health. Research findings are vital for decision makers to improve health services. Therefore, the priority is to formulate the optimal research design to best contribute to public health practice. Ultimately, the formulation of this research is vital to achieve the research objectives and reliably answer the research question (Tully 2014, Rezigalla 2020). Furthermore, a reliable research design will contribute to scientific knowledge and the clinical community. This chapter outlines how the research design was formed and identifies the best way to answer the research question.

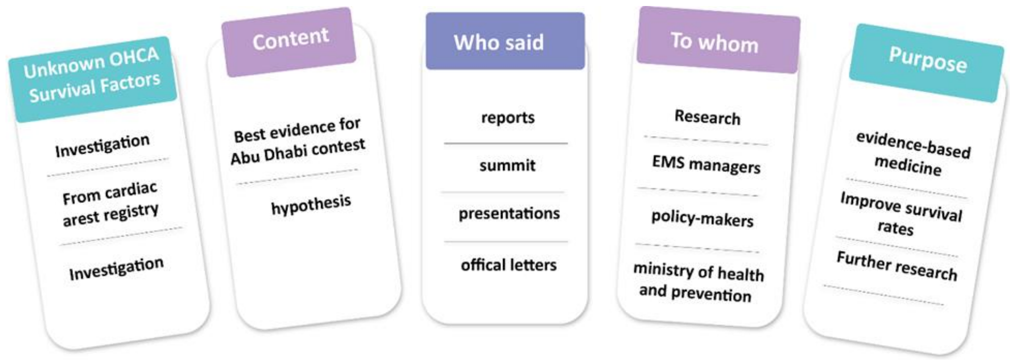


Figure 4-1 These are my proposed 5 steps process of translating knowledge into action for more effective EMS practice

Research question and objectives:

This study aims to explore and describe the influence of OHCA features, including early bystander CPR, early defibrillation, and EMS management, on patient outcomes in Abu Dhabi. A methodological approach was designed to answer the research question:

What are the factors that may influence survival or non-survival for an OHCA by Abu Dhabi EMS?

It also seeks to achieve the following objectives:

- To investigate the patient factors that may influence the survival of patients treated for an OHCA by Abu Dhabi EMS.
- To make recommendations for policymakers and EMS system strategies for the future.

4.2 Rationale

The following figure 4-2 outline the main phases of formulating the research design.

Figure 4-2 Outline of research philosophy, approach, methodology, and data source

4.2.1 Research philosophy

Science lacking a system of logic is unusable (Mill 1884), however, today a "system of logic" refers to research philosophy (de Balbian 2017). Evidence shows that a research philosophy must guide scientific research (Laplane et al. 2019). Scientific research is generally structured into multiple phases: developing the theory, observing, then experimenting (Kuhn 1962). Furthermore, scientific research is based on assumptions upon which to deliver new knowledge (Zukauskas et al. 2018).

Nonetheless, each researcher may have different assumptions. Therefore, each researcher has different methods for investigation (Cohen et al. 2013). Research philosophy is the guidance to generate knowledge (Mishra 2019). Before developing this knowledge, a series of logical steps must be followed to design the research. First, it is crucial to describe the research paradigm. The key features of the research paradigm are ontology and epistemology.

4.2.1.1 Ontology and Epistemology

Ontology refers to the belief in the existence of reality. Ontology is relevant to healthcare research, given the growth of available medical data (Robinson and Haendel 2020). Medical data is an interesting case, as it has a high ability to provide real insight and improve the application of services for patient quality of life (Leary et al. 2020). Epistemology seeks to answer what is the current reality and how we acquired it. The epistemological belief will lay the basis for the type of knowledge produced in the research project; therefore, epistemology is the theory of how the research will gain new knowledge (Carter and Little 2007). The researcher uses epistemology to set rules to discover reality (Harding and Hintikka 2003). There are four main research philosophies to develop: positivist, interpretivist, pragmatist, and realistic (Wahyuni 2012). Positivist philosophy follows an deductive approach that quantifies factors to generate knowledge objectively (Thomas 1998).

4.2.1.2 Positivist philosophy

This project reflected positivist philosophy, which guided the research (Ryan and Sfar-Gandoura 2018, Corry et al. 2019). Positivism refers to the belief that a cause can be determined (Mandelbaum 2019), which has been dominant in health science for more than 100 years (Schrag 1992, Park et al. 2020). In positivist philosophy, the cause is an observable phenomenon that can provide understanding and new knowledge by verifying the data systematically (Fain 2020). Therefore, by displaying the data, the possible realities are obtained; these being the facts and figures (Crotty 1998). This in turn provides a hypothesis about potential factors leading to OHCA patient's survival or non-survival. In pre-hospital emergencies, demographic variables, such as age or ambulance response times, are likely to influence patient outcomes. Also, specific interventions by the EMS crew for the patient may affect the outcome. Those variables are existing (ontology), observable and objectively measurable (epistemology).

Researchers commonly assume that implementing a "chain of survival" is a critical factor for OHCA survival (Iwami et al. 2009, Kill et al. 2017, de Visser et al. 2019). That was followed by recent evidence suggesting that OHCA is an illness and the patient can survive if identifiable factors are implemented (Yan et al. 2020). If identifiable factors can treat OHCA, then this research project seeks to examine the influence of some of the unidentifiable factors within Abu Dhabi, such as early CPR, early defibrillation, and EMS management on patient outcomes. This research will provide new knowledge on OHCA survival within the Abu Dhabi EMS system.

The new knowledge regarding EMS response systems is preliminary stage and has the possibility to guide the reform of EMS policies and procedures or provide a new perspective for further OHCA investigations. Therefore, it was essential to seek an objective view in reporting; no changes were made in any intervention. This study's quantitative methodological choice is from positivist philosophy benefit to eliminate bias when generating the theory and hypothesis through performing data collection and statistical analysis (Gasparyan et al. 2019). The generation of knowledge by quantifying pre-hospital care factors will enhance precision and provide comprehensive reporting of the study outcomes. In essence, this research utilised the positivist paradigm, to quantify and analyse the pre-hospital factors related to OHCA.

4.3 Deductive approach

Healthcare research has traditionally been driven by an empirical approach to obtain and test new evidence-based practices (Dang and Dearholt 2017). Choosing the appropriate methodology was vital for designing the research and aligned logically with the research philosophy. In previous studies, the two main analytical methods used are inductive and deductive (Procter 2013). A deductive approach sets out to generate or test a hypothesis to provide knowledge (DeCarlo 2018a), while inductive approaches concerns the generation of new theories (DeCarlo 2018b).

A deductive approach based on four phases was chosen for this study, which provides the quantitative possibility to measure the factors that may influence patient outcomes (Blaikie and Priest 2019). The initial step involved conceptualising possible pre-hospital factors affecting OHCA patient survival, using previous literature, followed by data collection. Third, statistical analysis was carried out to generate descriptive data for all variables. Finally, critical discussion regarding the significance of results was performed to highlight possible changes that could be made within Abu Dhabi EMS. This deductive approach allows for independent study validation and replication, given the data availability.

4.3.1 Quantitative method

This section describes several pre-hospital factors that may affect OHCA patient survival, which means analysing the data to produce a report based on the facts and figures. The end spectrum of OHCA reports will create descriptions for characteristics and demographics, including frequency counts and percentages. Moreover, this research will facilitate the gathering of relationships between characteristics that may influence patient outcomes. Therefore, a direct data collection method is required to systematically enhance the ability to observe these characteristics (Black 1999). Traditionally, researchers face a choice between quantitative, qualitative, or mixed methods of data collection (Noyes et al. 2019a). But based on the positivist position in this research, the quantitative method allowed the extraction of precise data to unveil reality (Noyes et al. 2019b).

The quantitative method allows the generation of both theory and hypothesis (Black 1999), which can then be tested with experimental studies. The method is determined by the research question, which intends to measure quantifiable demographics and patient characteristics, as shown in the defined variables below and the perspective of the end continuum from which this research attempts to describe OHCA. Quantitative analysis allows objective presentation of data to provide credible information to policy makers (Ellen et al. 2018). Specifically, it allows the narrowing of focus to examine a single factor (Brannen 2017), and has minimal risk of bias (Chew 2019). For instance, bias can occur in data collection, or analysis, and distorts the result and thus may cause researchers to make incorrect conclusion about their data (Simundić 2013).

4.3.2 Observational strategy

Based on the stated research question and given the choice of the deductive approach, an observational study was considered appropriate for the current project. The emerging issue of OHCA in Abu Dhabi, with a range of clinical questions, requires an innovative solution to achieve best practice. Evidence-based decisions are part of developing best practice and contribute to improving patient outcomes (Riemer et al. 2012). However, the complexity of the situation presents challenges for researchers and pre-hospital care providers to come to an informed decision (Myat et al. 2018). A well-designed research method is needed to identify which factors are pertinent, develop a research hypothesis for validation, and contribute to evidence-based medicine. Many researchers classify evidence into levels based on the methodological approach (Burns et al. 2011). Observational studies play an essential role in healthcare research as a preliminary step to identifying a problem and the factors that underlie it.

For example, during the 2020 pandemic, observations have shown that CVD patients are at increased risk of severe COVID-19 symptoms and complications (Guzik et al. 2020). In turn, observational studies have been used to evaluate and support the treatment of those critically infected with COVID-19 virus (Geleris et al. 2020), as they are particularly useful in describing multiple factors and outcomes (Rezigalla 2020). Furthermore, observational studies can describe broad problems in healthcare delivery, such as the lack of identification of CVD by EMS dispatchers in Abu Dhabi.

Observational studies use readily available healthcare data without manipulating patient interventions, allowing real-life events and their variables to be examined in detail after the fact. Also, observational studies are ethically acceptable in emergency care research. Finally, randomised control trials (RCT) are not appropriate for this study. RCT can be impossible, inadequate, or inappropriate to conduct (Fogel 2018). Further explanation is given in appendix 3.

4.3.3 Descriptive study

There are two types of observational research, descriptive or exploratory (Rezigalla 2020). Exploratory research is helpful to investigate how various factors influence outcomes. However, certain drawbacks are associated with this as it must be guided by a hypothesis (Reiter 2017). Therefore, a major problem exists with using this type of research for the current project, as a null hypothesis has not yet been developed because this is the first research concerning OHCA in the Abu Dhabi EMS context. This was attributed to the relatively new implementation of the EMS system. Also, exploratory research runs against the deductive approach.

Alternatively, a descriptive research study is one of the best-known tools for assessing a new inquiry area (Vetter 2017). These studies seek to answer the questions, "What is the issue? Where does it happen? When is it observed? And who are the patients?" (Süt 2014). For example, research into the early stages of the 2020 COVID-19 virus pandemic were based on descriptive analysis (Pan et al. 2020, Harlem and Lynn 2020) to uncover what already exists as a basis for further research (Abrams-Downey et al. 2020). Descriptive research initiates potential hypotheses that direct subsequent correlational, quasi-experimental, and experimental studies (Siedlecki 2020). Given the intention of this thesis to uncover OHCA issues and formulate a theory, a descriptive pathway was utilised for the observational study to form an OHCA profile of characteristics and demographic features, including their influences on the outcome.

4.3.4 Cross-sectional

Two types of descriptive studies exist, being cross-sectional and longitudinal. A cross-sectional study examines a phenomenon at a particular time and place, while a longitudinal study will examine a set of phenomena over time. A cross-sectional study was utilised to measure both the exposure and outcome at the same time (Mann 2003). Consideration was given to the longitudinal study type to follow all of the 2019 OHCA cases. However, it would be challenging to follow OHCA survival cases over one to two years due to the challenges facing such an extended follow-up (Jaramillo et al. 2020). Because of OHCA events' uncontrolled nature, patients may survive to hospital discharge but not revisit the hospital, which makes it challenging to gain further information for this thesis. A cross-sectional study is a type of observational research utilised to lay the groundwork by generating hypotheses (Setia 2016). Evidence demonstrates that a cross-sectional study is useful for strategic planning and to evaluate a healthcare system (Aggarwal and Ranganathan 2019). The estimation of prevalence and description of demographics and OHCA events formed the complete thesis profile. In terms of the participants, these were selected based on a set of inclusion conditions indicated below.

4.3.5 Prospective data collection

A cross-sectional study may be conducted prospectively or retrospectively. Initially, the retrospective approach was considered due to its accessibility of recorded data from previous years' cases (Manja and Lakshminrusimha 2014). Data accessibility makes answering the research question rapidly and relatively inexpensively easier. However, the previous year's data are not recorded for research purposes in Abu Dhabi. For example, the information on hospital outcomes could not be obtained. Therefore, the data are not complete, so their reliability is questionable.

In contrast, the prospective approach requires extra time to collect the data sufficiently for research purposes. Therefore, the prospective approach was selected for its reliability, validity, and robustness (Caruana et al. 2015). Furthermore, as this study aims to describe the patient outcomes after OHCA events, a prospective cross-sectional approach, using a cardia- arrest registry (CAR), was used to collect the data.

4.3.6 Study design

As explained above, the current study utilised a descriptive and cross-sectional approach based on a prospective data set to study of the effects of OHCA characteristics and pre-hospital factors on patient outcome.

4.3.6.1 Participants

The primary source of the participants identified was the cardiac-arrest registry (CAR). The CAR is a secondary data source, as explained below. An eligible patient must fulfil all the following to be included:

1. OHCA patient on whom EMS attempted resuscitation.
2. Age of 18 years or older.

Patients were excluded from the study if any of the following criteria were present:

1. Patients were suffering OHCA from trauma.
2. Resuscitation not attempted due to the patient being dead on or before the arrival of EMS.
3. Cardiac arrest occurred in a hospital or clinical facility.

Why not include traumatic OHCA cases?

The decision was made to select medical cardiac arrest patients only for the current study, rather than also including patients who sustained cardiac arrest after trauma. Traumatic cardiac arrest patients also frequently have a hypovolemic shock or brain injury. Traumatic cardiac arrest patients are less likely to survive and require different interventions to medical cardiac arrest (Khalifa et al. 2021). For example, hypovolemic shock is due to blood loss after the incident and may cause acidosis or pathological imbalances (Gruebl et al. 2021). I excluded trauma OHCA because the interventions are different from cardiac medical arrests, such as blood transfusion and ETI requirements. In addition, the key indicator for traumatic cardiac arrest is measured differently because clinical strategies to enhance traumatic cardiac arrest survival might involve a specific approach to improve certain treatment outcomes. These treatments are not used in medical cardiac arrest patients.

4.3.6.2 The rationale of the cardiac-arrest registry

A contribution to knowledge in the CAR project made in Abu Dhabi EMS by generating new data. I created CAR to record OHCA data prospectively, as previously, no data infrastructure existed in Abu Dhabi to record OHCA patient outcomes. The registry is significant for understanding developments in Abu Dhabi EMS to target OHCA survival (Figure 4-3). It collaborates with multiple structured departments as shown in the mind map (appendix 4). The most important reason is that the CAR utilised the Utstein variables (Baldi et al. 2020), developed to improve OHCA research outcomes and contribute to better public health through a framework that allows for the comparison of OHCA outcomes internationally (Cummins 1993). The Utstein reporting framework was founded in 1990 by a multidisciplinary group that held meetings in Utstein Abby, Norway, and in Surrey, Britain (Cummins et al. 1991). In that year, the multidisciplinary group discussed ineffective research outcomes on resuscitation because of the absence of consistent reporting and terminology in various countries.

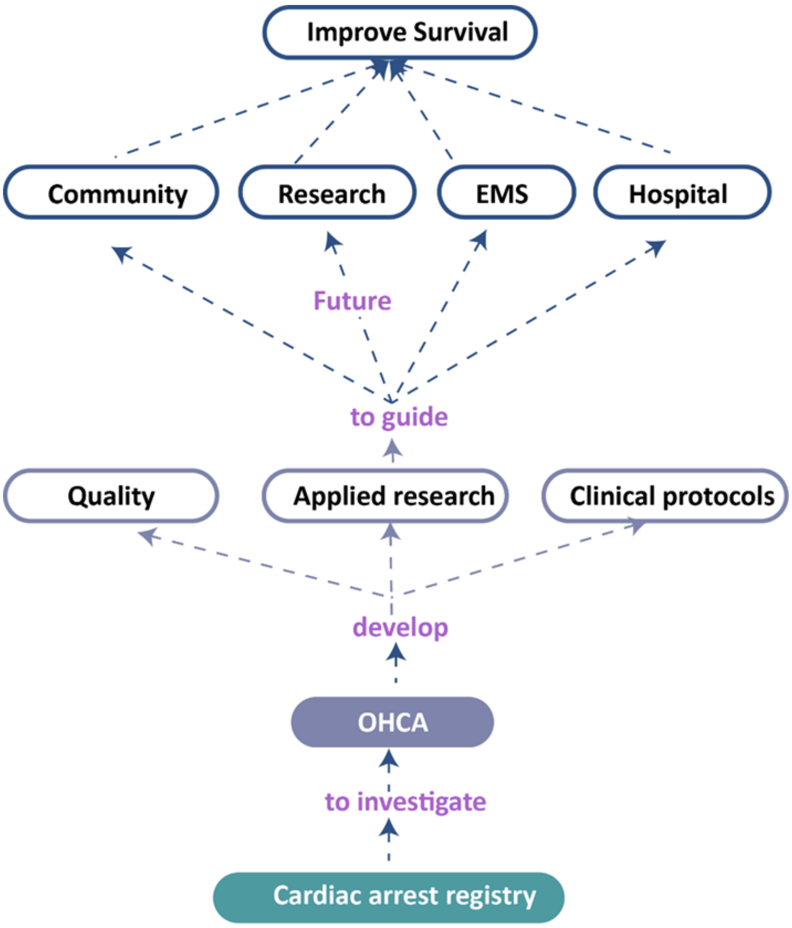


Figure 4-3 Registry to guide and improve OHCA survival. This figure shows the process of improving the patient survival, that start from cardiac arrest registry, which emphasize the significant of the project that contribute to the service

The utilisation of standard OHCA reporting meant that a research outcome could be compared with those from different systems or countries. Therefore, establishing standard OHCA variables may make it easier to advance research, communicate results and facilitate collaboration between systems and countries (Nishiyama et al. 2014). There are two updates to the Utstein variables made by the ILCOR (Jacobs et al. 2004, Perkins et al. 2015b). The ILCOR produces internationally recognised evidence-based resuscitation science in which they both use and support the use of the updated Utstein framework (Perkins et al. 2017). With these factors in mind, the CAR project adopted the latest update of the Utstein reporting style due to its constant scrutiny and revision, as well as two factors outlined below.

First, the Global Resuscitation Alliance (GRA), established in 2015 to improve OHCA outcomes internationally, recommends utilising Utstein to report OHCA as one of the fundamental elements necessary to improve cardiac arrest patient survival (Nadarajan et al. 2018a). The GRA's recommendation was highly compelling due to its inclusion of multiple countries and the WHO.

Second, in recent studies the Utstein style has been used extensively to measure and study OHCA outcomes. This tool has greatly enhanced the understanding of various resuscitation elements, while leading to better OHCA survival in some countries. For example, in Switzerland, a total of 3,367 OHCA patients have been observed for ten years, facilitating the analysis of differences in demographic characteristics and initial presentation on patient survival (Mauri et al. 2016). Furthermore, a South Korean study analysed a total of 128,888 eligible OHCA patients to conduct clinical trials using Utstein reporting for comparison (Kim et al. 2017). This study is similar to Mauri et al. (2016) because it demonstrates that patient characteristics and variables influence outcomes of OHCA. It may differ from the Abu Dhabi study result in different aspects, but it creates a stable base for future research. Finally, it would be unwise not to adopt the internationally recognised reporting system that has enabled services worldwide to monitor their performance and compare it with others.

4.3.6.3 CAR process of data collection

Data variables

I categorized Utstein data variables into several domains:

1) incident information,

2) patient information,

3) dispatch information,

4) prehospital resuscitation information,

5) emergency department information,

6) hospital outcomes,

The domain categorisation is to simplify the data collection process, structure the data into groups for future reports and studies, and because the data collection will take several stages from multi specialities to be completed.

My role is to propose the number of clinical and organisational performance variables to be collected. It was important to review the Utstein variables to align with a medication list, a list of medical staff's scope of practice/competencies, a list of staff's skills and privileges, list of current equipment that was being used by the ambulance crew in March 2018, and Electronic Patient Care Reports (EPCR). The purpose of this is to add any local variable as a core element needed to be collected. The additional information was added to the Utstein variables due to the mechanism of OHCA treatment in the local EMS and on advice and input of the PAROS network group. PAROS has adopted the Utstein reporting style with modifications from each participating country.

The variables within the data set were defined before collection, as explained and presented below. A data coordinator was explicitly assigned to the CAR project to assemble information collected from different sources, with access to the EMS reporting system. OHCA is a continuous sequence of events starting from the time of the patient's presentation to their discharge from the hospital, as follows.

1) the time from call receipt at the call centre until EMS is hands-on with the patient,
2) detailed interventions by EMS,
3) interventions by the emergency department in hospitals,
4) post-resuscitation outcomes from the patients' medical records.

The data collection protocol began with a mandatory form designed by me to be completed by ambulance crews for each OHCA case. The variables are recorded routinely in an EPCR. Therefore, a modification update was implemented in the EPCR system to include the Utstein variables. The EMS crew must report any witnesses, estimate the time when the patient collapsed, time of AED implementation, bystander CPR, and CPR started by EMS. Other variables added for further investigation included advanced airway intervention, failed endotracheal intubation, and epinephrine use. To ensure the accuracy of the data collected, a workshop was given to EMS staff by the medical director and EMS instructors to include the changes into their routine. Once a case is filed in EPCR, it is audited through the electronic-reporting system by the auditing team the following day. Auditors make sure all variables are filled in for research purposes. Additionally, the data coordinator must audit the call timings at the response centre, including the time of the call to the time of EMS hands-on patient and the estimated time of the arrest. The coordinator will have to access the call centre system to check the call time to do so.

After 30 days, the receiving hospitals provide feedback for those patients who are hospitalised. The feedback identifies if the patient is admitted to the intensive care unit (ICU) and gives the patient’s status after 30 days or at hospital discharge. The hospital feedback forms the outcome measures for this thesis. The sources within the hospitals are mainly from emergency departments or direct contacts. The hospitals obtain the neurological outcome assessment information as a routine procedure unless the patient has died. Hence, a period of at least 30 days is required to collect the quality-of-life data for surviving patients. It is also important to mention that the receiving hospital's data is only obtained for those transported by EMS. Finally, the completed case is recorded in the registry.

4.3.7 Quantitative variables

The ILCOR has recommended cardiac arrest data variables for research purposes (Jacobs et al. 2004, Perkins et al. 2015b). The variables included in the statistical analysis are based on ILCOR core data. The core data are required for continual quality improvement (CQI) and OHCA research for patients in pre-hospital care. The data variables were categorised into four domains: dispatch, patient, EMS management, and outcomes. The domain categorisation serves to structure the data into groups for the end report. Table 4-1 is a summary of data variables, with a brief description in table 4-2.

