University of Southampton

Faculty of Environmental and Life Sciences

Health Sciences

A Mixed Methods Investigation of Out of Hospital Cardiac Arrests Calls and Telephone Assisted Cardiopulmonary Resuscitation to Improve Cardiopulmonary Resuscitation Performance in Saudi Arabia

by

Meshary Saud Bin Hotan

Thesis for the degree of Doctor of Philosophy

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Abstract

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Out of hospital cardiac arrest (OHCA) is a global health problem with a survival rate of only 7-10%. Prompt and high-quality cardiopulmonary resuscitation (CPR) has the potential to improve survival rate. Whilst the use of telephone CPR (T-CPR) protocols by emergency medical service (EMS) dispatchers can improve the quality of CPR, they are still below international resuscitation recommendations for performance standards. Improving the language (e.g., the clarity and simplicity of choice of words) of T-CPR protocols is a modifiable factor that is likely to improve CPR performance. However, it is unclear how to improve it due to the lack of detailed investigation. OHCA studies performed in Saudi Arabia are limited but evidence suggests low rates of survival (5%). T-CPR is currently implemented in Saudi Arabia but its efficacy has not been investigated.

This project was undertaken with the aim of improving CPR timeliness and quality by investigating the nature of OHCA calls and the T-CPR protocol in current practice in Saudi Arabia and evaluating the impact of modified T-CPR instructions.

A sequential mixed methods design was conducted, and included a retrospective observation of OHCA call recordings, followed by before-after simulation study to test a modified set of T-CPR instructions (that focused on enhancing the protocol by simplifying the language used in the instructions). A sample of 100 OHCA calls made to the main EMS in Riyadh, Saudi Arabia were reviewed and characterised both quantitatively and qualitatively.

The ‘before’ component of the simulation study evaluated CPR performance of 50 participants using the current Saudi T-CPR protocol and investigated how language (e.g., word choices and phrases) might influence performance and how it can be improved. Data recorded included quantitative measures relating to the quality of CPR delivered during the simulation and semi-structured interviews to explore participants’ experiences of the T-CPR protocol.

An enhanced protocol was then developed based on findings from the observation of calls study and the ‘before’ component of the simulation study, as well as drawing on evidence from literature. Modifications included simplifying the T-CPR language to ‘plain’ language (e.g., using simple, precise, and concise terms and avoiding anatomical terms). The timeliness and quality of CPR performance while following the enhanced protocol was then evaluated in a separate sample 50 participants; the ‘after’ component of the simulation study.

Observation of calls identified low return of spontaneous circulation (ROSC) in current practice (10%). This low ROSC could be attributed in part to the prolonged time to starting chest compression by callers, with a median of 367 s (IQR 266.75–550.5) from EMS call receipt, which is below the resuscitation recommendation (by 217 s). A further observation of the calls identified a number of opportunities to save time compared with current T-CPR protocol. For example, where

instructions lacked precision and used local dialect languages resulting in the need for further clarification.

The use of the enhanced T-CPR protocol in the simulation study demonstrated a reduced median time to first compression from 110 (IQR 99.75-125.5) to 79 s (IQR 69 – 89.25), depth of compression was improved from 30 to 35 mm and did the chest compression rate from 94.5 to 105 compressions per minute. Participants that took part in qualitative interviews reported that the instructions given in the enhanced protocol were easier to understand and interpret compared with the language used in the current Saudi Arabian protocol. Improvements using the enhanced protocol is attributed to using the simplified 'plain' language.

This study contributes to the current literature by providing detailed investigation of factors that could possibly explain why time to first compression currently falls so far short of international guidelines. It is also the first study to investigate the characteristics of OHCA calls and T-CPR protocol in current practice in Saudi Arabia. It is also the first study to provide detailed investigation to how T-CPR language could be improved aiming to improve CPR performance. It might be hoped that by optimising language used in the T-CPR protocol, improvements in CPR timeliness and quality might improve survival rate.

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Research Thesis: Declaration of Authorship

Print name: Meshary Saud Bin Hotan

Title of thesis: A Mixed Methods Investigation of Out of Hospital Cardiac Arrests Calls and Telephone Assisted Cardiopulmonary Resuscitation to Improve Cardiopulmonary Resuscitation Performance in Saudi Arabia

I declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

I confirm that:

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Signature: .... Date: 08/07/2021

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Abbreviations

T-CPR	Telephone cardiopulmonary resuscitation
DA-CPR	Dispatcher assisted cardiopulmonary resuscitation
CPR	Cardiopulmonary resuscitation
OHCA	Out of hospital cardiac arrest
IHCA	In hospital cardiac arrest
AHA	American heart association
ERC	European resuscitation council
ILCOR	International Liaison Committee on Resuscitation
ROSC	Return of spontaneous circulation
BLS	Basic life support
ALS	Advanced life support
AED	Automated external defibrillator
PAD	Public access defibrillator
EMS	Emergency medical services
MPDS	Medical priority dispatch system
CBD	Criteria based dispatch
KSA	Kingdom of Saudi Arabia
MSA	Modern standard Arabic
SRCA	Saudi Red Crescent Authority
MD	Doctor of Medicine
PPI	Patient and public involvement
UK	United Kingdom

Abbreviations

USA	United States of America
KSAU-HS	King Saud bin Abdulaziz University for Health Sciences
ERGO	Ethics and Research Governance Online
IRB	Institutional Review Board
MOH	Ministry of Health
KAIMRC	King Abdullah International Medical Research Centre
PIS	Participant Information Sheet
SVE	Southampton Virtual Environment
DNR	Do Not Resuscitate

Chapter 1 Introduction

1.1 Project overview and chapter introduction

This thesis focuses on out of hospital cardiac arrest (OHCA) calls and the use of telephone cardiopulmonary resuscitation (T-CPR) protocol in Saudi Arabia. The research aims to improve CPR timeliness and quality by investigating the T-CPR protocol used in current practice in the Saudi Arabian emergency medical service (EMS); identifying the facilitators and challenges influencing the quality of T-CPR protocol in current practice; and developing and testing enhanced Saudi Arabian T-CPR protocol instructions to examine their impact on CPR timeliness and quality performance. Successful completion of this project has the potential to improve CPR performance by OHCA callers, which could lead to better survival rates and neurologic outcomes of OHCA patients.

This chapter introduces the central concepts associated with OHCA as well as the use of T-CPR protocols and other strategies that are employed to improve the survival rate after OHCA by focusing on improving CPR timeliness and quality performance.

Modifying the language of T-CPR instructions to improve CPR timeliness and quality performance is also outlined. The term 'language' modification in this context is used to describe the changing of words or terms used in the instructions (not translating them from Arabic to English, or vice versa). This PhD project was conducted in Saudi Arabia and therefore, the Saudi Arabian context (culture, EMS setting, and how calls are received) is outlined to highlight its significant relation to T-CPR protocols. Finally, the aim, objectives, and structure of the thesis are described.

1.2 OHCA: global health problem influencing survival outcomes

OHCA is a global health problem that can occur unexpectedly and frequently leads to patient death. The definition of cardiac arrest, its incidence, and patients' outcomes post-OHCA are explored in the following sections.

1.2.1 A global health problem: definition and incidence of cardiac arrest

Cardiac arrest is defined as the cessation of the mechanical activity of the heart, which is confirmed by the absence of signs of circulation (Jacobs *et al.*, 2004). Sudden cardiac arrest is one of the leading causes of death in Europe (Perkins *et al.*, 2015a) and heart disease death in the United States of America (USA) (Mozaffarian *et al.*, 2015). It is categorised as either cardiac or non-cardiac in origin based on its aetiology (Mozaffarian *et al.*, 2015). The majority of cardiac arrests are of cardiac origin, with coronary heart disease and a history of heart disease being the primary aetiology (Huikuri, Castellanos and Myerburg, 2001). Meanwhile, non-cardiac arrest can have a range of causes, including submersion, drug overdose, and trauma (McNally *et al.*, 2011).

Cardiac arrest is also categorised by the location of the event: in-hospital cardiac arrest (IHCA) and out of hospital cardiac arrest (OHCA). OHCA is more challenging than IHCA as it accounts for three-quarters of all cardiac arrests (Daya *et al.*, 2015), a third of OHCA occurs among people with no known history of heart disease, and half of these have no prodromal symptoms (Muller, Agrawal and Arntz, 2006).

Moreover, the incidence of OHCA varies greatly around the world as shown by a systematic review of 67 studies from Europe, North America, Asia, and Australia that concluded that there is a 10-fold global variation in OHCA incidences and outcomes (Berdowski *et al.*, 2010). The global average incidence was 55 adult OHCAs of presumed cardiac cause per 100,000 person-years. Meanwhile, in Europe, a cross-sectional study of 27 European countries reported an OHCA rate of 84 per 100,000 population (Grasner *et al.*, 2016). This is higher than in the USA, where the American Heart Association (AHA) reported a rate of 76 per 100,000 population (Mozaffarian *et al.*, 2015). However, in Saudi Arabia, no study has reported on the incidence rate of OHCA. Nevertheless, in the regional area of Saudi Arabia (Gulf countries), a retrospective study was conducted in Qatar to measure EMS-attended OHCA and reported an incidence rate of presumed cardiac-caused OHCA of 23.5 per 100,000 persons-year (Irfan *et al.*, 2016).

Thus, the high international incidence of OHCA highlights it as a global health concern that needs urgent intervention to manage and treat cases. The survival outcomes following OHCA is explored in the following section.

1.2.2 Survival outcomes

The survival rate following OHCA is low, but varies across communities worldwide (Sasson *et al.*, 2010). Sasson *et al.* (2010) conducted a systematic review and meta-analysis of 79 studies involving 142,740 patients and found that the survival to hospital discharge ranged from 0.1% to 33.6% with an aggregate overall survival rate of 7.6%. A further study that retrospectively reviewed 12 OHCA registries in 12 countries from Asia, Australia, Europe, and North America concluded that the survival rate to hospital discharge was 10% (Dyson *et al.*, 2019). This rate varied from 6 to 22% between the included OHCA registries, but the reasons for the variation were unclear. Meanwhile, in European countries, the overall survival rate to hospital discharge was reported to be 10.3%, which ranged from 1.1% to 30.8% across the 27 involved countries

(Grasner *et al.*, 2016). This survival rate is similar to the rate in America, which was around 10.6% (Mozaffarian *et al.*, 2015).

Across the Gulf countries, there is limited evidence regarding the OHCA survival rates. In Saudi Arabia, only two studies have investigated adult OHCA survival outcomes (Corony and Scott, 1999; Bin Salleeh *et al.*, 2015). First, Corony and Scott (1999) reviewed reports of non-traumatic OHCA and emergency department cardiac arrests at a tertiary care hospital in Riyadh from 1989 to 1995. Thirty-nine OHCAs were identified during that period, with only 5.1% survival to hospital discharge. Second, Bin Salleeh *et al.* (2015) who reviewed 96 OHCA reports of patients who were transported to an emergency department of a tertiary care hospital with traumatic (N = 12) and non-traumatic causes (N = 84) had similar findings. The study reported a low return of spontaneous circulation (ROSC) as achieved in the emergency department with only 4.2% of all included cases, and with 4.8% excluding traumatic cases with no further details reported for survival rate to hospital discharge. The findings from Saudi Arabia were lower than the global survival rate to hospital discharge as identified by Sasson *et al.* (2010) and Dyson *et al.* (2019). However, the sample size of the Saudi data is smaller than that of other studies from the USA and Europe, and the study conducted by (Corony and Scott, 1999) is rather dated. Meanwhile, other Gulf countries have also shown variations in survival rates, with 0.3% and 8.1% hospital to discharge in Kuwait and Qatar, respectively (Irfan *et al.*, 2016; Al Hasan, Yaseen and El Sayed, 2020) as well as 9.2% ROSC rate prior to hospital arrival in Emirates with no further data about survival to hospital to discharge or ROSC at the time of arrival at the hospital (Alqahtani *et al.*, 2019).

Here, the low survival outcomes are likely to be influenced by the low rates of bystanders performing CPR (known as bystander CPR rate), which is a key intervention to improve the survival rates (see section 1.3). According to Sasson *et al.* (2010), the bystander CPR rate has shown variations between communities with an overall rate of only 32%. Other studies revealed national bystander CPR rates as being between 10% and 65% in the USA (Girotra *et al.*, 2016), 14.5% to 55.2% in England (Moncur *et al.*, 2016; Hawkes *et al.*, 2017), and 10.5% to 40.9% across Asian countries (Ong *et al.*, 2015). However, there is limited data from Saudi Arabia, with the only two studies conducted by Corony and Scott (1999) and Bin Salleeh *et al.* (2015), who reported low bystander CPR rates of 3% and 20.8%, respectively. Meanwhile, other Gulf countries reported similar bystander CPR rates of 8.7% in Kuwait (Al Hasan, Yaseen and El Sayed, 2020), 20.6% in Qatar (Irfan *et al.*, 2016), and 30.7% in the United Arab Emirates (Alqahtani *et al.*, 2019).

The low OHCA survival rate of communities across the world requires urgent intervention to improve it. Ong *et al.* (2015) suggested that the differences in OHCA survival rates between communities could be attributed to how pre-hospital care is delivered, and its improvement can have the potential to raise the survival rate. Providing CPR instructions to bystanders via telephone is part of EMS pre-hospital care. Therefore, enhancing the T-CPR protocol could improve OHCA survival rate by guiding more bystanders to promptly perform high quality CPR. Thus, CPR timeliness and quality performance as well as their significant influence on survival rates are explored in the following section.

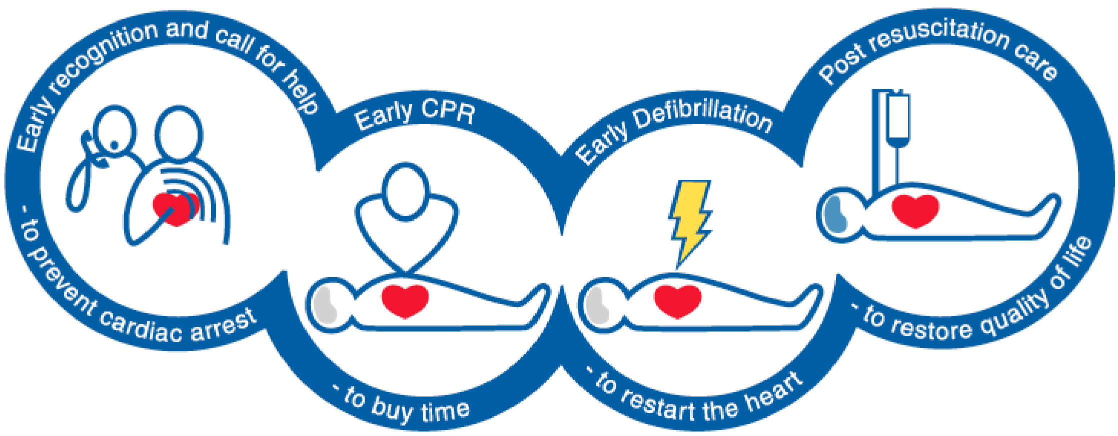
1.3 The significance of CPR timeliness and quality performance in survival

The purpose of CPR is to preserve brain and tissue viability by manually circulating blood (by chest compressions) and oxygen (by rescue breaths), which is normally achieved by a beating heart (Abella *et al.*, 2008). Thus, performing prompt, high-quality CPR is a key intervention to improve the survival rate following OHCA. The following sections explore the importance of time in OHCA events and how high-quality CPR performance can influence the survival rate.

1.3.1 The importance of time: chain of survival

The chain of survival was developed and implemented worldwide in an attempt to improve survival rates and neurologic outcomes following OHCA (Kleinman *et al.*, 2015; Perkins *et al.*, 2015a). It is a concept that represents integrated stages that are needed for successful resuscitation (Kleinman *et al.*, 2015; Perkins *et al.*, 2015a) and is divided into basic life support (BLS) that aims 'to buy time' until an ambulance crew arrives at the scene, whereupon advanced life support (ALS) is then administered by the EMS personnel, as part of pre-hospital care, as well as the medical teams in the hospital (see Figure 1).

Figure 1. The chain of survival needed for successful resuscitation. Reproduced from (Perkins *et al.*, 2015a).



The chain of survival aims to link the key stages in OHCA resuscitation and highlights the need for all links to be effectively performed in a short time to improve the chances of better survival rates and neurologic outcomes (Deakin, 2018). Therefore, it is essential to enhance and promptly achieve these vital links.

Early recognition of cardiac arrest and call for help

The first step in the chain of survival is early recognition of cardiac arrest and rapidly calling the EMS by a bystander. OHCA patients are likely to receive bystander CPR when OHCA recognition takes place, which, in turn, improves their survival outcomes (Rea, Eisenberg and Culley, 2002; Kuisma *et al.*, 2005; Wissenberg *et al.*, 2013). Additionally, when OHCA is not recognised in the EMS call, the survival after three months is 5% as compared to 14.5% when it is identified in the call (Berdowski *et al.*, 2009). However, the identification of OHCA by an untrained BLS bystander is challenging, and might be combined with other factors that delay or make it more difficult to be identified.

In this context, agonal breathing is one of the most common factors influencing OHCA recognition and presents in up to 40% of OHCAs (Clark *et al.*, 1992). It is caused by the response of the brain stem to ischemia and may persist for up to four minutes after collapse (Bobrow *et al.*, 2008; Lewis, Stubbs and Eisenberg, 2013). It commonly occurs with patients experiencing witnessed OHCA (Clark *et al.*, 1992; Lewis, Stubbs and Eisenberg, 2013), which could be confusing for a lay bystander to assume that the patient is not breathing normally and then, falsely perceives it as a sign of life. Additionally, seizure-like activity that is caused by a sudden reduction of blood flow to the brain following cardiac arrests may also be present in OHCA and misinterpreted as an epileptic attack (Nurmi *et al.*, 2006; Clawson *et al.*, 2007; Clawson *et al.*, 2008). Thus, clear communication by using simple and understandable questions and language between dispatchers and callers is vital to assess and triage patients and then promptly identify cardiac arrest (see section 1.4).

Early CPR performance

Following OHCA identification, CPR should be initiated immediately by a bystander as early initiation has the potential to double or quadruple the survival rate (Valenzuela *et al.*, 1997; Holmberg *et al.*, 1998; Holmberg, Holmberg and Herlitz for the Swedish Cardiac Arrest Registry, 2001; Waalewijn, Tijssen and Koster, 2001; Wissenberg *et al.*, 2013; Hasselqvist-Ax *et al.*, 2015). In addition, some studies have found that the survival rate can significantly increase if CPR is performed within four minutes of the arrest (Valenzuela *et al.*, 1997). However, even if OHCA is identified in a timely manner, some bystanders could hesitate to perform CPR because, for example, they lack confidence and CPR knowledge and may fear performing it incorrectly (Locke *et al.*, 1995; Rowe *et al.*, 1998; Shibata *et al.*, 2000; Johnston *et al.*, 2003; Swor *et al.*, 2006; Dwyer, 2008; Nishiyama *et al.*, 2008; Coons and Guy, 2009; Taniguchi *et al.*, 2012; Qara *et al.*, 2019). This causes unperformed or delayed CPR. Therefore, when an EMS dispatcher suspects an OHCA call, the dispatcher should guide the caller to commence CPR as early as possible by providing instructions that can simply be comprehended by untrained BLS bystanders (see section 1.4).

Early defibrillation

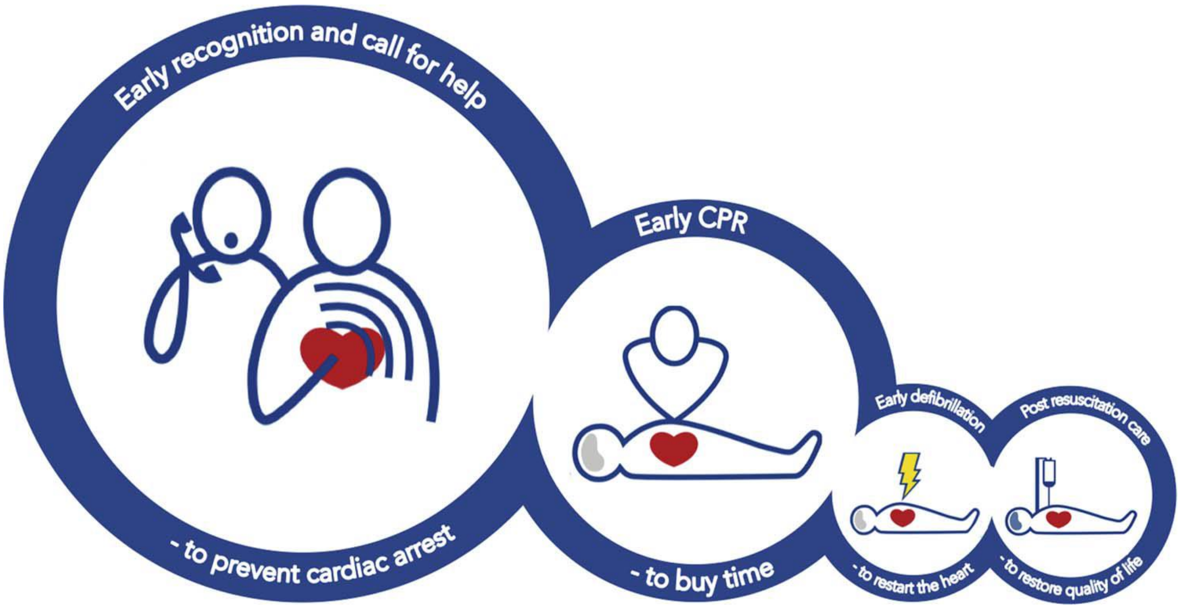
Early defibrillation, characterised by the prompt delivery of a specific dose of electrical current in the case of pulseless ventricular tachycardia and ventricular fibrillation, significantly improves survival rates in OHCA patients. In this context, the European Resuscitation Council (ERC) highlighted that delivering the electrical shock within 3–5 minutes from patient collapse can increase the survival rate by 50–70% (Perkins *et al.*, 2015a). Therefore, the EMS dispatcher should guide a caller to send someone, another bystander if available, to the nearest allocated automated electrical defibrillator (AED) for the arrested patient (Perkins *et al.*, 2015a). However, if there is no available bystander with the caller, then EMS dispatchers should guide them to perform continuous CPR to maintain the viability of the heart until the EMS crew arrives (Perkins *et al.*, 2015a). However, applying early defibrillation is not within the scope of this PhD project.

Early ALS and post-resuscitation care

When initial attempts at resuscitation fail to restore circulation, ALS such as intubation and intravenous drug treatment by the medical team are needed (Soar *et al.*, 2015). Further, when an OHCA patient has a successful ROSC, the subsequent prompt delivery of treatment and patient care will also be needed. Here, post-resuscitation care includes therapeutic hypothermia and coronary angiography, which aim to improve patient outcomes (Link *et al.*, 2015; Soar *et al.*, 2015). However, this part of the chain of survival is beyond the scope of this PhD project.

Whilst all four steps in the chain of survival are crucial for a good outcome from OHCA, the number of patients who pass from one step to the next diminishes (Deakin, 2018). Therefore, Deakin (2018) suggested a revised graphical representation of the chain of survival based on the number of patients each step applies to (the size of a step represents the number of patients, with a larger step representing a greater number of patients) (see Figure 2). This amended representation serves to highlight the steps where improvement would have the greatest benefits on OHCA outcomes. This underlines the need for further research, particularly in the steps leading up to and including early CPR.