Table4-1 Data variables

Dispatch	Patient	EMS	Outcome
Response time	demographics (age, race, gender, location) bystander CPR automatic external defibrillator first rhythm Aetiology	Epinephrine endotracheal intubation.	Survival event Survival to discharge

Table 4-2 Definition variables, adopted from Utstein (Perkins et al. 2015)

Data element	**Definition**	**Measures**
	Patients	
Age	patient date of birth	Number in years
Arrest location	The specific location where the event occurred.	Home; workplace; street/highway; public building; educational institution; other
Bystander CPR	Bystander CPR is CPR performed by a person who is not responding as part of an organized emergency response system to a cardiac arrest.	Yes; No
AED use	Bystander AED use	AED used, shock delivered/ AED used, no shock delivered/ AED not used
First rhythm	The first cardiac rhythm present when the monitor or defibrillator is attached to the patient after a cardiac arrest.	VF/Pulseless VT/Asystole/PED/bradycardia/AED no shockable/AED shockable
Aetiology	Cause of OHCA	Medical/traumatic cause/drug overdose/drowning/ electrocution/asphyxia/not recorded.
	Management	
Ambulance Service Response time	The time interval from incoming call to the time the first emergency response vehicle stops at a point closest to the patient's location. The time of the incoming call is when it is first registered at the centre answering emergency calls, regardless of when the call is answered.	mm:ss
Drugs use	The term drugs refer to the delivery of any medication (by IV cannula, IO needle, or tracheal tube) during the resuscitation event.	epinephrine/amiodarone/vasopressin/none given
Mechanical CPR	At any time during the resuscitation, was a mechanical CPR device deployed?	Yes/No

Outcomes		
Survived event	ROSC sustained until arrival at the emergency department and transfer of care to the medical staff at the receiving hospital	Yes/no
Survived to discharge	Was the patient alive at the point of hospital discharge/30 day	Yes/no

4.3.7.1 Time-related variables

4.3.7.1.1 Response time

The first most crucial interval in OHCA is the patient arrest to first CPR (Navab et al. 2019a). Earlier CPR for OHCA patients leads to a significant increase in patient survival (Moon et al. 2020), due to the markedly decreased likelihood of neurological complications. Studies have demonstrated that patients who survive OHCA received early CPR (Geri et al. 2017, Park et al. 2017, Hawkes et al. 2017b). Previous studies have found it difficult to investigate this time interval, as it is unknown when the patient first collapsed without a witness. However, the estimated time of collapse to first CPR on the witnessed patient was recorded for this study.

Additionally, the time a call is made to EMS is recorded. Therefore, the measure of response time is from call receipt to arrival of EMS paramedics at the patient's side. More specifically, this response time refers to the time interval from the incoming call to the time the first EMS vehicle stops at the point closest to the patient's location. The incoming call time is when it is first registered at the dispatcher answering emergency calls, regardless of when the call is answered.

4.3.7.2 Patient

The patient variables include demographics, bystander CPR, AED use, first rhythm, and aetiology.

4.3.7.2.1 Patient demographics

Demographic variables (age, race, gender, location) are essential in the research study. Researchers have attempted to evaluate these variables' impact because they influenced patient hemodynamic response to the illness.

4.3.7.2.2 Patient age

Advanced age has been noted to lower survival chances (Nakamura et al. 2019). Advanced age is defined as an OHCA patient more than 85 years old, which is associated with poor patient outcomes. Another study suggested that OHCA increases in the elderly population, with different patient outcomes from the non-elderly (Tagami et al. 2019). This is potentially due to comorbidities associated with advanced age (Fukuda et al. 2015), or patients' "do not resuscitate" orders (DNR) in some countries. Although Abu Dhabi EMS can retrieve patient medical history using EPCR by patient ID number, DNR is illegal in Abu Dhabi EMS. Furthermore, the survival rate of patients with advanced age has increased over time. While consideration to this point must be given, describing the influence of age on the outcome is important for EMS planning. Therefore, the patient's date of birth is documented and the age in years is recorded.

4.3.7.2.3 Patient gender

The term gender in this context refers to patient’s biological sex (either male or female). Sex may be associated with varying OHCA treatment outcomes. Some Japanese studies suggested that males exhibited a significant decrease in survival as their age increases (Oh et al. 2017, Hagihara et al. 2017). However, this account must be approached with some caution. It may not be extrapolated to other countries, because in another study by Blewer et al. (2018), American CAR data demonstrated that males had an increased survival of 23% compared to females. A possible explanation for these is the biological differences for males compared to females. Various studies have examined the influence of oestrogen, suggesting that it greatly affects outcomes following cardiac arrest (Bray et al. 2013, Bosson et al. 2016). Another explanation might be due to response factors, such as early CPR. Males who are ordinarily present in public locations are more likely to receive bystander CPR compared to females. In UAE, this due to specific cultural aspect among womens, which tend to be more conservative. This suggests important gender disparities in OHCA response, which may play a role in patient survival.

4.3.7.2.4 Patient location

Location refers to the specific area where the patient arrest occurred. This encompasses public areas (educational areas, shopping centres, workplaces, airports, or streets), residential areas (house, apartment, or compound), or any other location. Some studies reported that OHCA occurrence at home accounted for approximately two-thirds of all OHCA cases (Navab et al. 2019b, Kiyohara et al. 2019). This information is necessary to determine how to optimise the response of limited EMS resources and to reduce patient response time. For example, public education may be an important factor associated with better OHCA outcome. A systematic review by Cartledge et al. (2015) concluded that family members' training had been shown to have a positive impact on survival rates. However, the authors considered a high risk of bias due to the investigation involving families of high-risk cardiac patients. However, the location is considered an important factor in this study.

4.3.7.3 Bystander CPR

In general, resuscitation is performed by either EMS or bystander CPR . In this study, bystander CPR refers to CPR conducted outside of a health institution by a person who is a member of the community (Jacobs et al. 2004). Early CPR is a link in the chain of survival (Glass and Brady 2019), and has been shown to facilitate patient recovery sooner (Kristie 2018). In particular, bystander has a significant impact on survival to hospital discharge time (Deakin 2018b), and is considered a critical factor to include in this study.

4.3.7.4 Public access defibrillation

Public access to defibrillation (PAD) is an essential component for improving OHCA survival. For this study, PAD was defined as defibrillation attempts before EMS arrival. PAD can be performed in public areas using an AED (Riddersholm et al. 2017). The Abu Dhabi ambulance department recently implemented a project to increase AED distribution in public places, making PAD available for use by a layperson. Studies show that early defibrillation for OHCA patients who present with shockable rhythm is vital to bring the heart into sinus rhythm. For a few minutes after the arrest, the heart can pump oxygenated blood throughout the circulatory system, but dysrhythmia stops the heart's mechanical activity and hence the movement of oxygen-rich blood. In this phase, early defibrillation provides a chance to restore cardiac activity if the patient is in a shockable rhythm.

4.3.7.5 First rhythm

When an AED is utilised, the first cardiac rhythm displayed on the defibrillator is measured and classified into shockable and non-shockable. Ventricular fibrillation (VF) and pulseless ventricular tachycardia (VT) are known as shockable rhythms. Asystole, pulseless electrical activity (PEA), and bradycardia are non-shockable rhythms. There is an unambiguous relationship between heart rhythm and survival. Meta-analysis illustrates that shockable heart rhythm is a predictor for OHCA patient survival (Sasson et al. 2010).

4.3.7.6 Aetiology

The aetiology is classified as cardiac or non-cardiac (Moriwaki et al. 2013, Hawkes et al. 2017c). Most OHCA have a cardiac cause. That includes cardiac dysrhythmia, ischemia, acute cardiac syndrome (ACS), chronic heart failure, myocarditis, or other heart abnormalities. Evidence suggests that cardiac arrest triggered by abnormal coronary changes leads to sudden death (Farb et al. 1995). However, other non-cardiac causes may be drowning, drug intoxication, and asphyxia, among others. Aetiology plays a role in the UAE because of CVD issues. This research provides information to assess the overall proportion of patient cardiac arrest causes, and hence where the most effective educational and policy effort can be directed in the future.

4.3.7.7 EMS management

Several reports have demonstrated that early CPR and enhanced emergency management were linked to better patient outcomes. Evidence shows that advanced EMS procedures before hospitalisation have a positive relationship with survival chances (Cournoyer et al. 2017). In the local context, Abu Dhabi EMS introduced several operational advancements in 2016 and 2017, including more ambulances for faster response times and advanced OHCA intervention, such as drug administration and airway management. The aim of the EMS managers was to increase the number of ambulances to reduce the time to reach patients. If the ambulance response time to the patient could be reduced, it was thought by the policymakers that the outcomes would improve. Equally important, it was assumed that if an advanced paramedic provided the services, the outcome would be "better."

However, to date those advances have not been assessed in Abu Dhabi yet. This study describes the Abu Dhabi EMS system management of OHCA cases, including the influence of EMS response time, advanced drugs, and airway intervention on OHCA outcomes. The variables measured are:

1. Epinephrine;
2. Mechanical chest compression device; and
3. Endotracheal intubation.

4.3.7.8 Outcome measures

Survival of OHCA requires critical pre-hospital intervention. A major issue facing Abu Dhabi EMS, with regards to post-cardiac arrest mortality, is the low ROSC rates. A low ROSC rate pre-arrival to the hospital is associated with a lower survival rate (Giugni et al. 2018). The low survival rate is typically linked to neurological recovery failure (Sporer et al. 2017).

Furthermore, neurological injury is a key reason for morbidity and mortality following cardiac arrest (Sherrington and Smith 2012). The neurological damage can be reported based on the cerebral performance category (CPC) (Ajam et al. 2011). The CPC is a point scale ranging from 1 (good cerebral performance) to 5 (dead). However, data from the CAR project may not measure the quality of life for the surviving patient, specifically if the patient's neurological status after 30 days or six months is still in decline.

In contrast, this research study measures two core outcomes recommended by ILCOR:

1. Survival event, defined as ROSC sustained until arrival at the emergency department and transfer of care to the receiving hospital's medical staff.

2. Survival to discharge refers to the patient being alive at the point of hospital discharge.

4.4 Research data collection

4.4.1 Quality assurance

In the beginning, data collection took place in the clinical governance section. Before attempting data collection, the auditing team checks the data for quality assurance purposes. The auditing team includes physicians to oversee the daily operations and EMS calls. Although auditing is part of the clinical governance scope, each OHCA case is routinely reviewed against the following:

- missing variables,
- malpractice, and
- inconsistent treatment.

This is to diminish any errors during the completion of electronic patient care reports. If errors occurred, the EMS crew of that case would be called for questioning, and correction measures activated to reduce the possibility of a similar fault in the future.

4.4.2 Raw data

The data coordinator from the ambulance department provided the raw data. The raw data from January to December 2019 was exported in Excel format. Before the attempt, a statistical data cleaning procedure was carried out (outlined below) as part of bias mitigation.

4.4.3 Data cleaning

Human error may occur during data recording; hence, it is essential to prevent error via data cleaning (Brown et al. 2018). A comprehensive data check is recommended prior to statistical analysis (Tran et al. 2017), to ensure that any errors or missing data is identified and discarded to minimise its effect on the study outcome. For this, data cleaning and a correction framework comprising four phases is used, as recommended by (Van et al. 2005). Data screening is carried out in four stages.

First, any missing data was completed to the best possible standard. Any incomplete data represent a challenge during the analysis and interpretation of results (Pedersen et al. 2017). Missing data may occur when the EMS crew writes the patient care report non electronically, due to electronic system failure, or because the crew chose to write the patient report as a narrative description instead of ticking report boxes. In that case, the data is pulled from the narrative to complete the variables. Second, remove duplicate cases or cases that do not meet the inclusion criteria. In the third stage, pattern oddities were distinguished, for example those with large and extreme, or illogical values. For example, sometimes the EMS crew started resuscitation on a dead patient. These patients are known to be dead due to signs of rigor mortis. EMS may start resuscitation on such patients and transport them to the hospital because of combative relatives. Fourth, any erroneous data was identified, and corrected as best as possible.

4.5 Statistical methods

4.5.1 Feature Selection

The Random Forest Algorithm (R Statistical Software; Version 3.6.0) was deployed to select features before conducting logistic regression analyses. Patients within in the survival event and survival to discharge groups were used as classifiers. The mean decrease in the Gini Importance Index (reference) was used to measure the importance of the variable of interest. Higher importance, as estimated using the mean decrease in the Gini Importance Index, indicates higher significance of the classification feature.

4.5.2 Statistical Analysis

Descriptive statistics summarised patient characteristics using mean ±standard deviation (SD) or number (percentage) as appropriate. Continuous data were assessed for skewness by visual inspection of plots and normality tests. Independent sample tests were conducted to compare ROSC, survival event, and survival to discharge as the dependent variables for each continuous independent variable (i.e., response time, age, and time to arrest). Likewise, chi-square tests were conducted to compare ROSC, survival event, and survival to discharge as the dependent variables for each categorical independent variable (i.e. gender, nationality, location of the arrest, medical history, whether or not arrest witnessed, who witnessed the arrest, whether or not the bystander provided CPR, who initiated the first CPR, whether or not bystander applied AED, first arrest rhythm, whether or not pre-hospital defibrillation applied, whether or not mechanical CPR device used; first ECG rhythm, epinephrine administration, difficult/failed advanced airway, whether or not airway attempted, whether or not advanced pre-hospital airway used, and ROSC). Cramer's V was also computed to measure the association strength, where 0.0 to 0.10 was considered little if any association, 0.11 to 0.30 a low association, at 0.31 to 0.50 a moderate and >0.51 a high association.

All statistical analyses were carried out using SPSS® statistical software, version 26.0 (IBM Corp. Armonk, NY., USA), with the level of statistical significance set at 0.05. All plots were developed using the R Statistical Software (Version 3.6.0).

4.6 Ethical considerations

Gaining prior informed consent from the OHCA patient receiving care is impossible. Obtaining informed consent in emergency research from the patient who is experiencing an OHCA poses significant challenges. The challenges relate to prospective consent specific to patients suffering life-threatening events (Gupta 2013). It is impossible to predict cardiac arrest occurrence due to the patient's condition: loss of consciousness, location of the arrest (in or out of hospital), or the nature of the emergency (Schmidt et al. 2004). The conditions are time-sensitive and necessitate urgent intervention, such as immediate CPR required for OHCA cases to preserve life, restore health and/or limit disability (Mancini et al. 2015), all of which inhibit informed consent (Biros 2003). Additionally, it is impractical to consult next of kin/relatives, as this may delay treatment and hence be unethical and unprofessional.

However, this thesis for an observational study uses a cardiac-arrest registry that anonymised the data. All data is computerised at the Abu Dhabi government database with access restricted to the researcher and coordinators only. The ambulance department has developed a policy for data and risk management to assure patient safety and privacy. The purpose of the policy is to capture, process, store and interpret applicable and valid patient safety aggregated data, systematically and scientifically, within ethical, legal and business limits. Therefore, the approval for the study was obtained from the Sheikh Saif Academy to use the data (letter-number 14/23/128 dated 15/10/2020). Moreover, the QMU ethical board approved this study (letter in the appendix 5).

5. Chapter five: Research Results

5.1 Introduction

This chapter describes OHCA demographics and characteristics. The data were collected at the point of OHCA by the EMS team and include patient demographics, medical history characteristics, dispatch and bystander CPR, response timings, EMS management and patient outcomes. Figure 5-1 is a flow diagram that shows the filtering of EMS calls and exclusion of OHCA that did not meet the inclusion criteria.

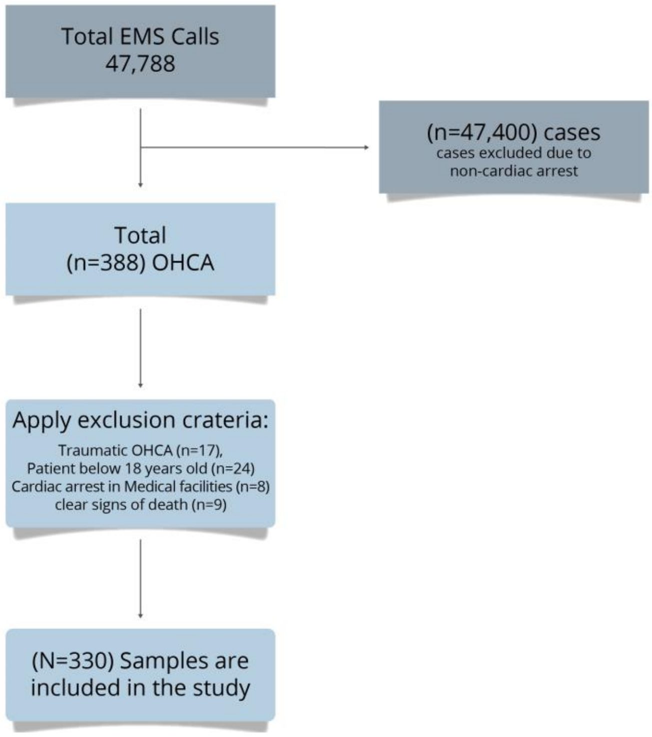


Figure 5-1 Flow Diagram of EMS calls and both included and excluded OHCA cases.

5.2 Overview

All results were recorded prospectively between January 1, 2019 and December 31, 2019, using the Abu Dhabi ambulance department CAR and by examining only those patients that had resuscitation attempted by EMS crews prior to hospital transport. A total of 47,788 calls were received that resulted in EMS response. Of these, EMS attempted OHCA resuscitation for a total of 388 (0.8%) patients. The

0.8% OHCA cases are therefore demonstrated to be a minority of events within pre-hospital care. OHCA incidence rate was 13 per 100,000 in the year 2019.

Following the application of inclusion/exclusion criteria, 330 patient cases were recruited to the study. Reasons for exclusion (Figure 5-1) include traumatic cardiac arrest (n=17), patients age below 18 years old (n=24), cardiac arrest in mobile clinics or medical care facilities (n=8), and discontinued resuscitation at the scene for patients due to clear signs of death (n=9).

5.3 Key results

The main objective is to determine then investigate the patient factors that may influence the survival or non-survival of those treated for an OHCA by Abu Dhabi EMS. Examining this data for 2019 highlighted the average OHCA patient. Therefore, five key results will be examined: 1) patient survival to hospital discharge was observed for 5% of the patients (n=16); 2) Most patients recorded for this study (n=330) were witnessed (72%), but all patients surviving to hospital discharge were witnessed at the point of collapse by either bystander (n=8), EMS (n=5), or family (n=3); 3) The majority of CPR was initiated by the EMS staff (82.4%) followed by a layperson bystander (9.7%) and a bystander healthcare provider (7.6%). Therefore, bystanders were not recognised cardiac-arrest patients, and low CPR was observed; 4) EMS arrived late to the patients, the EMS arrival at the patient side was 10.15 ± 4.92 minutes and the average time from patient collapse to EMS arrival was 14.7 minutes.; 5) more importantly, EMS interventions are not optimal.

5.4 Results in detail

5.4.1 Patient demographics:

Three hundred and thirty patients with OHCA (79 females, 250 males, 1 unknown) were included in this research. As found in the literature, a younger average age for OHCA is characteristic in UAE. The mean age of OHCA patients was 56.93 ± 18.67 years. Table 5-2 shows the summary statistics for patient ages.

Table 5-1 Gender

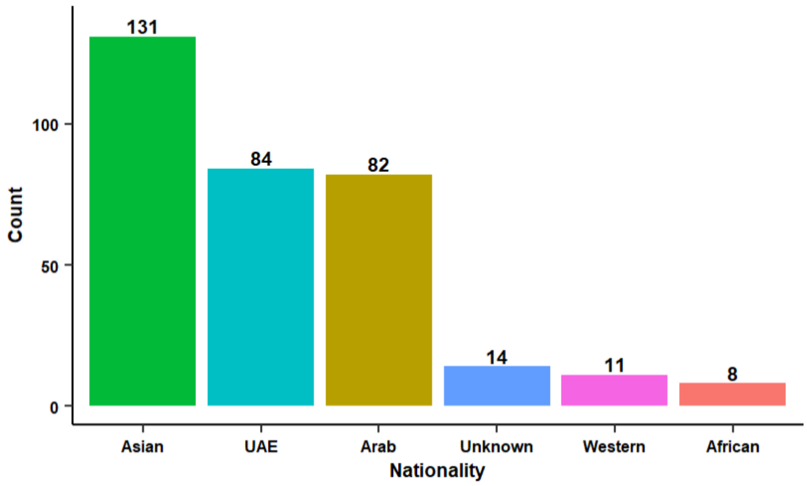
330 OHCA patients	Gender		
	male	**female**	**Unknown**
	250	79	1

Table 5-2 Baseline characteristics of patients (count) who survived to the time of discharge from the hospital

Variables		Outcome (Mean)		
	All patients (n=330)	**No survival to hospital discharge (n=314)**	**Survived to discharge (n=16)**	**P-value**
Age	56.94	57.20	51.81	0.261

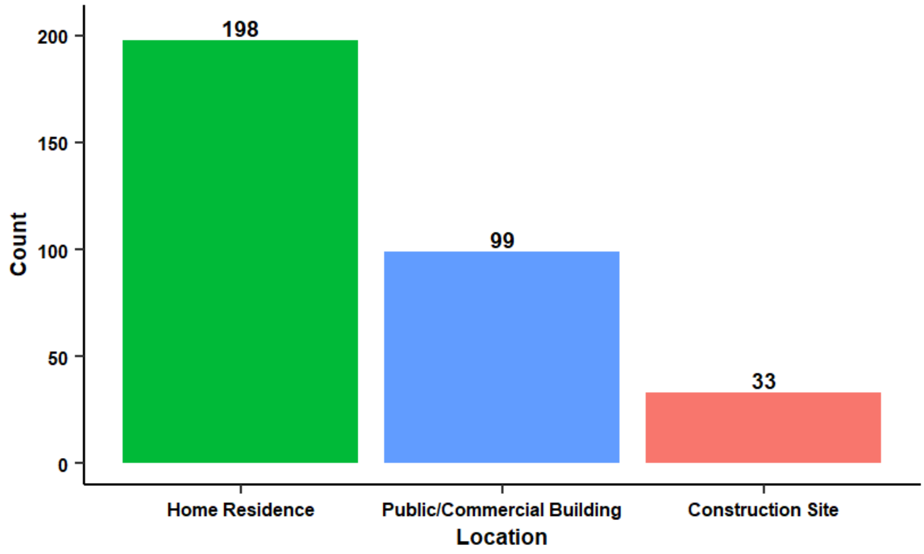
The average age of the patients who survived to hospital discharge is 51.8 years compared to patients who did not survive of 57.2 years old (p=0.261). While the patients who survived OHCA are slightly younger, this was not significant. Patients were then separated by nationality (Figure 5-2). As expected, most patients were citizens of Asian countries (39.7%), followed by citizens of UAE (25.5%), Arab countries (24.8%), unknown (4.2%), Western countries (3.3%) and African countries (2.4%).

Figure 5-2 Nationality of the patients



The majority of OHCAs happened at patients' homes (60%), followed by public/commercial buildings (30%) and construction sites (10%) (Figure 5-3).