Figure 2. Amended chain of survival by Deakin (2018).



Outcomes of the first two steps are enhanced by the T-CPR protocol (see section 1.4.2). Therefore, improving the T-CPR protocol can enhance the chain of survival, leading to better OHCA patients' survival outcomes.

1.3.2 The significance of high-quality CPR

Performing 'optimal' chest compression is indicated by the International Liaison Committee on Resuscitation (ILCOR) to be the key component of high-quality CPR (Perkins *et al.*, 2015c). The ILCOR was established in 1992 to provide a liaison between key resuscitation organisations worldwide, such as the AHA and ERC. Further, more importantly for this project, it characterised the quality of chest compressions by the number of chest compressions per minute (c/m), depth, hand position, chest wall recoil, and hands-off chest time (Perkins *et al.*, 2015c). These CPR parameters affect coronary perfusion pressure, intrathoracic pressure, and cardiac output, which, in turn, affect the clinical outcomes (Kleinman *et al.*, 2015).

The primary goal in cardiac arrest is to restore blood flow so that cardiac and brain function can be preserved (Lurie *et al.*, 2016). In each chest compression, the intrathoracic pressure increases and the heart is squeezed between the patient's spine and sternum (Kouwenhoven, Jude and Knickerbocker, 1960; Rudikoff *et al.*, 1980; Niemann *et al.*, 1981; Fisher *et al.*, 1982; Halperin *et al.*, 1988; Ma *et al.*, 1995). Additionally, the aortic and right arterial pressure increase during each chest compression (Paradis *et al.*, 1989; Paradis *et al.*, 1990; Paradis *et al.*, 1991). As a result, the blood is pushed to the coronary arteries, brain, and the rest of the body—the aim here is to restore blood flow (Rudikoff *et al.*, 1980; Feneley *et al.*, 1987; Halperin *et al.*, 1988). In each decompression, the heart is refilled with the blood to be pushed again in each compression (Lune *et al.*, 1998; Robertson *et al.*, 1998; Association, 2000; Lurie *et al.*, 2000; Lurie *et al.*, 2002; Aufderheide *et al.*, 2005), which represent the chest compression cycle. However, even in high-quality chest compression performance, the cardiac output is around 15 to 25% of the normal cardiac output (Duggal *et al.*, 1993; Lune *et al.*, 1998; Lurie *et al.*, 2000). This necessitates that the quality of chest compression performance be as high as possible.

In this context, high-quality CPR performed by bystanders can increase survival rate by more than three times as compared to low-quality CPR (Van Hoeyweghen *et al.*, 1993; Wik, Steen and Bircher, 1994; Gallagher and Lombardi, 1995). Further, some studies have shown that there is no difference in survival rate between poor-quality CPR and no CPR at all (Wik, Steen and Bircher, 1994; Gallagher and Lombardi, 1995). Therefore, it is crucial to ensure that high-quality CPR is performed.

Based on the latest available evidence, the ILCOR provides resuscitation recommendations for the CPR parameters to improve the quality of chest compressions with the aim of subsequently improving survival rates and neurologic outcomes. Thus, the recommendations of the CPR parameters should be achieved when performing CPR, either by trained or untrained BLS persons, to increase the effectiveness of the delivered chest compressions.

As this project aims to improve the quality of CPR performance, the following sections will describe the latest recommendations for the five parameters. These are summarised in Table 1.

Table 1. The ILCOR recommendations for high-quality CPR (Olasveengen *et al.*, 2020).

Parameters	Recommendations
Chest compressions rate	100–120 c/m
Chest compression depth	Approximately 5 cm but no more than 6 cm
Hand position	At the lower half of patient's sternum
Hands-off-chest time	As short as possible
Chest wall recoil	Allowing for the full chest wall recoil of patient

1) Chest compression rate

Chest compression rate is characterised as the number of chest compressions delivered to a patient in each minute. The recommended rate is between 100 to 120 c/m (Olasveengen *et al.*,

2020) and was essentially derived from two studies that found that the survival rate was higher in patients who received chest compressions at this rate (Linden *et al.*, 2012; Idris *et al.*, 2015). These studies also found an interdependent relationship between rate and chest compression depth, where a very high compression rate (above 120 c/m) was associated with declining depth. Accordingly, 100–120 c/m was recommended as the optimal chest compression rate.

2) Chest compression depth

The ILCOR recommends a chest compression depth of approximately 5 cm (2 inches) but no more than 6 cm (2.4 inches) (Olasveengen *et al.*, 2020). This recommendation was based on research that showed better survival rates when chest compressions were performed at approximately the 5 cm depth (Hostler *et al.*, 2011; Stiell *et al.*, 2012; Vadeboncoeur *et al.*, 2014). Additionally, Morse (2015) reviewed 9136 OHCA patients from a resuscitation registry and a large resuscitation trial and found that depth within the range of 4 to 5.5 cm was linked with a better survival rate. Pushing the chest during compressions deeper than 6 cm was associated with increased injury rates as compared to 5–6 cm depth in adults experiencing cardiac arrest (Hellevuo *et al.*, 2013). Therefore, chest compression depth of approximately 5 cm and no more than 6 cm is recommended.

3) Hand position

Hand position refers to the location of the rescuer's hands over a patient's chest when performing chest compression. The recommended positioning is on the lower half of the sternum in adult patients (Olasveengen *et al.*, 2020), which is based on limited evidence from experimental studies (Orlowski, 1986; Cha *et al.*, 2013; Qvigstad *et al.*, 2013) that revealed better hemodynamic responses with chest compressions on the lower half of the sternum.

4) Hands-off-chest time

The ILCOR emphasises that pauses in chest compressions should occur as infrequently as possible to improve the chest compression fraction (Olasveengen *et al.*, 2020), which is defined as the proportion of time when chest compressions are performed. However, some interruptions are necessary as part of the required care, such as checking the patient's rhythm to act accordingly. In this context, a pause of less than 10 s for pre- and post-shock with a chest compression fraction of more than 60% was associated with an improved survival rate (Christenson *et al.*, 2009; Cheskes *et al.*, 2010; Sell *et al.*, 2010; Vaillancourt *et al.*, 2011; Cheskes *et al.*, 2014). Thus, it is recommended that hands-off time be as short as possible (Olasveengen *et al.*, 2020), so that the chest compression fraction is as high as possible, with a minimum of 60% (Perkins *et al.*, 2015c). However, when there is no defibrillator available when a lay bystander is performing chest compressions, the recommendation is continuous chest compression with no pauses (Perkins *et al.*, 2015a).

5) Chest wall recoil

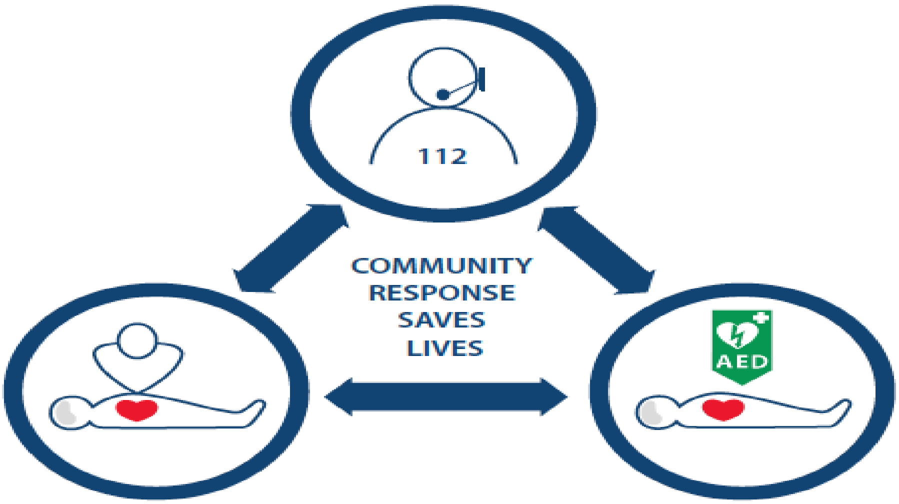
Leaning on the chest wall in between chest compression prevents chest wall recoil, which commonly occurs in CPR (Fried *et al.*, 2011; Niles *et al.*, 2011). However, not allowing full chest recoil has the potential to increase intrathoracic pressure, which will then reduce venous return, coronary perfusion pressure and myocardial blood, thereby having a negative effect on resuscitation outcomes (Zuercher *et al.*, 2010; Niles *et al.*, 2011). Therefore, it is recommended that leaning on the chest wall during chest compression be avoided to allow for full chest recoil (Olasveengen *et al.*, 2020).

To achieve these standards, practical CPR training is recommended. However, most studies show that CPR skills decline within three to six months of the CPR training course (Woollard *et al.*, 2004; Woollard *et al.*, 2006; Einspruch *et al.*, 2007; Roppolo *et al.*, 2007; Smith, Gilcreast and Pierce, 2008). Therefore, the ERC recommends frequent updates and annual retraining at least every 12–24 months as well as more frequent retraining for people who are likely to face cardiac arrest; if this is not undertaken, the CPR skills will be lost (Greif *et al.*, 2015). Therefore, if a lay bystander does not have CPR training within at least the previous 24 months, the bystander may be considered untrained in CPR, and then providing guidance from dispatcher using CPR instructions is needed to ensure high-quality CPR. However, there is no recommendation on how to phrase these CPR recommendations in T-CPR instructions to be provided for the untrained BLS callers (see section 1.4.2).

1.4 Delivering T-CPR Instructions

Rapid activation of the EMS system by bystanders is the first step in the chain of survival (as described in 1.3.1). The international resuscitation guidelines emphasise the critical importance of the interaction between EMS dispatchers and bystanders who call to report OHCA cases and provide first aid to patients (Kleinman *et al.*, 2015; Monsieurs *et al.*, 2015) (see Figure 3). In this context, clear instructions and communication between dispatchers and callers have the potential to improve survival after OHCA (Kleinman *et al.*, 2015; Monsieurs *et al.*, 2015). The following sections will describe how EMS dispatching systems receive and process bystander calls and will then explore T-CPR instructions in detail.

Figure 3. Interaction between an EMS dispatcher and a bystander. Reproduced from (Perkins *et al.*, 2015a).



1.4.1 EMS dispatch and telephone assessment

The EMS dispatch centre is the first contact between the caller and the emergency services responsible for receiving and managing public calls (Baabdullah *et al.*, 2020). The EMS dispatcher aims to promptly dispatch the best EMS response resources to patients and guide callers to provide on-scene first aid support (e.g., apply direct pressure for bleeding and chest compressions for OHCA), as necessary, to patients by providing pre-arrival instructions (Larribau *et al.*, 2020). EMS dispatch centres worldwide receive an average volume of calls of 300 to 1000 per day (Ahn *et al.*, 2010; Møller *et al.*, 2015; Viglino *et al.*, 2017; Penverne *et al.*, 2018). Thus, the demands for these centres present challenges in terms of triaging calls, then sending EMS crews to more critical patients—while having a limited number of crew on hand—and still ensure the safety of other less critical patients (Bohm and Kurland, 2018). Therefore, an accurate dispatching system is needed to perform the telephone assessments.

Dispatching systems are developed to be run by dispatchers, who are commonly not physicians, to assess and prioritise calls (Larribau *et al.*, 2020). However, there are differences in dispatching systems across countries and even regions of the same country in terms of how they negotiate with callers and how they are organised (Langhelle *et al.*, 2004; Pozner *et al.*, 2004). Internationally, there are two main commercial EMS dispatching systems: medical priority dispatch (MDPS) and criteria-based dispatch (CBD). The MPDS is algorithm based and common in

Anglo-Saxon countries (Bohm and Kurland, 2018). It follows a set of scripted questions and protocols to categorise patients based on the information received from callers, such as the main symptoms and patient consciousness (Baabdullah *et al.*, 2020). On the other hand, the CBD is a guideline-driven approach, and relies more on the experiences of the dispatcher to negotiate with callers (Bohm and Kurland, 2018). It is more commonly found in Nordic and European countries and is often used in EMSs that are staffed by nurses or paramedics (Larribau *et al.*, 2020). However, there is no consensus on the effectiveness of the dispatching systems used in telephone assessment (Bohm and Kurland, 2018).

Telephone assessment is based on the information given by callers, and therefore, their language (e.g., choice of words, vocabulary or description of the event) could influence the assessment. For example, callers reporting an emergency may use imprecise words such as 'traffic accident' that might influence dispatcher decision-making, as this vague description does not provide information about patients' conditions (e.g., severity of injury) and consequently, could lead to a range of different symptoms and situations (Larribau *et al.*, 2020). Similarly, the choice of words used by dispatchers could be difficult for callers to understand. This could potentially lead to prolonged assessments or incorrect decisions. Medical or technical terms used by dispatchers, such as 'unconsciousness', were found to be difficult for laypeople to understand, leading to misunderstandings and the potential for callers to provide incorrect responses or descriptions (Higgins *et al.*, 2001). In this context, Riou *et al.* (2017) conducted a linguistic study of EMS calls and examined how changing tense can impact how efficiently callers describe emergencies. They found that when dispatchers use the present perfect tense when asking about the chief complaint ('tell me exactly what's happened'), it increased the likelihood of callers responding with a succinct, informative report. This, in turn, led to a shorter time being taken to dispatch the EMS crew as compared to using simple past tense ('what happened'). Therefore, language and communication during EMS calls between dispatchers and callers play a critical role in telephone assessments and could have the potential to improve pre-hospital care.

1.4.1.1 Telephone triage and the provision of pre-arrival guidance

Call triage describes the prioritisation of calls based on the assessment of information given by callers to notify and dispatch the appropriate resources and provide pre-arrival first aid guidance (Newberger and Braithwaite, 2020). EMS systems receive many simultaneous calls from the public, and such systems have limited resources and thus, require decisions to be made about which calls are the most urgent and those that are less urgent and can be delayed (Sanko, Lane and Eckstein, 2020). This allows the priority management of patients with the greatest need for intervention. In this context, optimal call triaging involves following consistent guidelines from the local, regional or national EMS organisation, or a governmental agency (Newberger and Braithwaite, 2020).

Although guidelines for triaging and managing incoming EMS calls differ between EMS dispatch systems worldwide, they all aim to reduce the response time to calls (Penverne *et al.*, 2019). To provide immediate pre-hospital care (dispatch resources and provide pre-arrival instructions), calls should be immediately received and processed, which requires a sufficient number of dispatchers (Raknes, Morken and Hunskår, 2017). In addition, they should have guidelines, training, experience, and the confidence to promptly and accurately communicate with callers to correctly prioritise the severity of calls (Ornato, 2009).

In urgent cases, guidance by dispatchers following a set of instructions assists callers in managing medical emergencies while awaiting the arrival of EMS response resources. Those instructions could be provided to the calling patient or a caller reporting the case (Wise, Freeman and Edemekong, 2020). Pre-arrival instructions can include applying direct pressure or making tourniquets for bleeding control, Heimlich manoeuvres for choking, first aid for trauma, and chest compressions for cardiac arrest (Bakke *et al.*, 2017; Scott *et al.*, 2020; Wise, Freeman and Edemekong, 2020). In this context, people calling EMS typically expect to receive pre-arrival instructions from dispatchers (Billittier IV *et al.*, 2000). This could indicate that they are likely to follow them unless they face an obstruction that prevents them. Thus, pre-arrival instructions should use clear language designed for lay callers to comprehend and undertake (Wise, Freeman and Edemekong, 2020). Pre arrival T-CPR instructions for OHCA patients are one of the most used (Gardett *et al.*, 2016) and is the focus of this PhD.

1.4.2 T-CPR instructions

As part of the chain of survival, the ILCOR strongly recommends that each EMS dispatch centre has a system for dispatchers to provide CPR instructions to untrained CPR callers who are reporting adult OHCAs (Soar *et al.*, 2019). The ILCOR conducted a systematic review and meta-analysis to measure the impact of T-CPR on the clinical outcomes for both adult and paediatric OHCA patients. The review included 33 studies, which were all observational, and the certainty of the evidence was assessed as low or very low. This systematic review found that providing T-CPR instructions was associated with improved ROSC, favourable neurologic outcomes (at one month after OHCA and at hospital discharge) and survival rate (at one month after OHCA and at hospital discharge) of OHCA patients compared with not providing them (Nikolaou *et al.*, 2019). Thus, EMS dispatchers should be trained to promptly identify a cardiac arrest and guide callers to perform CPR (Soar *et al.*, 2019). However, the ILCOR highlighted several knowledge gaps in T-CPR including the essential elements for quality improvement programmes, optimal dispatcher training, optimal CPR instruction sequence, optimal criteria and dispatch algorithm to recognise OHCAs and the influence of language (Perkins *et al.*, 2015c; Soar *et al.*, 2019; Olasveengen *et al.*, 2020). The influence of language in T-CPR is explored further in 1.4.2.2.

Recognising cardiac arrest over the telephone is a challenging process, requiring both the caller and dispatcher to quickly identify it to activate the chain of survival (Monsieurs *et al.*, 2015). In this context, asking callers to check a patient's pulse to determine cardiac arrest is an inaccurate technique, which could lead to OHCA misrecognition (Bahr *et al.*, 1997; Moule, 2000; Nyman and Sihvonen, 2000; Tibballs and Russell, 2009; Tibballs and Weeranatna, 2010). Thus, to minimise the misrecognising of OHCA, the ILCOR recommends that if a patient is unconscious and not breathing/not breathing normally, the patient should be presumed to be in cardiac arrest, and therefore, T-CPR instructions should be provided (Perkins *et al.*, 2015c). To improve the effectiveness of T-CPR instructions, dispatchers should promptly identify OHCA using a few questions and then deliver concise and clear instructions (Michiels *et al.*, 2020). However, there are no internationally standardised T-CPR instructions for callers, and therefore, the methods of delivering them differ between EMS systems (Rasmussen *et al.*, 2020). In this context, Rasmussen *et al.* (2020) compared T-CPR protocols used in ILCOR member countries and found that they use nationwide, local, and some do not use T-CPR protocol at all. The contents of these different protocols used also varied in terms of how language was used to deliver the instructions (to use 'push as hard as you can' or 'push 5–6 cm deep') and how distressed callers were to be managed (to provide encouragement or not). Such variation could be attributed to the differences in the EMS dispatching system, language spoken, and culture.

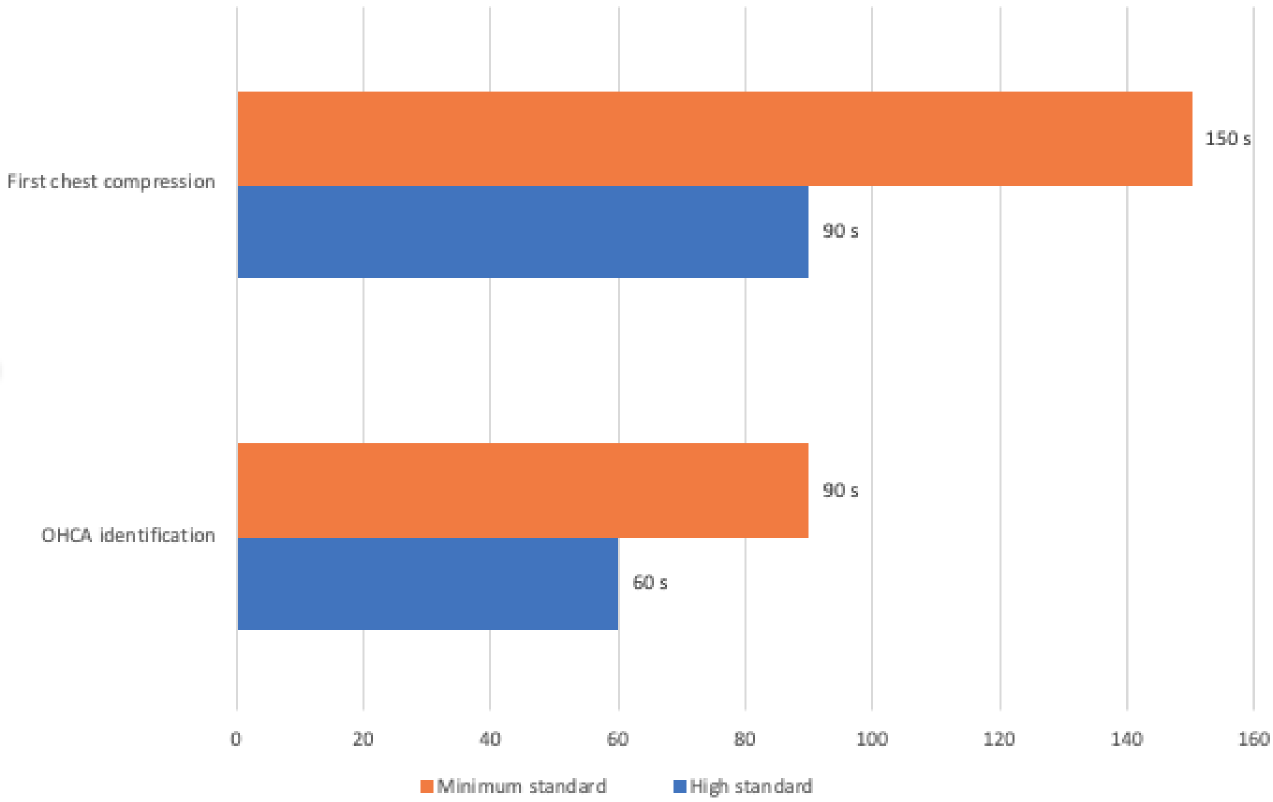
The international resuscitation guidelines provide step-by-step instructions to describe the technical process of performing high-quality CPR (see Appendix A). However, there is no recommendation regarding the wording of these instructions over the telephone (Kleinman *et al.*, 2015; Perkins *et al.*, 2015a; Chung *et al.*, 2016). While BLS training courses provide step-by-step instructions to trainees followed by a visual demonstration to improve their understanding, visualisation is not available for T-CPR instructions. Therefore, their phrasing and formulating these CPR instructions in T-CPR differs from one protocol to another (for examples, see Appendix B). Further, these differences could have the potential to influence the quality of the T-CPR protocol in terms of promptly identifying OHCA and then enabling callers to perform early, high-quality CPR, which subsequently influences the survival rate.

1.4.2.1 Quality performance of T-CPR in current practice

The AHA has recently released a policy statement to introduce a standard performance level for T-CPR protocol to improve survival rates (Kurz *et al.*, 2020). This standard performance level measures the ability of a dispatchers to correctly recognise OHCA and then, guide callers to perform prompt CPR and emphasised the following:

1) Dispatchers should recognise OHCA less than 90 s from EMS call receipt and guide first chest compression in less than 150 s (minimal acceptable standard). These time intervals are reduced to less than 60 s and 90 s in high performance systems for the aforementioned steps, respectively (see Figure 4).
2) Dispatchers should correctly identify 75% of all OHCA and 95% of all identifiable OHCA (excluding calls in which, for example, callers hung up or were hysterical).
3) Dispatchers should successfully guide callers to perform CPR in 75% of correctly recognised OHCA (excluding calls in which, for example, CPR is already in progress or the caller is physically unable to perform CPR).