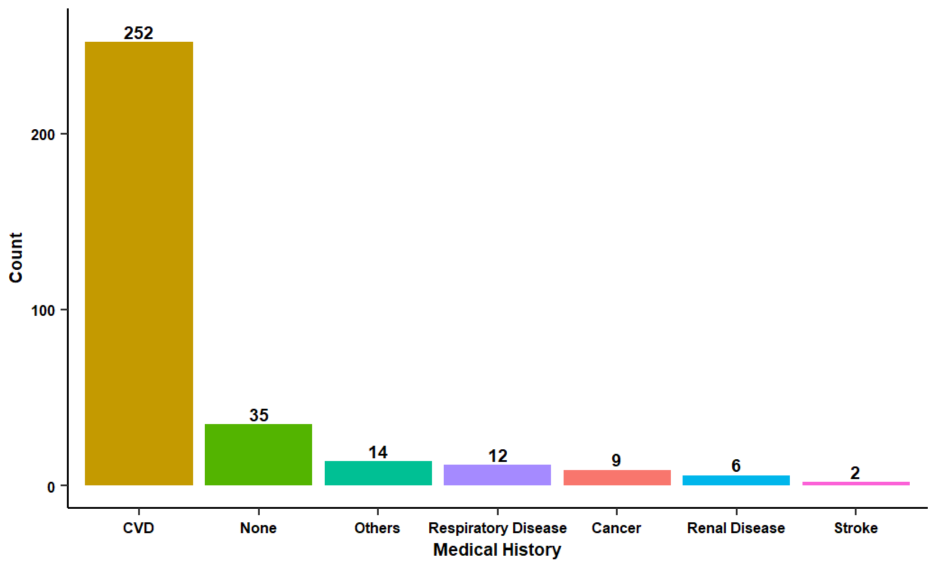
Figure 5-3 Location of the cardiac arrest



5.5 Patient characteristics

The Abu Dhabi EMS CAR summarised patient medical histories once an OHCA patient was included (Figure 5-4). More than two-thirds of the patients had a history of CVD (76.4%), followed by no significant history (10.6%), other diseases, such as anaemia, anxiety, depression, epilepsy, psychiatric or unknown (4.2%), respiratory diseases (3.6%), cancer (2.7%), renal disease (1.8%), and stroke (0.6%).

Figure 5-4 Medical history of patients



Almost two-thirds of the participants (64.8%) had an asystole as the first arrest rhythm, followed by VF (18.5%), PEA/MED (12.4%), and other (2.4%). The first arrest rhythm was not reported for four individuals with OHCA (Figure 5-5). The rhythms of some participants converted from asystole to VF, and shock was given. However, there was no exact data if the rhythm converted during pre-hospital resuscitation.

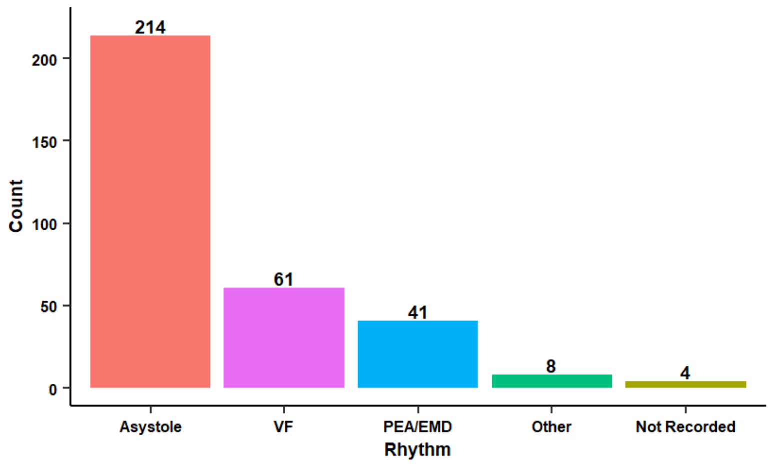


Figure 5-5 Rhythm of the first arrest in individuals with OHCA

The leading ECG rhythm observed in pre-hospital treatment before the arrival to hospital was asystole (67.0%), followed by VF (18.2%), and PEA (12.7%) (Figure 5-6).

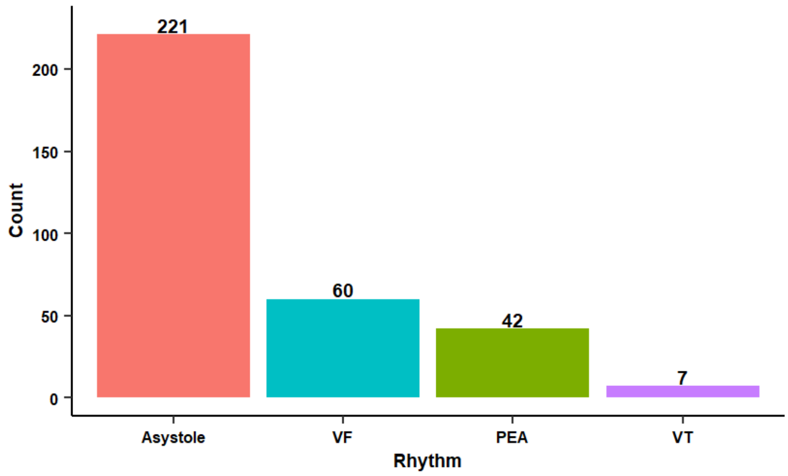


Figure 5-6 First ECG Rhythm

5.6 Dispatch

This study is unique in that it analysed not only the ambulance response time, but the interval between patient collapse and the commencement of EMS CPR. Overall, the targeted EMS response time in Abu Dhabi is less than 10 minutes. In this study, the average time from when the call registered at the dispatch centre to EMS arrival at the patient side was 10.15 ± 4.92 minutes. The estimated average time between patient arrest and CPR administration by EMS staff was assessed and found to be 14.7 minutes. This was possible as most arrests were witnessed by bystanders. This data was further examined for patients who did and did not survive (Table 5-3). Mean response time for patients who did not survive was assessed at 15.11 minutes, which is significantly higher than the response time for those that survived of 7.27 minutes ($p = 0.02$). The patient survival to hospital discharge appears to be affected by response time and time to EMS CPR.

Table 5-3 Key response times

Variables		Outcome (Mean)		
	All patients (330)	**No survival to hospital discharge (314)**	**Survived to discharge (16)**	**P-value**
Mean response time	10.12	10.18	9.00	0.35
Time of Arrest to EMS CPR	14.73	15.11	7.27	***0.02***

We now turn to the dispatch services for the time for EMS to arrive at the patient location. The dispatch centre did not provide any basic life support instructions to the bystanders. In sixty-five (19.8%) of these incidents, bystanders provided CPR. There was no medical first responder system in place; therefore, none of the police staff or fire defence staff responded to any case.

OHCA was witnessed in 237 of 330 patients (72.4%). OHCAs were mostly witnessed by a non-family member bystander (62.2%), followed by a family member (25.2%) and EMS staff (12.6%).

Table 5-4 Outcome according to patient witnessed at the time of collapsed

Arrest witnessed (n=237) 72%	**Outcome (Count)**		*p-Value*
	No survival to hospital discharge (n=221)	**Survived to discharge (n=16)**	
Bystander (n=148)	140	8	0.07
EMS (n=30)	25	5	
Family (n=60)	56	3	

When cases that were witnessed by EMS were excluded, it was found that 2% of patients received AED. In these cases, AED was used by an off-duty healthcare provider bystander. In two of these cases, the patient got ROSC before hospital arrival, was admitted to ICU, and survived hospital discharge. Those patients were ages 76 and 79, respectively, had a history of CVD and whose arrests were witnessed by a family member.

An EMS staff initiated the majority of CPR (82.4%), followed by a layperson bystander (9.7%) and a bystander healthcare provider (7.6%) (Figure 5-7).

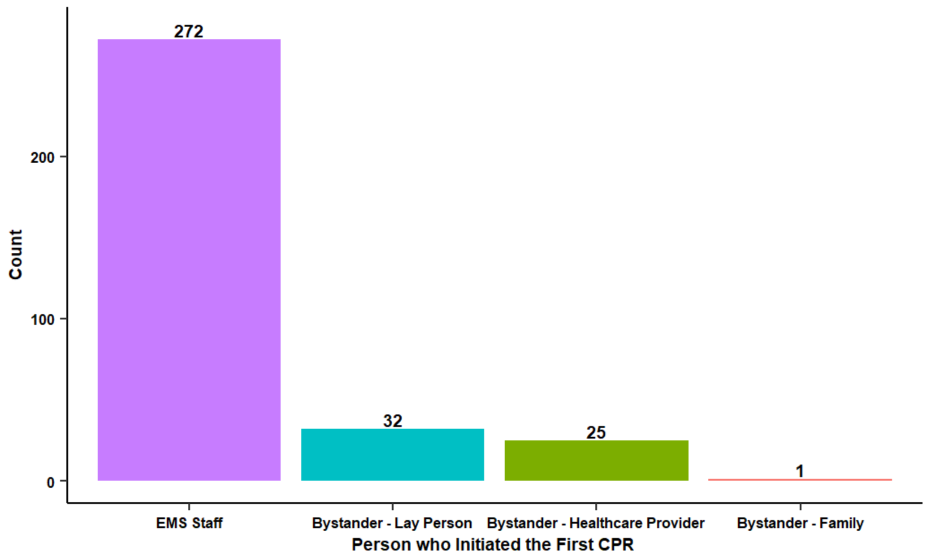


Figure 5-7 The first person who initiated the CPR

Table 5-5 Bystander response

Bystander intervention From total (n=330)	Bystander CPR (n)		Bystander AED Applied (n)	
	Yes	No	yes	no
	65	265	6	324

5.7 EMS management

Pre-hospital defibrillation was administrated for 115 individuals with OHCA (34.8%). A mechanical CPR device was used for 259 individuals with OHCA (78.5%). Epinephrine injection was administered for 277 (83.9%) individuals with OHCA. Advanced pre-hospital airway intervention was administered via endotracheal intubation (ETI) for 99 individuals with OHCA (30%).

Table 5-6 Summary of EMS interventions

<table>
<tr><td rowspan="3">EMS intervention From total 330 + percentage</td><td>Pre-hospital Defibrillation</td><td colspan="2">Mechanical CPR Device Used</td><td colspan="2">Epinephrine administered</td><td colspan="2">Pre-hospital Advanced Airway</td></tr>
<tr><td rowspan="2">115 (34.8%)</td><td>Yes</td><td>No</td><td>Yes</td><td>No</td><td>Yes</td><td>No</td></tr>
<tr><td>259 (78.4%)</td><td>71 (21.5%)</td><td>277 (83.9%)</td><td>53 (16.1%)</td><td>99 (30%)</td><td>231 (70%)</td></tr>
</table>

Of 99 individuals with OHCA who received ETI attempts, the attempt failed in 57 cases (58%). A total of 16 participants who received ETI got pre-hospital ROSC; 20 survived to hospital admission, and 4 survived to hospital discharge. Further analysis demonstrated that of the 57 failed ETI attempts, only 3 got pre-hospital ROSC, 4 survived to hospital admission, and none survived hospital discharge (p = 0.001). Therefore, a failed ETI attempt resulted in the patient not surviving to hospital discharge. In failed ETI attempt patients, alternative measures were used, like a bag valve mask (BVM) or an attempt to secure a supraglottic airway device.

Table 5-7 Outcome for patient received advanced airway management

	Not survived	Survived to hospital discharged	*p-Value*
Advanced airway (n=99)	95	4	0.001
Failed attempt advanced airway (n=57)	57	0	

5.8 Outcomes

Pre-hospital ROSC was observed in only 56 individuals with OHCA (17%). Of 330 individuals, only 16 individuals with OHCA (5%) survived (6 females, 10 males) to discharge from the hospital.

Table 5-8 Survival to hospital discharged according to gender

Gender	Total number	Not Survived	Survived to hospital discharged	*p-Value*
Male	250	240	10	0.19
Female	79	73	6	
Unknown	1	1	0	

5.8.1 Subgroup analysis

The subgroup analysis of the patient outcome was made to patients witnessed, bystander CPR, and outcome according to the rhythm. This analysis compared the outcome between EMS and bystander CPR interventions to assess pre-hospital care according to cardiac-arrest cases.

Table5-9 Outcome according to patient witnessed

Outcome		Pre-hospital ROSC		Survival event		Survival to hospital discharge	
		No	Yes	No	Yes	No	Yes
Patient witness 72.4% (237)	By all bystanders (n=207)	172	35	173	34	196	11
	by EMS (n=30)	20	10	20	10	25	5
Not witnessed 27.5% (n=91)		80	11	79	12	91	0
Unknown (n=2)		2	0	2	0	2	0

Table 5-10 Outcome according to bystander intervention

Outcome		Pre-hospital ROSC		Survival event		Survival to hospital discharge	
Bystander CPR		No	Yes	No	Yes	No	Yes
	No (n=265)	222	43	220	44	252	12
	Yes (n=65)	52	13	53	12	61	4

Table 5-11 Arrest witnessed by any bystander according to the rhythm

Outcome	First rhythm	Pre-hospital ROSC		Survival event		Survival to hospital discharge	
Bystander CPR		No	Yes	No	Yes	No	Yes
	VF (n=18)	13	5	13	5	16	2
	VT (n=3)	1	2	1	2	3	0
	Asystole/PEA (n=46)	40	6	41	5	44	2

Further analysis

Table 5-12 summarises the results of an independent *t*-test comparing pre-hospital ROSC, survival event, and survival to hospital discharge for continuous independent variables of interest. A significant difference was observed between the patients' arrest time to the EMS CPR and survival event ($p < 0.001$). The lower the time between the arrest and EMS CPR, the higher the chance of a survival event. Likewise, a statistically significant difference was observed between the arrest's time to EMS CPR and survival to discharge ($p = 0.02$). The lower time between the arrest and EMS CPR, the higher the rate of survival to discharge.

Table 5-12 The independent t-test comparing pre-hospital ROSC, survival event, and survival to discharge for continuous independent variables of interest.

	Mean Difference	**95%CI**	***p-Value***
Response Time (minutes)			
pre-hospital ROSC	-0.18	-1.55:1.20	0.88
Survival Event	0.61	0.81:2.02	0.40
Survival to Discharge	1.18	-1.29:3.65	0.35
Age (years)			
pre-hospital ROSC	-3.34	-8.55:1.87	0.21
Survival Event	-3.26	-8:64:2.12	0.23
Survival to Discharge	2.39	-4:03:14.81	0.26
Time of Arrest to EMS CPR (minutes)			
pre-hospital ROSC	-0.68	-4.30:2.94	0.71
Survival Event	7.24	3.65:10.82	***0.001***
Survival to Discharge	7.85	1.41:14.28	***0.02***

Abbreviations: CI: confidence interval

Table 5-13 summarises the chi-square test results and the strength of association of pre-hospital ROSC, survival event, and survival to discharge for the categorical independent variables of interest. A strong association was observed between pre-hospital ROSC and age ($X^2 = 99.84$, $p<0.05$), between difficult/failed advanced airway attempt and survival to discharge ($X^2 = 27.99$, $p< 0.00$), and between pre-hospital ROSC and survival event ($X^2 = 86.00$, $p< 0.00$). A moderate association was observed between difficult/failed advanced airway attempt and survival event ($X^2 = 8.65$, $p< 0.00$), between difficult/failed advanced airway attempt and pre-hospital

ROSC ($X^2 = 13.49$, $p < 0.00$), and between first ECG rhythm and survival to discharge ($X^2 = 32.78$, $p < 0.00$).

A low association was observed between age and survival event ($X^2 = 4.99$, $p = 0.03$), gender and survival event ($X^2 = 5.00$, $p = 0.03$), medical history and survival to discharge ($X^2 = 13.53$, $p = 0.04$), whether or not the arrest was witnessed and survival to discharge ($X^2 = 6.43$, $p = 0.01$), the rhythm of the first arrest and pre-hospital ROSC ($X^2 = 10.81$, $p = 0.03$), the rhythm of the first arrest and survival event ($X^2 = 14.55$, $p < 0.00$), the rhythm of the first arrest and survival to discharge ($X^2 = 23.66$, $p < 0.00$), pre-hospital defibrillation and survival event ($X^2 = 5.22$, $p = 0.02$), pre-hospital defibrillation and survival to discharge ($X^2 = 8.64$, $p < 0.00$), whether or not mechanical CPR device used and pre-hospital ROSC ($X^2 = 6.08$, $p = 0.02$), whether or not mechanical CPR device used and survival event ($X^2 = 10.11$, $p < 0.00$), whether or not mechanical CPR device used and survival to discharge ($X^2 = 8.03$, $p < 0.00$), the rhythm of the first ECG and survival event ($X^2 = 24.35$, $p < 0.00$), the rhythm of the first ECG and pre-hospital ROSC ($X^2 = 11.11$, $p = 0.01$), epinephrine administration and pre-hospital ROSC ($X^2 = 3.95$, $p < 0.05$), epinephrine administration and survival event ($X^2 = 5.69$, $p = 0.02$), and epinephrine administration and survival to discharge ($X^2 = 9.51$, $p < 0.00$).

Table 5-13 The chi-square test results of pre-hospital ROSC, survival event, and survival to discharge for categorical independent variables of interest.

	X^2	***p-Value***	***Cramer's V***
Age			
Pre-hospital ROSC	99.84	***0.05***	0.55**
Survival Event	4.99	***0.03***	0.12
Survival to Discharge	1.75	0.19	0.07
Gender			
Pre-hospital ROSC	2.40	0.12	0.09
Survival Event	5.00	***0.03***	0.12
Survival to Discharge	1.75	0.19	0.07
Nationality			
Pre-hospital ROSC	4.81	0.44	0.12
Survival Event	5.14	0.40	0.13
Survival to Discharge	6.37	0.27	0.14
OHCA Location Type			
Pre-hospital ROSC	1.81	0.41	0.07
Survival Event	2.05	0.36	0.08

Survival to Discharge	3.72	0.15	0.11
Medical History			
Pre-hospital ROSC	10.40	0.11	0.18
Survival Event	6.08	0.41	0.14
Survival to Discharge	13.53	***0.04***	0.20
Arrest Witnessed			
Pre-hospital ROSC	2.17	0.14	0.08
Survival Event	1.31	0.25	0.63
Survival to Discharge	6.43	***0.01***	0.14
Arrest Witnessed By			
Pre-hospital ROSC	4.60	0.10	0.14
Survival Event	5.07	0.08	0.15
Survival to Discharge	5.37	0.07	0.15
Bystander CPR			
Pre-hospital ROSC	0.61	0.43	0.04
Survival Event	0.12	0.73	0.02
Survival to Discharge	0.29	0.59	0.30
First CPR initiated by			
Pre-hospital ROSC	6.23	0.10	0.14
Survival Event	5.38	0.15	0.13
Survival to Discharge	0.23	0.97	0.03
Bystander AED Applied			
Pre-hospital ROSC	1.15	0.28	0.06
Survival Event	1.51	0.28	0.06
Survival to Discharge	1.84	0.18	0.08
First Arrest Rhythm			
Pre-hospital ROSC	10.81	***0.03***	0.18
Survival Event	14.55	***0.00***	0.21
Survival to Discharge	23.66	***0.00***	0.27
Pre-hospital Defibrillation			
Pre-hospital ROSC	2.98	0.08	0.10
Survival Event	5.22	***0.02***	0.13
Survival to Discharge	8.64	***0.00***	0.16
Mechanical CPR Device Used			
Pre-hospital ROSC	6.08	***0.02***	0.14
Survival Event	10.11	***0.00***	0.18
Survival to Discharge	8.03	***0.00***	0.16
First ECG Rhythm			
Pre-hospital ROSC	11.11	***0.01***	0.18
Survival Event	24.35	***0.00***	0.27
Survival to Discharge	32.78	***0.00***	0.32*
Epinephrine			
Pre-hospital ROSC	3.95	***0.05***	0.11
Survival Event	5.69	***0.02***	0.13
Survival to Discharge	9.51	***0.00***	0.17
Difficult/Failed Advanced Airway Attempt			
Pre-hospital ROSC	13.49	***0.00***	0.49*

Survival Event	8.65	***0.00***	0.39*
Survival to Discharge	27.99	***0.00***	0.70**
Pre-hospital Advanced Airway			
Pre-hospital ROSC	0.074	0.78	0.02
Survival Event	1.13	0.29	0.06
Survival to Discharge	0.21	0.65	0.03
Pre-hospital ROSC			
Pre-hospital ROSC	1.83	0.18	0.08
Survival Event	0.05	0.82	0.01
Survival to Discharge	3.97	***0.05***	0.11

*Low association, **moderate association, ***high association.

5.9 Odds of a good outcome for clinical and demographic variables

I deployed the Random Forests Algorithm (R Statistical Software) to select features before conducting logistic regression analyses. Membership in the 'Patients survived hospital discharge' or 'Not Survived' groups were used as the classifiers. The mean decrease in the Gini Importance Index was used to measure the importance of the variables reported in the cardiac arrest registry. Gini Importance Index is the average of a variable's total decrease in node impurity, weighted by the proportion of samples reaching that node in each individual decision tree of the random forest (Aldrich, 2020). The results show the higher importance among the variable models selected here and in the 5.10 subsection, estimated using the mean decrease in the Gini Importance Index, indicating the higher significance of that feature in the classification. In addition, the literature review in chapter three shows and weighs the importance of the EMS variables selected here.

A direct binary logistic regression analysis was conducted to evaluate survival membership prediction for individuals who survived (n=16) or did not survive (n=314), using the presence of age (years), the response time (minutes), first ECG rhythm (VF), bystander CPR (yes or no), and pre-hospital ROSC. Multicollinearity between variables was not present in the dataset. As a significant disparity existed between sample sizes, only 64 patients were chosen (n=48 for non-survival and n=16 for survived) and included in the model development.

The full model included the variables listed above and was significant (X^2 (5) = 31.61, p< 0.000, Nagelkerke R^2 = 0.58). Overall, 89.06% of the participants were correctly classified (6-7), with better classification in the non-survival group (97.92%) over the survival group (62.50%) (Table 5-14).

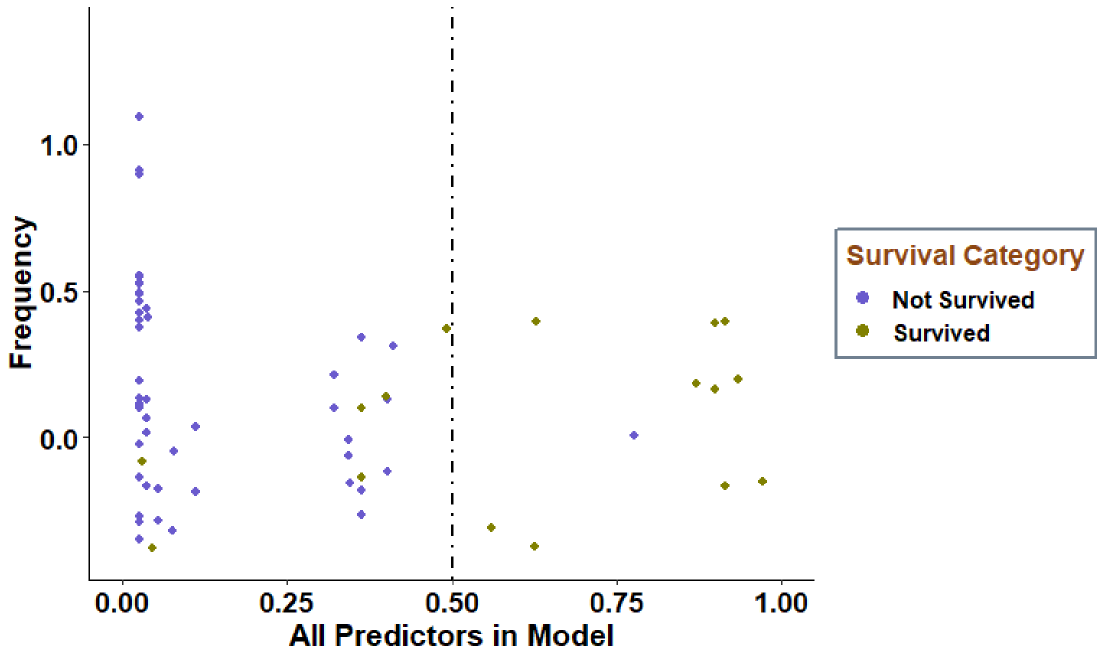


Figure 5-8 Model performance in predicting the outcomes

Table 5-14 Exponent B and Significance Values for Predictors.