Figure 4. The AHA recommendations for time to identify OHCA and start first chest compression from EMS call receipt.



However, a range of factors affect the ability to reach this standard performance, and these are explored below.

1. Factors that influence time taken to recognise OHCA and start chest compression.

OHCA calls could involve factors influencing the time to recognise OHCA and to start the first chest compressions. Several studies in the literature have examined OHCA call recordings in different countries using different versions of T-CPR instructions—including MPDS, CBD, and local protocols—and reported different time intervals. A few EMS dispatch centres successfully identified OHCA within the minimum AHA standard (< 90 seconds) (Hauff *et al.*, 2003; Heward, Donohoe and Whitbread, 2004; Lewis, Stubbs and Eisenberg, 2013; Dameff *et al.*, 2014; Dami *et al.*, 2015; Ho *et al.*, 2016; Plodr *et al.*, 2016; Huang *et al.*, 2017; Zhang *et al.*, 2020; Gram *et al.*, 2021). In two studies, callers were successfully guided by dispatchers to start the first compression within the minimum AHA standard (< 150 seconds) (Plodr *et al.*, 2016; Gram *et al.*, 2021). However, the majority of EMS systems did not achieve the AHA standards in regard to cardiac arrest identification (Kuisma *et al.*, 2005; Vaillancourt *et al.*, 2007; Clegg *et al.*, 2014; Travers *et al.*, 2014; Shah *et al.*, 2017; Michiels *et al.*, 2020) and starting first chest compressions (Hauff *et al.*, 2003; Heward, Donohoe and Whitbread, 2004; O'Neill and Deakin, 2007; Van Vleet and Hubble, 2012; Lewis, Stubbs and Eisenberg, 2013; Clegg *et al.*, 2014; Dameff *et al.*, 2014; Hardeland *et al.*, 2014; Stipulante *et al.*, 2014; Travers *et al.*, 2014; Dami *et al.*, 2015; Hardeland *et al.*, 2016; Ho *et al.*, 2016; Oman and Bury, 2016; Hardeland *et al.*, 2017; Huang *et al.*, 2017; Shah *et al.*, 2017; Michiels *et al.*, 2020; Zhang *et al.*, 2020). Factors influencing the time intervals were not sufficiently examined and included factors relevant to language and communication, asking unnecessary questions by dispatchers, and call processing and EMS systems.

Language comprehension and communication between callers and dispatchers is associated with delayed recognition of OHCA, and commencement of CPR. Michiels *et al.* (2020) analysed OHCA calls in Belgium and found that lack of language comprehension impacted the flow of communication, causing delays in OHCA recognition and the first chest compression. However, it was not clear whether the lack of language comprehension was due to the dispatchers and/or callers using unclear or complex language (e.g., word choices), or due to the low proficiency of the official language (e.g, English). Similar findings have been reported in other studies (Lewis, Stubbs and Eisenberg, 2013; Case *et al.*, 2018). In this context, Case *et al.* (2018) highlighted the need to pay more attention to local language to improve communication and subsequently, the time intervals. Thus, exploring language used in verbal T-CPR instructions is a potentially modifiable factor to improve time intervals (see Chapter 2).

A simulation study measured the association between how callers clearly describe cardiac arrests with time intervals (Stangenes *et al.*, 2020). The dispatchers identified cardiac arrest faster when callers provided the correct medical conditions by indicating that the patient was in cardiac arrest or dead, followed by those who provided signs and symptoms (e.g., patient not breathing, collapsed, or turning blue) and last by those who provided incorrect medical conditions (e.g., patient is having a seizure). Thus, how callers use their language (word choices and phrases) to describe the cardiac arrest could influence time to chest compression.

Asking 'unnecessary questions' by dispatchers were also shown to be a factor influencing the time intervals. Lewis, Stubbs and Eisenberg (2013) reviewed OHCA calls in King County EMS centres in the USA and found that the time to first compression in 33.1% of the calls was delayed by dispatchers asking unnecessary questions regarding the patients' age, sex, or chief complaint. Michiels *et al.* (2020) also identified other such questions as those about the medical history, pulse, medication, body temperature, and colour. All these questions were considered unnecessary as were asked after confirming that the patient was unconscious with no/ abnormal breathing, after which CPR instructions should have been provided. Thus, omitting unnecessary questions from T-CPR protocols and ensure dispatchers asking only necessary questions could improve time to first chest compressions.

Call processing and EMS systems can also influence time delay. Kim *et al.* (2020) evaluated the impact of hourly call volume received by EMS on OHCA calls and found that as the volume of calls increased, the time to provide T-CPR instructions became longer, which subsequently impacted the time to first compression. However, the call volume was defined as the number of calls without considering the duration of the calls. The call duration might have influenced how quickly the EMS responded to the calls and subsequently, influenced the time taken for the first compression. Further, difficulty in determining patients' locations/addresses by EMS dispatching system was also found to be a factor influencing the time intervals in two studies (O'Neill and Deakin, 2007; Lewis, Stubbs and Eisenberg, 2013). Therefore, it is crucial for the EMS dispatching centres to have sufficient staff to answer incoming calls and a well-established call tracking system to quickly identify patients' locations to subsequently, identify OHCA and guide chest compressions in a prompt manner.

Other factors relevant to callers (being emotionally unable to cooperate with the dispatchers, leaving or ending the call, and inability to move patients) (Lewis, Stubbs and Eisenberg, 2013; Chien *et al.*, 2019; Michiels *et al.*, 2020), the presence of agonal breathing (Case *et al.*, 2018), and the suspicion of seizures (Schwarzkoph *et al.*, 2020) were also found to influence the time intervals.

2. Factors influencing the recognition of OHCA

OHCA calls could involve factors that influence the ability of dispatchers to identify it. The literature has reported variations in the ability of EMS dispatchers to meet the AHA standards. A systematic literature review including 16 studies found a median sensitivity to dispatchers recognising OHCA of 73.9% (ranging from 14.1–96.9%) (Viereck *et al.*, 2017b). The factors influencing the proportion were varied across the studies and included factors relevant to language (e.g., words choices of callers), the presence of agonal breathing, and callers' responses (such as being emotionally unable to cooperate with dispatchers).

The language and word choices used by callers influenced the ability of dispatchers to identify agonal breathing, resulting in misrecognition of OHCA. Agonal breathing, which was found to be a main factor influencing OHCA recognition in such calls (Bang, Herlitz and Martinell, 2003; Vaillancourt *et al.*, 2007; Lewis, Stubbs and Eisenberg, 2013), was described by callers using a range of different words and phrases, including poor, difficulty, barely, and noisy breathing as well as snoring (Bang, Herlitz and Martinell, 2003; Berdowski *et al.*, 2009; Fukushima *et al.*, 2015). These wide descriptions might have impeded dispatchers' identification of agonal breathing or delayed its identification. These descriptions of agonal breathing often differ depending on callers' use of language (word choices and terms) or culture, which necessitates the need for each local EMS to explore how callers in the community are likely to describe agonal breathing to subsequently, enhance OHCA identification (Fukushima and Bolstad, 2020).

Further, semi-structured interviews with 24 dispatchers highlighted that one of the reasons for the misrecognition of agonal breathing is the poor description of breathing quality provided by callers (Jensen *et al.*, 2012); however, no further details on these descriptions were reported. Meanwhile, a study conducted in English by Riou *et al.* (2018b) analysed how callers used language (their choices of words and terminology) to describe and explain the breathing quality of OHCA patients and found variations in how callers answered questions about breathing. In patients with abnormal/ agonal breathing, many callers answered the breathing question (is he/she breathing) to confirm but provided additional descriptions such as 'yes but gasping'. Those types of answers were considered by the dispatchers as a 'yes' question to the presence of breathing, and thus, 63% of those OHCAs were misrecognised. This would suggest that the choice of language and how clinical questions are conveyed to callers is challenging and could impact the quality of T-CPR.

Other factors were also found to be relevant to OHCA misrecognition. Dispatchers deviating from T-CPR protocols used has been reported in several studies as a factor (Calle *et al.*, 1994; Kuisma and Määttä, 1996; Bång, Herlitz and Holmberg, 2000; Heward, Damiani and Hartley-Sharpe, 2004; Alfsen *et al.*, 2015; Hardeland *et al.*, 2016; Chien *et al.*, 2019). This could be due to their feeling that their clinical experience would lead to a better patient outcome, even though they were trained to follow the protocol (Hardeland *et al.*, 2016). Further, callers were also shown to be a factor by being emotionally unable to cooperate with dispatchers and or having lack of physical access to patients to exchange needed information with dispatcher (Eisenberg *et al.*, 1986; Culley *et al.*, 1991; Kuisma and Määttä, 1996; Bång *et al.*, 2002; Hauff *et al.*, 2003; Weslien *et al.*, 2005; Swor *et al.*, 2006; Vaillancourt *et al.*, 2007; Alfsen *et al.*, 2015; Viereck *et al.*, 2017a).

3. Factors that influence callers' initiation of CPR

Many factors influence whether a caller decides to undertake CPR when prompted to do so by the dispatcher. Studies show uptake to range between 9–85%, with the majority falling short of the AHA recommendation (75%) (Hauff *et al.*, 2003; Heward, Donohoe and Whitbread, 2004; Ma *et al.*, 2007; O'Neill and Deakin, 2007; Vaillancourt *et al.*, 2007; Lewis, Stubbs and Eisenberg, 2013; Clegg *et al.*, 2014; Dameff *et al.*, 2014; Fujie *et al.*, 2014; Huang *et al.*, 2017; Kim *et al.*, 2018; Riou *et al.*, 2018a; Syväoja *et al.*, 2018; Chien *et al.*, 2019; Lerner *et al.*, 2019; Michiels *et al.*, 2020; Zhang *et al.*, 2021). The interaction between a dispatcher and caller is key to determining whether the caller will perform CPR or not. The factors influencing caller CPR rate varied and included factors relevant to language (clarity of instructions and comprehension), callers, and the EMS system.

The clarity and language used in T-CPR instructions have been shown to be factors influencing callers' abilities to start performing CPR. In this context, Lerner *et al.* (2008) analysed OHCA in three USA dispatch centres to investigate T-CPR instructions. Callers' inability to understand T-CPR instructions was shown to be a factor influencing their agreement to perform CPR. Similarly, Dami *et al.* (2015) found that the difficulty in understanding T-CPR instructions prevented callers from performing CPR even though callers showed a willingness to perform it. However, this study and that of Lerner *et al.* (2008) have not provided qualitative data to explain why callers did not understand instructions. Here, the lack of clarity of the language used in the T-CPR instructions could be why callers could not understand the instructions. Meanwhile, Ho *et al.* (2016) reviewed OHCA call recordings in Singapore and found that unclear instructions and language barriers influenced callers' ability to perform CPR. However, the clarity of T-CPR instructions and the language barriers were not defined. Moreover, similar language barriers and comprehension were found in other studies (Hauff *et al.*, 2003; Lewis, Stubbs and Eisenberg, 2013; Michiels *et al.*, 2020). Thus, the clarity of T-CPR instructions has proven to be an important factor that determines the ability of callers to perform CPR. Therefore, the language should be clear and understandable for the lay callers so they can follow the instructions and perform CPR.

There are identified other factors that influence callers' ability to start performing CPR, including barriers preventing callers from talking to dispatchers (disconnecting the calls, inability to move patients, and being away from the patient), callers being emotionally unable to perform CPR, being afraid of harming patients, callers' beliefs (believing the patient is dead or alive, suggesting another intervention, and lack of CPR skills) and callers' refusal (Vaillancourt *et al.*, 2007; Lerner *et al.*, 2008; Lewis, Stubbs and Eisenberg, 2013; Clegg *et al.*, 2014; Dami *et al.*, 2015; Ho *et al.*, 2016; Riou *et al.*, 2018a; Chien *et al.*, 2019; Michiels *et al.*, 2020; Zhang *et al.*, 2021). Other factors were related to the EMS system and included the arrival of EMS crew prior to callers starting CPR or dispatchers not providing CPR instructions for unknown reasons (Hauff *et al.*, 2003; Lerner *et al.*, 2008; Lewis, Stubbs and Eisenberg, 2013; Riou *et al.*, 2018a).

<u>Summary</u>

Most EMS systems worldwide have been shown to fall short of the time standards recommended by the AHA to identify OHCA and to start the first compression. Also, many systems fall below these standards in regard to the proportion of recognised OHCA and callers' CPR rate. The factors influencing the quality of T-CPR were varied and included factors relevant to language and communication, asking unnecessary questions by dispatchers and the EMS systems. Noticeably, most of the studies were conducted in European and North American countries, and English was the main language used for these investigations. This has left a gap in knowledge in other contexts and languages. Further, only one study in Kuwait explored Arabic T-CPR instructions and revealed a very low OHCA recognition rate of only 12.9% with no exploration of the factors (Al Hasan *et al.*, 2019). Therefore, further investigation in other settings is required.

1.4.2.2 Optimisation of language used in T-CPR instructions to enhance CPR timeliness and quality performance

The timeliness and quality of CPR performed by untrained lay bystanders following T-CPR instructions are below the ILCOR and AHA standards (Cheung *et al.*, 2007; Ghuysen *et al.*, 2011; Asai *et al.*, 2018). This is because CPR instructions via the telephone are limited in their ability to be translated into effective actions (Deakin *et al.*, 2007). In this context, the ILCOR highlighted the influence of language in T-CPR as a knowledge gap that needs further investigation in order to improve T-CPR performance (Perkins *et al.*, 2015c; Olasveengen *et al.*, 2020). The knowledge gap included the influence of language on OHCA identification, time to first chest compression and quality of CPR performance. The word choices and terminologies in which the T-CPR instructions are written were highlighted in a scientific statement published by the AHA and are considered to have a potential impact on CPR timeliness and quality performance (Lerner *et al.*, 2012). In this context, Trethewey *et al.* (2019) found that resuscitation terminologies influence CPR performance, and modifying the terminologies used in T-CPR instructions could be one way to improve caller CPR performance (see Chapter 2). While there have been improvements, CPR timeliness and quality performance still fall short of the international resuscitation guidelines, and thus, further modifications of T-CPR instructions are needed.

Healthcare delivery involves the use of medical, anatomical, and technical terms that can be incomprehensible or difficult for laypeople (Chapple, Campion and May, 1997; Cooke *et al.*, 2000; Wolf *et al.*, 2007; Pieterse *et al.*, 2013; Barker, Reid and Minns Lowe, 2014; Rancher *et al.*, 2016; Gunn *et al.*, 2017; von Itzstein *et al.*, 2020; Weetman *et al.*, 2020). The use of plain language has been advocated by researchers and laypeople to improve understanding and communication in healthcare contexts (Jefford and Moore, 2008; Rancher *et al.*, 2016; Williams, Moeller and Willis, 2018; Elliott *et al.*, 2020; Tammy *et al.*, 2020; Weetman *et al.*, 2020).

Plain language is defined as communication that an audience can understand the first time they hear or read it (US Plain Language, 2004b; Garwood, 2014). It uses straightforward, clear, and simple words to ensure understanding while avoiding ambiguity and convoluted sentence construction (Mazur, 2000; Jefford and Moore, 2008). It also uses as few words as necessary to avoid unnecessary information (US Plain Language, 2004a). Further, plain language avoids using jargon, anatomical, technical, and clinical terms in the healthcare context (see Chapter 2) to provide the best possibility for an audience to analyse and understand the language (Garwood, 2014). Thus, allowing them to focus on the message rather than being distracted by complicated language (US Plain Language, 2004a). The International Plain Language Federation highlighted communication as plain language if the audience can easily understand and use the information being transferred (International Plain Language Federation, 2019). Thus, the term 'plain language' is an attempt to simplify the language (using simple language) for the audience (Garwood, 2014). However, language that is simple and easily understood by one group of people might not be the same for others (US Plain Language, 2004b). Thus, there is a need to involve the targeted audience when simplifying instructions, documents, or any other messages into plain language (see Chapter 2).

In the context of this project, the use of plain language in T-CPR clinical instructions may help remove ambiguity and increase the clarity of the instructions, and subsequently, improve callers' CPR timeliness and quality performance. The need to simplify the T-CPR instructions into plain language is also supported by the context where the instructions are provided, which are cognitively and emotionally demanding. Performing CPR while receiving and analysing the language is a cognitively complex task that involves working memory. Working memory is defined as the ability to store information in the mind and process this information while performing a task (Brito, Grenell and Barr, 2014; Cowan, 2014). However, many studies have suggested that the capacity of working memory differs between individuals leading to differences in the task performed (Daneman and Carpenter, 1980; Case, Kurland and Goldberg, 1982; Turner and Engle, 1989; Daneman and Merikle, 1996; Engle *et al.*, 1999; Conway *et al.*, 2002; Cowan *et al.*, 2006). In addition, the emotions experienced by people have been shown by many studies to influence their cognitive processes including perception, reasoning and memory (Isen, Daubman and Nowicki, 1987; Lupien and Lepage, 2001; Wolf, 2003; Phelps, 2004; Vuilleumier, 2005; Lupien *et al.*, 2007; Sandi and Pinelo-Nava, 2007; Jimenez-Ortega *et al.*, 2012; Um *et al.*, 2012; Jung *et al.*, 2014). Specifically, being under stress is associated with impairment of the working memory and cognitive function (Kirschbaum *et al.*, 1996; Mendl, 1999; Oei *et al.*, 2006; Cibrian-Llanderal, Melgarejo-Gutierrez and Hernandez-Baltazar, 2018). These factors have the potential to influence how callers receive and analyse the T-CPR instructions, and subsequently influence their CPR performance. Thus, simplifying T-CPR instructions to plain language could reduce the cognitive demands of this task, leading to better CPR performance.

A further consideration for this thesis is that most international resuscitation guidelines and articles are published in English (including the ILCOR). Therefore, non-English speaking countries may have to adapt how English instructions are translated and phrased to target the core meaning of each instruction. These changes require adding or deleting instructions to reach the core meaning (van Nes *et al.*, 2010; Al-Amer *et al.*, 2016). Further, the process of translation from one language to another could influence the quality of the instructions. Meanwhile, in Saudi Arabia, a T-CPR protocol was developed based on the ILCOR recommendations. However, the ability of callers to understand and interpret instructions and subsequently, perform prompt and high-quality CPR has not been explored. Thus, the study context of Saudi Arabia is explored in the following section.

1.5 Study context: the Kingdom of Saudi Arabia

The Kingdom of Saudi Arabia (KSA) was established in 1932, constituting around 80% of the Arabian Peninsula with over 2,150,000 km^2 (AlShammari, Jennings and Williams, 2017). The total population living in Saudi Arabia is approximately 33.4 million (General Authority for Statistics, 2018). The research described in this thesis was conducted in the capital city of Riyadh, which is the largest city in Saudi Arabia with a population of approximately 6.8 million (Saudi Geographical Survey, 2012). This section will highlight the potential association between language and culture in providing EMS care in Saudi Arabia. Additionally, the EMS system, including how calls are processed and T-CPR instructions provided, is also explored.

1.5.1 The Arabic language

Arabic is the official language of Saudi Arabia (Guellil *et al.*, 2019). The Arabic language can be classified into three forms: classical Arabic, modern standard Arabic (MSA), and dialect. The classical Arabic is the language of the Quran and literary text (literature). The MSA (known in Arabic as *Fusha*) is a modernized equivalent of classical Arabic (Rakhlin, Aljughaiman and Grigorenko, 2020). MSA is mainly used in formal conversation and writing such as in academic institutions and official news or media (Guellil *et al.*, 2019). The last form is dialect (known in Arabic as *al-'Ammiyya*), which is typically an oral rather than written form of language used in informal communication and daily conversation (Al-Amer *et al.*, 2016). Socially, there are three subdialects that are recognised within the same area: city residents, village dwellers, and Bedouins (Al-Amer *et al.*, 2016). Thus, a dialect could not be comprehended by all people living in a country, as each region/group of people has their own dialect (بوديريانتو, 2020). The differences in dialects include differences in terms and word choices (بوديريانتو, 2020). As Saudi Arabia is a large country, there are many dialects.

The T-CPR instructions in Saudi EMS are written in MSA, which might influence the ability of callers to comprehend and understand the instructions, as it is not used in daily conversation. Comprehension of MSA could be particularly challenging when received in a stressful situation, such as calling about an OHCA (Mendl, 1999; Cibrian-Llanderal, Melgarejo-Gutierrez and Hernandez-Baltazar, 2018). Therefore, it is important to measure how the language used in Saudi T-CPR instructions influences the quality of CPR performed by callers.

1.5.2 Cultural context associated with pre-hospital care

Saudi Arabia, just like any other country, has its own traditions and cultures. A notable part of this culture is the role of sex segregation, which is present in most of the daily activities in Saudi Arabia, including those in schools, universities and most workplaces (Almalki, 2020). It is important to note this since it could have an impact on the EMS system in Saudi Arabia. In this context, in an observational study, Hamam *et al.* (2015) reported that 17.7% of the participants refused the provision of EMS care provided by male paramedics to female patients in the absence of a male guardian. A further study reported that 20–30% of participants did not contact EMS in an emergency as they did not want a male paramedic to treat a female patient (Alharthy *et al.*, 2018). Thus, cultural norms could influence the ways in which bystanders assess or perform chest compression when they were asked by a dispatcher during T-CPR.

Cultural considerations might also influence the design of research studies. Many Saudi women do not interact with men who are unknown to them (Altorki, 1986; AlMunajjed, 1997; Le Renard, 2008). While many women might be willing to engage in conversations and participate in some forms of research (e.g., completing a questionnaire), others may not consent to participating in studies that require them to actively interact with men (e.g., performing a physical task such as CPR). Such cultural considerations require adapting research designs to ensure that women are more willing to participate (see Chapter 3).

Another cultural and public belief that could influence pre-hospital care is the transportation of patients using private cars. Corony and Scott (1999) and Bin Salleeh *et al.* (2015), who investigated OHCA cases, reported that 86.2% and 53.1% of the included patients were transported using family or private cars, compared with only 13.8% and 35.5% by EMS crews, respectively. Along similar lines, AlHabib *et al.* (2016) compared the EMS and non-EMS transportations of patients complaining of acute ST-elevation myocardial infarction in Gulf countries, including Saudi Arabia, and found very low proportions of the use of EMS transportation at only 3.7%. AlShammari, Jennings and Williams (2017) explained this as a Saudi cultural habit to help people who are in need and thus transporting patients using private car, with the thought process that they are helping them. However, this might also be linked with other factors than just culture, such as socioeconomic status, public awareness and also education (Alanazi, 2012; AlHabib *et al.*, 2016). Transporting patients using private cars could interrupt the process of T-CPR when a dispatcher asks a caller (who is either the driver or another person in the same car) to assess the patient or perform CPR. In this case, the dispatcher might ask the driver to stop the car to assess or perform CPR, thus causing delay.