	B	***S.E.***	***Wald***	***p***
Age	0.001	0.020	0.706	0.944
Response Time	0.060	0.101	0.288	0.553
First ECG Rhythm	3.030	0.940	7.643	0.001**
Pre-hospital ROSC	3.013	0.942	3.013	0.001**
Bystander CPR	1.121	1.994	0.789	0.259
Note. df = 1.				

Abbreviations: df: degree of freedom; ***p < 0.001*

First ECG rhythm and pre-hospital ROSC were significant predictors of survival status, while no significant prediction was determined for age, response time, and bystander CPR. In general, participants whose first ECG rhythm was VF and had pre-hospital ROSC were likely to be classified in the survival category.

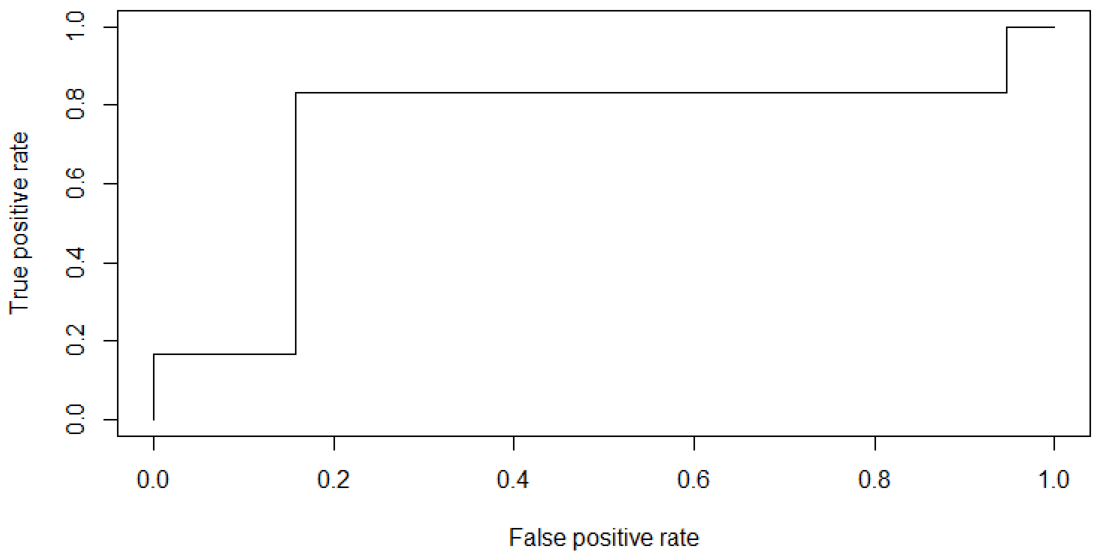
Variable importance

The results' variable importance analysis indicated that the first ECG rhythm is the most critical variable, followed by pre-hospital ROSC in predicting the outcomes.

Validation of Predicted Values

To assess the robustness of the model performed, two models were used to validate the predicted values. The first is the receiving characteristic operating curve (Figure 5-9). The analysis yielded an area under the curve (AUC) = 0.74, indicating that the model was able to discriminate between the two categories (survival and non-survival), which comprise our target variable.

Figure 5-9 Receiving characteristic operating curve for the survival model



Second is K-Fold Cross-Validation. The data are divided into ten folds, one-fold was held out for validation while the other 9 folds were used to train the model and then used to predict the target variable in our testing data. This process was repeated three times, with each model's performance in predicting the hold-out set being tracked using accuracy (Table 5-15).

Table 5-15 Exponent B and Significance Values for Predictors for 10-folds, 3 repetitions

	B	**S.E.**	***p***
Age	0.001	0.020	0.944
Response Time	0.060	0.101	0.553
First ECG Rhythm	3.030	0.940	0.001**
Pre-hospital ROSC	3.013	0.942	0.001**
Bystander CPR	1.121	1.994	0.259
Note. df = 1.			

5.10 Odds of a good outcome for EMS variables

A direct binary logistic regression analysis was conducted to evaluate survival prediction for patients who survived or did not survive using advanced pre-hospital airway (yes or no), epinephrine use (yes or no), and mechanical CPR device used (yes or no). In a similar manner to the analysis above, and due to the large discrepancy between the group numbers, 64 patients were chosen (48 randomly selected from the non-survived, and 16 from the survived group) for the final analysis.

Multicollinearity between variables was not present in the dataset. The full model included the variables listed above and was significant (X^2 (3) = 8.50, p= 0.04, Nagelkerke R^2 = 0.18). Overall, 79.69% of the participants were correctly classified (Figure 5-10), with better classification in the non-survival group (97.92%) over the survival group (25.00%) (Table 5-16).

Figure 5-10 Model performance in predicting the outcomes

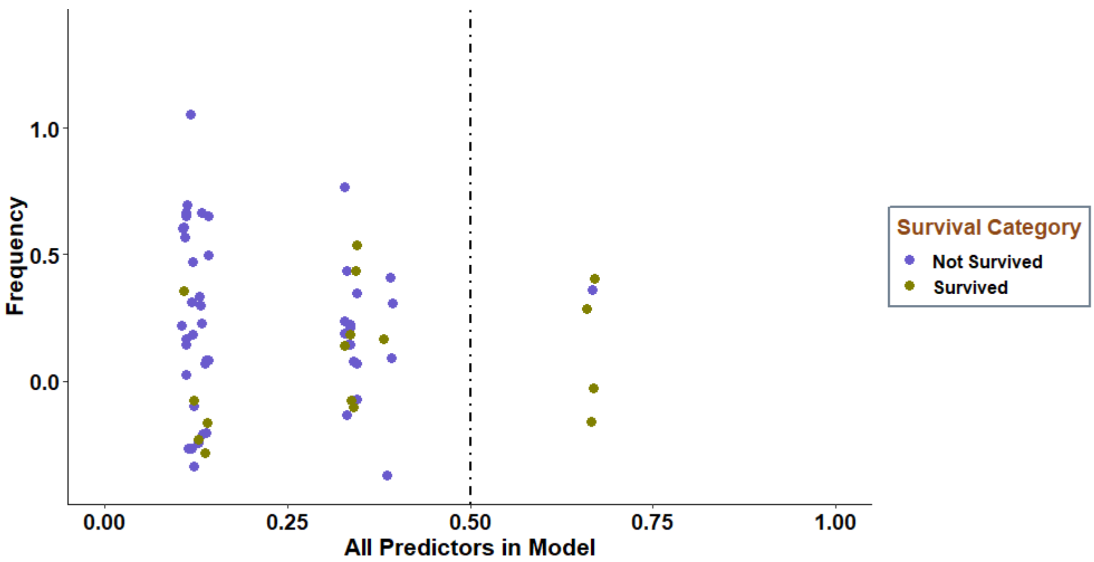


Table 5-16 Exponent B and Significance Values for Predictors.

	B	***S.E.***	***Wald***	***P***
Mechanical CPR Device Used	-1.388	0.642	0.878	0.030*
Epinephrine Injection	-1.357	0.744	1.512	0.068
Pre-hospital Advanced Airway	0.211	0.775	1.363	0.786
Note. df = 1. *$p<0.05$				

Abbreviations: df: the degree of freedom;

All variables were non-significant predictors of survival status. Specifically, no significant relationship was found between mechanical CPR devices, epinephrine injection, advanced airway administration, and patient survival. This result may be because of the low sample size. However, the variable importance analysis results indicated that the epinephrine injection is the most crucial variable in predicting the outcomes followed by pre-hospital advanced airway administration. Conversely, the mechanical CPR device was the least important variable.

Validation of Predicted Values

To assess how well the model performed, I used two models to validate the predicted values.

Receiving characteristic operating curve

A receiving operating characteristic curve analysis was conducted (Figure 5-11), and yielded an AUC = 0.68, indicating that the model does not do a good job in discriminating between the two categories (survival and non-survival), which comprise our target variable.

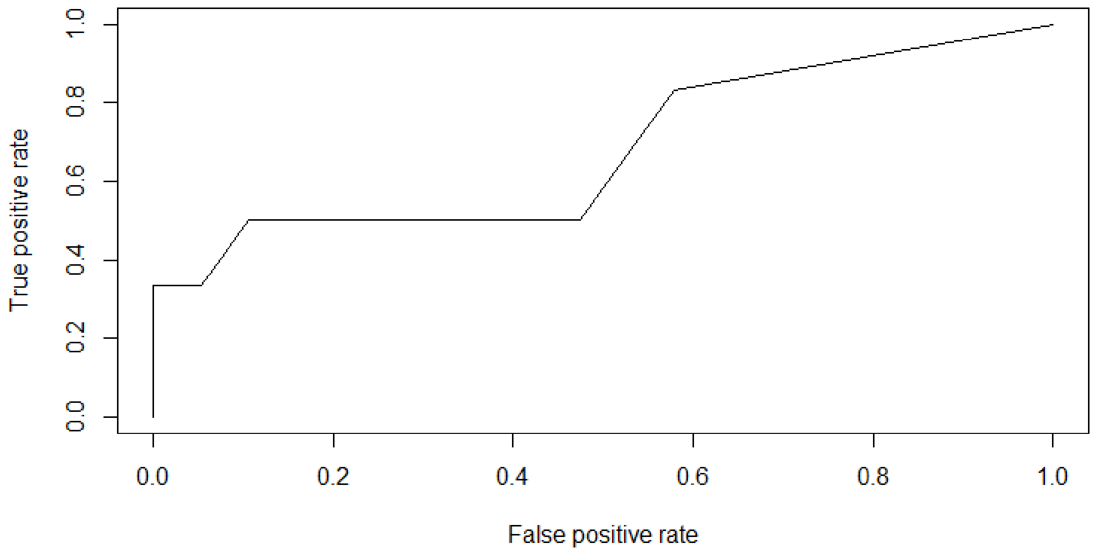


Figure 5-11 Receiving characteristic operating curve for the survival model

K-Fold Cross-Validation

The data were divided into ten folds; one-fold was held out for validation while the other 9 folds were used to train the model and then used to predict the target variable in testing data. This process is repeated three times, with each model's performance in predicting the hold-out set being tracked using accuracy (Table 5-17).

Table 5-17 Exponent B and Significance Values for Predictors for 10 folds, 3 repetitions

	B	***S.E.***	***p***
Mechanical CPR Device Used	-1.388	0.642	0.031*
Epinephrine Injection	-1.357	0.744	0.068
Pre-hospital Advanced Airway	0.211	0.775	0.786
Note. df = 1. **p<0.05*			

Abbreviations: df: degree of freedom;

5.11 Discussion of the results

5.11.1 What are the factors that may influence survival or non-survival?

This thesis identified the following possible factors that influenced patient survival following OHCA in Abu Dhabi:

1) The patient collapse must be witnessed; and

2) Resuscitation started within the first seven minutes from the time of patient collapsed.

On the other side, factors that probably worsen the survival rate include:

1) Patients may be not recognised in cardiac arrest condition;

2) Low bystander CPR rate;

3) Abu Dhabi EMS arrived late; and

4) Abu Dhabi EMS interventions not being optimised.

5.11.2 Sample Size

A small sample size of (n=330) for OHCA is inevitable, given that the event rarely happens, and the data was recorded for only one year. It must be said that priority 1 cases are even low within Abu Dhabi EMS (figure 5-12). However, rare OHCA is consistent with those in other neighbouring countries (Alqahtani et al. 2019, Al Hasan et al. 2020). However, the sample size is small compared to Western countries. By comparison, a study by Karam et al. (2017), reporting the characteristics and outcomes of OHCA in Paris, included a much larger sample (n=9834). Similarly, a study by Gaieski et al. (2017) included (n=5198) in an investigation of non-trauma-related OHCA in Philadelphia, USA. While samples in both the Paris and Philadelphia-based studies were collected over four years, the sample sizes are still at least 4 times higher per year than for the current study.

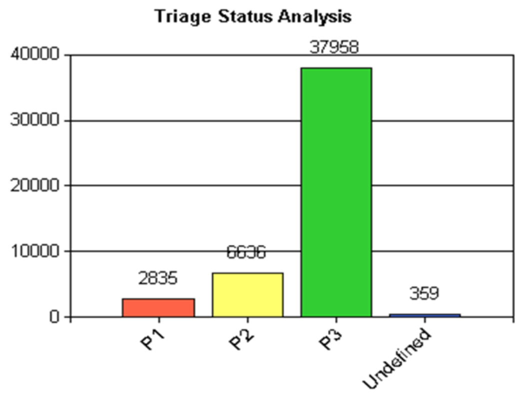


Figure 5-12 Overall priority for total EMS cases for 2019. The p 1 is consist of less than 3% of the total EMS cases showing the rare of the red cases

It is worth noting that these studies' results are different from the current, given that the EMS systems differences. The sample size for this study was sufficient for reporting OHCA in Abu Dhabi. But the important question is whether the lack of significant effect of EMS intervention is simply due to the small sample size. The answer likely relies on other factors, such as EMS response time, and might be low level of competency of EMS staff. Both of these will be discussed in the next chapter.

Besides, in the current study, one interesting finding is that the OHCA incidence rate was 13 per 100,000 in 2019. By comparison, the number of cases recorded in Poland in 2018 amounted to nearly 70 cases per 100 000 people (Nadolny et al. 2020). Overall, in Europe the rate of OHCA was estimated to be 56 per 100,000 persons (range 27–91 per 100,000 population per year) within 28 countries (Gräsner et al. 2020).

Furthermore, the small sample size highlights another issue. There may be a possibility that the small sample size is correlated with the ability to recognise cardiac arrest. The interlinks with the probable explanation for the small sample size in Abu Dhabi is that most people may not know how to ask for help if a patient collapses. This is evidenced by hospitals reporting that demonstrated another (n=112) OHCA did not activate EMS. Moreover, it may be that cultural factors negatively impact people's decision to call for help. It seems possible that the negative impact is due to low public knowledge about cardiac arrest. The public may not understand that cardiac arrest has a time-critical nature or they do not recognise patients in a critical condition. No attempt has been made to address whether people in UAE hesitate to call for help and why. It could be that people do not trust the EMS system and drive to the hospital themselves without seeking pre-hospital care, as was found in Australia (Case et al. 2018), and this would be an interesting follow-up investigation for the Abu Dhabi population.

5.11.3 Patient characteristics

5.11.3.1 Age

A key stand-out of this study was that age was not a factor in whether the patient survived or not. This contradict the evidence that younger age is prognostic factors for OHCA patient survival (Huang et al. 2021). The overall mean age of patients (56.9 years of age) in the current study is noticeably young compared to another nations. Overall, younger survival age was observed, with a mean age of approximately 50 years of age (range 19-93). This finding corresponds with data published in the North Emirates (Alqahtani et al. 2019), which report a median age of OHCA patient cases of 50 years old. What is surprising is that previous study in South Korea in similar EMS practice to Abu Dhabi found that younger OHCA patients have a greater chance of survival (Rhee et al. 2020). However, the survival rate in the current study (5%) is low compared to Rhee et al. (2020) (11.8%). Population differences might affect the outcome. For example, six years review of Irish cardiac arrest registry show high prevalence of non-medical OHCA among younger age patients (Tanner et al. 2021). The Irish study is conflicting with a local context found a higher incidence of co-morbidities in younger people in Abu Dhabi (Abduelkarem et al. 2020, Mezhal et al. 2020).

A note of caution is due here, since there is no method to measure comorbidities in Abu Dhabi, such as the Charlson Comorbidity Index (CCI), and Elixhauser score to predict cardiac arrest and mortality (Austin et al. 2015, Cai et al. 2020). Such a method has been used as a model to grade COVID-19 infected patients in critical condition based on comorbidities and clinical information (Zhou et al. 2020). Previously, Terman et al. (2015) studied the effects of age and previous arrest using CCI and found that higher age was significantly associated with lower survival outcome in patients with

OHCA. However, Terman et al. (2015) result is conflicting with recent evidence show the older patients has a 11% chance of survival (Zanders et al. 2021). It is important to note that even if the mean age of a surviving patient is low, the oldest survival occurred at the age of 93 and second eldest at the age of 85. Despite this, it can be suggested that patient age may not be the only factor to consider survival to hospital discharge in this study. This finding was also observed in Taiwan and Japan (Okabayashi et al. 2019, Huang et al. 2020). In general, the effect of age factor on the outcome is debatable, and there are better predictors than age of patient survival.

5.11.3.2 Comorbidity

The results presented herein demonstrate most patients (76.4%) have a comorbidity of CVD which is associated with lower survival chances. There may also be an association between CVD and OHCA event. To understand the influence of comorbidity on OHCA in the local context, further research is required. Though cardiac conditions have been shown to influence health status in UAE (Aziz et al. 2018, Govender et al. 2019, Al-Shamsi et al. 2019), the impact on cardiac arrest in UAE is unclear. The finding of the current study is confirmed in another context, a systematic review of 29 observational studies by Majewski et al. (2019) that shows comorbidity is generally associated with reduced OHCA survival. The most substantial evidence in terms of sample size and design shows a significant effect of comorbidity on patient survival in Australia and the Swedish registry of cardiopulmonary resuscitation (Andrew et al. 2017, Hirlekar et al. 2018).

Previous studies on comorbidity and OHCA have not explained the reason for low survival. It could be biological factors that are difficult to explain. Furthermore, it may be that later hospital treatment is influenced by past medical history. Søholm et al. (2015) found people with multimorbidity are less likely to receive the highest level of care, and Winther-Jensen et al. (2016) shows patients with less comorbidity received better medical care. Therefore, it could be in-hospital factors that explain the reasons for low OHCA survival among patients in the current study. Because the issue in Western studies is affected by "do not resuscitate" orders which not applied in UAE, it is important to bear in mind the possible bias in these studies.

5.11.3.3 Ethnicity

Ethnicity was found to not be a factor in patient survival in Abu Dhabi, although this is contrary to the current literature which shows that different ethnicities may have lower OHCA survival rate (Starks et al. 2017, Casey and Mumma 2018). A possible explanation is that the other result based on ethnicity may be because lifestyle or comorbidities associated with that nationality put the patients at higher risk of OHCA. It is almost certain that the UAE population is at increased risk of cardiovascular diseases and OHCA, as explained in chapter two. The current study found that past medical history, specifically CVD, is a significant factor in patient survival in this study. This is consistent with Govender et al. (2019), who investigated a cohort of patients with a history of CVD and found significant predictors of recurrent CVD in UAE. However, no attempt was made to quantify the association between CVD and OHCA. Another prospective observational study in Singapore by Rakun et al. (2019) found that Malays and Indians may be at high risk of OHCA due to comorbidities. Therefore, comorbidity may be associated with some ethnicities, which in turn cause an increased risk of cardiac arrest.

Another explanation for low OHCA survival in some studies examining show that patients may receive less medical care after being hospitalised from an OHCA event, based on ethnicity, and therefore have a lower survival rate. For example, it has been shown that certain ethnicities receive less medical care after OHCA event in New Zealand (Dicker et al. 2019b). In another example by Woo et al. (2020), a retrospective study of hospitalisations for 51,198 OHCA in all acute care cases in California, USA found lower survival amongst Blacks, Hispanics, and Asians. The reason found by Woo et al. (2020) is that racial and ethnic minorities are less likely to receive recommended treatments. These results reflect those of Chan et al. (2020) who also found that most Black patients have lower survival rates following OHCA because of unequal treatment compared to other ethnicities.

In general, we can argue that some communities face inequality issues in accessing pre-hospital medical care (Blewer et al. 2020). As a consequence, such matters may impact OHCA outcomes. However, the critical problem with the above explanation is that ethnicity has no impact on patient survival if the treatment is the same. For example, Lupton et al. (2020) conducted a sizeable secondary analysis of 3,002 OHCA patients of White, Black, Hispanic, and other ethnic and racial identities and found no differences in medical interventions and survival outcomes. It can thus be suggested that nationality may not be a significant factor in patient survival in Abu Dhabi. Nevertheless, these claims need to be further studied.

5.11.4 "Chain of Survival"

The current study's potential strength is that it addresses the pre-hospital chain of survival links in detail. As mentioned in the literature review, OHCA survival depends on the chain of survival. Gaps were observed in all chain of survival links within Abu Dhabi EMS practice. The current study illustrated that low OHCA survival is due to the following circumstances: 1) cardiac arrest may not be recognised immediately by bystanders; 2) there is a delay in calling emergency services for help; 3) dispatchers are not participating in the resuscitation process; 4) there are barriers that lower the incidence of bystander CPR; 5) there is a delay in starting effective CPR; 6) a shockable rhythm is not present; 7) or EMS arrives late to the patient; and 8) finally, EMS resuscitation may not be adequate. These findings are consistent with a study in the Northern Emirates (Batt et al. 2017), that found weaknesses in all links of the survival chain. One can argue that OHCA survival depends on a multidisciplinary system that in Abu Dhabi has weaknesses throughout all the respective links.

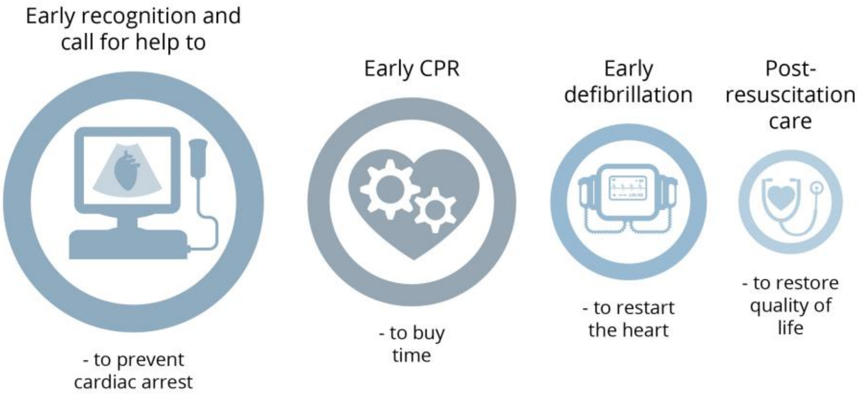


Figure 5-13 Chain of survival following cardiac arrest. The result shows the larger the circle, the larger the chance of survival if that step is implemented, which is consistent with (Deakin 2018).

However, in this result chapter some variables may not be truly independent and this taken into consideration in the interpretation of the results in the next chapter.

However, not all links in the survival chain are equally crucial because survival diminishes rapidly as patients succumb in each link (figure 5-13). The most important links are initiated in the pre-hospital setting. The recent consensus evidence shows that early recognition is the most critical link for patient survival (Merchant et al. 2020, Berg et al. 2020b). Furthermore, a recent ERC statement shows that early recognition of dispatchers is an important step in enabling CPR direction and timely EMS response (Olasveengen et al. 2021). More importantly, the AHA treatment guidelines in both 2015 and 2020, which Abu Dhabi EMS follows, stated that rapid recognition of a cardiac arrest event is crucial, and a bystander should simultaneously and promptly activate the emergency response system and initiate CPR (Kleinman et al. 2015, Panchal et al. 2020b). Early recognition and CPR are the most important links, followed by EMS interventions, but these are the weakest in Abu Dhabi. This is evidenced by Abu Dhabi EMS's lack of a medical triage system that activates the case as a life-threatening emergency early. In essence, all the chain of survival variables is controlled by Abu Dhabi EMS except hospital care.