Another cultural habit is to not undergo BLS training if it is not a mandatory requirement. Unlike other countries where CPR courses are mandatory prior to, for example, having a driving license or being enrolled in some jobs; they are also integrated into secondary school curricula, such as those in Japan, Norway, and Austria (Kuramoto *et al.*, 2008; Rajapakse, Noč and Kersnik, 2010; Sipsma, Stubbs and Plorde, 2011; Chair *et al.*, 2014; Özbilgin *et al.*, 2015; Bray *et al.*, 2017). However, until the current time, CPR training courses are not a mandatory requirement in Saudi Arabia, except in a very few workplaces, such as some hospitals (Qara *et al.*, 2019). As a consequence, community CPR knowledge and awareness have been found to be poor in several studies (Al-Turki *et al.*, 2008; Alanazi *et al.*, 2013; Al-Turkistani, 2014; Al Enizi *et al.*, 2016; Al-Musa *et al.*, 2017; Ahmad *et al.*, 2018; Owaid Alsharari *et al.*, 2018; Sheikho, Alyahya and Alzahrani, 2018; Qara *et al.*, 2019; Al Haliq *et al.*, 2020). Although not undergoing BLS training might be found in other cultures, its influence in Saudi Arabia are likely to be greater, as the bystander CPR rate was found to be lower than the international bystander CPR rate average. This low level of CPR knowledge could make it difficult for bystanders to identify OHCA, understand T-CPR instructions, and subsequently, promptly perform high-quality CPR. Therefore, exploring the role of dispatchers in identifying OHCA and guiding callers to promptly perform CPR in current practice and how the language of instructions influences the quality of CPR performance is vital to improve the survival rates in Saudi Arabia.

1.5.3 Saudi Arabian EMS: Saudi Red Crescent Authority

EMS in Saudi Arabia is maintained by the Saudi Red Crescent Authority (SRCA), which is free of charge for citizens and residents of the Kingdom. The SRCA is responsible for all pre-hospital care calls across the country, with minor exceptions—for example, catchment zones of the military sectors, some medical city hospitals, and large companies that respond to their employees and residents on their own (AlShammari, Jennings and Williams, 2017). The SRCA responds to all types of pre-hospital healthcare, ranging from minor to life-threatening injuries, including cardiac arrests. It consists of 384 stations covering all areas in Saudi Arabia (Saudi Red Crescent Authority, 2015). The central region of Saudi Arabia, also called Riyadh province, is maintained by more than 77 ground ambulance stations of the SRCA (Saudi Red Crescent Authority, 2015). The ambulance crews are manned by physicians, paramedics, and emergency medical technicians. In 2015, the SRCA ambulances in Riyadh responded to 102,308 cases (approximately 280 cases per day), of which 2,468 were urgent cardiac conditions (Saudi Red Crescent Authority, 2015).

The work done by the SRCA might be influenced by the lack of publications on the key performance indicators that would help improve their quality (AlShammari, Jennings and Williams, 2017). More specifically, till date, there has been no published data about OHCA calls in Saudi Arabia with no national OHCA registry. The lack of these data could influence the quality of the associated T-CPR, as there is a lack of quality assessment and improvement.

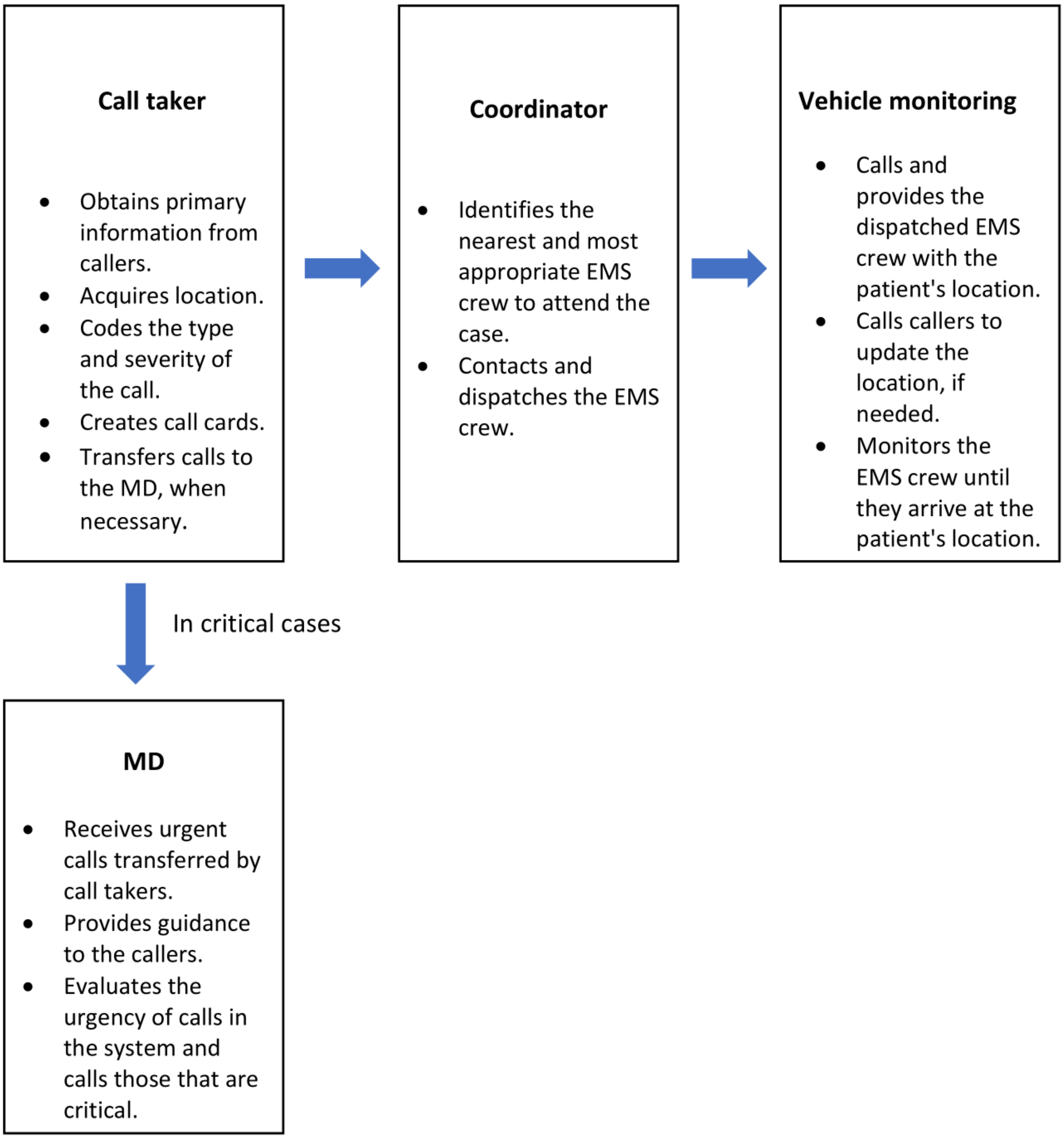
Meanwhile, a limited number of publications have identified areas for improvement to improve the survival rates. A recent population-based registry study compared the SRCA ambulance response times between urban and rural areas in Riyadh province and reported an overall median of 17 minutes and 17.6 minutes, respectively (Moafa *et al.*, 2020). Another study by Alnemer *et al.* (2016) measured the SRCA ambulance response time for cardiac emergencies in Riyadh city and revealed an average of around 13.2 minutes (standard deviation 7.9 min). This is longer than the 5–8 minutes reported by most EMS systems worldwide (van Alem *et al.*, 2003; Weisfeldt *et al.*, 2010; Fothergill *et al.*, 2013; Perkins *et al.*, 2015b). While bystanders wait for the ambulance, the dispatcher might ask them to provide first aid, including T-CPR. This will lead to them performing CPR for a longer period, which could cause fatigue prior to ambulance arrival resulting in low CPR performance (Hightower *et al.*, 1995; Ashton *et al.*, 2002; Heidenreich *et al.*, 2006). In addition to the prolonged response time, the public access defibrillator (PAD) is still not well established in

Saudi Arabia. A survey was conducted to explore CPR awareness and AED availability in Saudi malls and reported that 100% of the participants (N = 207), who are administrators and security personnel, agreed that there was a lack of AED in the workplaces (Al Haliq *et al.*, 2020). Ambulance response time and AED have the potential to improve survival rate (Berdowski *et al.*, 2009; Blom *et al.*, 2014; Ringh *et al.*, 2015; Holmén *et al.*, 2020), However, they are not well established in Saudi Arabia. Therefore, enhancing the EMS system, including the T-CPR instructions in Saudi Arabia, is critical to improving the survival rate.

1.5.3.1 The process of receiving and managing calls to the SRCA

All calls received by the SRCA are triaged using algorithms and guidelines in the Saudi Red Crescent Computer Aid Dispatching system (Moafa *et al.*, 2020). Based on the urgency of the call, the appropriate ambulance crew is dispatched to the patient. The call process from call receipt until ambulance arrival for patients is achieved through three main stages with the assistance of a medical director (MD) if necessary. The three stages and the MD’s role are explored in the following sections and summarised in Figure 5.

Figure 5. A flow diagram of the three stages representing the call process at the SRCA and the MD's role.



First stage: call taker

The call taker, who is not necessarily clinically trained, answers the call. The call taker routinely asks a set of primary questions to identify the type and severity of the call and then identifies the caller's location. The primary questions are as follows (these are approximate translations from the Arabic language and not indicative of actual word choices):

- Are you the patient or the caller?
- Is the patient conscious?
- Is the patient breathing?

- What is the gender of the patient?
- Approximately how old is the patient?
- What is the nature of the injury?
- Which body part is affected (asked in trauma cases)?
- Is the patient trapped?

While the SRCA has a tracking system that can automatically locate the caller's location by identifying the nearest mast receiver (for mobiles) or building (for landlines), many call locations are not identified (for example, due to the quality of the call tracking system). In such cases, the call taker will ask callers to describe their location, which could be time-consuming if callers cannot accurately describe their location. This process might influence the T-CPR by causing a delay in its initiation. However, more recently, the SRCA has developed a system for cases when a caller cannot describe their location—a text message is sent to the caller with a link to share the location. Another recent method is by using the national address details. Each resident (e.g., flat and house) has a specific national address (that contains several digits and a street name), which the SRCA can use to identify their location.

Once the primary questions have been asked and the location identified, the call taker will code the type of the call (e.g., cardiac and respiratory) and the severity (minor, moderate, or severe), and then create an electronic call card. The call card, which includes all the data the call taker obtained from the caller, will then be automatically sent to the second stage.

Second stage: coordinator

The coordinator is a person who receives all call cards from the call takers, then triages and contacts the appropriate available EMS crew, and accordingly, dispatches them. The call card will then be sent to the third stage to provide the ambulance crew with the patient's location.

Third stage: vehicle monitoring

The vehicle monitoring role provides the dispatched ambulance crew with patients' locations and, when necessary, calls the callers again to further describe their location if, for example, the location was inaccurate or incorrect. The vehicle monitoring person continues to organise contact between the dispatched ambulance crew and patient until the ambulance arrives.

Prior to ambulance arrival, callers will receive instructions to provide first aid, if necessary, to patients, and this includes T-CPR. The related instructions are provided by the MD.

The MD and T-CPR instructions

Call takers routinely transfer critical calls, including suspected OHCA calls, to MDs who are available 24/7. The MD has also access to all call cards in the system and can subsequently contact any caller to provide pre-arrival instructions; for example, when an MD suspects that the patient needs an urgent intervention, but the call was mistakenly not transferred by the call taker. Transferring the calls from call takers to MD might be time consuming and therefore delay urgent intervention, such as the provision of T-CPR instructions.

The SRCA uses a T-CPR protocol (see Appendix C) that was developed in late 2016 by the MDs and was derived from the ILCOR recommendations. The protocol starts with primary questions to investigate more about the call, such as asking about patient's age, scene safety, and then about consciousness and breathing quality to check if CPR instructions are needed. The MD will then deliver CPR instructions or other suitable instructions according to the patient's situation. As explained in 1.4.2, T-CPR protocols are different worldwide, and some are not published due to possible commercial reasons, and there is no standard T-CPR protocol to be compared with the Saudi T-CPR protocol. However, the study by Rasmussen *et al.* (2020), which compared T-CPR protocols across ILCOR member countries, showed that some ILCOR countries use different instructions to those used in Saudi Arabia. These differences included using 'push as hard as you can' to guide the depth of compression, asking the dispatcher to check agonal breathing and providing regular engorgements during CPR. However, Rasmussen *et al.* (2020) also showed similarities including checking the consciousness and breathing to identify OHCA, asking callers to activate speaker function, guiding hand position using the instruction 'centre of the chest' and providing chest compression only CPR instructions.

Till date, the use of the T-CPR protocol has not been reported in Saudi Arabia. Thus, the proportions of OHCAs that are correctly identified by the MDs, the time taken to identify OHCAs and to start first chest compression along with callers' willingness to perform CPR might be below the AHA standards. Also, the ability of callers to understand and correctly interpret T-CPR instructions and then promptly perform high-quality CPR has not yet been examined, which could also be below the ILCOR standards. Therefore, it is important to conduct this research to explore the T-CPR protocol in current practice in Saudi Arabia and investigate how modifications to the language used in T-CPR instructions could improve CPR timeliness and quality performance.

1.6 Aim and objectives

The aim of this project is to improve CPR timeliness and quality by investigating the nature of OHCA calls and the T-CPR protocol in current practice in Saudi Arabia and test and evaluate possible language modifications to T-CPR instructions.

The objectives are to:

1. Evaluate the quality of the Saudi T-CPR protocol (time to recognise OHCA and to start first chest compression, OHCA recognition rate, and caller CPR rate) in the current practice in Saudi Arabia.
2. Investigate the factors that influence the quality of the Saudi T-CPR protocol in current practice in Saudi Arabia.
3. Describe the basic characteristics (gender, nationality, and relationship of callers and patients) of OHCA calls in current practice in Saudi Arabia.
4. Measure the CPR timeliness and quality performance of participants receiving instruction using the Saudi T-CPR protocol in OHCA simulation sessions.
5. Explore facilitators and challenges of the Saudi T-CPR protocol that influence CPR timeliness and quality performance in OHCA simulation sessions.
6. Explore the language of the Saudi T-CPR instructions (e.g., word choices and clarity), which influences CPR timeliness and quality performance in OHCA simulation sessions.
7. Develop, test, and evaluate the impact of an enhanced version of T-CPR protocol to improve CPR timeliness and quality performance in OHCA simulation sessions.

1.7 Summary

OHCA is a global, major, and critical health problem that has a low survival rate. Prompt initiation of high-quality CPR by bystanders has the potential to double or quadruple the survival rate. ILCOR has recommended providing T-CPR instructions during suspected OHCA calls to improve survival rate. Nevertheless, the current timeliness and quality of CPR performance following T-CPR instructions that have been reported in the literature suggests that they are still below the AHA and ILCOR standards. Adapting the terminology used in the T-CPR instructions could be one of the limited modifiable factors that can influence caller CPR performance—for example, using plain language to avoid ambiguity (e.g., avoiding anatomical terms and technical phrases).

Saudi Arabia is a particularly interesting context in which to study this topic because there is limited data regarding the OHCA survival rate. Whilst a T-CPR protocol is currently in use in Saudi Arabia, there is no research about how the protocol is used in current practice (timeliness, OHCA recognition rate, and caller CPR rate) or whether callers are able to understand and correctly interpret the Saudi T-CPR instructions to promptly perform high-quality CPR.

1.8 Thesis outline

This PhD thesis consists of six chapters, including this 'Introduction' chapter. Chapter 2 reviews the literature regarding plain language and language modifications to T-CPR protocols. Chapter 3 sets out the sequential mixed-method design, the data collection methods, analysis, and ethical considerations of the study. Chapter 4 and Chapter 5 report the findings of the study (the findings from an observation of current practice are presented in Chapter 4, followed by the before-after simulation study in Chapter 5). Chapter 6 is the concluding chapter, which reviews the key findings of the study in the context of the current literature. The strengths and limitations are discussed, and the implications of the research and research recommendations are highlighted.

Chapter 2 Literature review of plain language and the use of T-CPR instructions

2.1 Introduction

The introduction chapter highlighted the difficulty of clearly and simply communicating information and instructions in healthcare contexts. Clearer T-CPR instructions have the potential to improve CPR timeliness and quality performance. Therefore, the purpose of this chapter is to examine the existing literature relevant to the use of plain language in health contexts and language modifications in T-CPR instructions. The overall literature review comprises two parts, each with a different search strategy. The first aims to assess the influence of plain language within healthcare contexts on the understanding and communication between patients and healthcare professionals. The second aims to review the evidence about how modifications to language used in T-CPR instructions might improve the timeliness and quality of bystander CPR.

The chapter starts by describing the search strategy and screening process used to select articles for inclusion. Identified articles are organised to: 1) developing plain language in the healthcare context to improve comprehension and understanding for patients and laypeople; and 2) language modifications to T-CPR instructions to enhance CPR timeliness and quality performance of bystander. These aims were investigated in detail and suggested the knowledge gap in T-CPR instructions and how to apply plain language to them to enhance CPR timeliness and quality performance.

2.2 Search strategy and inclusion criteria

Two literature searches using a systematic method in accordance with PRISMA guidelines (a set of items used to improve the reporting of the identified studies) (Moher *et al.*, 2010) were conducted to identify articles relevant to the search aims. As they had distinct aims, different sets of keywords, along with their synonyms, were identified to run the searches. Moreover, a truncation symbol, such as (*), was used where necessary at the end of the keywords and synonyms to explore the different forms of the word. For example, using 'guid*' to search for the different forms such as guide, guidance, and guideline. Three major health electronic databases (CINAHL, MEDLINE, and EMBASE) were used in this search. The systematic search was conducted by combining the keywords and synonyms together using 'OR', and then grouping them into a different search using 'AND'.

Plain language in healthcare contexts

This literature search aimed to identify and synthesise the existing literature on using plain language in the healthcare context and how it might improve patients' understanding and comprehension in healthcare. To this end, inclusion and exclusion criteria were developed (see Table 2) to ensure that relevant articles were included. The inclusion criteria focused on including plain language that was used in healthcare contexts, as T-CPR is within the healthcare context. Papers with a focus on language disorders and communication for people with disabilities (e.g., hearing loss) were excluded as they are less relevant to the focus of this thesis. Further, research was included if the outcome measures were relevant to the influence of plain language on communication, understanding, and performing a physical task. Other outcomes, such as evaluating the satisfaction of patients and physicians in using plain language and how to train novices to use plain language, were excluded.

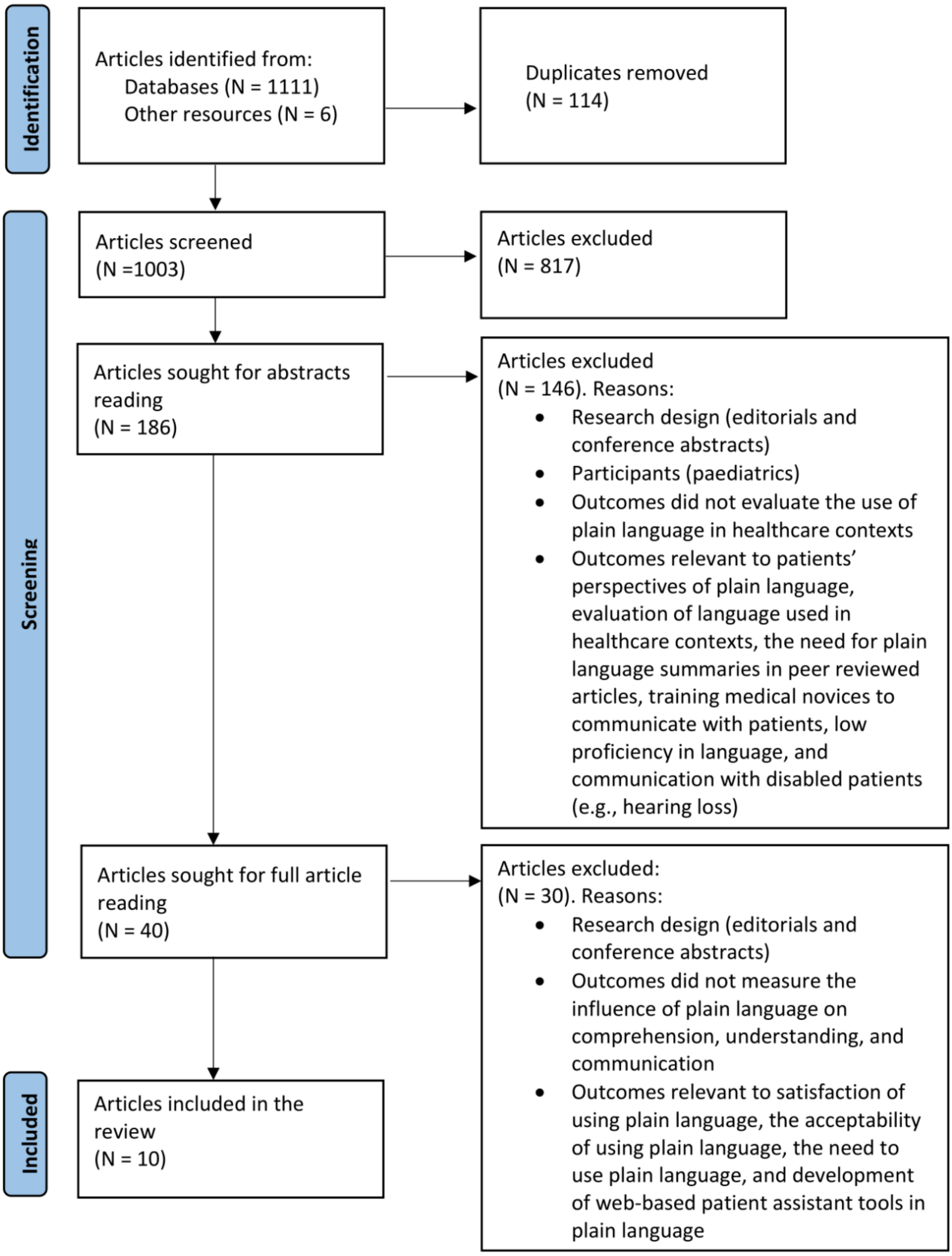
Table 2. Inclusion and exclusion criteria for the plain language search strategy

Criteria	Inclusion	Exclusion
Focus:	Plain language in healthcare contexts such as in consent forms and medication instructions	Studies relevant to speech, aphasia, technology, delivering bad news, low language proficiency, language disorder (e.g., child language disorder), how to communicate with patients with disabilities (e.g., hearing loss, mental illness), using picture to improve understanding, how to design a leaflet or brochure (e.g., using font size), body language (e.g., facial expression), and any other irrelevant focus of plain language
Study design:	Primary research	Editorials, opinion pieces, conference abstracts, and secondary research
Participants:	Adult healthcare professionals, patients, or laypeople	Paediatrics
Study settings:	All countries	None
Outcome measure:	Any outcome relevant to comprehension, understanding, communication, or physical performance	Outcomes relevant to the exclusion focus. Satisfaction and accessibility of using plain language, training medical students to use plain language, plain language summaries of peer-reviewed studies, and any other irrelevant outcome on comprehension, understanding, communication, or physical performance
Language:	No language restrictions	None
Date:	As far as the databases go until 31/05/2021	None

This literature search followed the SPICE model (an acronym used to formulate questions for finding evidence in existing research) to create key words (Cleyle and Booth, 2006). These key words were searched for in the three databases in addition to the synonyms provided by these databases (e.g., MeSH terms). The key terms included ‘healthcare’, ‘telemedicine’, ‘plain language’, ‘simplified language’, ‘understanding’, and ‘communication’. Other search terms and synonyms are provided in Appendix D.

The initial search identified 1111 publications in the three databases, combined with six articles from other resources. The PRISMA guidelines were then applied to identify all relevant articles (see Figure 6). First, duplicates were removed then screening the titles of all articles to determine if they met the inclusion criteria was completed (see Table 2). This resulted in a total of 186 articles, in which the abstract was read in full to ensure that they were relevant. Following this step, 40 full articles were retrieved for detailed reading to ensure that they met the inclusion criteria. Finally, 10 articles were included in this review of plain language in healthcare contexts. Further, no other relevant articles were identified by checking the references and cited articles

Figure 6. Flow diagram of the PRISMA guidelines used to identify plain language articles.



Language modifications to T-CPR

The second literature search identified and synthesised evidence about language modifications to T-CPR instructions in relation to the CPR timeliness and quality of performance of untrained bystanders (Table 3). The focus included any article that focused on the use of T-CPR instructions. This search excluded articles relevant to the use of AED and CPR education and retention as they are beyond the scope of this search. Paediatric articles were also excluded as the T-CPR instructions for adults, which are the focus of this PhD, are different than children. Finally, the studies were included if the outcomes were to measure CPR timeliness and quality performance following language modifications.

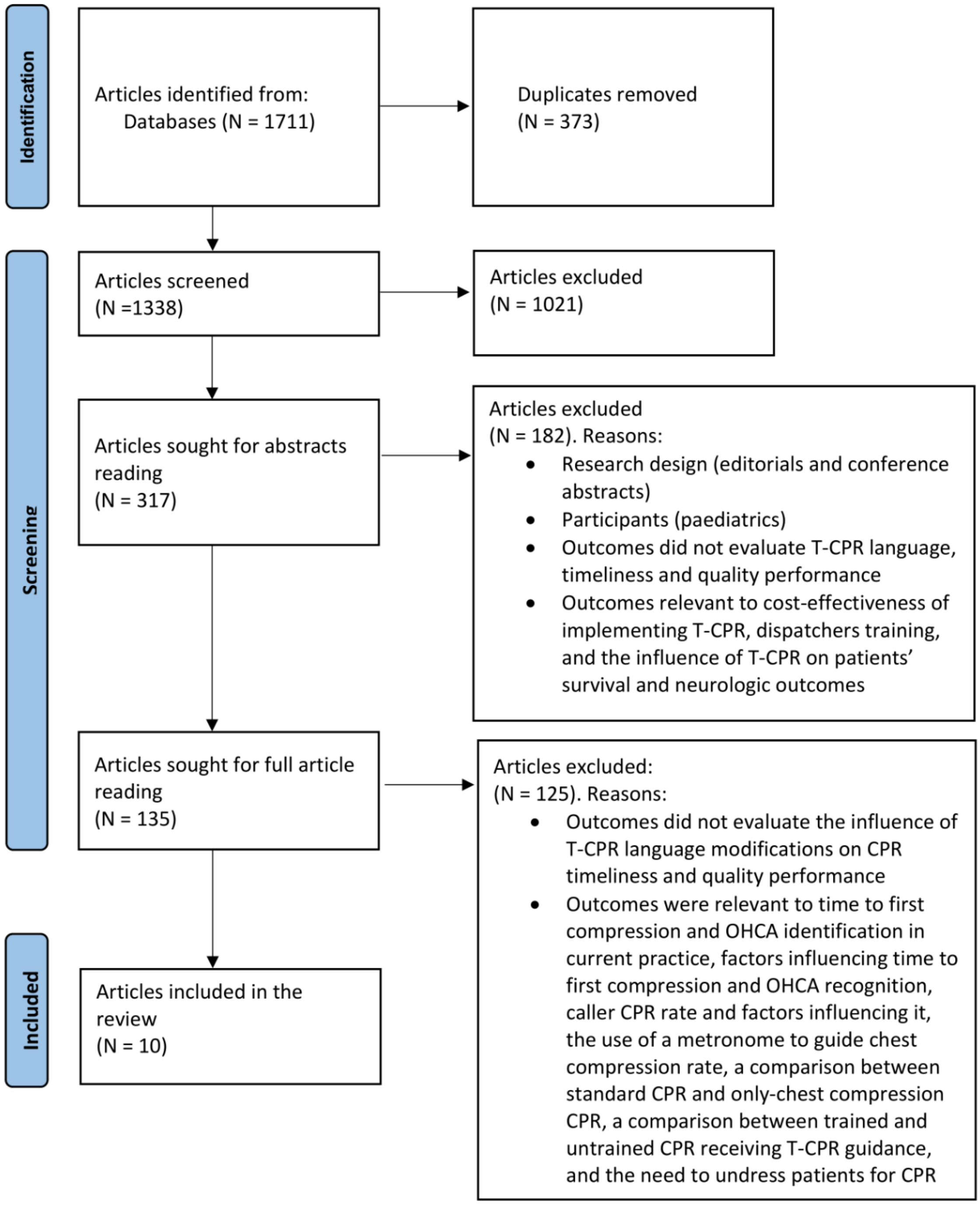
Table 3. Inclusion and exclusion criteria for the language modifications to the T-CPR instructions search strategy

Criteria	Inclusion	Exclusion
Focus:	The use of T-CPR instructions	The use of AED, CPR education and retention, extracorporeal CPR, and telemedicine in other health cases (e.g., heart failure).
Study design:	Primary research	Editorials, opinion pieces, conference abstracts, and secondary research.
Participants:	EMS dispatchers/call takers and adult patients, callers, and participants.	Paediatric patients, callers, and participants
Study settings:	All countries	None
Outcome measure:	The influence of language modifications on CPR timeliness and quality performance	Feasibility to implement T-CPR protocol, cost-effectiveness, influence of video as compared to audio EMS calls, dispatchers' training tuitions, comparison between standard CPR and chest-compression-only CPR, the use of metronomes, the influence of T-CPR on survival outcomes, the quality of T-CPR performance in current practice as well as any other outcome did not measure the influence of language in relation to CPR timeliness and quality performance
Language:	No language restrictions	None
Date:	As far as the databases go until 30/05/2021	None

The literature search used general key words and synonyms regarding T-CPR to capture all relevant articles to T-CPR instructions including language modifications. The key words included ‘dispatch’, ‘telephone’, ‘CPR’, ‘chest compression’, ‘instructions’, and ‘protocol’. The full table of search terms and synonyms are provided in Appendix E.

The initial search resulted in 1711 articles. Similar to the first search process, PRISMA was followed, and the inclusion and exclusion criteria were applied, which narrowed the search down to language modifications. Ten articles were finally included in this literature review (see Figure 7). Further, no other relevant articles were identified by checking the references and cited articles.

Figure 7. Flow diagram of the PRISMA guidelines to identify articles that focus on language modifications to T-CPR instructions.



After reading the full articles, themes for each literature search were generated and extracted. While reading the articles in their entirety, information about each article was extracted and similar articles (e.g., in methodology or primary outcomes) were then grouped together to form a theme. The themes were generated to articulate the current evidence relevant to the two literature searches aims.

Approach taken to critically appraising the quality of the literature:

All of the articles included were read in full and the relevant information was extracted. General rules for critically appraising the quality of an article were followed (Burls, 2014; Alderson, 2016; Pinchbeck and Archer, 2020). These included checking the research question/aim (e.g., was it clear and appropriate?), study design (e.g., was it appropriate to achieve the aim/question?), internal validity (e.g., risk of selection/ sampling bias and sufficient statistical power), applicability (e.g., were the participants representative?) and outcomes (e.g., outcomes measures). The quality of the included studies is critiqued in the following sections, and the relevant information is summarised in Appendix F and Appendix G. However, as this review is not a systematic literature review and meta-analysis study, no scoring system to quantify the quality was conducted.

2.3 Developing plain language in healthcare contexts to improve comprehension and understanding for patients and laypeople

The use of plain language has been evaluated in a wide range of healthcare contexts. Some literature has assessed the acceptability of plain language for patients or the lay public, including the development of web-based patient assistant tools (Topac and Stoicu-Tivadar, 2013; Alfano *et al.*, 2020; Langford, Studts and Byrne, 2020) and guidance for healthcare professionals to assist communication with patients (van der Giessen *et al.*, 2020) as well as the production of plain language summaries of peer-reviewed clinical articles (Pushparajah *et al.*, 2018) and public health education materials (Rudd *et al.*, 2004; Otal *et al.*, 2012). However, these studies did not measure whether plain language was associated with better understanding or communication with laypeople, and are thus beyond the scope of this literature review. This section focuses more specifically on studies that assessed whether plain language was associated with laypeople's understanding of health-related information as compared to the language used in healthcare. The modifications made to the language, which are discussed in the following sections, are summarised in Appendix F.

Plain language used in written public health information

Health information (e.g., documents) designed for a public audience aims to provide evidence-based recommendations about a health subject. Such information is often designed to ensure that it is easily understood by using simple and clear language. In this context, McCormack et al. (2016) conducted a randomised experiment in the USA to test the effectiveness of using plain language in a public safety message regarding a smoking cessation medication published by the US Food and Drug Administration in comparison to the use of standard language of the message.

The revised information was developed using plain language (following recommendations from (US Plain Language, 2004b)), clear communication (following recommendations from (Centers for Disease Control and Prevention, 2014)), and principles of health literacy that included simplifying the reading level (e.g., by using short sentences), format, and design (e.g., sub-headings). Further, participants who received the revised version (N = 624) answered significantly more questions regarding comprehension of the instructions compared to those who were given the standard message (N = 620) at 63% and 52% ($p < 0.001$), respectively. More participants in the revised version group agreed that the message was clear as compared to the standard message at 82% and 73% ($p < 0.001$), respectively. However, this study lacks detail about exactly how the language was simplified to plain (e.g., whether or not familiar words were used).

Along similar lines, Michie and Lester (2005) simplified the public clinical guidelines for schizophrenia issued by the National Institute for Clinical Excellence, which provides information about psychological and medical treatment. The plain language form included avoiding highly technical language and a negative/alarmist approach. The message was personalised by using active verbs and appropriate numerical information. The layout of the two forms was similar except that the plain form used headings, bullet points, and boxes with key points. Participants receiving the plain language form showed greater intention to use it in the future and more positive attitudes toward the value of the information in terms of decision-making. They also found it more helpful to make decisions as compared to the standard form. However, there was no difference in comprehension or satisfaction between the two forms. Similar to that of McCormack et al. (2016), this study also provided little detail about exactly how the plain language was modified—for example, how highly technical terms were identified. It also lacks clarification of where the alternative terminologies were drawn from, which might not be the optimal option for the targeted audience. More importantly, none of the participants were diagnosed with schizophrenia and were therefore, not the targeted audience, which might have influenced the extent to which people understood the findings. Involving the target audience in suggesting modifications to health information might have the potential to improve written health information.

Plain language used in designing consent forms

Consent forms should include sufficient information about the clinical study to ensure that participants understand the information and make informed decisions about whether to take part in research (Kao *et al.*, 2020). The use of plain language in designing consent forms for clinical trials has been evaluated and has been shown to result in an improved understanding of the consent content.

In a quantitative study, Kim and Kim (2015) randomly assigned 150 participants to receive either a standard consent form (N = 75) of cancer clinical trials used in two university hospitals in South Korea or a simplified version of this form (N = 75). The simplified version included using plain language, fewer words, sentences, and characters in addition to other layout changes (e.g., larger font size and using pictures). To validate the content of the consent form, three expert investigators in chemotherapy and two members of an ethical review board reviewed the form. The final version of the simplified form was developed based on feedback from five laypeople. Participants' understanding of the consent forms was measured using the Quality of Informed Consent tool (Joffe *et al.*, 2001), which is a questionnaire answered by participants. In the end, it was found that the simplified form significantly improved participants' actual ($p = .001$) and perceived ($p = .001$) understanding levels of the consent content as compared to the standard form. Further, the simplified form was associated with better understanding of the experimental procedure, alternative treatments as well as health and procedural information. Participants were family members of cancer patients but did not include patients with cancer (who are actual users of this form in real life). Additionally, both the language and the layout were modified, so the impact of these two distinct influences is unclear. Similar findings were found in another study (Young, Hooker and Freeberg, 1990), where a consent form was amended to reduce the reading level by using familiar lay terminologies, less jargon, shorter sentences, and an improved layout. The level of comprehension was assessed using a multiple-choice question test and followed-up with a question to rate the difficulty of understanding. The comprehension significantly ($p < .005$) improved when the amended form was used as compared to the standard one (with means of 14 and 13.4 correct answers, respectively). Participants also reported that the amended form was easier to understand (64%) than the standard form (33%).

Conversely, Davis *et al.* (1998) simplified a breast cancer clinical trial consent form and found no improvement in comprehension. The simplified form was brief, direct, avoided jargon, and written in plain English as well as presented in a clearer format (e.g., coloured headers and graphics). Prior to commencing the study, patients' feedback regarding the simplified form was received, and then the final version was developed. Interviews were conducted using oral questionnaires with 183 participants (114 for simplified and 69 for standard) to test comprehension. Following the interviews, the participants received the alternate form and were asked about their preferences regarding the forms. The findings found no differences in comprehension between the simplified and standard forms at 58% and 56%, respectively. However, 62% of participants preferred the simplified form ($p = .003$), and almost all of them (97%) thought it was easy to read ($p < .0001$). However, the participants did not include people with breast cancer, and therefore, they were not candidates for the trial. Thus, they may not reflect those actually considering taking part in the trial, who might be more anxious, and who find reading consent forms more challenging in reality. Additionally, the validity of the questions asked by interviewers was not tested to ensure that they appropriately assessed the comprehension, which might have influenced the findings. However, this study can be used to highlight the difficulty of rewriting a health-related document in plain language to improve comprehension.

Although the literature on consent forms might be different from the T-CPR instruction context, they share some similar principles. Consent forms use medical, anatomical, and technical phrases and include information about experiments and procedures. Similarly, the T-CPR instructions include similar terms to explain how to perform CPR. However, there are some differences that might not be transferred, such as the layout modifications (e.g., larger font size). Further exploration of similarities and differences is discussed later in this section.

Plain language used in medication instructions

The use of plain language has also been used and evaluated in the content of information designed to improve medication instructions and labelling. Medication instructions usually include procedural and health information that patients need prior to taking medication. For example, dosage instructions about how a medication should be taken as well as the frequency and the number in each intake (e.g., two pills twice daily) (Maghroudi *et al.*, 2020). It also includes supplementary advice (e.g., take with milk or food) and warnings (e.g., do not drink alcoholic beverages) (Maghroudi *et al.*, 2020). Therefore, they must be written in clear language to avoid misinterpretation and medical harm.

In this context, Ancker *et al.* (2017) conducted a randomised experimental study in the USA to measure parents' and caregivers' comprehension of revised plain language instructions of a paediatric medication as compared to the standard version. The plain language instructions included the following: 1) replacing unfamiliar terms, jargon, and abbreviation with familiar terms and explaining unreplaced medical terms; 2) performing computation (e.g., replacing 'every X hours' with recurrent events such as in the morning or mealtime); 3) breaking down the complex sentences that contain multiple instructions; 4) using active voice; and 5) using illustrations. The participants were randomly assigned to the plain (N = 471) or standard (N = 480) instructions groups and subsequently, received 15 online questions that measured their comprehension of the information. The plain language group showed better comprehension as they answered more questions correctly than the standard group with means of 9.4 and 8.3 questions, respectively ($p < .01$). The study also found a significant reduction in responses leading to the risk of underdosing (but not overdosing) when the plain instructions were followed as compared to the standard instructions with means of 2.1 and 3.2, respectively ($p < .01$). However, the study did not explain how the modifications to language were developed—for example, where the familiar words were drawn from or how complex sentences in the standard version were identified. Further, the questionnaire was not tested to ensure that it measured comprehension. Similar findings were found in studies on drug labelling (Wolf *et al.*, 2010; You *et al.*, 2011; Mohan *et al.*, 2014). These studies include some concepts that have implications for T-CPR. Explaining the process of taking a medication (e.g., how, when, and how many) and medical information—such as side effects and risks, which are often written using medical, technical and anatomical phrases—might be similar to having to explain a clinical procedure such as CPR. However, using pictures in medication labelling and modifying the layout of written information are clearly not transferable to the T-CPR context. The section 'Transferability of plain language to T-CPR context' below explores further similarities and differences.

Plain language used to improve the performance of a physical task

Improving people's understanding of a set of instructions is associated with enhancements in the performance of physical tasks. Smith and Wallace (2013) developed a plain language version of instructions to measure how participants would interpret them. Standard medication instructions that described how to self-administer an auto-injector pen were simplified into plain language and then distributed to 50 participants using priori random assignment (N= 24 in the standard group, and N=26 in the plain group). The plain language instructions were shorter and included only the most pertinent instructions and information. One-to-one cognitive interviews were used to gain input from chronically ill adult patients to inform the design and materials of both versions. Using a rating checklist (of correct and incorrect option), participants were asked to describe the preparation procedure (six items) and the pre-injection steps (three items) to assess their understanding of the instructions. They were then asked to physically demonstrate the whole procedure and were assessed using a 15-question rating checklist, correct and incorrect options. Participants following the plain language were better able to describe the steps in how to prepare the medication compared with the standard version group, with a mean of 4.5 and 3.1 correct items respectively ($p = 0.01$). The participants also showed significantly better understanding in describing the pre-injection steps compared with the standard version group, a mean of 2.4 and 1.6 correct items respectively ($p = 0.01$). Consistently, the plain language group demonstrated more correct steps for the self-injection procedure as compared with the standard group, with a mean of 13.1 and 10.8 ($p = 0.05$) correct steps, respectively. However, this was a pilot study in which the sample size was small and not statistically calculated. The improvement in physical task performance using plain language instructions could suggest the need to use such language when laypeople need to perform a physical task, particularly in situations where there is no visual mentoring by health professionals. This is similar to performing CPR on scene while waiting for an ambulance to arrive, after having received T-CPR instructions.

<u>Transferability of the evidence about plain language to the T-CPR context</u>

None of the studies presented in this section investigated the use of plain language in the context of T-CPR. However, it is important to note that these studies evaluated written health information and not spoken information or instructions. Understanding information or instructions that are spoken is a different skill to reading written information, which might require slightly different knowledge and abilities. Nevertheless, some broad principles could be transferable to T-CPR instructions. Conversely, there are also some differences between the contexts, which means there are limitations on the transferability of this literature.

The principle of using medical and anatomical terms in written healthcare documents, such as in consent forms and medication instructions, are likely to be similar to T-CPR instructions, but with different medical and anatomical term options. Also, explaining technical procedures in clinical trial consent forms and in medication instructions (e.g., how to take the medication) share a similar principle in that an EMS dispatcher is required to explain how to perform a CPR procedure to a lay bystander. Moreover, the measurements provided in medication instructions, such as in dosages and frequencies (e.g., take 2 ml of X syrup every 8 hours), might be similar but probably at different levels of difficulty to the measurements provided in CPR instructions, such as those used in guiding compression depth (e.g., push 5 cm deep). Further, the pressure to not make errors that people might feel when taking medication after reading instructions might be similar, probably with varying levels of pressure, to that felt by lay bystanders performing CPR after receiving T-CPR instructions. Furthermore, taking medication usually occurs with no visual mentoring of healthcare professionals, which is similar to performing CPR on scene while waiting the ambulance. However, in T-CPR there is telephone mentoring. Finally, the improvement of physical task performance after having received procedural instructions in plain language, such as for taking medication (e.g., self-administer an auto-injector pen), is similar to that of CPR physical performance described in T-CPR instructions.

However, there are some differences between the contexts that cannot be transferred. The studies discussed in this section assessed the comprehension of laypeople following the reading written health content but did not include listening content. In T-CPR, lay bystanders receive verbal instructions via telephone, with no visualisation on the text. This might limit the transferability of the visual modifications of instructions explained earlier, such as using pictures and larger font size. Additionally, T-CPR is often performed in stressful circumstances (in OHCA), and such callers will be under greater stress than those people who are, for example, reading public health information. Being under stress influences the cognitive ability of people (Mendl, 1999; Cibrian-Llanderal, Melgarejo-Gutierrez and Hernandez-Baltazar, 2018), which, in turn, might interfere with the ability of lay bystanders to comprehend instructions. The presence of stress, combined with a cognitively complex task, increases the need to use simple and clear instructions (plain language) in situations such as when CPR is being performed.

Moreover, providing plain language to improve the clarity of the instructions by, for example, using familiar, deleting unnecessary information, and avoiding anatomical and technical terms is likely to be important when giving T-CPR instructions. As indicated in Chapter 1, CPR performance following T-CPR instructions is below resuscitation standards, and modifying the language used in T-CPR instructions is a potential area for improvement.

Conclusion

The use of plain language significantly improved understanding of lay people regarding health-related instructions and documents compared with the standard language used in healthcare. The improvement in instructions understanding showed to subsequently improve how to convey these instructions to physical tasks, such self-injection. Involving the targeted audience in informing and designing healthcare information and instructions was important in making plain language modifications. The input of the targeted audience will identify which items in the standard version of instructions are difficult (e.g., a technical phrase) and how to simplify it (e.g., using familiar words) as they are the likely audience to receive this plain language instructions.

However, none of these studies investigated how to make modifications to T-CPR instructions in order to simplify them to plain language. Although several attempts were conducted to modify the T-CPR instructions using simple phrases, they lacked detailed investigation to simplify them to plain language (as discussed in the following literature). Additionally, none of these studies used Arabic when modifying the plain language, and this requires further investigation.

2.4 Language modifications to T-CPR instructions to enhance CPR lay-bystander timeliness and quality performance

CPR timeliness and quality as performed by untrained lay bystanders after receiving T-CPR instructions are below resuscitation standards (Cheung *et al.*, 2007; Ghuysen *et al.*, 2011; Asai *et al.*, 2018). Therefore, it is important to consider how the language of T-CPR instructions (such as word choices and terminologies as highlighted by the AHA) (Lerner *et al.*, 2012)) influence CPR performance. Several studies have attempted to modify the language in which T-CPR instructions are written and have shown varied degrees of improvement in CPR timeliness and quality performance (Woollard *et al.*, 2003; Deakin *et al.*, 2007; Dias *et al.*, 2007; Birkenes, Myklebust and Kramer-Johansen, 2013; Painter *et al.*, 2014; van Tulder *et al.*, 2014a; van Tulder *et al.*, 2014b; Rasmussen *et al.*, 2017; Trethewey *et al.*, 2019; Leong *et al.*, 2020). However, the language modifications, the methods of deciding on how to modify language, and the T-CPR protocols used in these studies varied and are summarised in Appendix G. Meanwhile, the literature has reported other modifications in T-CPR instructions, such as using a metronome (Park *et al.*, 2013) and asking bystanders to perform CPR over patient's clothes (Eisenberg Chavez *et al.*, 2013), and demonstrated improvement in timeliness and/or quality performance. However, as these studies did not modify the language, they are not included in this literature review. This section will review the evidence on modifications to T-CPR instructions in relation to CPR timeliness and quality performance.