Surprisingly, and despite the presence of advanced EMS technology in Abu Dhabi, OHCA survival was poor in 2019. This suggests significant gaps in the EMS system. As a result, Abu Dhabi EMS's ability to fully implement the AHA guidelines and apply evidence-based practice could be questioned. Inhibitors to the performance of the Abu Dhabi EMS could include the availability of and access to training, competency levels of staff, and access to medical staff expertise in the field. These factors are based on the audit and result of weaknesses in all EMS interventions, which are discussed further in section (6.7). Generally speaking, medical directives instruct and evaluate the entire EMS system, including the dispatchers, and provide medical control. As is evident, OHCA is the most critical type of case that EMS must treat in pre-hospital care. Therefore, the evaluation of performance within each link in the chain of survival is essential. For example, AHA recommends that EMS team feedback and debriefing protocols be used to improve resuscitation teams' performance in subsequent resuscitation events (Berg et al. 2020). AHA recommendations are based on the latest available science, that not necessarily be a high level of evidence, and the challenge is to implement this practice in Abu Dhabi.

5.11.5 Summary

This research set out to identify OHCA patients' characteristics and survival factors in Abu Dhabi EMS in terms of the study's objectives. This study has determined that OHCA is a rare pre-hospital event. The significant finding was that people might not recognise cardiac-arrest patients or activate EMS, and thereby worsening the survival rate. The most prominent finding to emerge is that patients are young and likely have one or more comorbidities. The findings will be of interest to cardiovascular epidemiological studies, given that patients most likely have CVD. In this report, and based on patient characteristics, no certain survival predictor was established. But if the patient collapse was witnessed, and CPR started within the first seven minutes from the time of collapse, the chance of survival increased. In the next chapter, significant factors that possibly interlink and cause a low OHCA survival rate will be discussed.

6. Chapter six: Discussion

6.1 Contributions

This research is related to and contributes to our knowledge regarding the possibility of patient survival following OHCA. Specifically, this addresses the study's first objective: to investigate the patient factors that may influence the survival or non-survival of patients treated for an OHCA by Abu Dhabi EMS and to provide new knowledge regarding the Abu Dhabi EMS.

6.2 New knowledge

A critical factor to emerge from this study is that scientific research is now recognised by the Abu Dhabi EMS for the first time since its inception in 2001. Previously, Abu Dhabi EMS practice was unproven, and changes to promote the pre-hospital services are based on opinions. As a result, there was difficulty in identifying which changes could improve patient outcomes. At the same time, improvement initiatives and remediation used to help Abu Dhabi EMS did not embrace evidence-based medicine, specifically in the complexity of an OHCA event, which required a multidisciplinary dimension investigative method.

This study provides new knowledge that indicates the possibility of a patient's survival following OHCA and suggests important changes in pre-hospital care. The findings reported in the results, and this chapter, shed light on current pre-hospital abilities concerning critical patients' care. These findings will be of interest to local and international EMS managers to lay the groundwork for the direction of resources and provide a knowledge base for future OHCA research.

6.2.1 Knowledge transferability

While this research is based within Abu Dhabi, an Emirate within UAE, the methods and results could be replicable both within the same EMS organisation or are likely to be transferrable to other contexts for comparison. The Abu Dhabi Emirate sample shares similar demographic, economic, societal factors, and general health status in other Emirates (Alqahtani et al. 2019), including similar policies and laws that regulate the healthcare system. Thus, given the sample characteristics and setting, the current findings discussed below focus on transferability to other Emirates and how the current research presents an opportunity to expand the scope of future research in other contexts.

The transferability of the findings could also be relevant to a range of Gulf countries, given the similarity in social settings, economic, and health system challenges (Mamtani and Lowenfels 2018). While the knowledge provided may not directly apply to other practices, it may provide key preliminary research by highlighting the key survival factors, namely the time of the cardiac arrest to first CPR.

6.3 Survival factors

This research contributes to EMS practice, highlights that the survival rate from OHCA in Abu Dhabi is poor, with a 5% chance of survival through to hospital discharge. Prior to this study, evidence of patient survival possibility was purely anecdotal. This research fills a knowledge gap regarding OHCA patient survival in the Abu Dhabi context by its objective and empirical investigation. This study defines one key factor that influences survival for OHCA treated by Abu Dhabi EMS, being that the patient was more likely to survive if basic life support is started within seven minutes or less from when the patient collapsed.

6.3.1 Key survival factor - Time of cardiac arrest to first CPR

This study was able to record the estimated time from when the patient collapsed to EMS CPR, finding a time of 7.2 vs 15.1 minutes for surviving and non-surviving patients respectively. The survival factor found is a significant contribution to knowledge. Before this study, little was known about the impact of the time interval between collapse to EMS CPR. The surviving participants in the current study benefitted from a shorter time between collapse and EMS intervention. It is important to bear in mind that the quality of chest compression was not measured in this study. However, it is believed that there is an increased chance of survival when EMS promptly provides the highest possible quality of care, specifically in the first minutes following a collapse. Therefore, this study suggests that a response time of ≤ 7 minutes for EMS may lead to better survival outcomes in OHCA patients.

These findings are consistent with Lee et al. (2020), who found that EMS' shorter response times may lead to favourable neurological outcomes in OHCA patients. Those findings are broadly consistent with another recent study that found a shorter time interval between collapse and EMS intervention increased patient survival chances (Navab et al. 2019c). Furthermore, research points to bystander CPR as a significant opportunity for earlier CPR (Goto et al. 2018). Generally speaking, bystander CPR is a practical approach to reduce time to first CPR. Bystanders are the first ones present on the scene and can begin chest compressions earlier than EMS (Rajan et al. 2016).

However, in the context of Abu Dhabi, EMS services are needed on-site as the public are not yet prepared to undertake effective basic CPR. This finding has important implications for developing faster EMS. However, these findings may be able to raise community initiatives that are fundamental for earlier CPR intervention, such as education and training in CPR and first aid. This research demonstrates that considerable attention needs to be dedicated to faster EMS response to reduce the interval times between patients collapses to CPR. However, this is just one of the gaps in pre-hospital care identified by this study.

6.4 Gaps in Abu Dhabi pre-hospital care

This research has provided a significant insight into the main clinical issues leading to low survival of OHCA. Community non-participation (early recognition, non-presence of bystander CPR, non-use of AED) seem to weaken the patient survival chances, while long response times and EMS management practices can heavily influence OHCA outcomes. Furthermore, the research identified significant gaps in EMS practice, as discussed below. The identified practice gap in Abu Dhabi provides tentative support for more effective resource allocation for Abu Dhabi EMS.

6.4.1 OHCA Recognition

A particularly prominent finding in this study that early recognition is non-existent for Abu Dhabi EMS dispatchers, thereby weakening their ability to influence patient survival. These findings are rather disappointing but may help policymakers realise the current Abu Dhabi pre-hospital care situation. As discussed in the literature review, early recognition is the first link in the chain of survival, and unrecognised cardiac arrest may influence the time to EMS activation. In this study, the time interval from when a patient collapsed to EMS CPR was estimated to be 14.7 minutes, while the EMS average response time is 10 minutes. Bystanders or dispatchers may influence the differences between patient recognition and EMS activation. First, bystander recognition, rather than the dispatcher's role in identifying cardiac arrest, will be discussed. Though the goal is to recognise patient collapse in the early seconds, the difficulty is to achieve this goal in a community that has limited knowledge of First Aid and/or medicine. The 2020 international consensus on resuscitation shows a connection between patient recognition and the community orientation toward cardiac arrest (Greif et al. 2020). Thereupon, a reasonable approach to tackle this issue could be to assess community education on cardiac arrest.

To begin with, community education on this topic is critical for patient survival (Semeraro et al. 2021) and is associated with a short time to CPR (Ko et al. 2020). Citizens' knowledge of cardiac arrest might influence the decision to call for help, which has been discussed in the results chapter. In this study, EMS teams reported that bystanders likely took a long time to recognise that a patient needed assistance due to limited knowledge of cardiac arrest signs. Bystanders may not be educated because there has been no public initiative to activate the early emergency response in Abu Dhabi. Communities that are not educated to recognise cardiac arrest significantly affect patient survival (Ro et al. 2016; Tay et al. 2020). This explanation is consistent with recent studies, which found that OHCA patients in less-educated communities may experience significant delays prior to CPR being commenced (Berger 2020, Yu et al. 2020). Therefore, it seems that implementing a community education strategy on cardiac-arrest symptoms may increase the chances of recognising OHCA patients.

It is important to realise that such an educational strategy may need significant resources to benefit pre-hospital care; therefore, key indicators are required to measure the strategy's effectiveness. One way of estimating the patient collapse time and the significance between this timing and first CPR. However, data on time between patient collapse and first CPR must be carefully examined. Indeed, the observed patient collapse time was based on witnesses' memory, which may not be 100% accurate. However, it has been used in a similar study (Hara et al. 2015), where the EMS interviews with the bystanders before leaving the scene and were measured in minutes. Thus, there is the potential for bias to favour witnessed patients over non-witnessed ones because the time of collapse from OHCA is challenging to obtain (Perkins et al. 2015b). This contrasts with in-hospital cardiac arrest, where the patient is controlled by staff and monitored by medical equipment (Nolan et al. 2019). The difficulty arises when a patient in critical condition is unresponsive or whose gasping induces panic in witnesses. In medical emergencies, it is unlikely for the witnesses to be aware of the collapse time, unless they have been trained to record the onset of an event as healthcare professionals are educated to do. With this in mind, the time of collapse is not accurate, but an estimate made under duress. Recording the time of patient collapsed to first CPR was the best strategy to measure early recognition in this thesis. However, strategies to enhance early patient recognition might involve different measures or key indicators for success. These could include early recognition by dispatcher centre, or public education of the signs and symptoms of cardiac arrest.

6.4.2 Dispatcher recognition

In addition to bystanders not recognising cardiac arrest, a similar issue was discovered in emergency dispatchers. That again leads to a reduction in survival chances. Though the recognition of cardiac arrest requires two simple questions about patient consciousness and if he/she is breathing normally (Bobrow et al. 2016, Panchal et al. 2019), Abu Dhabi EMS does not attempt to provide information on dispatcher recognition because it does not yet have a professional EMS dispatch system. This was discussed in chapter two that no early EMS system is established in the dispatchers (section 2.3.1). As a result, when dispatchers at the emergency call centre do not recognise cardiac arrest signs, no specific steps or path follow, for example sending an appropriate EMS team to the event. Rapid dispatch for OHCA patients is significantly associated with the probability of patient survival (Gnesin et al. 2021). However, it appears that Abu Dhabi EMS takes a longer time to respond to the OHCA, as shown in figure 3-6 (page 39). There are three levels of EMS crews in Abu Dhabi, and evidence shows that sending an appropriate crew to respond to the call is paramount for patient survival (Park et al. 2021). An example would be that the EMS crew is not equipped for resuscitation, resulting in an extended period for another crew to reach the patient. Further discussion regarding this topic is found in the EMS management subsection, showing a great influence in the advanced intervention process.

European Resuscitation Council (ERC) guidelines (2018) show the vital role of dispatcher recognition of cardiac arrest and its relation to patient survival (Perkins et al. 2018). The latest evidence from the AHA illustrated the significance of dispatcher recognition of cardiac arrest and suggested using new technology, such as bystander smartphones (Panchal et al. 2020c). Even though dispatcher recognition is mentioned in the clinical guidelines, and various ways to detect cardiac arrest by phone are available (Blomberg et al. 2019, Riva, Gabriel et al. 2020, Derkenne et al. 2020), there is no evidence that dispatchers recognise cardiac arrest in Abu Dhabi. The absence of a dispatcher role in EMS is not encouraging for improving patient survival (Zhang 2020a).

It is difficult to explain why no dispatcher role exists in Abu Dhabi EMS to detect cardiac arrest, despite consistent literature on its significance. For example, a recent statement from the AHA shows that early dispatcher recognition, coupled with telephone-CPR, markedly improves survival chances (Kurz et al. 2020), because telecommunicators are the first line of contact with the patient or bystanders. It is important to realise that cultural aspects, such as having a new medical role for non-medical dispatchers, together with a lack of training, may be the main barriers. The EMS preparation for responding to OHCA does not yet include dispatcher recognition of cardiac arrest. Furthermore, there are barriers to compliance with CPR instructions by the caller, including language barriers in the Abu Dhabi population context and inability to provide correct instructions or refusal of the caller to initiate patient assessment (Meischke et al. 2015, Zhang et al. 2020b, Fukushima and Bolstad 2020).

Those barriers will negatively affect the EMS response time and response time to first CPR.

6.4.3 Response time

This study discovered that a long EMS response time is a significant issue in Abu Dhabi, which directly causes a significant decrease in OHCA patient survival chances. This information is significant for Abu Dhabi EMS advances. The prolonged EMS response time delayed the treatment and significantly decreased patient survival to hospital discharge (Ornato et al. 2021). The average EMS response time of 10.12 minutes is considered long for OHCA patients, but is in line with the Dubai ambulance response time of 10 minutes (Ong et al. 2015b), and 13 minutes in Saudi Arabia (Alnemer et al. 2016). Previous evidence shows that shortening EMS response time increases survival (Park et al. 2020, Holmén et al. 2020). An observational analysis of 204,277 OHCAs between 2006 and 2012 in Japan found that a response time of ≤6.5 min was strongly associated with survival to discharge and good neurological outcomes (Ono et al. 2016). Additionally, Al-Dury et al. (2020a) found that the first 10 minutes without CPR decrease the patient chance of survival by half, and a shorter time until CPR begins significantly increases patient survival.

There are a number of factors that may influence response times, other than those discussed above regarding the dispatchers. Community education on ambulance services and first aid might affect local attitudes toward ambulance services. Delays may be caused because the EMS crew suffers from other drivers' tendency to block the road by not pulling over for the ambulance to pass. Therefore, a public-information campaign will help reduce adverse acts toward ambulance vehicles. Another factor in the longer response time in Abu Dhabi might be the traffic situation during rush hours (Jeon et al. 2020). Motor vehicles are the dominant form of transportation in Abu Dhabi (Qamhaieh and Chakravarty 2020), and the influx of expatriates has only increased their usage in recent years.

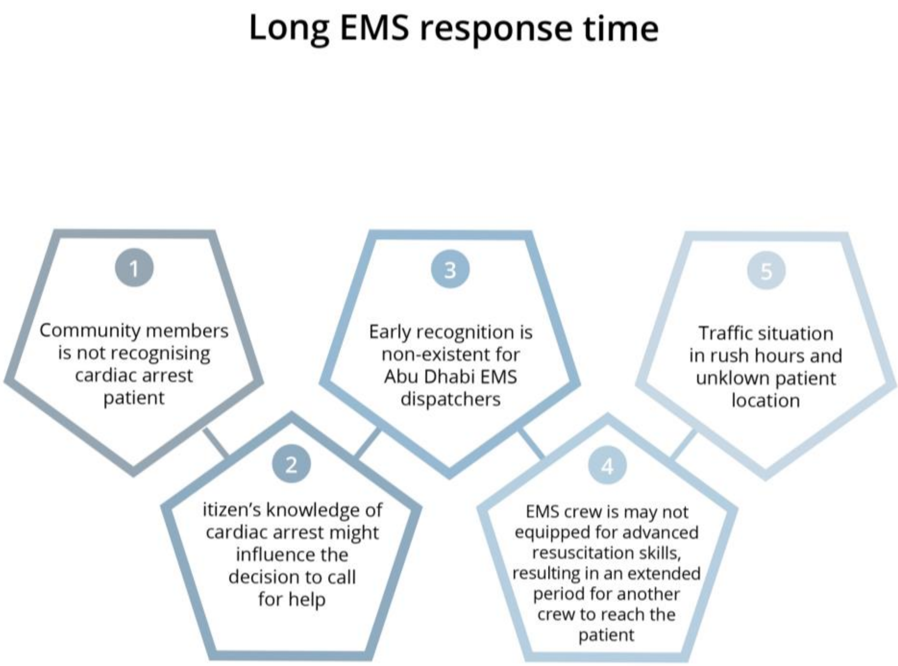


Figure 6-1 Possible explanation of weak early OHCA recognition in Abu Dhabi

Figure 6-1 summarises possible explanations for longer recognition time that might affect the next chain of survival links. Thus, these explanations can link drivers' actions toward an ambulance, the local traffic situation, and a high volume of expats from multiple nationalities. This paradigm was used to frame the first key issue in pre-hospital care regarding the time-delayed between patients collapsed to the first CPR by EMS.

6.5 Bystander CPR

Interestingly, bystander CPR was not found to significantly influence patient survival. Furthermore, this research reveals a significant gap in the chain of survival in Abu Dhabi, being the absence of very early CPR as a critical link. The lack of community involvement delivering early chest compression, which is a necessary treatment, is a vital issue in Abu Dhabi. This study discovered a rather disappointing result for bystander-administered CPR, with only a small number of surviving patients having received it.

The finding is disappointing because while early CPR is proven to be a key factor for patient survival (Doan et al. 2020b), in the current study bystander CPR was shown to be lacking in Abu Dhabi. These results strongly suggest a hypothesis that weaknesses exist in community participation for pre-hospital care, as bystanders are likely to not recognise the signs of cardiac arrest, while also not knowing what to do in the event. Chapter three discussed compelling evidence regarding resuscitation being a significant influence of the early bystander link in the chain of survival, and how it can significantly increase patient survival (Park et al. 2017, Kragholm et al. 2017, Sondergaard et al. 2019, Christensen et al. 2019, Moon et al. 2020). For example, a prospective cohort study by Blewer et al. (2020) analysed 6,788 OHCA events through the Singapore registry and found that bystander CPR was associated with increased survival to hospital discharge compared to no bystander intervention. It is important to note that Blewer et al. (2020) concluded that developing targeted community-wide training improved bystander CPR, while dispatch-assisted CPR further improved survival rate. It appears that Singapore's strategic approach to strengthening community-based training made a remarkable difference in survival. In general, it seems that supporting community response greatly benefits OHCA survival.

However, the best example is the Seattle EMS system, regarded as amongst the most sophisticated globally, which aggressively developed the community response for OHCA through training and orientation. This development led the Seattle ambulance services to achieve the world-best OHCA survival rate of 56% if a bystander witnessed the patients' arrest. Furthermore, this data excludes patient collapse witnessed by EMS, demonstrating the strength of pre-hospital care. Eisenberg (2013) reported that early identification of cardiac arrest, and early initiation of bystander CPR/AED were crucial for patient survival in Seattle. These results may be explained by the fact that the time from call pick-up to start of compressions is 2 minutes, 58 seconds in Seattle, and the bystander CPR rate is 73% (Smith 2020). The Seattle case provides insights into the factors that play a crucial role in patient survival and highlights significant evidence that efforts and resources to increase survival rates through community intervention are a successful strategy. Hence, it could be hypothesised that CPR education for the Abu Dhabi community is an important aspect of providing bystander intervention.

But the result in the current study was not very encouraging. To put a particular issue of low bystander CPR in the context, it is important to understand a series of weaknesses that are likely causes for the low rate of bystander CPR in Abu Dhabi.

First, the EMS system in Abu Dhabi is not designed to target bystander interventions. One may argue that bystander intervention is not part of the EMS system in Abu Dhabi. However, bystander intervention is part of the community that participates in saving a patients' life. In turn, once the bystander calls for help, he/she might participate in a reasonable intervention such as simply recognising a cardiac arrest. Early recognition is a critical part of the chain of survival to support the pre-hospital response (Lerner et al. 2012, Syväoja et al. 2018, Rao and Kern 2018). During the call to dispatchers, the ability to recognise a cardiac arrest patient is positively associated with bystander CPR provision (Viereck et al. 2017). However, as stated earlier, the existing situation in Abu Dhabi is that EMS dispatchers fail to recognise cardiac arrest. Perhaps the most serious disadvantage is dispatchers not influencing the bystander willingness to perform chest compressions. If the bystander is willing to start chest compressions, they could reasonably expect CPR instructions from the dispatcher, that significantly increase neurologically intact survival (Mathiesen et al. 2019, Eberhard et al. 2021). But if having dispatchers recognise cardiac arrest early is not happening, this makes it difficult for bystander interventions. A study by Viereck et al. (2017) to analyse 548 OHCAs in Denmark found 65% of bystander-initiated CPR with the help of dispatch centre instructions. Therefore, it may be possible to improve bystander CPR rates, even when individuals have not been previously trained. Dispatchers can implement a standard protocol of two questions about breathing and pulse, that will lead them to determine which patients are likely to be in cardiac arrest. Then dispatchers can, and should, have training in how to give CPR directions over the phone to untrained bystanders. In countries that have implemented these changes, the survival rate has increased (Hardeland et al. 2017, Lee et al. 2018, Derkenne et al. 2020).

Additionally, weak early cardiac arrest recognition may hinder early activation of pre-hospital advanced life support (ALS) teams. Studies show that early ALS activation and shortening of the time to definitive care improve patient survival (Lee et al. 2020). Weak cardiac arrest recognition by dispatchers and the negative effects on

ALS will be discussed below. Rapid dispatch and priority codes should be implemented to indicate which calls are the critical ones that require rapid EMS response.

Second, bystanders should be expected to be trained to perform CPR (Park et al. 2020). However, despite the evidence pointing towards the importance of public education as a factor associated with high bystander CPR rate (Beck et al. 2016, Kuvaki and Özbilgin 2018, Malsy et al. 2018), there is no public education by the government, schools, or any other community organisation that has a foundation for CPR in Abu Dhabi.

Perhaps the most serious disadvantage is having EMS managed by police, whereas the city police and personnel are not trained to recognise cardiac arrest or perform CPR. Evidence shows that dispatching trained and AED-equipped police forces result in earlier and significantly more successful resuscitation of OHCA (Stein et al. 2017, Hasselqvist-Ax et al. 2017b, Krammel et al. 2020b). It seems possible that public health initiatives are one element best contributing to enhanced public education efforts (Fordyce et al. 2017). For example, medical students can conduct large-scale hands-only chest compression education for the public to improve knowledge of CPR (Anderson et al. 2020), which show successful methods to teach CPR in Brazil (Ribeiro et al. 2013). Having EMS managed by police would enable easier and more vigorous initiatives, like mandatory basic life support training for police officers. These initiatives would significantly contribute to the community, providing police officers who can perform First Aid.

Implementation of CPR training and practice by police may be another matter however, as performing chest compressions correctly and with high quality is exhausting and not easy (Shin et al. 2014). The harsh warm environment (41°C and 98% humidity) in Abu Dhabi can reduce CPR's efficacy (Martin-Conty et al. 2020). In addition, high temperature is associated with increase mortality rate in OHCA patients (Hensel et al. 2018, Kranc et al. 2021). The element of weather should not limit the bystander CPR rate in Abu Dhabi, but I noted that factors of climate and the quality of CPR by laypersons, police officers, or off-duty healthcare workers that are not doing their best may accidentally hurt the patients. Even though bystanders are obligated to help the patient reasonably, they must be protected from being judged for harming them while assisting them.

Therefore, the third most significant weakness in the UAE pre-hospital care systems is the lack of a Good Samaritan Law. Because even if bystanders are obligated to perform CPR or first aid, there is no legal protection for bystander in the case of patient injury or death. A fear of legal issues may be why people are unwilling and refuse to touch cardiac-arrest patients. Performing medical help for someone in need is a moral duty, but to promote bystander CPR properly, legal measures should be implemented (Moon et al. 2019). In most nations, individuals will stop to help accident or illness victims because they are protected if they accidentally hurt the person (Choi and Lee 2019, Hung et al. 2019, Murphy et al. 2020). Activating emergency services is the least help a person can do if he/she suspects a life-threatening situation for the patient. Causing patient injury during CPR can be mitigated through quality control and consistent training. Nonetheless, breaking a patient's ribs while applying chest compressions is a minor injury compared to the need for life-or-death intervention.