Language modifications to a single T-CPR parameter

Some studies have modified a single CPR parameter and then tested it for performance improvement—for example, depth of compression, time to the first compression, and hand position. The T-CPR instructions used to guide the depth of compression is one such common modification. Here, van Tulder *et al.* (2014a) replaced the depth instruction used in MPDS T-CPR, 'push down firmly 5 cm', with the simpler phrase 'push as hard as you can' and tested it in a randomised simulation study. The study reported no significant difference in depth between the intervention and control groups, with a mean of 46.1 and 44.1 mm ($p = 0.66$), respectively. However, it is worth noting that almost all the study participants had BLS training as this study was conducted in Austria, where such courses are mandatory to obtain a driving license. This might have influenced the findings, as the participants had some previous knowledge of CPR. Later, a simulation study conducted by Trethewey *et al.* (2019) examined the impact of resuscitation terminologies used to guide depth of compression as per the Resuscitation Council of Asia—'approximately 5 cm' (Chung *et al.*, 2016)—and the AHA and ERC—'at least 5 cm' (Kleinman *et al.*, 2015; Perkins *et al.*, 2015a)—with what is used in high-profile media campaigns by the AHA and British Heart Foundation (BHF)—'hard and fast'. Each of these phrases resulted in different depth and rate performances, but none of them reached the ILCOR recommended depth and rate. However, using the phrase 'hard and fast' significantly improved the depth of compression as compared to 'approximately 5 cm', with means of 46.8 and 35.4 mm, respectively ($p < .001$), and the rate of compression, with means of 98.9 and 71.2 c/m, respectively ($p < .001$). Further, the phrase 'hard and fast' also resulted in significant depth improvement as compared to 'at least 5 cm', with means of 46.8 and 40.9 mm, respectively ($p = .009$), and significant rate improvement, with means of 98.9 and 83.7 c/m, respectively ($p = .002$). However, 68% of participants who followed 'hard and fast', 100% who followed 'approximately 5 cm', and 94% who followed 'at least 5 cm' did not reach the ILCOR recommended depth. Moreover, an important limitation of this study was that it did not simulate a real OHCA call. Participants were informed that the patient (a simulator manikin) was in cardiac arrest, and they received T-CPR instructions from an audio recording rather than a dispatcher via a call. This might have influenced the findings, as the participant did not simultaneously communicate with the dispatcher, which would have added further difficulty to the CPR task. However, this study does highlight the potential difficulty that untrained lay rescuers have in correctly interpreting the resuscitation terminologies and translating them into the correct CPR action.

A further randomized four-armed factorial simulation study reported that repeating the depth instruction or using intensified depth instructions did not improve performance (van Tulder *et al.*, 2014b). Using MPDS standard depth instructions, intensified wording 'it is very important to push down the chest firmly 5 cm every time!' and repeating the two instructions did not meet the ILCOR standards. After adjusting for female sex and body mass, the depth significantly decreased when using intensified wording and repetition at 13 mm ($p = 0.04$) and 9 mm ($p = 0.13$), respectively. Finally, this study concluded that repeating or intensifying incorrectly interpreted instructions by the participants did not improve performance. However, it is worth noting that this study included participants who have valid BLS training, which might have influenced their CPR performances as they might have the necessary skills.

The time taken to start the first chest compression improved when CPR instructions were simplified. In this context, Leong *et al.* (2020) conducted a before-after study to examine the impact on time to first chest compression of the simplified instruction to 'push hard and fast' as compared to the conventional phrase 'push 100 times a minute 5 cm deep' (which is the current practice in Singapore). The simplified phrase showed shorter time to first compression from call receipt with means of 229.8 s and 240.7 s, respectively. However, neither reached the minimum or high AHA standards. The findings also revealed low dispatcher compliance with the conventional phrase (in 15.2% of the calls) as compared to the simplified phrase (in 72.8% of the calls). This could highlight the difficulty for dispatchers to comply with the conventional phrase or could be indicative of their thoughts that this phrase might not be the optimal option for callers, which resulted in their non-compliance. It might also provide a possible explanation that using simpler phrases makes it easier for dispatchers to adhere. Hence, dispatchers significantly rephrased the simplified phrase (by using their own terms to deliver the same message) more than the conventional one in 81.5% and 60.4% ($p < .001$) of the calls, respectively. This might highlight the need to find more optimal simplified phrases that dispatchers can follow and that bystanders find simple. Thus, this study's findings highlight the importance of word choices in T-CPR instructions and the need to simplify them.

Instructions to guide the position of the hands in administering CPR have also been examined. Here, Woollard *et al.* (2003) modified the hand position in a T-CPR instruction to 'place your hands in the middle of her/his chest' and tested it using a randomised simulation study. The modified instructions significantly decreased the number of participants who placed their hands correctly for 75–100% of the compressions as compared to the standard instructions, at 14% and 38% ($p = .04$), respectively. However, the standard instructions were not defined. Additionally, time to first compression significantly improved in the modified group compared to the standard group, 184 s and 245 s ($p < .001$), respectively. However, this improvement may be most likely attributed to the removal of the ventilation instructions in the modified protocol as compared to providing ventilation prior to chest compressions in the standard protocol. However, the sample size was small, and the study may not have had sufficient power to detect changes. Further, Birkenes, Myklebust and Kramer-Johansen (2013) developed a new instruction to clarify how to position the hands after analysing an observation from a previous video analysis study (Birkenes *et al.*, 2012). The previous video analysis study showed that almost half of the participants initially placed their hands in the abdominal region following the instruction 'put one of your hands on top of the other on the chest, between the nipples'. Birkenes, Myklebust and Kramer-Johansen (2013) then conducted a randomised study to compare the new instruction (Appendix G) with the ERC hand position instruction (Appendix G) and reported an improvement in the positioning of the hands. None of the participants who followed the new instructions placed their hands on the abdominal region as compared to the five out of 18 who followed the ERC instructions ($p = 0.045$). However, this study did not measure the other CPR quality parameters to evaluate whether the new instructions would influence them or not (e.g., reducing their performance). Specifically, time taken to start the first chest compression was not measured and was expected by the study authors to be longer due to the new instruction. This delay in starting chest compression may decrease the chances of survival for OHCA patients. Thus, in the case of modifying the language of a T-CPR instruction, the other CPR quality parameters should also be assessed to measure how the modification influences them.

Language modifications to multiple T-CPR parameters

Several studies have modified the CPR instructions of different T-CPR protocols to improve CPR timeliness and quality performance (Deakin *et al.*, 2007; Dias *et al.*, 2007; Painter *et al.*, 2014; Rasmussen *et al.*, 2017). Based on the findings from studies in the literature, Rasmussen *et al.* (2017) modified the language of a T-CPR protocol to include the phrases 'push as hard as you can' and 'place one hand in the centre of the chest, right between the nipples, and the other on top'. These were in addition to other changes that included activating the mobile phone speaker, using a metronome, and providing regular encouragements. Subsequently, this modified T-CPR protocol was comparing to the T-CPR protocol used in Denmark, where the study was conducted. In this randomised controlled study, participants who followed the modified protocol scored higher on measures of overall CPR quality performance than those that followed the Danish one, with 18.6 and 17.5 points out of 22 ($p < 0.001$), respectively. However, the overall CPR quality performance was measured using an assessment tool that was not validated and was developed for the purpose of this study based on the ERC recommendations and the Cardiff test of CPR performance (Whitfield, Newcombe and Woollard, 2003). Despite this, the modified protocol compared with the standard one significantly improved the time to first compression with a median of 65 s and 72 s ($p < .001$), respectively, and the number of participants who placed their hands correctly, which was 61% and 36% ($p = 0.02$), respectively. However, hands-off time was significantly longer in the modified protocol as compared to the standard version, with a median of 6 and 1 s ($p < .001$), respectively. Although the modified protocol significantly improved depth of compression as compared to the standard one, with means of 58 mm and 52 mm ($p = .02$), respectively, as well as the rate of compression, with means of 114 c/m and 110 c/m ($p = .04$) respectively, they are both within the ILCOR recommendations. This could suggest that the population included in this study, or generally in Denmark, is likely to be aware of CPR or to have CPR skills regardless of the T-CPR instructions provided. This might also suggest that communities might interpret T-CPR instructions differently and subsequently, perform CPR of varying qualities.

Similarly, Painter *et al.* (2014) modified the CBD T-CPR protocol by re-sequencing the opening questions (asking cardiac arrest questions prior to other less urgent questions). Focus groups were then convened with participants with limited English proficiency to explore the language. The focus groups included Mandarin, Cantonese, and Spanish speakers to identify challenging terms to understand and provide alternatives. Dispatchers were also interviewed about their perceptions of the challenging terms. The modified protocol was tested in a randomised controlled study that recruited primary English speakers. The findings revealed significant improvement in the modified protocol compared to the standard one in terms of time to first compression, with means of 99 s and 123 s ($p < .01$), respectively, as well as depth of compression, with means of 32 mm and 25 mm ($p < 0.05$), respectively. However, the modified protocol significantly reduced the accuracy of the hand position as compared to the standard protocol, with means of 63 and 86% ($p < .01$), respectively. Additionally, the improvement in the time to first chest compression was not likely due to the simplification of the challenging terms. Here, Painter *et al.* (2014) suggested that this may be attributed to dispatchers asking fewer questions prior to establishing that the patient is unconscious and not breathing due to the re-sequencing of the opening questions in the modified protocol. Thus, modifying the language of the T-CPR instructions for primary English speakers using focus groups with limited English proficiency who have not had T-CPR experience might not identify the actual challenging terms. This is because the sample included in amending the language was different from that of the targeted audience that was receiving the language. Therefore, involving the targeted audience in modifying the language might have the potential to improve CPR timeliness and quality performance. Similar findings have been shown in other studies (Deakin *et al.*, 2007; Dias *et al.*, 2007).

Lack of guidance on how to modify the language

Whilst modifying the language has been shown in the literature to improve CPR performance, the modifications still do not meet the resuscitation recommendations and the reasons for this are not clear. Deakin *et al.* (2007) highlighted that changing verbal instructions to improve CPR timeliness and quality performance is not easy. The current literature lacks detailed investigation of the language used in T-CPR instructions (e.g., conducting interviews). It lacks details of why the language was difficult to comprehend and interpret, and how to further simplify it for the targeted audience (callers). While Painter *et al.* (2014) conducted focus groups to amend T-CPR language, there was no qualitative data reported about the language findings (e.g, why the language was difficult). A further study qualitatively analysed video and audio recordings of T-CPR in a simulation study and reported that some T-CPR instructions were not clear and consequently impacted the communication between the dispatchers and participants (Nord-Ljungquist, Brännström and Bohm, 2015). The unclear instructions were relevant to complex instructions and dispatchers not being compliant with the T-CPR protocol and therefore using their own phrases. However, the study did not highlight which instruction was complex nor the reason for the complexity. Thus, the possible language difficulties (e.g., using difficult and imprecise terms) influencing callers understanding and interpreting the instructions are not identified. Thus, further in details investigation in T-CPR language is required.

Using plain language in CPR instructions that aims to remove ambiguity and clarify the instructions by for example, using familiar words, avoiding anatomical terms, and technical phrases could have the potential to improve callers' understanding and interpretation of instructions, which in turn could lead to better CPR performance. Involving the targeted audience to inform developing the plain language T-CPR instructions is important as they are the users whom likely to receive the instructions. Therefore, conducting interviews with participants who have been through a T-CPR experience to firstly explore their perspectives toward the standard version of T-CPR instructions (facilitators and barriers such as phrases understanding and interpretation) then how to improve the instructions from their point of views (e.g., using familiar word choices) could have the potential to improve the instructions understanding and subsequently CPR timeliness and quality performance.

2.5 Conclusion

This literature review explores the influence of plain language in a range of healthcare contexts, and some of this literature is transferable to the T-CPR context. The review also examined the literature on language modifications made to T-CPR instructions specifically.

It is clear that using plain language improved participants' understanding of health instructions and documents as compared to standard language. Further, using anatomical, technical, and clinical terms and providing a lot of information was often difficult for laypeople to understand. Replacing these with familiar and precise terms, defining the technical terms (if there was no replacement), and removing unnecessary information improved understanding. In turn, improved understanding can result in improvements in physical task performance. In this context, input from the targeted audience (i.e., those who will potentially be the recipients of health information or instructions) was important in the design of modifications. The investigated contexts share some similar principles that can be transferred to the T-CPR context, such as avoiding anatomical and technical phrases.

Many language modifications that have attempted to simplify T-CPR instructions have resulted in improvement. However, language modifications to improve CPR timeliness and quality performance, such as replacing 'push down 5 cm' with 'push as hard as you can', still do not meet the recommended standards, and further improvement is required. Further, the current literature includes only quantitative data that present the changes along with CPR performance. However, it is unclear how laypeople would analyse and interpret T-CPR instructions and then apply them to a CPR performance. Moreover, the lack of qualitative data, such as interviews with participants who performed CPR following the receiving of T-CPR instructions, limited the recognition of the weaknesses in the language used for T-CPR instructions and how they could be improved. Therefore, exploring the perspectives of participants and their perceptions of, for example, the anatomical and technical terms and how to improve instructions (e.g., using familiar terms), could have the potential to improve the understanding of the T-CPR instructions and subsequently, CPR performance.

The current literature investigated the issues regarding plain language and T-CPR instructions that mainly used the English language and were conducted in the European and North American context. Saudi Arabia, where Arabic is the spoken language and there is a different context from the presented literature, could bring additional value to the current literature. Therefore, this PhD project conducts a before-after OHCA simulation study to assess participants’ CPR timeliness and quality performance using the standard Saudi T-CPR instructions, after which the participants are interviewed to explore the language. The study then makes modifications to language using plain language and then tests these modifications.

Chapter 3 Methodology

3.1 Introduction

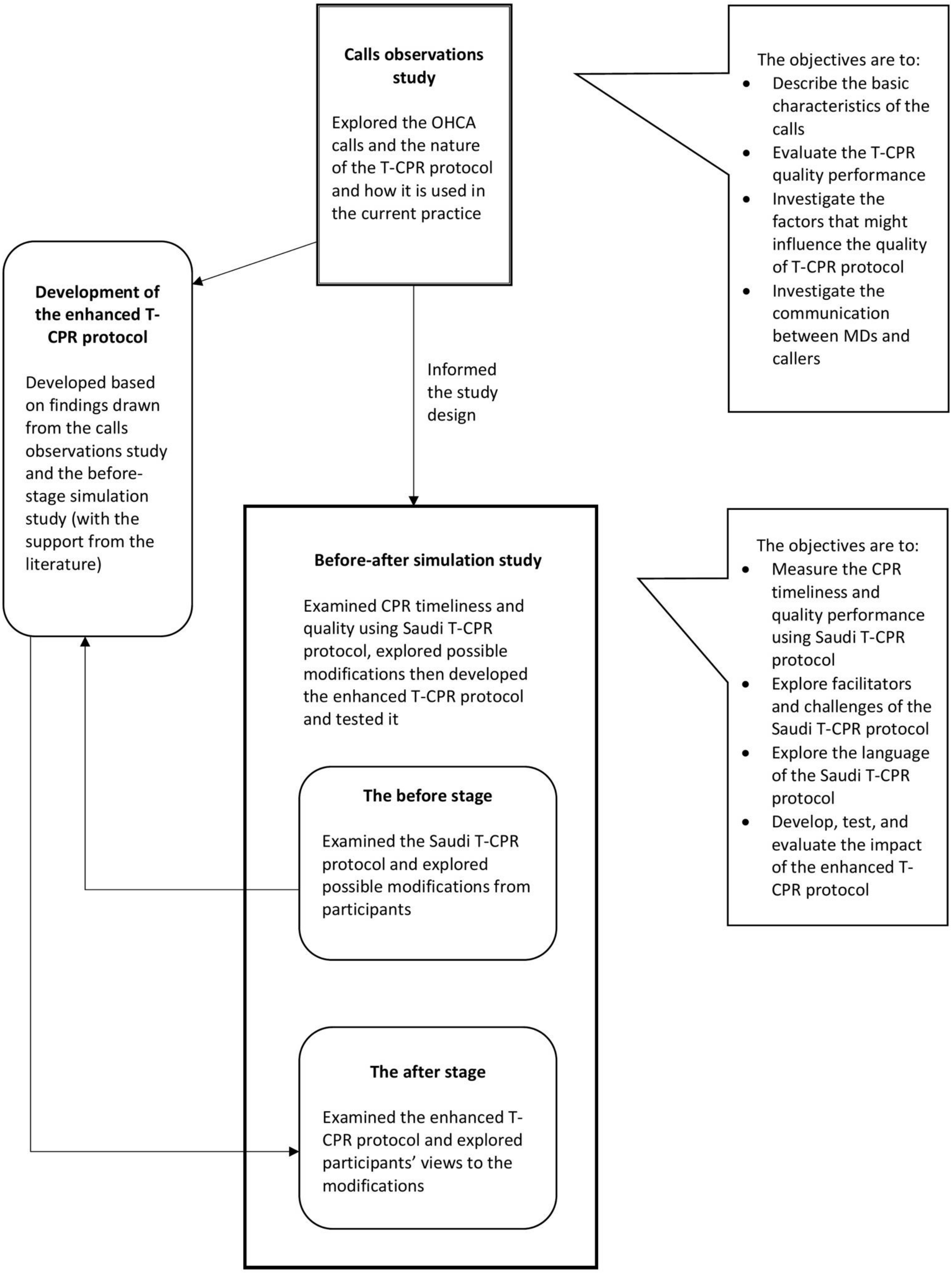
A sequential, mixed-method study design was used to conduct this PhD project. First, an observation of calls study using a mixed method design was conducted to investigate the content and the characteristics of OHCA calls and T-CPR in current practice in Saudi Arabia. This component of the study aimed to examine the quality performance of T-CPR and explore any potential factors that influenced it. This was followed by a before-after mixed-method simulation study of CPR performance. This study component was designed to examine CPR performance of participants receiving the current Saudi T-CPR protocol and investigate potential factors influencing the performance, after which an enhanced T-CPR protocol was developed and tested to address these factors.

This chapter describes the mixed-methods study design used in addition to the setting, data collection methods, and analysis. Ethical considerations and access to the study setting is then outlined. Due to the inclusion of qualitative methods, the possible influence of my background on the data collection was discussed.

3.2 Research design

A sequential mixed-method study design was conducted and consisted of an observation of calls in current practice and a before-after simulation study. The observations of calls gathered both quantitative and qualitative data retrospectively (see section 3.3). The before-after simulation study used mixed methods that collected data prospectively (see section 3.4). Here, the sequential accumulation of the collected data in the two studies formed this PhD project. Figure 8 shows the overall study design, how the objectives relate to the different components and how these fit together.

Figure 8. Flow diagram of the research design.



The aim of using mixed methods was to balance the limitations of one methodological approach by using the strength of the other approach to more deeply understand the investigated issue (Services and Board, 2000; Thurmond, 2001). Further, this design can provide insights that may be unavailable when quantitative and qualitative studies are conducted independently (O'Cathain, Murphy and Nicholl, 2007). For example, quantitative data in the observation of calls study identified the time taken to start the first chest compression, but the qualitative data provided possible explanations of how the time was spent. Further, as Morse (2003) highlighted, mixed methods research is a comprehensive method and the use of both quantitative and qualitative data allows the researcher to build up a more complete picture of the investigated issue, which is the aim of this PhD project.

Moreover, a sequential design was chosen so that findings from the observation of calls study could inform the development of the enhanced T-CPR protocol and the before-after study (see Figure 8). First, the observation of calls study, which was based on OHCA call recordings from the SRCA, explored the content and the characteristics of the calls, focusing particularly on the T-CPR protocol and how it is used in current practice. The purpose of this study component was to examine the quality performance of T-CPR and investigate factors that might impact on it. Here, the quantitative data examined the quality of T-CPR protocol in current practice (e.g., time taken to start the first chest compression) and observed the calls' characteristics (e.g., ROSC and caller demographics). Meanwhile, the qualitative data explored the nature of the calls (e.g., the language used) and possible explanations for the examined quality of T-CPR protocol (e.g., possible reasons for delayed time to first chest compression). As this was the first study to explore current practice in Saudi Arabia by examining OHCA calls and T-CPR, the findings (e.g., the T-CPR protocol and how it is used in the current practice and caller demographics) informed the design of the before-after simulation study, which replicated the OHCA in current practice using simulation sessions. In addition, the findings from the observation of calls (notably, the observations about language) informed the development of the enhanced T-CPR protocol, which was used in the before-after simulation study.

Following the observation of calls study, a mixed-method before-after simulation study was conducted. The before stage collected quantitative data that examined participants' CPR timeliness and quality of performance using the Saudi T-CPR protocol in OHCA simulation sessions. The qualitative data from post-simulation interviews explored participants' experiences of T-CPR and their reflections on T-CPR instructions in terms of whether there were weaknesses and how to improve them, with the aim of improving CPR timeliness and quality performance. The findings (e.g., how to improve the T-CPR instructions language) informed the development of the enhanced T-CPR protocol, which was then used in the after stage. Finally, the development of the enhanced T-CPR protocol was informed by the observations of calls study and the literature as well as the before-stage findings of the simulation. The final component of the project was to examine the enhanced T-CPR protocol in the after stage which was otherwise the same in nature to the before stage.

3.3 An observation of calls study to establish baseline performance of T-CPR in current practice

This retrospective observation of calls aimed to investigate the nature of OHCA calls and T-CPR protocol, and explore how the protocol is used in current practice. OHCA call recordings were listened to, and both qualitative and quantitative data were then collected to provide data on OHCA calls and the T-CPR protocol. Specifically, the quantitative data included call characteristics, the proportion of MDs successfully identifying OHCA, the time taken to identify OHCA and to start the first chest compression, the proportion of callers who performed CPR, and the ROSC outcomes. Meanwhile, the qualitative data were used to provide a deeper understanding of OHCA calls (e.g., language and communication) and the use of the T-CPR protocol (e.g., factors influencing the time to first chest compression) to provide a picture of the nature of the OHCA calls. The findings informed the design of the before-after simulation study (see section 3.4.1) and the development of the enhanced T-CPR protocol (see section 3.5).

A retrospective design was chosen to ensure that the required sample size was reached (see section 3.3.2). This was because the proportion of OHCA incidence and calls in Saudi Arabia is unknown, which made it difficult to collect data prospectively, especially within a PhD project timeframe. Thus, a retrospective design was the most time-efficient way of achieving the proposed sample size. Also, this study aimed to evaluate the performance of the dispatching system, and collecting the data prospectively might introduce a bias as the MDs and call takers would know about the purpose of the study which could subsequently influence their behaviours.

3.3.1 Settings

Call recordings were collected from the central station of the SRCA in Riyadh. The SRCA is the EMS that manages the pre-hospital cases in Saudi Arabia, including OHCA (see section 1.5.3). It is also where the dispatching department that handles all EMS calls in the Riyadh province is located and where all OHCA call recordings are stored. Permission to access the SRCA was obtained to enter the department and collect data accordingly (see section 3.9.1).

3.3.2 Sample size and inclusion and exclusion criteria

A hundred consecutive OHCA calls that matched the inclusion criteria were included. The T-CPR protocol was implemented in the SRCA in late 2016, and therefore, OHCA calls starting from January 2017 to July 2018 were reviewed to include 100 consecutive OHCA calls. The sample size of 100 was chosen to reflect the literature of similar studies (Heward, Donohoe and Whitbread, 2004; Clegg *et al.*, 2014; Travers *et al.*, 2014; Alfsen *et al.*, 2015; Case *et al.*, 2018; Michiels *et al.*, 2020). Thus, it was deemed that the sample size would be sufficient to meet the objectives of this study. Additionally, due to the standard timeframe of PhD projects, a sample size of 100 calls was considered a feasible number.

The OHCA calls included calls from adult callers (≥18 years old or was presumed to be an adult based on the voice) reporting on adult OHCA patient (≥18 years old) who spoke Arabic fluently. Calls were excluded if they matched any of the exclusion criteria presented in Table 4.

Table 4. Exclusion criteria for OHCA calls

Exclusion criteria	Rationale
Traumatic OHCA	Due to conflicts of whether CPR should be initiated or considered futile (Konesky and Guo, 2018)
Presence of trained CPR person on scene	The T-CPR guidance was not provided.
CPR was in progress prior to the EMS call	The T-CPR guidance was not provided.
EMS crew arrived before OHCA identification by the MD	The T-CPR guidance was not provided.
Non-Arabic speaker callers	The T-CPR protocol is written in Arabic and designed for Arabic speakers. Other sets of instructions would be provided to non-Arabic speakers.

Meanwhile, incomplete call recordings, which are defined as any call that an MD did not finish, were treated in the following ways:

- When the MD successfully completed the call, but the call recording was missing or corrupted (could not be analysed) due to a technical issue in storing the call at the SRCA, the call recording was excluded.

- When the call was not complete because the caller hung up (or for similar reasons), the call was included for further analysis.

3.3.3 Data source and identifying OHCA calls

Following ethical approval (see section 3.9.1) and permission to access data from the dispatch department at the central SRCA station, the call recordings were listened to and relevant data were extracted (see section 3.3.4). Listening to the call recordings was enabled by the use of specific call software in the SRCA, which stores the calls digitally. The call recordings were listened to in a private office in the dispatch department.

To identify OHCA calls, EMS crew reports of OHCA cases were reviewed. The SRCA has several folders of EMS crew reports, which are organised depending on the cases. For example, there are different folders pertaining to infectious disease and OHCA cases. Here, the OHCA folder was reviewed, relevant call recordings were listened to, and accordingly, data were extracted.

However, the SRCA has a simpler method to identify and listen to call recordings, which was not applicable for OHCA cases. As indicated in section 1.5.3.1, each call received in the SRCA has a specific electronic call card that includes data about the call, such as patient and caller information, the code of the call (e.g., cardiac, respiratory, and car accident), and the severity (minor, moderate, or severe). These call cards are saved in the SRCA system, which allows for searching using the codes. For example, all saved cardiac calls can be found when searching using the word 'cardiac', which is the code in this case. However, there was no such code for OHCA; therefore, the relevant case folder was reviewed to identify these cases and subsequently, the relevant call recordings.

3.3.4 Data collection

All identified OHCA calls were reviewed from the time of call receipt until the call ended to extract relevant data. Data were captured using data extraction forms (see Appendix H).

Next, the time measurements of key events in all call recordings were extracted and included the following:

- Time from call receipt until location acquisition (was considered complete once the call taker confirmed it or moved to the next question/step)
- Time from call receipt until it is transferred to the MD (was considered complete once the MD started to talk)

- Time from call receipt until cardiac arrest recognition (was considered complete when the MD confirmed it or started to provide CPR instructions)
- Time from call receipt until the first chest compression (was considered to have started when the caller confirmed that he/she was doing it, when the counting of chest compressions began, or when the compressions were heard)

These time measurements were chosen to establish the baseline performance and to enable comparison with the AHA recommendations to evaluate the quality of T-CPR in current practice.

The quantitative data also measured the proportion of MDs correctly recognising OHCA (%), the proportion of MDs who provided CPR instructions following the identification of OHCA (%), and the caller CPR rate. Those measurements were also compared with the AHA recommendations to establish the baseline performance of T-CPR. At the end, the ROSC outcomes of the patients were recorded.

The qualitative data provided clarity and context for the quantitative data (e.g., factors influencing time to first chest compression) and insight into the way in which language was used by callers and MDs. As the call taker role was limited to asking the caller for primary information (e.g., patient's gender and chief compliant) and acquiring the location before transferring the call to the MD for assessment, only brief notes were recorded to complete the picture (e.g., why the time taken for location acquisition was long). However, the MD calls were transcribed verbatim, except in a few instances in which irrelevant information was discussed during the call. For example, when an MD asked many follow-up questions about a patient's medical history, general observations were recorded rather than verbatim notes. In addition, relevant non-verbal observations, such as voice tone, background activity, lengthy pauses, and others were recorded in a consistent manner and denoted by square brackets—for example, [crying] and [EMS crew sounds in background]. The qualitative data were then analysed using a thematic analysis (see section 3.7.2).

To complete the picture of the OHCA calls, patients' and callers' characteristics were noted. Further, data on the gender of patients and callers, as well as their relationships, were collected. The relationship aspect only focused on identifying whether callers and patients had family relationships, which included parents, spouses, siblings, and other relations considered relatives in the Saudi context including grandmothers and uncles. Additionally, callers' and patients' nationalities (Saudi or non-Saudi) were also captured.

3.4 Before-after simulation study to establish baseline CPR performance

The before-after simulation study aimed to examine participants' CPR timeliness and quality performance using the current Saudi T-CPR protocol, explore possible modifications to the T-CPR protocol, and then develop and test an enhanced T-CPR protocol using a mixed method observational design. The simulation study used OHCA scenarios and a manikin that represented the OHCA patient (see section 3.4.4).

The simulation study design was selected as the only possible design to examine the CPR performance of an untrained CPR volunteer. Here, it is clear that it would be unethical to evaluate clinical performance (CPR quality) as performed by an untrained person (untrained CPR volunteer) on a real patient experiencing a life-threatening condition (OHCA) as any error from the former might lead to the latter losing their life. Further, it is also not practical to conduct this study in a real OHCA setting, as the pre-hospital location is unknown prior to the OHCA call and therefore, the required equipment for evaluating CPR performance would not be available. There, a simulation that can provide an investigation opportunity for clinical practice without harming patients or anyone else even when errors are made was used (Alinier *et al.*, 2006; Perkins, 2007). Additionally, a systematic review and meta-analysis conducted by Mundell *et al.* (2013) concluded that using simulations in resuscitation evaluation and training is an effective method. Thus, a simulation study was chosen using an advanced simulated manikin (see section 3.4.4).

In the before stage, the participants received Saudi T-CPR protocol (which are the same protocol used in the SRCA), and their CPR timeliness and quality performance were measured in OHCA simulation sessions. The CPR timeliness included time to first compression, and the quality performance included chest compression rate, depth, hand position, hands-off-chest time, and chest wall recoil. Following each OHCA simulation session, the participants were invited to attend semi-structured interviews designed to explore their experiences with T-CPR and their views about how the T-CPR protocol could be modified to subsequently improve CPR timeliness and quality performance. These findings informed the development of the enhanced T-CPR protocol (see section 3.5).

Subsequent to the before stage, an enhanced T-CPR protocol was developed (see section 3.5) to be used in the after stage. Following the development of the enhanced protocol, the after stage examined participants' CPR timeliness and quality performance after receiving the enhanced protocol in OHCA simulation sessions, as per the method described previously. Similar to the before stage, the participants were then invited to attend semi-structured interviews to explore their experiences and to compare the Saudi T-CPR and enhanced T-CPR protocols.

The decision to use a 'before-after' design was made to balance the aim of the study with the need to obtain a sufficient sample size in light of available resources. The study aimed to first evaluate the current CPR performance and identify how the Saudi T-CPR protocol could be enhanced in one data collection package, and then examine the enhanced T-CPR protocol in another data collection package. Replacing the 'after' stage with a randomised controlled trial, which is optimal to determine a cause-effect relationship (Kendall, 2003), would have required the recruitment of more participants to detect a significant difference between the control (Saudi protocol) and intervention group (the enhanced protocol). The resources required (see 3.4.4) and time were limited within a PhD project. Therefore, conducting a well-designed before-after study was chosen in preference to conducting an inappropriately designed randomised controlled trial. However, it is acknowledged that the before-after study design has limitations, which are discussed in 6.3.2.

3.4.1 Settings

The study was conducted in the simulation room located in the EMS department, College of Applied Medical Sciences, King Saud bin Abdulaziz University for Health Sciences (KSAU-HS), Riyadh, Saudi Arabia (KSAU-HS, 2021). KSAU-HS is a public university that teaches health sciences-related subjects through three branches in three cities in Saudi Arabia. The main campus is in Riyadh and consists of several colleges (e.g., pharmacy and health informatics) and an administrative building. KSAU-HS is occupied by a large number of employees and students with different backgrounds, levels of education, and social classifications, which assisted in recruiting the participants (see section 3.4.2).

This setting was chosen due to its potential to access a large number of employees and students from which a sample representative of OHCA callers may be drawn. While it is recognised that this proxy sample may not be fully representative of the wider population of Saudi Arabia, it includes a range of people with different levels of education (from PhD level to school degrees), backgrounds, and social classifications. Most importantly, the strength of this sample is that it would encourage more women to take part compared to women drawn from the wider population (see the following section). Including women in the study is crucial as they represent the majority of OHCA callers (Bergner and Eisenberg, 1982; de Vreede-Swagemakers *et al.*, 1997; Dorph, Wik and Steen, 2003), and the observation of calls study found that women accounted for a large number of OHCA callers in Saudi Arabia (see section 4.2).

Despite KSAU-HS being a health sciences university, CPR training is not a requirement to work or study here. In addition, as indicated in Chapter 1 (see section 1.3.2), CPR skills decrease within 3–6 months from CPR training, and re-training is required at least every 12–24 months to maintain these skills or the person will be considered as untrained in CPR. Thus, this study only included untrained CPR participants (see section 3.4.3), who represent actual users of T-CPR protocol in current practice.

Gender considerations influencing recruitment

As indicated in the introduction chapter (see section 1.5.2), sex segregation is a cultural norm in Saudi Arabia that limits the interaction between males and females. The observations of calls study also found there were gender differences in current practice (see Chapter 4). However, women sometimes participate in some forms of research (e.g., completing a questionnaire). Nevertheless, at the outset of the research, it was anticipated that many women would not consent to be video recorded while performing a physical task (i.e., CPR), which will be viewed and analysed by a man unknown to them. While this posed a limitation to this project, it was mediated by recruiting from a setting where potential participants for this study were employees and students in KSAU-HS, where males and females commonly work together. Thus, the KSAU-HS setting was considered the best option to ensure the inclusion of female participants in this PhD project. Here, it is accepted that this sample may limit the generalisability of the results, but it also ensured that women were able to participate in the project.

3.4.2 Sample size and population

A hundred participants were recruited in this study: 50 each in the before and after stages. This sample size was calculated to detect 15 c/m and 15 mm chest compression depth differences in CPR performance—when compared with the ILCOR standards—at 80% power and a 0.05 significance level as the primary outcome. As there is no study in the literature that has examined CPR performance in Saudi Arabia either with or without the assistance of a T-CPR protocol, the standard deviation and the average chest compression rate and depth used to calculate sample size in this study were pooled from similar studies in the literature. To this end, studies that examined either chest compression rate or depth as a primary outcome and used a T-CPR protocol were first identified (Deakin *et al.*, 2007; Dias *et al.*, 2007; Park *et al.*, 2013; Painter *et al.*, 2014; van Tulder *et al.*, 2014a; van Tulder *et al.*, 2014b; Rasmussen *et al.*, 2017).The average performance in these studies was 95 c/m (standard deviation of 26) in 35 mm depth (standard deviation of 13). However, the ILCOR recommends CPR performance be between 100-120 c/m to a depth of at least 50 mm (but no more than 60 mm), which is clinically linked with better survival rates (Babbs *et al.*, 2008; Bohn *et al.*, 2011; Linden *et al.*, 2012; Stiell *et al.*, 2012; Vadeboncoeur *et al.*, 2014; Idris *et al.*, 2015). Therefore, an effect size of 15 c/m and a 15 mm depth change would be clinically significant.

Participants were adult volunteers (≥18 years old) who are working or studying at KSAU-HS in Riyadh. To ensure the recruitment of both male and female participants from different age groups, levels of education, and social classifications, three strata were created: 1) academic staff; 2) other staff; and 3) students. Academic staff describes those who deliver academic materials to the students by giving lectures, seminars, and lab sessions. 'Other staff' describes those who work at KSAU-HS and include, for example, information technology specialists and administrative assistants. These strata were drawn from employees' and students' names lists in KSAU-HS (separate lists for males and females).

Thirty-three potential participants from each stratum were identified using the Nth number from each stratum list (almost equally from male and female lists). First, the total population in each stratum was divided by the number of potential participants to identify an interval for each stratum. Then, a fixed random Nth number in each interval (for each stratum) was chosen and selected periodically in each interval to identify the potential participants in each stratum. This technique was used similarly in both the before and after stages, but with the use of updated name lists in the latter as it was conducted one year after the former.

The potential participants were sent an invitation via email that explained that the study aims to test '997' EMS instructions for first aid skills (rather than specifically mentioning cardiac arrest scenarios). The email also showed the importance of this study in saving and improving the quality of patients' lives and the significance of participants taking part in it. It then explained how to contact me through email or phone number to take part in this study or to ask for further details if interested. It was made clear that participation was voluntary and that the individual could withdraw at any time. The participants who were interested in taking part were then contacted, and a suitable time to meet at the simulation room in the EMS department to take part in the study was agreed upon (see section 3.4.5). A target to recruit almost equal male and female participants was controlled by not recruiting more than 25 participants from each gender in the before stage and similarly in the after stage. Additionally, almost equal recruitment from these three strata was controlled using the same technique.

3.4.3 Inclusion and exclusion criteria

This study included untrained CPR adults (≥18 years old) who speak Arabic.

Participants were excluded if he/she met the exclusion criteria in Table 5.

Table 5. Exclusion criteria in the before-after simulation study

Exclusion criteria	Rationale
CPR trained	T-CPR instructions are designed for those who are untrained in CPR. Further, CPR-trained individuals might influence the testing of the quality of the T-CPR instructions.
Having a medical condition restricting physical exercise (such as an arm fracture or pregnancy)	To avoid causing harm to the participant as CPR requires the participant to perform a physical task
Took part in the before stage (this criterion was only applicable in the after stage)	To avoid any bias in the results when comparing the before and after groups

3.4.4 Study tools

This study simulated OHCA using a simulator manikin and involved participants performing CPR based on instructions received from an MD. They were then invited to participate in semi-structured interviews. The tools used in this study and the characteristics of the MD are explained in the following sections.

<u>The manikin and simulation room</u>

The manikin used in this study was a SimMan 3G advanced patient simulator (a full body simulator) from Laerdal (Appendix I). This is a high-fidelity manikin that can realistically simulate a real patient (Laerdal, 2016). It has numerous characteristics that can be used to evaluate trainees or participants in topics such as airway management, difficulty in breathing, abnormal body circulation, and pharmacology. Moreover, it is of particular importance to this study that this simulator can be used to evaluate the quality of participants' CPR performance as it is compliant with international CPR guidelines (Laerdal, 2016). In this context, it is important to note that this manikin can measure and provide data about the following:

- Chest compression per minute
- Hand position
- Depth
- Hands-off time
- Chest wall recoil

The ERC recommends using high-fidelity manikins (SimMan 3G is one of them), which are superior to low-fidelity or basic manikins in resuscitation training, including CPR (Greif *et al.*, 2015). This is due to the ability of the manikin to physiologically react with interventions, enable several procedures to be performed on it, provide physical findings and vital signs, and provide more physical realism (Greif *et al.*, 2015). In this context, Laerdal is a leading company that provides manikins for healthcare purposes, and these have been extensively used in the literature, especially in studies examining similar objectives to this study—T-CPR timeliness and quality performance (Woollard *et al.*, 2003; Brown *et al.*, 2008; Ghuysen *et al.*, 2011; Park *et al.*, 2013; Birkenes *et al.*, 2014; Painter *et al.*, 2014; van Tulder *et al.*, 2014a; van Tulder *et al.*, 2014b; Asai *et al.*, 2018; Teo *et al.*, 2019; Trethewey *et al.*, 2019). Therefore, this manikin can provide the data needed to achieve the objectives of this study.

The scenarios set up in the SimMan 3G are controlled using an instructor laptop, which is remotely connected to the simulator. Thus, the instructor can start the scenario, observe the performance of the participants on the simulator (e.g., chest compression per minute), and amend the scenario as necessary (e.g., change vital signs of the simulator).

The instructor laptop has the Laerdal Learning Application (LLEAP), which is used to create and start simulation scenarios as well as monitor participants' performance (e.g., what intervention is being performed, the quality of the intervention, and the time taken). With regard to this study, LLEAP was used to start an OHCA scenario (unconscious and not breathing patient) and to measure the CPR quality performance of the participants. The LLEAP shows the live quality performance of the participant (e.g., the depth in each compression) as well as the average performance (e.g., the average performance of depth of compressions in a period of time). Once the session is completed, a session debriefing that summarises all interventions completed by the participant along with the quality of the average performance (e.g., average of chest compression rate per minute) can be accessed through the Session Viewer application using the instructor laptop. Further, for this study, the quantitative data of the CPR quality performance was extracted using the Session Viewer application.

The simulation room in the EMS department in KSAU-HS was equipped with the simulator manikin, a video recorder, and a mobile phone to run the simulations. The manikin was placed on the ground of the simulation room. A video recorder to record the participants' CPR performance was placed with the camera angle providing a clear view of the simulator and participant. The video recordings were later used to extract relevant data (see section 3.4.5). A mobile phone that was not password protected and had a speaker function was provided in the simulation room; it was handed to the participants prior to them entering the simulation room. The mobile phone was used by participants to make the call. The simulation room had an adjunct room where I was sitting and using the instructor laptop to monitor the simulation session and extract relevant data (see section 3.4.5). The simulation room was safe for the participants to enter and perform CPR on the simulator with no harm.

The MD and T-CPR protocols

The 'MD' in this study was the person who received the calls from the participants and followed the T-CPR protocols. Here, it is noteworthy that the T-CPR protocol in current practice in the SRCA is provided by an MD who is a male doctor of medicine and speaks Arabic as their first language. Paramedics are experts in emergency cases and able to answer relevant medical questions that might be asked by the participants in this study. Thus, the MD's role in this study was undertaken by a qualified paramedic registered with the Saudi Commission for Health Specialities, which is a scientific commission that regulates healthcare practices and accreditations in Saudi Arabia for paramedics. Further, to replicate MDs in current practice, the paramedic chosen is a man who speaks Arabic as his first language and has received training in the use of the Saudi T-CPR protocol to explain it and its delivery. To avoid the influence of the MD when comparing the findings of Saudi T-CPR and the enhanced T-CPR protocol, the same MD ran both the simulation sessions in the before and after stages of this specific study.

3.4.5 Study procedure and data collection

After obtaining ethical approval (see section 3.9.1), access to the simulation room to run the simulation sessions and interviews and then extract relevant data using the data extraction form (see Appendix J) was secured. The simulation room was equipped with all necessary tools for this study, including the SimMan 3G manikin with the instructor laptop (Laerdal SimMan 3G®, Laerdal, Stavanger, Norway), a mobile phone, and a video recorder. The quantitative data were extracted from the simulation session using the Session Viewer and from the video recorder, while the qualitative data were collected using the post-simulation interviews. Prior to taking part in the study, all participants signed a consent form (see Appendix K).

Participants were welcomed and rested for a minimum of ten minutes prior to starting the simulation session. A female research assistant (who acted as a chaperone) was also present to welcome female participants to ensure that they felt more comfortable.

Participants were given a standardised simulation scenario (Appendix L) and a mobile phone. The scenario did not mention CPR, but it was indicated that there was a collapsed patient and they had to call '997' to report the case and then, receive first aid guidance from an acting EMS MD, which they should follow as closely as possible. Participants were instructed to make the call using the mobile phone provided; the MD's phone number was previously saved as '997'. The participants were also asked to imagine the scenario as a real case and the manikin as a real patient and also act according to the MD's guidance. Here, a brief description of the features of the simulated manikin and how it is similar to a real person was provided. To ensure the familiarity of the participants in using the mobile phone, they were shown how to use the phone to access the contacts, make a call, and activate the speaker. The participants then entered the simulation room to start the simulation session.

Once the call was made, the MD answered the call and followed the T-CPR protocol, through which he guided the participants to identify OHCA and then perform CPR. The MD and participants did see each other prior to or during the session. This was to avoid any bias or unintentional self-correction or the provision of additional instructions if the MD were to see the participant performing CPR incorrectly.

Each participant performed CPR for two minutes, at which point the simulation session was ended. This duration was chosen to simulate the standard performance of a CPR cycle in current practice. Krogh *et al.* (2014) highlighted the importance of maintaining the two-minute time limit when simulating cardiac arrest for training to make it realistic.

Post-simulation semi-structured interviews were then conducted with each participant. Quantitative data were extracted during the simulation session, and the qualitative data were collected using the post-simulation interviews.

<u>Quantitative data (simulation session)</u>

The data regarding the CPR quality performance were measured and extracted using Session Viewer from the instructor laptop (explained in 3.4.4). These data included the following:

- Chest compression rate—the average number of compressions per minute
- Chest compression depth—the average depth in mm
- Hand position (measured in %)—the percentage represents the accuracy of participants' hands on the simulator chest according to the ILCOR CPR recommended hand position (at the lower half of the sternum); higher percentage represents a more accurate/correct hand position. This percentage is calculated automatically by the manikin, which has a sensor to accurately detect where the participants are placing their hands when performing chest compressions

- Chest wall recoil (measured in %)—the percentage represents participants allowing chest wall recoil according to the ILCOR CPR guidelines; higher percentages represent more compliance with the guidelines

Time measurements were recorded manually from the video recordings. The time from call receipt to participants starting the first chest compression was extracted and presented in seconds. Due to the lack of definition in how to measure 'hands-off chest time', the hands-off chest time was considered as a summation of no compression lasting 1.5 s or more, which was manually measured from the video recordings. This definition was recommended by Kramer-Johansen *et al.* (2007) to uniformly report CPR quality measurements. The hands-off chest time can also be used to indicate the chest compression fraction, which is the proportion of time when chest compressions are performed (see 1.3.2).

<u>The qualitative data (post-simulation interviews)</u>

A semi-structured interview was conducted with each participant immediately after the simulation session. The interviews lasted between 10 and 30 minutes and were recorded using an audio recorder. They were later transcribed verbatim for analysis (3.7.2).

The interviews were guided by an interview topic guide (see Appendix M), which was developed based on the findings of the T-CPR literature that highlighted difficulties in comprehending health language and information. The findings from the observation of calls also informed the interview guide. Prior to the interview, each participant was handed a copy of the T-CPR protocol (to aid participant recall). Subsequently, I performed and explained how chest compressions were to be correctly performed. This was done to allow for it to be discussed in the interviews. The interviews started with the introduction of the study, followed by some opening questions designed to elicit basic demographic information and help participants feel comfortable. Gender, nationality, occupation, age, and level of education were then recorded on the data extraction form. Participants' ages were grouped as follows: 1) 15–24, 2) 25–54; 3) 55–64; and 4) 65 years and over. This age grouping was derived from the World Factbook provided by the Central Intelligence Agency (The World Factbook, 2020). This age grouping is broad and covers the age groups presented by the general authority for statistics in Saudi Arabia, which grouped age into three groups: 1) less than 15; 2) 15–64; and 3) above 64 (General Authority for Statistics, 2017). Meanwhile, the 'levels of education' groups were derived from the general authority for statistics in Saudi Arabia, which categorises education as follows: 1) PhD; 2) master's/high diploma, 3) bachelor's; 4) diploma; 5) secondary school; 6) elementary school, 7) primary school; and 8) less than primary school (General Authority for Statistics, 2017).