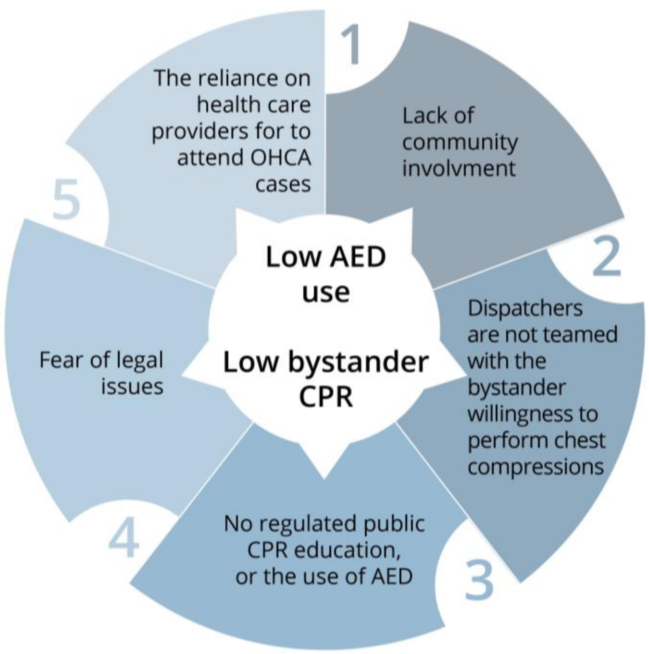


Figure 6-2 Gaps that affect early CPR and the use of AED by Abu Dhabi people

In the end, and for the three factors above, a significant gap in community participation in cardiac arrest is demonstrated. As summarised in figure 6-2, the gaps relate to community education, legal issues, or cultural factors that impact bystander interventions. I do think Abu Dhabi EMS policymakers must increase accountability and community participation to help, where possible, following a cardiac arrest. This does not suggest in any sense that ordinary people are responsible for not helping patients. However, people in Abu Dhabi must be ready to help cardiac-arrest patients by educating themselves to improve the culture of act and to overcome bystander CPR barriers. Additionally, these claims do not undermine the EMS organisation's influence, but it asserts that additional reform in pre-hospital care must be taken to respond to OHCA. Barriers to administer bystander CPR are also found in Scotland, specifically in deprived communities (Dobbie et al. 2020). However, national Scottish strategy initiated to improve community response to OHCA.

In the implementation view, the above explanations will doubtlessly be scrutinised in Abu Dhabi because further research is required for each factor. However, there is no doubt that dispatchers can play a crucial role in recognising OHCA and assisting bystanders in performing CPR. Abu Dhabi EMS may seek assistance from previous EMS expertise in places like Seattle to build its modern dispatcher system. That may faster influence how Abu Dhabi recognises and assists cardiac arrest and in turn, greatly influences patient survival. A systematic review and meta-analysis support dispatcher-assisted CPR, as it improves outcomes from cardiac arrest (Nikolaou et al. 2019). These factors, however, are highly related to robust early recognition strategies. The European Resuscitation Council highlighted that the caller and the dispatcher are the first resuscitation team (Monsieurs et al. 2015). Given the discussion above, further work is required to establish early bystander CPR to improve patient survival in Abu Dhabi.

6.6 Bystander AED

Another concern regarding OHCA patient survival rates revolves around infrequent early AED use in Abu Dhabi public places. This study discovered early bystander AED use in 2% of cases and did not significantly contribute to patient survival. This percentage is even lower than European countries' lowest AED use of 3.8% in Copenhagen in Denmark (Gräsner et al. 2021). However, this needs to be qualified that AED was used in an exceedingly small number of cases in Abu Dhabi, and therefore, the evidence in the current study is not conclusive. Interestingly, and even though AEDs are distributed around government buildings, public places, and shopping malls, EMS crews reported that AED was not used. The EMS crew assertion again highlights the issue concerning the use of AED.

Another area of uncertainty is that an off-duty healthcare provider used AED in all six cases in which it was possible to deliver defibrillation, showing concern about the lack of public certainty regarding such an electrical device. The most interesting finding was that in two of these six cases, the patient got ROSC before hospital arrival, was admitted to ICU, and survived to hospital discharge. Those patients were ages 76 and 79, both had CVD and their arrests were witnessed by family members. It was a coincidence that an off-duty healthcare provider happened to be at the scene and contributed to patient survival. The apparent reliance on healthcare providers to attend to OHCA cases can arguably contribute to the survival chances low in Abu Dhabi.

Immediate patient defibrillation is the only known treatment to reverse VF or pVT (Nolan et al. 2020). The latest evidence from the AHA shows that early defibrillation is critical for survival when a cardiac arrest is caused by VF or pVT (Panchal et al. 2020c). An example from a registry-based study in Copenhagen, Denmark of 566 OHCA events found that survival nearly doubled when a bystander used AED (Karlsson et al. 2019). Also, the time to defibrillation is crucial for patient survival, as demonstrated by the ILCOR. In the current study, however, the defibrillation was carried out by EMS, for which the response time was not sufficient to promptly reach the patient. Long EMS response time was a challenge found in another study; the Swedish cardiac-arrest registry reported 59,926 OHCA events between 1992 to 2011 (Strömsöe et al. 2015), and found that survival doubled for shockable patients who received early defibrillation. These results are likely to be related to patients present in shockable rhythms which may prognostic determined the survival (Majewski et al. 2021). That shows the significant differences early defibrillation can make.

There is opportunity to increase the use of AED in pre-EMS arrival; dual dispatch is a strategy to overcome the EMS response-time challenge, which refers to dispatching a second, closer unit equipped with AED, such as a police car. Dual dispatch strategy may work in Abu Dhabi, given that EMS is managed by police as well as other emergency services. Stockholm EMS implemented the dual dispatch strategy using police cars and firefighters in parallel with EMS teams, which reduced defibrillation time (Hollenberg et al. 2009). However, it might be that double dispatch emergency units are costly because we need to train emergency services on first aid. A pilot trial in specific geographic areas may provide a clear answer if they can shorten defibrillation time. Alternatively, most recent evidence shows that efforts to support the general public's ability and willingness to use AED will also improve survival (Berg et al. 2020).

This study revealed the present opportunity of distributed AED in public places, but the absence of training hinders the ability to deliver a shock. However, critics question the ability of the Abu Dhabi community to perform early defibrillation. One problem is legal issues that may arise if a bystander harms the patient, and this is potentially responsible for the low AED rates found in this study. Besides, the EMS system suffers from a lack of community integration which constrains the potential for public intervention. In such a situation, bystanders are often not trained to use the AED device unless they are healthcare providers. In the end, implementing new laws to absolve bystanders of legal repercussions could improve community AED use.

6.7 EMS interventions

The current study found that Abu Dhabi EMS interventions (epinephrine injection, ETI administration, and mechanical CPR device) do not yet significantly affect patient survival. No evidence currently supports that EMS alone can increase survival of OHCA patients. Interestingly, the current study showed that EMS frequently interrupted the resuscitation process, as Abu Dhabi EMS paramedics are concerned with prioritising advanced pre-hospital skills rather than the quality of resuscitation. This was evident in Abu Dhabi EMS crews that reported a brief halt to resuscitation to administer advanced interventions, which may greatly influence patient survival chances (Hanisch et al. 2020). Combining the two certain aspects of EMS performance, namely long response times and interruption of resuscitation, could contribute to lower patient survival. This information is significant contribution to the practice, and could be used to develop strategy to enforce early EMS response or prioritising BLS.

The findings of no effect of advance EMS intervention are consistent with previous research (Stiell et al. 2004). This large Canadian sample of controlled clinical trials on OHCA demonstrated that those patients who received advanced EMS intervention did not significantly experience improved survival rates. Despite the controlled design and the large sample size (n=5638), Stiell et al. (2004) could not identify any evidence of benefit from advanced EMS. It appears that there are procedural similarities between Abu Dhabi EMS and this controlled clinical trial, which included ETI and the administration of epinephrine.

Moreover, in the Stiell et al. (2004) study, logistic regression analysis showed that the odds ratio for survival in the advanced EMS interventions, compared with rapid defibrillation, was 1.1 (95% CI, 0.8 to 1.5). In the Stiell et al. (2004) study, the first three links in the chain of survival had odds ratios as follows: early access (cardiac arrest witnessed by a bystander), 4.4 (95% IC, 3.1 to 6.4); early CPR (CPR administered by a bystander), 3.7 (95% IC, 2.5 to 5.4); and early defibrillation (AED used within eight minutes after cardiac arrest), 3.4 (95% IC, 1.4 to 8.4). However, the studies reviewed in chapter three evaluating EMS interventions yielded controversial results. The inconsistency may be due to variations in EMS and healthcare system provisions. The methodological approach in those studies having a retrospective design or differences in the study population makes it challenging to compare them with the current research. Specifically, the Abu Dhabi EMS system was disadvantaged from a lack of early identification and having longer response times, which may compromise survival chances. The data relating to the time of advanced EMS intervention is a major limiting factor (Ornato et al. 2020). For example, a study has noted the importance of early ALS intervention, arguing that ALS can improve patient survival if initiated within 6 minutes (Kurz et al. 2018). These results show that time is an essential factor in resuscitation. The following sections are detailed discussions of the three EMS variables.

6.7.1 Epinephrine use

A significant finding of this study is the longer EMS response time and the delay in administering epinephrine. That shows concern due to long EMS response time not benefitting from advanced interventions. An epinephrine injection was administered for 83.9% patients with OHCA. The current study found a low association between epinephrine administration and survival to discharge (X2 = 9.51, p<0.00). Abu Dhabi EMS follows AHA OHCA treatment guideline 2015, although these are a recommendation from ILCOR, which suggested using epinephrine based on countervailing evidence (Soar et al. 2015). For example, an RCT of the use of epinephrine in OHCA in Australia including 534 OHCA patients, showed no statistically significant improvement in the primary outcome of survival to hospital discharge but improved ROSC and survival events (Jacobs et al. 2011). While this study size is small compared to the latest research, a recent and larger RCT by Perkins et al. (2018) in England that included 8,014 OHCA patients showed that epinephrine improved patient survival to hospital discharge. The problem with the Perkins et al. (2018) result is that more survivors had severe neurologic impairment in the epinephrine group. This indicates a concern that epinephrine may harm long-term patient survival, which is likely to explain the low association between epinephrine and survival to hospital discharge in the current study.

Additionally, for the current study, it could be that epinephrine is given to OHCA patients late, after neurological damage has occurred, and therefore, it is likely that the survival rate may fall. The latest systematic review and meta-analyses indicate that epinephrine markedly improves ROSC and short-term survival to hospital admission (Holmberg et al. 2019), but may harm neurological function in the long term. The Holmberg et al. (2019) systematic review includes 67 observational studies, 8 randomised trials, and 15 RCTs, showing confidence in the use of epinephrine for short-term survival to hospital admission. But the review illustrates that epinephrine is most beneficial when given earlier, particularly for patients with non-shockable rhythm. This could explain the low influence of epinephrine on survival in the current study because the average EMS response time in the present research is long.

The recent consensus ILCOR treatment recommendation for OHCA suggests that early CPR and early epinephrine are likely to improve patient survival (Berg et al. 2020). The improved short-term survival is the clinical justification for ILCOR to include epinephrine in the latest treatment recommendation. At the same time, the long-term effects are uncertain, because the latest systematic review by Aves et al. (2020) shows a gap in knowledge on the impact of the dose and method of epinephrine administration on survival beyond three months. In theory, early epinephrine will increase the myocardial perfusion pressure. Increased myocardial pressure during cardiac arrest may increase the probability of ROSC (Paradis et al. 1990). The study behind the theory involved animal experiments to test the epinephrine mechanism during CPR and showed a substantial increase in blood flow, and both coronary and cerebral pressure (Michael et al. 1984). Furthermore, epinephrine is a catecholamine drug, stimulating vascular alpha-adrenergic receptors, causing vasoconstriction. The vasoconstriction effect of epinephrine is a mechanism to increase blood flow, preventing coronary artery collapse (Dalal and Grujic 2020).

Another area that may delay epinephrine in Abu Dhabi is administration route. To give epinephrine injections, EMS must establish an intravenous (IV) or intraosseous (IO) cannula (Zhang et al. 2020). While IO is preferable in EMS situations because of its faster access line with high success rates and a low incidence of complications (Tyler et al. 2020), ILCOR's latest guideline recommends an IV line for resuscitation (Berg et al. 2020b). However, prioritising CPR and ventilation may delay IV establishment. Also, the attempt to establish an IV line in intense out-of-hospital resuscitation may cause a failed attempt and failed IV attempts show a negative effect on OHCA patient survival (Fujii et al. 2017). This leads to another issue of resuscitation teams consisting of two EMS crews; however, the latest study shows that the optimal OHCA resuscitation team is five paramedics (Tsai et al. 2020). Adding to all the above, the Abu Dhabi EMS weakness is, therefore, the delay time to epinephrine and a lack of crew members once they arrive on scene. Hence, determining the influence of epinephrine use in Abu Dhabi EMS was not feasible in this study.

6.7.2 Airway management

A strength of the current study is that successful ETI attempts were recorded. This was able to confirm a major concern that failed advanced airway attempts are strongly associated with lower survival to hospital discharge. The major drawback in Abu Dhabi EMS is while 42% of ETI attempts were successful, 58% failed on the first attempt. The rate of successful ETI attempts in Abu Dhabi is far lower than in other pre-hospital services; for example, in Geneva, Switzerland the overall ETI success rate was 96.8% (Chan et al. 2020). Therefore, this study identified a low association between ETI administration and survival to hospital discharge. It is somewhat unsurprising that no correlation is observed between ETI and survival, given the numbers of failed attempts. The current study identified the low success rate of advanced airway assistance in Abu Dhabi EMS as a severe weakness in practice.

This data highlights concerns regarding patient safety during and following critical interventions in pre-hospital care. Specifically, the largest RCT examining the benefit of advanced airway management for OHCA suggested that ETI offers no clinical advantage over BVM (Benger et al. 2020). According to the current study data and latest RCT, it can be inferred that basic airway management such as BVM should be the strategy of choice for EMS in the resuscitation of patients with OHCA within Abu Dhabi EMS system, due to the high failure rate of ETI attempts and the controversy of ETI use in OHCA.

The latest ILCOR treatment recommendation suggested BVM ventilation or ETI for adult OHCA, but supraglottic airway for adult OHCA in settings with a low ETI success rate (Berg et al. 2020c). Criticism of the ILCOR recommendation suggests it is based on weak evidence due to the lack of certainty about the advantages of advanced airway management. Although advanced airway management is common during resuscitation (McMullan et al. 2014), recent studies failed to determine whether it improves patient survival. A large randomised controlled trial of ETI versus supraglottic airway in England, including 9296 patients with OHCA showed no statistically significant differences in ETI patient survival (Benger et al. 2020). Another RCT by Jabre et al. (2018), including airway management with BMV (n =

1020) and ETI (n = 1023), failed to demonstrate a benefit for the survival of OHCA patients.

Furthermore, a recent RCT showed uncertainty about the quality effect of advanced airway management in OHCA (Wang et al. 2021). This was because the trial setting or EMS system design may affect ETI attempt outcome (Myers et al. 2016). Finally, a failed ETI attempt is an independent risk factor for decreased pre-hospital ALS effectiveness (Wang and Benger 2020).

The subsequent issue for the poor rate of successful ETI attempts is attributed to lowering the survival rate for patients attended by Abu Dhabi EMS. Perhaps the most severe disadvantage of attempting ETI is interference with other critical interventions, such as chest compression and defibrillation. The paramedic might stop chest compressions to intubate the patient. Paramedics may also not maintain the necessary skills to perform such interventions. The failed ETI attempt may be caused by the limited opportunity of paramedics to acquire expertise. EMS crews encounter OHCA only rarely; therefore, they are not accustomed to performing critical interventions such as ETI, not to mention that intubation is a complicated skill often requiring three or more attempts (Frerk et al. 2015, Natt et al. 2016). The complexity of advanced airway management in out-of-hospital settings requires sufficient paramedic training to maintain skills (Deakin et al. 2009). However, the current study did not assess the competency level of the paramedics. Still, since the ETI failure rate was high, this suggests that Abu Dhabi EMS crew competency level is questionable. This adds to an understanding of failed ETI among the EMS system. In the end, the controversy in the literature and the complexity of airway management in out-of-hospital settings with low ETI attempts in Abu Dhabi EMS presents important challenges. This suggests policymakers undertake strategies to promote EMS crew skills.

6.7.3 Mechanical chest compression

The current study found a low association between using a mechanical chest compression device and survival to discharge. The mechanical chest compression device was routinely used in 78.5% of OHCA patients, although it was found to be the least important EMS intervention. These findings are consistent with three RCTs that did not show significant improvement in survival after the use of mechanical chest compression (Hallstrom et al. 2006, Rubertsson et al. 2014, Wik et al. 2014), followed by a recent two systematic reviews showing no evidence that mechanical chest compression improved survival (Wang and Brooks 2018, Williams et al. 2021). Moreover, a recent observational study found no significant differences between mechanical or manual chest compression on patient survival (Jung et al. 2020). In fact, ERC recommended not to use mechanical chest compression devices as a routine in pre-hospital (Soar et al. 2021), because the resuscitation interrupted by long pause to deploy the device worsen the clinical outcome (Fohle et al. 2021).

The device in Abu Dhabi EMS is heavy and big, so along with their heavy EMS equipment bags, paramedics may not always carry the device with them when they initially arrive on scene. Specifically, EMS is not informed by the dispatcher that the call involves cardiac-arrest patients. Therefore, the device may be deployed at a later stage, which causes further time delay and negates the benefit. Another drawback is the time spent to deploy the device. It may be that one paramedic in the crew runs back to bring the device from the ambulance, leaving a single paramedic to continue CPR. Having one paramedic doing chest compression and ventilation can interrupt the quality of resuscitation.

Another issue is that the device may be mispositioned during transportation, which causes a quality issue. The implementation and quality of mechanical chest compression in Abu Dhabi EMS is questionable, especially for paramedics who are not informed that they are attending OHCA and having a smaller EMS crew negatively affected patient survival. A randomised controlled study in a simulated setting by Tsai et al. (2020) found that the optimal EMS crew for successful resuscitation is five. The current study is significant in one respect: a smaller crew size deployed in Abu Dhabi EMS should focus more on manual CPR quality.

Earlier, the first review on mechanical chest compression by Safar and Harris (1963) showed concern regarding immediate availability and user-friendliness. Although the machine has undoubtedly developed further in the modern era, there is no current evidence that it improves patient survival. Furthermore, there is also concern that the device may create severe or life-threatening visceral damage for OHCA patients (Koster et al. 2017). Thus, the use of mechanical chest compression to support OHCA patients in Abu Dhabi EMS is questionable, and controversial (Ong and Anantharaman 2015). The main idea is that mechanical chest compression can overcome fatigue and low paramedic endurance, which is lower during manual chest compressions (Abelairas-Gómez et al. 2018). Abu Dhabi EMS uses the Lund University Cardiopulmonary Assist System 2 (LUCAS-2) for chest compression. It provides supportive continuous compressions for intubated OHCA patients.

However, there are multiple drawbacks to use of the LUCAS-2 device. First, the only randomised controlled trial on LUCAS-2, which enrolled 4,471 patients (1,652 assigned to the LUCAS-2 group and 2,819 assigned to manual compression) in four UK ambulance services found that the mechanical CPR device in routine use does not improve survival (Perkins et al. 2015). One could speculate that the mechanical chest compressions provided by the LUCAS-2 device could enhance the quality of CPR by reducing interruption time (Tranberg et al. 2015). However, the trial by Perkins et al. (2015) showed lower neurological survival among the LUCAS-2 group than the manual CPR group (adjusted OR 0.72, 95% CI 0.52–0.99). The inferior survival among the LUCAS-2 group in Perkins et al. (2015) trial may be due to other circumstances. Such circumstances are present in Abu Dhabi EMS, such as the time of device deployment, patient downtime interval, or the clinical indication.

6.7.4 Post ROSC

The results of this study demonstrated that the ROSC rate is low (17%), and that Abu Dhabi EMS did not provide post-ROSC treatment. Therefore, it was not possible to examine patient quality of life after survival to discharge from hospital. However, many patients who had a successful resuscitation suffered post-synaptic brain injury, similar to another study (Davies et al. 2017). The leading cause of this injury is extended post-anoxic brain injury. So, targeted temperature management

(TTM) is the recommended strategy to minimise or prevent the severity of brain injury post-ROSC (Kuroda and Kawakita 2020). A recent systematic review and meta-analysis of animal experimental studies on cardiac arrest show favourable neurological result of TTM post resuscitation (Arrich et al. 2021). This management is mild cooling of the patients, setting the temperature to 33 to 36ºC for neuroprotection. However, there are potential side effects of this intervention, like electrolyte disturbances. An RCT suggested that TTM is the definitive therapy to improve OHCA survival rate and neurological outcome in patients that have been treated if cooling is initiated within the first 10 minutes after ROSC (Hypothermia after Cardiac Arrest Study Group 2002). The latest RCT showed that TTM doubled the patient survival rate (Lascarrou et al. 2019). Therefore, TTM is included in ILCOR recommendations and AHA clinical guidelines (Panchal et al. 2020d). However, whilst TTM is present in the AHA OHCA clinical guidelines, Abu Dhabi EMS did not implement this service. The reason might be the lack of a well-constructed protocol, absence of quality control, or inability to avoid side effects. It must be noted that TTM is a complicated intervention to perform and not all hospitals are adopting this therapy because the best method to provide high-quality TTM to patients is not clear. The timing and method of TTM initiation are important and it must continue at least 24 hours post-ROSC. However, another problem with this approach is that the lack of EMS collaboration with hospitals may make it difficult to start this treatment in the pre-hospital setting. For example, transport patient to cardiac arrest centre associated with improve survival (von Vopelius-Feldt et al. 2021). In conclusion, there is presently no additional treatment to improve patient survival after pre-hospital ROSC, but opportunity to transfer patients to the cardiac centre may improve the survival chances.

6.8 Summary

This study represents the first study undertaken in Abu Dhabi EMS. The study set out to determine survival or non-survival factors for OHCA in Abu Dhabi EMS. Certain variables identified in the literature as proven to improve survival were found not to be significant predictors. This study has identified weaknesses in the pre-hospital chain of survival links, including early recognition, early bystander CPR, and early AED use. More importantly, no significant correlation was found between EMS interventions and outcome. The investigation of OHCA has shown that survival to hospital discharge is poor. For a patient to survive, resuscitation must start within 7 minutes or less from the time of patient collapse. A variable included in this study that was not routinely noted in previous studies is the time interval between patient collapse and first chest compressions, which is significant for patient survival.

7. Chapter seven: Conclusion

7.1 Summary

This research was essential to describe OHCA features in Abu Dhabi, particularly to investigate the impact of early bystander CPR and defibrillation, and EMS advance management on the outcome. Because cardiac-arrest events are the biggest challenge facing Abu Dhabi EMS, due to the complex interventions required and low survival rate (5%), the factors associated with cardiac arrest survival in Abu Dhabi are now known. The purpose of this research was to investigate the chain of survival concept, measure how many patients survived, and the influence of each link in the chain on those who survived.

The methodology chapter formulated the optimal research design to best contribute to local pre-hospital practice. Ultimately, this original contribution to knowledge is the ability to address several pre-hospital care issues. In addition, the problem addressed has the potential to formulate a hypothesis for further investigation.

7.2 New knowledge

First, before this research was undertaken, the local EMS performance reports were limited to a generalised database, and there was no chain of survival investigations in existence. Before this thesis, EMS managers could not rely on the reports because of consistency issues as there is no procedure to test the data, due in part to the extremely limited variables used. The unreliable data and the lack of systematic statistical analysis limit the ability to explain or draw rigorous conclusions about OHCA survival factors in Abu Dhabi.

Throughout the research, factors contributing to patient survival following OHCA were identified. The finding significantly indicates that the time from patient collapse to first professional CPR should be seven minutes or less to facilitate likely patient survival. In this study, all patients that survived were witnessed at the time of the collapse. The advantage of patient witness is the shorter time to CPR, which is the most important factor to predict survival chances in an OHCA event.

Second, a particularly prominent finding in this study is that early recognition is a weak link in the chain of survival, and its ability to influence patient survival may not currently exist. The issue found in this study was that emergency dispatchers are not recognising cardiac arrest, leading to a decrease in survival rate. The dispatcher role is not built within the EMS system response, which may weaken the pre-hospital care ability to detect critical cases.

Third, there is a significant gap in Abu Dhabi with regards to early CPR and AED usage in the community. This leads to a longer time to first CPR and/or AED usage, which again lowers the patients' survival chances.

Fourth, while recent studies evaluating EMS interventions on OHCA outcomes yielded controversial results, the current study found that Abu Dhabi EMS interventions do not yet significantly affect patient survival. The main contribution is that no evidence supports the idea that EMS alone can increase the survival of OHCA. This study found that long EMS response time is a significant issue in Abu Dhabi. The long response time caused prolonged cardiac arrest downtime without resuscitation, significantly decreasing OHCA patient survival chances in Abu Dhabi.

While the EMS organisation, as the professional identity that responds to OHCA, cannot impact survival, there is still debate regarding whether EMS alone is responsible for increasing the survival rate. The debate carries on now as to the public interventions. It seems this is a national public education and awareness issue, and is about how society operates, the prevailing cultural context, and influences on individual conduct. However, moral values and legal position are further debatable. If the EMS provider is obligated to increase OHCA survival, they may not blame the bystander at the scene if they do not begin early CPR. On the other hand, even if bystanders are obligated to perform CPR, there is no legal protection for bystanders.

Lastly the investigation of patient's characteristics revealed that cardiac-arrest patients are young and most have a history of CVD. There may be a connection that exists between the history of CVD and OHCA patient outcomes.

7.3 Significance to OHCA resuscitation research

The findings will be of interest to resuscitation investigators in two areas. First, this work contributes to existing knowledge of early CPR by providing evidence of interest to investigate the relationship between time from collapse to first CPR and survival. This research provides further evidence that a shorter time to CPR is a significant predictor of patient survival.

Second, this study's contribution has been to highlight that EMS interventions without public engagement may not optimise the survival of OHCA. This claim is specifically related to advanced interventions (epinephrine use, endotracheal intubation, and mechanical chest compression CPR).

7.4 Significance to Abu Dhabi EMS

This is the only study so far documenting any intervention in the EMS system in Abu Dhabi. The EMS intervention analysis related to cardiac arrest undertaken here has provided new knowledge to policymakers and managers to assess the EMS performance. The first issue is dispatchers are not yet integrated as part of EMS response. Second, the delayed response time and non-significance of EMS interventions. Third, the EMS crews reported prioritising advanced interventions over basic life support may significantly decrease patient survival. Prioritising advanced intervention did not help survival. This is an alarm for another significant issue: the competency level of the crew, specifically to conduct ETI, given the high failed attempt rate.

7.5 Significance to the community

This research demonstrated a significant gap in community participation in witnessed cardiac-arrest events, including both legal and educational. Those possibilities doubtless need much scrutiny in Abu Dhabi because further research is required for each factor.

7.6 Limitation

Clearly, this study is a step forward in reporting OHCA in Abu Dhabi. While the study demonstrates OHCA trends and survival factors, some aspects need to be more thoroughly measured. Therefore, the next section will outline potential weaknesses of this study.

7.6.1 Study design

The key limitation of the study design was the measurement of intervention influences rather than establishing causation. The reason is the multiple effects on the cardiac-arrest patient treatment which goes into pre- and in-hospital interventions. The study is based on a pre-hospital care setting and excluded any influences from the in-hospital procedures and interventions. Specifically, it is difficult to measure the post-survival events in which the patient survives to hospitalisation and is placed in the intensive care unit, a fact that will likely pose a problem for future research.

7.6.2 Scope of the study

The study only includes OHCA cases treated by Abu Dhabi EMS in a pre-hospital setting. This is the exclusive EMS provider in Abu Dhabi; however, I am aware that OHCA cases are carried to the hospital emergency room by family or bystanders without considering activating the EMS. Therefore, the cases that are not being responded to by the EMS cannot be captured by a CAR until they are an in-patient. It is wise to say that not activating the EMS may mean the patient is less likely to survive, given the survival factor that needs immediate high-quality CPR, which is unlikely to be provided by the public. However, it was unfortunate that the study did not include the cases outside the EMS organisation to have a full national review of the OHCA issues, although this was outside the scope of the research.

7.6.3 Survival measurements

Another important limitation to be considered is that long-term survival following OHCA was not measured. This would require additional resources from both the EMS and hospital systems to collect patient data following hospital discharge and are beyond the scope of this research. This would include follow-up neurological examinations, which are difficult to control and record the outcomes of in multiple hospital settings. This study was limited to examining patient survival post-hospital discharge and cannot compare a similar outcome in another context. Also, an issue that was not addressed in this study was the patient's quality of life after survival. This may be measured through neurological assessment. An option would be to measure long-term survival in a limited geographical area. However, at some stage due to its prevalence and impact, addressing OHCA nationally should remain a primary health priority in UAE.

7.7 Future research and recommendation

EMS dispatchers do not recognise patients in critical conditions, such as cardiac arrest. A reasonable approach to tackle this issue could be introducing an EMS response system that can ask questions to recognise the patient condition. By recognising which patients are critical, versus those that are not, the dispatcher will prioritise the call and send appropriate EMS units. Furthermore, the call taker should be able to provide first aid instruction to any bystanders willing to help, including chest compression. The challenge now is to address the legal issues in the UAE context. A key policy priority should therefore be to plan for the good Samaritans policy. Ordinary people should not be liable if they intervene for CPR, specifically with regards to the outcome of the patient. Also, provision for a CPR campaign will aim to enhance peoples' recognition of cardiac arrest and the importance of undertaking effective and timely CPR to minimise morbidity and reduce mortality.

7.7.1 Thesis Extendibility

First, the question remaining from this study is the long-term patient survival rate. A long study has assessed patients survived at 18 months only (Peskine et al. 2021). However, a further extended study could also assess the long-term effects of the time interval between patient collapse to CPR and association with neurologically intact survival, which has not been examined to date. A challenge for this research is that the pool of surviving patients is small. This thesis shows a significant issue is the impact of delayed CPR, but not described the odds ratio impact of each minute's delay on long-term survival beyond six months. This extension of the research presented herein could also consider other factors such as the patient's heart rhythm. A greater focus on long-term survival could produce interesting findings that facilitate more accurate integration of both pre- and in-hospital factors and their influence of long-term patient survival.

Second, in October 2020 AHA introduced an updated "chain of survival" concept, to acknowledge the importance of recovery, rehabilitation, and patient transition to social life post-cardiac arrest (Panchal et al. 2020).

Figure 7-1 Adult chain of survival of 2020 added recovery link post patient survival (Ashish et al. 2020)

It was recommended to address psychological wellbeing after cardiac arrest as a recovery stage (Davies et al. 2017). However, there is limited knowledge about psychiatric complication and quality of patient life after OHCA (Naber and Bullinger 2018, Lupton and Daya 2021). Psychological distress case studies may extend from the research data presented in this dissertation, in a control group that survived OHCA to hospital discharge. Sixteen patients in the cohort experienced a potentially fatal event and survived. Patients may view life differently because of distress post-cardiac arrest due to anxiety as demonstrated in another study (Lilja et al. 2015). Establishing research on the quality of patient life beyond neurological function would help long term recovery process.

Third, the issue of low rates of bystander CPR is an intriguing one which could be explored in further research. The bystanders may view themselves as out of the response system, and so a greater focus on bystander interventions could produce interesting findings that account for why the local context's bystander CPR rate is low. Also, there are three potential future investigations: establishing an orientation campaign; legal issues if a bystander hurt the patient; and the unique cultural factors for expatriates that may impact bystander interventions. If the EMS system also integrated public intervention into the system, these barriers need to be investigated. Additionally, a survey engaging a wide range of the public about helping patients may be the start. Investigating bystander barriers may find enablers to improve future bystander CPR rates.

7.7.2 Engagement research

The data presented in this thesis alone cannot improve the patient outcome, but it makes contributions later. This original contribution to the local EMS knowledge and practice is determining current service provision issues that impact patient outcomes following OHCA. Interestingly, EMS providers do not have an established and easy pipeline to transfer new knowledge into practice (Cone 2007). The engagement needs to be patient-centred, focusing on the short- and long-term outcome (Forsythe et al. 2018), which may have a fast track to improve the pre-hospital care in Abu Dhabi. Therefore, the future role of this is innovative communication within Abu Dhabi EMS practice to understand the issues they face and initiate new improvement strategies. It is likely the data presented herein will act as a base for future research or policy that can aid a significant improvement of local EMS services in Abu Dhabi. The Appendix 7 reports the researcher’s reflection on the doctorate journey.

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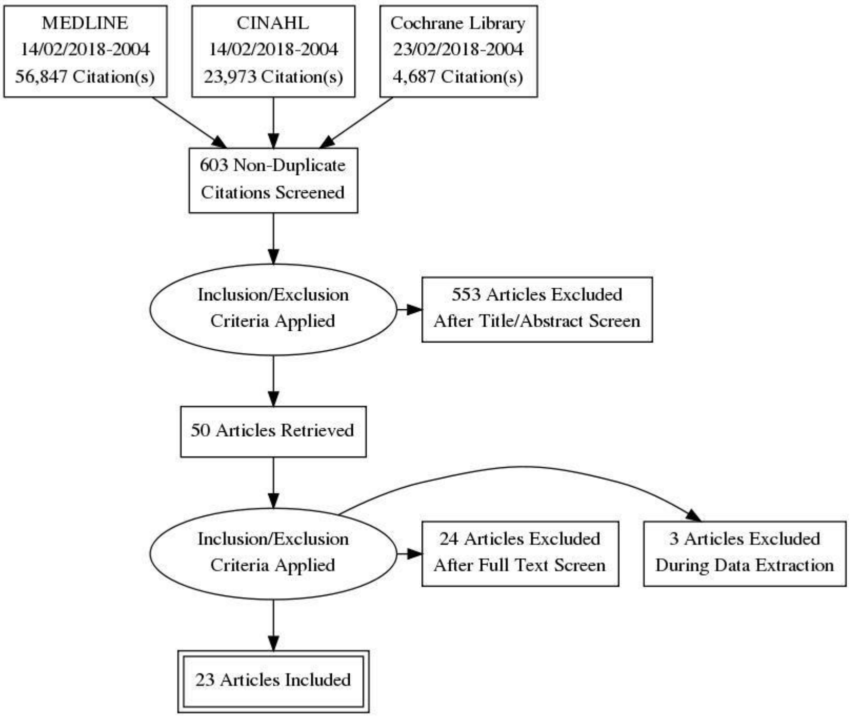
Appendix 1: Search strategy for initial literature review done in 2018

I used an electronic database to conduct the search in January 2018. The following table shows the research strategy:

Search terms		Combinations
Condition	35. MH "Heart Arrest" 36. "OHCA" 37. "Cardiac arrest" 38. "sudden OHCA" 39. MH "sudden cardiac arrest" 40. MH "sudden cardiac death" 41. MH "Out-of-hospital cardiac arrest" 42. MH "out of hospital cardiac arrest"	43. #1 OR #3 44. #2 OR #4 OR #5 OR #6 OR #7 OR #8
Intervention	45. MH "prehospital CPR" 46. MH "EMS CPR" 47. MH "bystander intervention" 48. MH "community CPR program" 49. MH "community CPR" 50. MH "bystander effect" 51. MH "bystander CPR" 52. "cardiopulmonary resuscitation" 53. "CPR" 54. MH "prehospital resuscitation" 55. "OHCA resuscitation" 56. "bystander CPR effectiveness" 57. "community CPR program"	58. #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23
Outcome	59. "ROSC" 60. "return of spontaneous circulation" 61. "OHCA" AND "ROSC" 62. "cardiac arrest survival" 63. "Bystander" AND "ROSC" 64. "Prehospital" AND "ROSC" 65. "Bystander" AND "ROSC" 66. "EMS" AND "ROSC" 67. "cardiac arrest survival" 68. "OHCA" AND "long term survival" 69. "OHCA" AND "short term survival"	70. #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35
Combination		71. #9 OR #10 72. #37 AND #24 AND #36

Study selection

The selection was made by the researcher in February 2018, screening the research finding to determine the eligibility for inclusion in the initial review. Author record 603in the search then excludes 553 after screening title and abstract. The following is a summary of the study selection process.



Data items

Data extracted by using PICO measure;

1. The participants are out of hospital cardiac arrest patients age 18 or above.
2. They must get intervention by Bystander CPR to compare with EMS personnel.
3. Data must show the ROSC outcome to hospital admission or hospital discharge.

Result

Four key results are: 1) early CPR to OHCA is associated with better neurological intact, 2) significantly early CPR is collated with bystanders in educated communities, 3) the most striking result to emerge from the literature is EMS intervention alone is not associated with better OHCA survival, 4) the correlation between bystander CPR and EMS of interest because associated with neurological intact.

Table 18 Studies retrieved from first literature reviewed in 2018

Author	Publication date	Title of article or chapter	Journal title	Objective	Topic/Focus/question	Study Aim	Method	Design	Country	Population	Type of intervention (bystanderor EMS)	Sample	Data collection (Long-term or Sort-term survival)	Problem	Purpose	Outcome Measure	Result	Summary (what is it about?)	Analysis (strengths and weaknesses)	Conclusion
Fothergill et al.	2013	Increases in survival from out-of-hospital cardiac arrest: A five year study.	Resuscitation	To report improvements in survival over a five-year period	Out-of-hospital cardiac arrest and survival rates	To examine reasons for increase in OOH cardiac arrest	Analysis of data from cardiac arrest registry	Clinical paper	UK	8,200,00	EMS	2612	Short-term	low survival rates	assess survival rates	percentage of survival rates	survival has been increasing	The relationship between hospital cardiac attention and survival rates	large population; existing records	further study needed to better assess outcomes
Kragholm et al.	2017	Bystander Efforts and 1-Year Outcomes in Out-of-Hospital Cardiac Arrest.	New England Journal Of Medicine	To measure long-term outcomes to the functioning of cardiac arrest survivors	How is the functioning of survivors affected?	To assess outcomes	Analysis of survivor data, functioning data, and death rates	Observational study	Denmark	42089	EMS and bystander	2855	Long-term	Impaired functioning as a result of OOHCA	To better understand outcomes		Bystander resuscitation is helpful	Outcomes to OOHCA survivors who have bystander intervention as opposed to none.	Lack of detail om sorts of interventions, clear results	Bystander intervention is beneficial
Becker et al.	2013	Treatment of Cardiac Arrest with Rapid Defibrillation by Police in King County, Washington	*Prehospital Emergency Care*	To evaluate a police defibrillation program	Can such a program be helpful?	To measure the effect of such a program	Measurement of dispatch frequency and time to patient	Prospective observational study	US	237000	EMS	231	Short-term	Lack of effective response to OOHCA	To measure the potential of this program	Survival data	Some improvement in survival	Police program to intervene in OOHCA	The limited region, clear assessment	Police involvement can be helpful
Ong et al.	2015	Outcomes for out-of-	Resuscitation	To improve understa	What are the character	To better understand these	Analysis of	Cohort study	Seven Asian countries	66780	EMS	41.004	Long-term	Need for better understa	To better this	Survival to hospital	Low bystander		Lack of detailed understa	Much variation in

		hospital cardiac arrests across 7 countries in Asia: The Pan Asian Resuscitation Outcomes Study (PAROS).		nding of resuscitation in Asia.	istics of resuscitation in Asia?	characteristics	OHCA data							nding of resuscitation in Asia	understanding	discharge	defibrillation		nding due to size; provides strong general results	resuscitation and outcomes across Asia
Ro et al.	2016	Public awareness and self-efficacy of cardiopulmonary resuscitation in communities and outcomes of out-of-hospital cardiac arrest: A multi-level analysis.	Resuscitation	Bystander CPR	What is he relationship between bystander CPR and survuval?	To measure this relationship		Cross-sectional study	Korea	228921	bystander	29052	Long-term	Need to better understand relationship between bystander CPR and long-term survival	To improve this understanding	Bystander CPR and survival to medical discharge		The relationship between bystander resuscitation and survival rates		Bystander intervention improves survival rates.
Hwang et al.	2013	Cardiopulmonary resuscitation—From the past into the future.	*Journal Of Acute Medicine*	To improve understanding of scientifically preferable resuscitation methods	What is the scientific basis for resuscitation methods?	To better understand this basis	Secondary research	review article	various	N/A	EMS and bystander	N/A	both	Lack of understanding of science underlying preferred CPR methods	To illustrate where knowledge is needed	N/A	Improved understanding is needed	Preferred CPR methods and ways that understanding is lacking	Original premise, no original research	Improved understanding will help sufferers of OOHCA
Viereck et al.	2017	Effect of bystander CPR initiation prior to	Resuscitation	To assess time of bystander	How long do bystanders take to	To assess this period of time	Statistical analysis of intake data	Observational study	Denmark	1386	bystander	548	Short-term	Need to better understand survival	To explore this relationship	Rates of survival at 30 days	Those with CPR initiated prior to	Relationship between time CPR	Some data could not be determin	Dispatcher-assisted CPR is associate

		the emergency call on ROSC and 30day survival—An evaluation of 548 emergency calls.		initiation of CPR	initiate CPR?									rates and time taken by bystanders to initiate CPR			emergency call had better outcomes.	was initiated and survival rates.	ed; unique topic	d with improved outcomes.
Cournoyer et al.	2017	Prehospital Advanced Cardiac Life Support for Out-of-hospital Cardiac Arrest: A Cohort Study.	*Academic Emergency Medicine*	To assess the relationship of advanced cardiac life support and basic cardiac life support to survival.	How do ACLS and BCLS influence outcomes?	To better understand this relationship	Examination of records	Cohort study	Canada	7475	EMS	7134	Long-term	Lack of understanding of relationship between ACLS, BCLS and outcomes	To better this understanding	Survival to hospital discharge	Similar survival in both groups	The impact of prehospital life support on patient outcomes	Size of study, able to show associations but not causality	No significant difference to survival rate form these forms of lie support.
Yamaguchi et al.	2017	Improvements in Out-of-Hospital Cardiac Arrest Survival from 1998 to 2013.	Prehospital Emergency Care	To study trends in OHCA survival rates	What are factors influencing survival rates?	To better understand these factors	Assessment of data	Observational cohort study	US	440000	EMS	2528	Long-term	Lack of understanding of trends influencing survival	To assess the factors influencing survival	Survival to hospital discharge	These factors have a positive influence	Contributing factors to OHCA survival	Reflects associations, not cause	Additional study needed
Morais et al.	2014	Out-of-hospital cardiac arrest: determinant factors for immediate survival after	*Revista Latino-Americana De Enfermagem*	To assess factors contributing to survival of OHCA	Factors influencing survival	To better understand these factors	Examination of records	Observational, retrospective study	Brazil	4407	EMS	1165	Long-term	Need for better understanding of factors influencing survival	To assess the factors influencing survival	Survival to hospital discharge	Improved survival rates when OHCA observed by those with CPR training	The elements that impact survival rates.	Strong overview of general trends; lacking in specifics	Basic life support, when used alone, does not lead to favorable outcomes.

		cardiopulmonary resuscitation																		
Gräsner et al.	2016	EuReCa ONE□27 Nations, ONE Europe, ONE Registry.	Resuscitation	To examine trends in OHCA throughout Europe	How OHCA is responded to	To better understand trends in OHCA	Extraction and analysis of data	Prospective international study	various (Europe)	10682	EMS	6414	Short-term	Need to better understand OHCA trends	To assess response to OHCA	survival to 30 days after incident	10% of cases with CPR survived to 30 day mark	Factors influencing survival of OHCA, particularly CPR	Good illustration of trends, unable to show causality	OHCA continues to present a major health concern and more information is needed.
von Vopelius et al.	2015	The impact of a pre-hospital critical care team on survival from out-of-hospital cardiac arrest.	Resuscitation	To examine the effect of a critical care team	How does such a team impact survival?	Assessing the effect of the team	examining records	Observational study	UK	1851	EMS	1851	Long-term	Effect of CCT unknown	To assess effect of team	Survival to hospital discharge	Does not significantly improve survival	How CCTs impact outcomes for OHCA patients	Abundance of data, unable to show causality	CCT is not specifically associated with survival
Hawke et al.	2017	Epidemiology and outcomes from out-of-hospital cardiac arrests in England.	Resuscitation	To examine OHCA outcomes	What are the characteristics of OHCA in England?	To better understand these characteristics	Data from OHCA registry	Prospective observational study	England	28729	EMS	28729	Long-term	Better understanding of OHCA needed	To examine characteristics	various	Response to OHCA can be improved	Characteristics of OHCA	Large amount of data, somewhat unfocused	Response to OHCA must be improved
Mauri et al.	2015	Better management of out-of-hospital cardiac arrest increases survival rate and improves	*Europace*	To better understand OHCA in Switzerland	What are the characteristics of OHCA in Switzerland?	To better understand these characteristics	Following of all OHCA cases over a specific period of time	Observational cohort study	Switzerland	10000	EMS	1492	Long-term	Better understanding of OHCA needed	To improve this understanding	Neurological functioning	EMS response improves outcomes	Relationship between EMS response and outcomes		EMS has a significant impact on outcomes

		neurological outcome in the Swiss Canton Ticino.																		
Hasselqvist-Ax et al.	2015	Early Cardiopulmonary Resuscitation in Out-of-Hospital Cardiac Arrest.	*New England Journal Of Medicine*	To better understand relationship of early CPR to survival rates	How does early CPR impact survival rates?	To better understand this relationship	Analysis of all OHCA cases within a period		Sweden	30381	bystander	30381	Long-term	Better understanding of OHCA needed	To improve this understanding	30 day survival	Positive affiliation	How early CPR impacts 30 day survival rates	Much information, somewhat general	Early CPR has a positive association with 30 day survival
Malta Hansen et al.	2015	Association of Bystander and First-Responder Intervention With Survival After Out-of-Hospital Cardiac Arrest in North Carolina, 2010-2013.	*JAMA*	To assess changes in bystander response following education efforts	How do education efforts impact bystander behavior?	To assess education efforts	Registry data	Observational study	US	4961	bystander	4961	Long-term	Better understanding of bystander behavior needed		Resuscitative efforts and defibrillation	Increase in resuscitative efforts	How education programs change bystander behavior		Bystander education efforts improve outcomes
Iwami et al.	2015	Dissemination of Chest Compression–Only Cardiopulmonary Resuscitation and Survival After Out-of-Hospital	*Circulation*	To assess best CPR approach	Which approach is best?	To examine CPR approaches	Examination of all OHCA cases	Observational study	Japan	816 385	bystander	816 385	Long-term	Better understanding of bystander behavior needed	To understand preferred CPR methods and bystander behavior	survival to 30 days after incident	Bystander CPR efforts improved with education	How education efforts impact bystander efforts	Large amount of data, somewhat unfocused	Bystander education results in increased CPR efforts

		Cardiac ArrestClinical Perspective.																		
Stiell et al.	2004	Advanced cardiac life support in out-of-hospital cardiac arrest*.	*Obstetrics & Gynecology*	To assess the combined impact of advanced life support with defibrillation	Does this approach improve outcomes?	To better understand this relationship	Examination of records	Controlled clinical trial	Canada	5638	EMS	5638	Long-term	Better understanding of this approach needed	To improve this understanding	Survival to hospital discharge	Did not significantly improve	Relationship between this approach and improved outcomes	General study; strong overview but many unknown factors	No significant affiliation between pairing of advanced life support with defibrillation and survival outcomes.
Wampler et al.	2012	Cardiac Arrest Survival Is Rare Without Prehospital Return of Spontaneous Circulation.	*Prehospital Emergency Care*	To examine the impact of ROSC on survival rates	What is the relationship between ROSC and survival rates?	To better understand this relationship	Study of existing data	Retrospective analysis	US	2483	EMS	2483	Long-term	Understanding of the impact of ROSC is needed	To improve this understanding	Survival and neurological functioning	Positive correlation of field ROSC to survival	Whether ROSC prior to hospitalization has an impact on survival	Shows relationship well	Field ROSC is important to survival
Nagata et al.	2017	Factors associated with the outcome of out-of-hospital cardiopulmonary arrest among people over 80 years old in Japan.	Resuscitation	Understanding whether resuscitation efforts should be suspended for older adults	Should such efforts be suspended?	To assess this question	Existing records	Observational study	Japan	377577	EMS	377577	Long-term	Older individuals have poor outcomes after OHCA	To assess whether resuscitation is worthwhile	Survival and neurological functioning	ROSC is an important factor in outcomes		Detailed analysis of data	ROSC is an important predictor for positive outcomes.

Wissenberg et al.	2013	Association of National Initiatives to Improve Cardiac Arrest Management With Rates of Bystander Intervention and Patient Survival After Out-of-Hospital Cardiac Arrest.	JAMA	To understand bystander behaviors over time	Do initiatives make a difference in bystander behaviors?	To assess education efforts	Examination of records	Observational study	Denmark	19 468	bystander	19 468	Long-term	Need to improve bystander efforts	To assess impact of initiatives	Bystander CPR and survival to medical discharge	Improved efforts and survival	Relationship between education efforts and improved outcomes	Strong explanation of education efforts, not enough specifics about cases	Such programs can be valuable to survival
Cartledge et al.	2016	A systematic review of basic life support training targeted to family members of high-risk cardiac patients.	Resuscitation	To assess effectiveness of life support training	Do such training programs make an impact?	To assess education efforts	Search of databases	Systemic review	various	n/a	bystander	n/a	Long-term	Need to better understand results of education efforts	To assess this relationship	N/A	No significance to family member training	Whether specific training for family members has a positive impact	Effective overview of studies	Family training can still have value despite lack of significance
Rajan et al.	2016	Association of Bystander Cardiopulmonary Resuscitation and Survival According to Ambulance	Circulation	The relationship between CPR and survival to defibrillation	To what extent are these correlated?	To better understand this relationship	Independent research	Research article	Denmark	7623	bystander	7623	Long-term	Need to better understand how CPR can impact survival to defibrillation time	To better understand this relationship	30 day survival	Positive correlation	How CPR affects survival	strong analysis	Positive correlation

		Response Times After Out-of-Hospital Cardiac ArrestClinical Perspective.																		

Appendix 2: Literature review search strategy

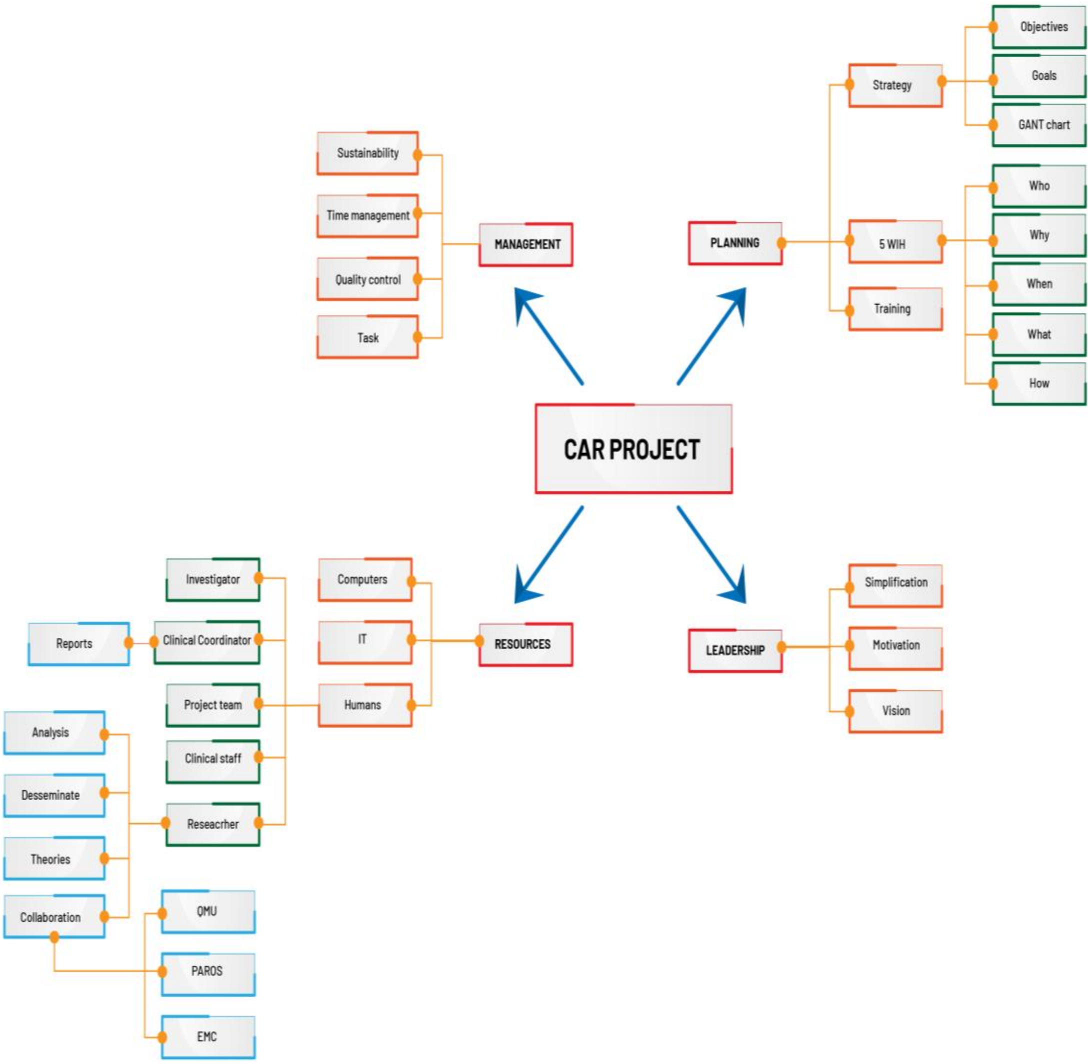
The reviewed studies were selected from CINAHL Plus and Science Direct electronic databases in January 2020, followed by the scanning of peered reviews of published papers. The search was limited to studies written in the English language of OHCA published papers of patients treated in out of hospital settings. Other criteria in study selection were that any of the chain of survival links had to be conducted as an intervention and the outcome had to entail either ROSC or survival where the patient would remain neurologically intact.

The search terms are “OHCA” OR “sudden cardiac arrest” AND “Abu Dhabi” OR “UAE” OR “Middle East”, “chain of survival” AND “early access” OR “early recognition”, “chain of survival” AND “community intervention” OR “early CPR” OR “early EMS” OR “ACLS” OR “Advanced intervention” AND “survival” OR “ROSC”.

Appendix 3: Why randomised control trials are not used for this project?

Randomised control trials (RCT) have the highest hierarchical position in providing clinical evidence due to their low level of bias (Bondemark and Ruf 2015). However, RCTs may not be conducted sufficiently for this study because this design requires the researcher to have 'control' over the external factors to which the research subjects are exposed. Notably, the main reason is the factors of the chain of survival cannot be controlled by the researcher. Furthermore, it is important to realise that the RCT design is used to test the research hypothesis and null hypothesis (Bhide et al. 2018). However, the researcher has not yet developed a null hypothesis that can be tested because this thesis is the first research in the Abu Dhabi ambulance context. There is an intention to use this research to begin to formulate a research hypothesis and generate research questions for further investigation. Also, there are challenges to provide logistical resources for a RCT study. Furthermore, a significant ethical issue may arise due to some OHCA patients possibly receiving different interventions for experimental purposes (Weijer et al. 2011). Therefore, the RCT is considered as being not appropriate to answer the research question.

Appendix 4: Cardiac-arrest registry mind map



Appendix 5: The study ethical approval from QMU

Queen Margaret University

EDINBURGH

Assim Alhmoudi
Professional Doctorate Candidate
Nursing
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10 February 2021

Dear Assim,

Ethical Approval – Characteristics and outcome of patients suffering out-of-hospital cardiac arrest within Abu Dhabi Emergency Medical Service system

I am writing to confirm that Professor Jan Dewing, Director of The Centre for Person-centred Practice research, reviewed your application for ethical approval of the study *"Characteristics and outcome of patients suffering out-of-hospital cardiac arrest within Abu Dhabi Emergency Medical Service system"* and full ethical approval was granted on 27 May 2020.

Yours sincerely

Lucy Hinds
Secretary to the Research Ethics Panel

DIVISION OF GOVERNANCE AND QUALITY ENHANCEMENT
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Appendix 6: Data extraction sheets

Descriptives

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Response Time (Hours)	330	31	0	31	10.15	4.919
Age(Years)	330	99	18	117	56.93	18.667
Time of Arrest to EMS CPR	312	81	0	81	14.69	12.453
Valid N (listwise)	312					

Descriptive Statistics

	Variance
Response Time (Hours)	24.196
Age(Years)	348.445
Time of Arrest to EMS CPR	155.065
Valid N (listwise)	

Frequencies

Statistics

		Gender	Nationality	Location Type	Medical History	Arrest Witnessed
N	Valid	329	330	330	330	330
	Missing	1	0	0	0	0

Statistics

		Arrest Witnessed By	Bystander CPR	First CPR initiated By	Bystander AED Applied	First Arrest Rhythm
N	Valid	238	330	330	330	328
	Missing	92	0	0	0	2

Page 1

Statistics

		Prehospital Defibrillation	Mechanical CPR Device Used	First ECG Rhythm	Epinephrine	Dificult/Faild Advanced Airway attempt
N	Valid	330	330	330	330	58
	Missing	0	0	0	0	272

Statistics

		Prehospital Advanced Airway	Prehospital ROSC	Spontaneous Circulation	Survival Event	Survival to discharge
N	Valid	330	268	329	329	329
	Missing	0	62	1	1	1

Frequency Table

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	79	23.9	24.0	24.0
	Male	250	75.8	76.0	100.0
	Total	329	99.7	100.0	
Missing	System	1	.3		
Total		330	100.0		

Nationality

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	African	8	2.4	2.4	2.4
	Arab	82	24.8	24.8	27.3
	Asian	131	39.7	39.7	67.0
	UAE	84	25.5	25.5	92.4
	Unknown	14	4.2	4.2	96.7
	Westren	11	3.3	3.3	100.0
	Total	330	100.0	100.0	

Location Type

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Construction Site	33	10.0	10.0	10.0
	Home Residence	198	60.0	60.0	70.0
	Public/Commercial Building	99	30.0	30.0	100.0
	Total	330	100.0	100.0	

Medical History

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Cancer	9	2.7	2.7	2.7
	CVD	252	76.4	76.4	79.1
	None	35	10.6	10.6	89.7
	Others	14	4.2	4.2	93.9
	Renal Disease	6	1.8	1.8	95.8
	Respiratory Disease	12	3.6	3.6	99.4
	Stroke	2	.6	.6	100.0
	Total	330	100.0	100.0	

Arrest Witnessed

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	91	27.6	27.6	27.6
	Yes	239	72.4	72.4	100.0
	Total	330	100.0	100.0	

Arrest Witnessed By

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Bystander	148	44.8	62.2	62.2
	EMS	30	9.1	12.6	74.8
	Family	60	18.2	25.2	100.0
	Total	238	72.1	100.0	
Missing	System	92	27.9		
Total		330	100.0		

Bystander CPR

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	265	80.3	80.3	80.3
	Yes	65	19.7	19.7	100.0
	Total	330	100.0	100.0	

First CPR initiated By

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Bystander - Family	1	.3	.3	.3
	Bystander - Healthcare Provider	25	7.6	7.6	7.9
	Bystander - Lay Person	32	9.7	9.7	17.6
	EMS	272	82.4	82.4	100.0
	Total	330	100.0	100.0	

Bystander AED Applied

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	324	98.2	98.2	98.2
	Yes	6	1.8	1.8	100.0
	Total	330	100.0	100.0	

First Arrest Rhythm

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Asystole	214	64.8	65.2	65.2
	Not Recorded	4	1.2	1.2	66.5
	Other	8	2.4	2.4	68.9
	PEA/EMD	41	12.4	12.5	81.4
	VF	61	18.5	18.6	100.0
	Total	328	99.4	100.0	
Missing	System	2	.6		
Total		330	100.0		

Prehospital Defibrillation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	215	65.2	65.2	65.2
	Yes	115	34.8	34.8	100.0
	Total	330	100.0	100.0	

Mechanical CPR Device Used

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	71	21.5	21.5	21.5
	Yes	259	78.5	78.5	100.0
	Total	330	100.0	100.0	

First ECG Rhythm

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Asystole	221	67.0	67.0	67.0
	PEA	42	12.7	12.7	79.7
	VT	7	2.1	2.1	81.8
	VF	60	18.2	18.2	100.0
	Total	330	100.0	100.0	

Epinephrine

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	53	16.1	16.1	16.1
	Yes	277	83.9	83.9	100.0
	Total	330	100.0	100.0	

Dificult/Faild Advanced Airway attempt

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	1	.3	1.7	1.7
	Yes	57	17.3	98.3	100.0
	Total	58	17.6	100.0	
Missing	System	272	82.4		
Total		330	100.0		

Prehospital Advanced Airway

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	231	70.0	70.0	70.0
	Yes	99	30.0	30.0	100.0
	Total	330	100.0	100.0	

Prehospital ROSC

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	268	81.2	100.0	100.0
Missing	System	62	18.8		
Total		330	100.0		

Spontaneous Circulation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	273	82.7	83.0	83.0
	Yes	56	17.0	17.0	100.0
	Total	329	99.7	100.0	
Missing	System	1	.3		
Total		330	100.0		

Survival Event

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	273	82.7	83.0	83.0
	Yes	56	17.0	17.0	100.0
	Total	329	99.7	100.0	
Missing	System	1	.3		
Total		330	100.0		

Survival to discharge

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	313	94.8	95.1	95.1
	Yes	16	4.8	4.9	100.0
	Total	329	99.7	100.0	
Missing	System	1	.3		
Total		330	100.0		

Appendix 7: Critical Reflection

The main personal reason to investigate OHCA

During a New Year celebration on the evening of December 31, 2012, a 58-year-old man named Ahmed collapsed while walking with his family on Cornish near the beach of Abu Dhabi, the capital city of UAE. Ahmed's family knew he was having cardiovascular diseases. However, they did not know what to do when he collapsed. One of his family members shouted for help. I was just behind them as one member of the crowd waiting to welcome the 2013 New Year and to watch the fireworks. I was off duty, however, spontaneously I checked him; he was in cardiac arrest so I shouted for EMS and started CPR.

At that time, I was thinking about how to use all my skills and knowledge to help that patient. Ahmed regained his life with a minimum neurological deficit after a week in the hospital. Doctors said that very early CPR was a key to saving this patient's heart and preventing brain damage. My feeling of jubilation to save Ahmed's life led to enthusiasm to save similar lives through my role as a paramedic and currently a researcher.

I became concerned about Out-Of-Hospital Cardiac Arrest (OHCA) to eradicate fatal events in Abu Dhabi. I discovered that researching and writing a professional doctorate would transfer the best evidence theory into Abu Dhabi EMS to save OHCA patients via recurrences like Ahmed's story.

What Happened

For decades, one of the most evident concepts to ameliorate low OHCA outcomes has been the chain of survival (Cummins et al. 1991). My evaluation in Abu Dhabi EMS found a series of non-systematic efforts to educate the local community about first aid, place Automatic External Defibrillator (AED) in public areas and improve EMS operationally. It appears that by placing AEDs publicly, EMS has partially implemented a chain of survival without intending or persuading the enhancement and measurement of OHCA outcomes. However, the AED project has not been evaluated. (Perkins et al. 2016) argue for rigorous evaluation of England's national initiative to improve OHCA survival. With that in mind, the reporting and evaluation of development projects are absent. The gap in Abu Dhabi EMS lacked a corresponding intelligible unity to understand and measure the efforts made to improve pre-hospital care and specifically OHCA in Abu Dhabi. Based on an initial literature review done in 2018, several international initiatives to enhance OHCA survival have built clinical development through the cardiac-arrest registry (CAR) foundation (Chia et al. 2017, Schleelein et al. 2018, Stub et al. 2018).

Therefore, recent theoretical developments have revealed that CAR is fundamental to measuring and understanding any OHCA improvement. There are examples from practices using the CAR approach in the USA, Australia, UK, and France (Hansen et al. 2015, Dyson et al. 2016, Rajagopal et al. 2017, Escutnaire et al. 2018). Those EMS practice expanded the CAR role to research on OHCA. Those countries have a long tradition of using CARs as a source of data to find what survival factors strengthen it. However, the aggregate, non-systematic processes to improve EMS within Abu Dhabi may not improve fatal OHCA events. That is why the CAR project is equally important to any other project to determine the influencing factors. In essence, major work would create CAR in Abu Dhabi EMS.

Experience

My experience of leading vital project leads me to evaluate my capabilities and skills as a researcher and professional paramedic. The experience makes me grow in the academic field. The doctoral developments helped to kick off planning and designing of this thesis project. I believe I enhanced my skills professionally, which is equally important to improving academically. If I don't have those skills to use reliable data for studies, I will not be able to convince academics and policymakers about CAR project implementation. I realise that gaining better professional skills to deal with a difficult situation is a must.

The components of my development are to implement my CAR project to report OHCA; to measure/evaluate current or future strategies; and to conduct studies and research on the factors that assume improving survival in Abu Dhabi. My role was to provide insight and evaluation of the current EMS standing. There is personal experience achieved by planning, designing, and partially implementing a series of processes to set up the OHCA registry by becoming involved.

This thesis was challenging. However, I achieved my target to gather OHCA data and analysis. The project planning and implementation went as expected. My project went well on the professional side because there was an opportunity to contribute to EMS knowledge. Academically, it went better because of higher confidence and use of robust data.

Analysis

An established thesis project means the OHCA reports are detailed to analyse the survival issue and provide the basis for further research. Large scale data collection and analysis on patients contribute to successful health systems (Nelson et al. 2016). That is significant to describe trends and features of OHCA in Abu Dhabi. There are several factors that helped in my project's success. First, the underpinning concept of the project makes it logical to start with the registry. The registry is similar to others internationally to improve OHCA survival (Stub et al. 2018, Cox et al. 2018, Schleelein et al. 2018), where they measure clinical/non-clinical outcomes and quality of patient care. Second, OHCA outcomes challenges are a priority to be addressed in EMS. Third, the thesis report is essential to start better evaluating current initiatives. There are several international, attractive leads to follow this thesis project. The Global Resuscitation Alliance (GRA) to improve survival for OHCA matches my development approach, which started with robust data collection and analysis.

My thesis has a significant impact on the Abu Dhabi EMS practice because it is properly constructed and designed. This thesis addressed OHCA challenges in Abu Dhabi that there is a definite need to better survival rates. I achieved my intention, which was to bring to light the OHCA issue. Therefore, a key policy priority should be to plan for addressing the gap identified in this thesis.

Nevertheless, this project has significantly contributed to developing further better OHCA strategies and predicting the likelihood of success. The chain of survival model status in Abu Dhabi is now clearer. The thesis outcome must be right to create further studies to answer questions related to OHCA. Also, now there may be a different approach to implement developments strategies in Abu Dhabi EMS.

My opinion is this thesis project will return significant investment in the future for both the practice and researchers. The data analysis from this project is the first solution for better EMSs in Abu Dhabi. Indeed, this thesis has thrown up many questions in need of investigation. Those thesis results are a step forward for additional research papers. I did consider two other approaches/projects post this thesis. The projects required extra resources and a team to implement them, although both directions could have improved OHCA. However, it required greater abilities and a higher management level to implement those approaches. In addition, it required a set of budgets and human resources at the practice level. Nevertheless, those approaches depend on this thesis outcome.

First, start a community CPR education project. My thesis suggests that bystander intervention can play a major role in positively impacting the survival rate, which is consistent with other nations (Bakke et al. 2017, Riddersholm et al. 2017, Kragholm et al. 2017, Hawkes et al. 2017, Buick et al. 2018). The idea is to create a programme that would educate and encourage Abu Dhabi community members to become the first respondents to the OHCA patient. This project is expected to have a very low impact at the first stages; therefore, the community CPR education should be measured in five or ten years. A low, short outcome impact is expected because of the initial barrier to overcome this barrier. For example, it is difficult to measure its impact on the survival rate, specifically in Abu Dhabi. The reason is that implementing a community CPR education programme is not straightforward and remains contingent on outside factors other than community participation. In addition, cultural norms in Abu Dhabi and UAE can pose a significant barrier to the successful implementation of community CPR (Batt et al. 2016, Bouland et al. 2017). Also, there is public hesitance due to concerns about potential legal responsibilities in the case of accidental injury.

Second, I considered measuring the chain of survival model in Abu Dhabi in another five years. The idea is to implement the first three steps in this sequence (early CPR, early defibrillation, and early EMS intervention), which are arguably the most important, then test the project influence at later stages. I should stress that my idea is primarily concerned with the time and effort needed to implement these steps. However, the chain of survival is restricted to multiple OHCA interventions that in which EMS practice control. Therefore, it will be a clear implementability of the chain of survival in Abu Dhabi if a team project is provided.

Furthermore, on research papers, clearly, the thesis project is a step forward to report and study OHCA in Abu Dhabi. Subsequently, the project needed to demonstrate OHCA survival trends. That because this thesis only includes OHCA cases that were treated from Abu Dhabi EMS, which is in a pre-hospital setting only. Second, it is important to measure long-term survival with additional resources needed from both EMS and hospitals to collect cardiac arrest survival beyond 30 days. In the end, due to its prevalence and impact, addressing OHCA nationally should remain a primary health priority in UAE.

Ending

I am convinced that this doctoral is a beginning era for me. This doctoral journey has been challenging at an academic and personal level. However, it has advanced me as a person. Also, it is rewarding when I help to resuscitate a patient successfully. My next target is to keep developing my research skills and disseminate my findings.

Additionally, I will be reflexive in practice and will keep investigating and improving the EMS system. I am much interested in transferring new knowledge and evidence-based medicine into EMS practice. In the end, saving lives is the goal.