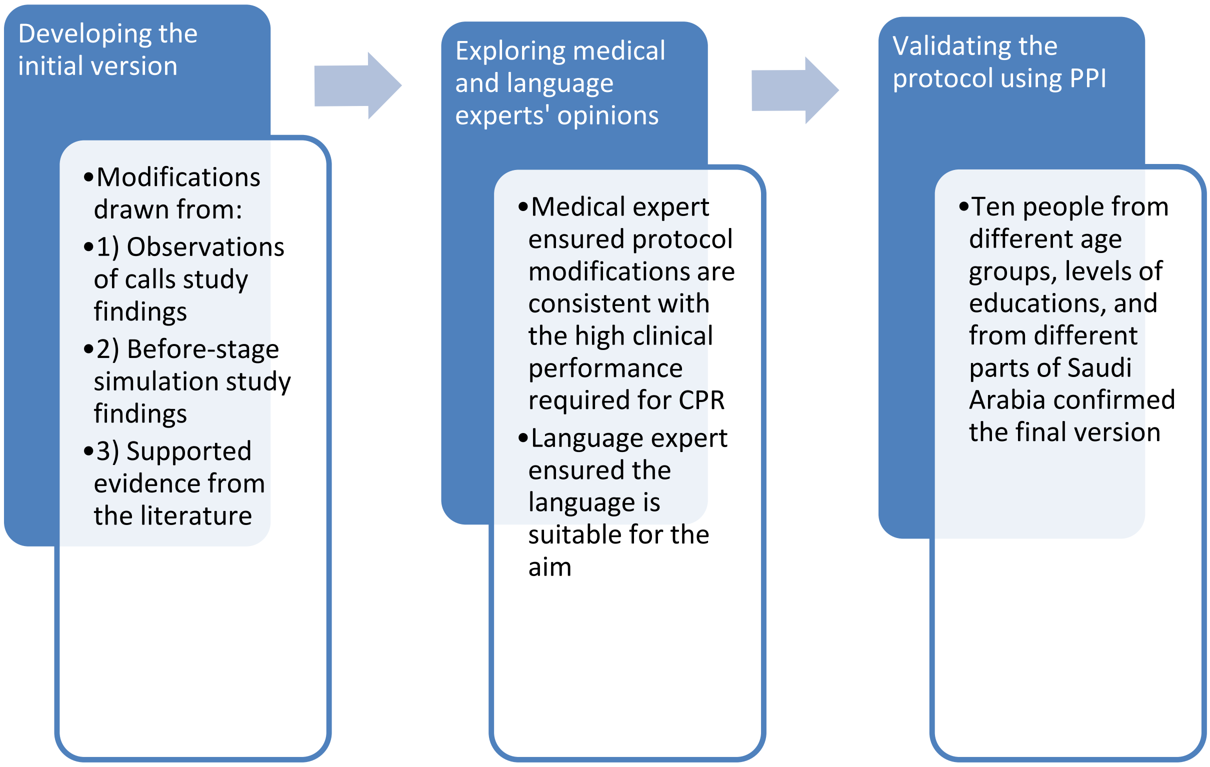
The interview was designed to focus on exploring participants' experiences with T-CPR instructions and the CPR task in more depth. This included examining the language used (e.g., identifying incomprehensible terms), the process of receiving and communicating CPR instructions over the phone, the experience of performing physical CPR tasks over the phone as well as facilitators and challenges. Suggestions for improving the T-CPR instructions, such as providing simpler terms to replace any terms that participants found difficult during the simulation, were also explored. These allowed for the identification of potential weaknesses in the T-CPR instructions and how they could be improved. Follow-up questions and probes were asked depending on the participants' answers to elicit more comprehensive and detailed data. The findings from the interviews informed the development of the enhanced T-CPR protocol (see section 3.5).

The participants in the after-group interviews were asked an additional question to compare the Saudi T-CPR and enhanced T-CPR protocols. The participants were provided with a copy of the Saudi T-CPR protocol at the end of the interview to compare it with the previously provided enhanced T-CPR protocol. The participants' preferences of instructions between the two protocols along with their explanations were then explored and discussed. The participants were guided through each T-CPR instruction to encourage them to provide feedback for every single instruction. This activity provided data to compare the two protocols.

3.5 Developing the enhanced T-CPR protocol

The enhanced T-CPR protocol was developed and then examined in the after-stage of the before-after simulation study. The enhanced protocol aimed to improve CPR timeliness and quality performance as compared to the Saudi T-CPR protocol by improving the language used in the instructions. The language modifications in the enhanced protocol were guided and informed by three sources, which were from the findings of the observation of calls study and the before stage of the before-after simulation study as well as evidence from the literature. The strength of the enhanced protocol is that it was developed based on observations of T-CPR instructions between MDs and callers in current practice and interviews with the audience that was targeted with T-CPR instructions in the simulation study. Further, the literature review highlighted the importance of involving the targeted audience when amending the language of a set of instructions (see Chapter 2). Next, the combination of the three sources developed the initial version of the enhanced protocol, which was subsequently reviewed by medical and language experts and validated using patient and public involvement (PPI). The process of developing the enhanced protocol is summarised in Figure 9.

Figure 9. The process of developing the enhanced T-CPR protocol.



<u>Developing the initial version of the enhanced T-CPR protocol</u>

The analysis of the quantitative data regarding CPR timeliness and quality performance in the before stage of the before-after simulation study showed the current baseline performance and the need for improvement (see Chapter 5). Further, the analysis of the post-simulation interviews in the before stage provided descriptions and possible explanations for language difficulties in the Saudi T-CPR protocol that could influence CPR timeliness and quality performance and suggested modifications to improve them (these modifications are set out in detail in Chapter 5). The analysis of the observation of calls also provided data about possible language difficulties and the preferred form of Arabic that the callers used to speak with the MDs when receiving T-CPR instructions in current practice (see Chapter 4). These potential language modifications to the T-CPR instructions were supported by the evidence from the literature as they showed how to improve participants' understanding and comprehension, which consequently improved the physical task performance (e.g., CPR) (see Chapter 2). Based on these findings, an initial version was developed.

Exploring the opinions of medical and language experts

An initial version of the enhanced T-CPR protocol was reviewed by medical and language experts to ensure that the revisions to the protocol achieved its goal of using plain language. First, the medical experts reviewed the initial version to ensure the protocol modifications were consistent with high clinical performance of CPR and did not conflict with the ILCOR recommendations. The experts included an MD in the SRCA who used to provide T-CPR instructions in its current practice, an emergency medicine consultant with experience in the EMS field, and a paramedic with a PhD degree. Moreover, these medical personnel have clinical experience in emergency cases, including OHCA and CPR performance. Therefore, there was confidence in their revisions and modifications to the initial version of the enhanced T-CPR protocol.

Next, the language experts included three individuals with PhDs and a professor of Arabic and Linguistics who they have published articles in the areas of language and linguistics reviewed the language of the protocol. These experts teach Arabic in Saudi universities and/or work as official translators for an Arabic translation company. They were informally approached via email or phone calls and asked to review the language used in the enhanced T-CPR protocol, after which they were asked for their views on whether the instructions could be described as being in plain Arabic, easy to understand, and not using dialect terms or those that a lay audience might find incomprehensible. The structure and format of the instructions were also checked. It was also important to gain an understanding of the enhanced protocol from a lay perspective. Therefore, laypeople were also included by using PPI (which is explained in the following section).

Validating the enhanced protocol using PPI

The enhanced T-CPR protocol was also validated using PPI, which is defined as '*research carried out "with" or "by" members of the public rather than "to", "for" or "about" them*' (National Institute for Health Research, 2015). Further, PPI has been used at different stages of research studies to help develop study tools, inform recruitment strategies, and enhance dissemination and implementation of the findings (Brett *et al.*, 2014). More specifically, including PPI in PhD projects (e.g., designing) has been shown to be valuable in the research process (Coupe and Mathieson, 2020). Thus, 10 PPI volunteers were informally approached to capture a range of educational levels, age groups, and people from different parts of Saudi Arabia. Variations between the volunteers were targeted to include laypeople from different educational levels and spoken dialects. Then, they were asked to share their thoughts and reflect on the enhanced T-CPR protocol. They were also specifically asked whether the language used could be considered plain Arabic and if it was easy to understand and to identify whether there were any incomprehensible or vague terms. The final version of the enhanced protocol was then confirmed (see Chapter 5).

The enhanced T-CPR protocol was then used in the after-stage of the simulation study. The influence of the enhanced T-CPR protocol on participants' CPR timeliness and quality performance was measured and compared with the Saudi T-CPR protocol in the before-after simulation study (see section 3.4) and reported in the results chapter.

The Saudi and enhanced T-CPR protocols were translated by me then checked by two bilingual personnel in addition to being discussed as part of the PhD supervision. The English versions are illustrative and presented to convey a picture of the Saudi protocol and the modifications made in the enhanced protocol (see translation from Arabic to English in section 3.7.2).

3.6 Pilot studies

Pilot studies for both a sample of the OHCA calls in the observation of calls study as well as the OHCA simulation sessions and post-simulation interviews were conducted prior to starting the main studies. The piloting of these methods aimed to identify any unforeseen difficulties and verify that the study was feasible.

With regard to the observation of calls study, six call recordings were reviewed before the main study was started. The aim here was to become familiar with how the T-CPR protocol is used in current practice, test the length of time taken to extract the data, how it is to be extracted, and gain insight into the nature of OHCA calls. The data extraction form was also checked to ensure that it was suitable for collecting the appropriate data to meet the study objectives. As a result of this pilot, it was decided that the MD calls would be transcribed verbatim, rather than brief notes. This allowed for the capture of a more detailed picture of OHCA calls and the T-CPR protocol.

Piloting the before-after simulation study comprised ten OHCA sessions along with post-simulation interviews—five each for the before and after groups. Here, the pilot study aimed to ensure that the study tools and the simulation process were feasible and effective. It also ensured that the MD could practise performing his role. Moreover, piloting allowed for verifying that the study tools (e.g., simulator) were working as expected and for testing for the best place to site the video recorder. Initially, the video recorder was placed at an angle that did not fully capture the participants and simulator. Consequently, a better angle was found and used in the simulation study. Thus, the pilot study enabled familiarity and practice in running a simulation session as well as in extracting relevant data using the instructor laptop.

For the qualitative study component, I became familiar with how to conduct the post-simulation interviews and noticed that taking notes during the interviews may have unintended consequences. Here, some participants, based on their facial expressions, seemed uncomfortable.

Perhaps, they felt flustered as they sometimes stopped talking when I was taking notes. As a result, in the main study, no notes were taken during the interviews, as they were audio recorded instead.

3.7 Data analysis

This project included both quantitative and qualitative data. The analysis of these data is explained in the following two sections.

3.7.1 Quantitative analysis

All of the quantitative data collected for this project were analysed using IBM SPSS statistics software version 27. Data were first assessed using a Shapiro-Wilk test to identify distribution. Normally distributed data are presented as means and standard deviations (SD), while non-parametric data are presented as medians and interquartile ranges (IQR). Data that were not normally distributed included, for example, time to first chest compression in call observations and depth of compression in the before-after simulation study.

All categorical quantitative data are presented as counts and percentages—for example, the closed questions in the observation of calls (e.g., did the MD provide CPR instructions?) as well as gender and nationality information from the before-after simulation study.

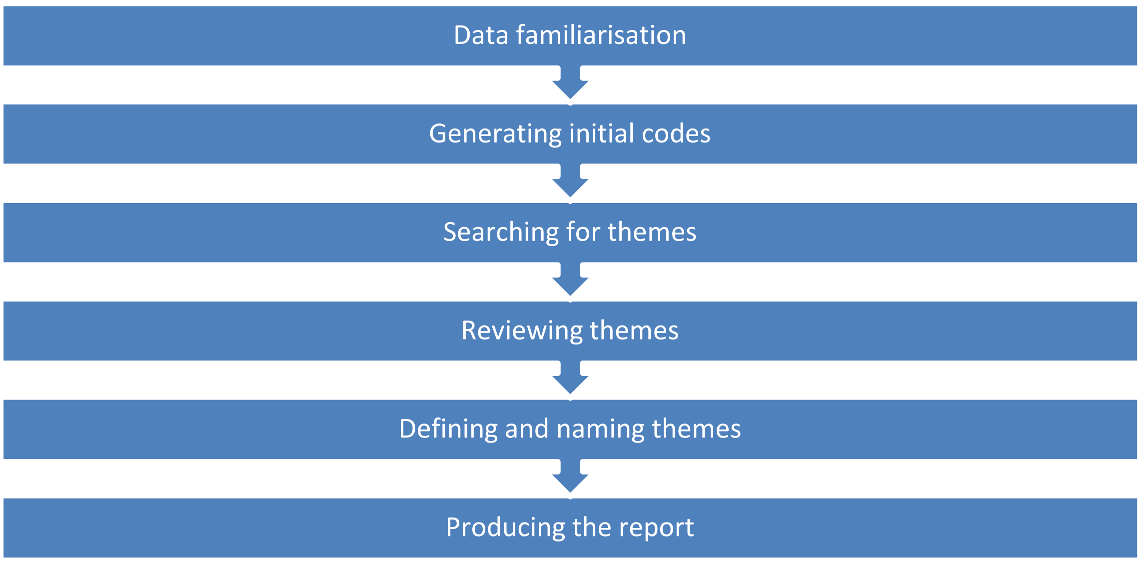
Comparisons between the data sets were examined for significance using either an independent sample t-test or a Mann Whitney U-test. The Shapiro-Wilk test was first applied to determine the data distribution, and then the appropriate test was selected. The comparisons included, for example, comparing male and female callers in the time taken to start the first chest compression in the observations of calls study as well as the CPR timeliness and quality performance between the before and after groups in the before-after simulation study. The effect size between the before and after groups were also measured to provide a magnitude of the difference in performance. As IBM SPSS statistics does not measure effect size for Mann Whitney U-test, the effect size was measured manually when Mann Whitney U-test was used. The effect size was measured based on the formula $R = \frac{z}{\sqrt{n}}$ as recommended by Fritz, Morris and Richler (2012), where ‘z’ represents the absolute z-score and ‘n’ represents the total sample size. The effect size is classified as 0.1 (small), 0.3 (moderate) and 0.5 (large) according to Cohen (2013). Larger effect sizes refer to a larger practical significance of the research outcomes.

3.7.2 Qualitative analysis

All qualitative data were analysed using inductive thematic analysis, as outlined by Braun and Clarke (2006). When the calls observation and post-simulation interviews were completed and transcribed, thematic analysis was undertaken.

Thematic analysis is a method used to identify, analyse, and report patterns/themes of collected data (Braun and Clarke, 2006). This inductive analysis approach is used to identify themes that emerge from the data without trying to make them fit into a pre-existing coding frame (Braun and Clarke, 2006). In this context, Braun and Clarke (2006) describe six phases of thematic analysis (see Figure 10). These include familiarisation with data, generating initial codes, searching for themes, reviewing themes, defining and naming themes and producing the report. Here, it is important to note that the analysis was not a linear process and was developed over time, as recommended by Ely *et al.* (1997). Thus, the analysis involved moving back and forth between the phases.

Figure 10. Thematic analysis phases. Reproduced from (Braun and Clarke, 2006).



1) Familiarisation with the data

This phase aims to ensure familiarity with the data collected (Easterby-Smith, Thorpe and Jackson, 2012). As I collected and transcribed the data, I became very familiar with the data. Further, data transcription is viewed as an interpretive act that enables researchers to become involved with the data (Bird, 2005). Braun and Clarke (2006) suggested that researchers should 'immerse' in the data until they are familiar with its depth and breadth. Thus, I read and reread the transcriptions until I became sufficiently familiar with the data and started to identify initial patterns in it.

2) Generating initial codes

In this phase, I started to write initial codes of the data to capture early ideas that looked interesting and relevant to the topic being examined (Braun and Clarke, 2006). As the data were in Arabic (see translation section below) and qualitative analysis software (such as NVivo) does not support Arabic, manual coding was applied by creating notes in the transcripts using Microsoft Word. The initial codes were generated using as many codes as needed to capture all interesting and relevant data. The initial codes were then collated to prepare for the next phase.

3) Searching for themes

The initially identified codes were organised and sorted into potential themes. Themes are different from codes as they include broader analysis and interpretation (Braun and Clarke, 2006). Further, the potential themes were ensured to be distinct and conceptually different. The definition of each theme along with a clear concept were then developed. The relationship and potential patterns between the different codes and sub-themes and how they can be combined to create a theme were also considered. At the end of this phase, the candidate sub-themes and themes with the relevant extracts of the data were identified.

4) Reviewing the themes

In this phase, sub-themes and themes were reviewed. The extracts were first reviewed to ensure that they had a coherent pattern to the themes they were forming. Then, similar sub-themes were grouped to be articulated in a theme. Additionally, similar themes were grouped to be articulated in an overarching theme.

5) Defining and naming themes

This phase defined and refined the themes to be present in the analysis. The essence of what each theme was and what the overall themes were about were identified, as was the relationship between the themes (and sub-themes). A detailed analysis of each theme was then conducted and written down along with the narratives of the themes in relation to the study objectives.

6) Producing the report

This phase produced the report of the final analysis. However, during the write-up, some analysis was conducted as necessary to clarify the themes and concepts. The analysis along with the extracts, to provide evidence of the themes, is written in the result chapters of this PhD (see Chapter 4 and Chapter 5).

<u>Translation from Arabic to English</u>

All qualitative data (audio files and transcripts) were in Arabic. It is recommended that qualitative analysis be conducted using the source language of the data (which was Arabic) and then, the final report be translated into the target language (which is English in this PhD project) to avoid the loss or hindrance of the meaning of the data, which could influence the validity of the analysis (van Nes *et al.*, 2010; Al-Amer *et al.*, 2016). Thus, the quotations in this PhD thesis were translated to target the meaning rather than being translated word by word. This is because a word-by-word translation is likely to influence the meaning due to language differences, as concepts of a language (e.g., Arabic) might be understood differently in another language (e.g., English) (van Nes *et al.*, 2010). As I collected, transcribed and analysed the data and speak Arabic and English fluently, I translated the Arabic quotes into English, with the aim of conveying the meaning of the quotes.

3.8 The impact of my background on the research

This PhD project is relevant to my clinical background as a paramedic with a master's degree in critical care, which invariably influenced the way in which I undertook this research. More specifically, I worked clinical shifts as a paramedic in current practice in Saudi Arabia. Thus, as part of my training and clinical work, I have seen and treated many OHCA patients. Communication with patient's family members, who are under emotional stress, is part of the treatment I provide in OHCA cases. This experience enabled me to listen to OHCA calls, which are stressful, and accordingly extract the needed data. In this context, Pierce and Lilly (2012) highlighted that around 32% of 911 dispatcher reported peritraumatic syndrome due to receiving 911 calls, including OHCA calls. However, my background helped me cope with the OHCA calls and accordingly extract the data, while remaining aware of how to seek mental health support if needed.

Also, I am considered to be conducting 'insider research' in this setting. Greene (2014) defined insider research as one where the researcher is conducting research within a group of society or culture that he/she is a member of. Moreover, insider research has the potential to ask meaningful questions to research participants in the interviews and read non-verbal cues that could add value to the data collected (Merriam *et al.*, 2001). Additionally, being an insider provides an understanding of the culture of where the study is conducted (Merriam *et al.*, 2001). Thus, this helped me to understand the context of communication between the MDs and callers, as the communication was influenced by some cultural considerations relevant to gender differences (see Chapter 4). Further, it helped me to approach participants and ask questions, while cultural considerations taking into account, especially when dealing with female participants. It also guided me to make the decision to involve a female chaperone, which made it easier to approach female participants. Although the female chaperone was not present in the interviews, the interviews did not discuss private or sensitive topics. Therefore, the female participants looked comfortable and responded to all the questions asked.

Additionally, I also have an academic background in teaching paramedic students, which assisted in the flow of the post-simulation interviews in the before-after simulation study. CPR teaching is a key part in teaching paramedic students, and I therefore had already become familiar with the difficulties that novices might face when they perform CPR. This enabled me to understand what the participants in the before-after simulation study were going through while performing CPR. This assisted the flow of the post-simulation interviews, as my background provided me with the knowledge to ask meaningful follow-up questions and prompts about the CPR task.

However, being an insider might have some disadvantages, such as being at risk of bias and subjectivity (Greene, 2014). To avoid them, no personal assumptions or views were conveyed to the participants during the interviews. Regular meetings and discussions with the PhD supervisors were conducted during data collection and analysis to receive opinions and further guidance from outsiders. Additionally, the data analysis was conducted rigorously to avoid any subjectivity in the analysis.

Therefore, as explained above, my background played a role in assisting in the data collection of this PhD project.

3.9 Ethical considerations

This PhD project followed the general ethical principles to ensure good research practice and integrity. This included obtaining all required ethical approvals and informed consent (recruiting participants with signed consent forms) as well as ensuring the anonymity, confidentiality, and safe storage of data.

3.9.1 Ethical approval

This PhD project involved three key stages of data collection: 1) the observation of calls study; 2) the before stage of the simulation study; and 3) the after stage of the simulation study. Thus, three separate applications were made to obtain ethical approval.

Ethical approval for the observation of calls study was sought from the University of Southampton Ethics and Research Governance Online (ERGO) (ID: 40967). A further ethical approval submission was sought for approval to collect data in Saudi Arabia. For research that takes place at the SRCA, researchers are required to obtain ethical approval from the Institutional Review Board (IRB) at the Ministry of Health (MOH) in Saudi Arabia. Additionally, completing a training course entitled 'Protecting Human Research Participants' was a pre-requisite by the MOH to be given ethical approval.

Two separate ethical approvals were obtained for the before-after simulation study from the University of Southampton ERGO (ID: 47622 and 54195). KSAU-HS requires researchers seeking to conduct research within KSAU-HS premises obtain ethical approval from the King Abdullah International Medical Research Centre (KAIMRC) in Saudi Arabia. Consequently, ethical approval from KAIMRC was successfully obtained. The KAIMRC provided one ethical approval, with an extension that covered both the before and the after stages of the simulation study. Access to KSAU-HS to use the simulation lab and carry out data collection was then secured.

3.9.2 Informed consent and the patient information sheet

Consent forms and patient information sheets (PIS) were provided to participants prior to their involvement in the before-after simulation study. The observation of calls study obtained ethical approval using a 'waiver of consent form'. This allowed for the collection of anonymised routine data from health services without the need to obtain individual caller consent.

Each participant in the before-after simulation study was given a PIS prior to taking part, and any questions they had about the study were answered. The PIS described the nature of the study and what participation would involve. Before they agreed to participate, participants were notified that they could end the simulation session or the post-simulation interviews at any time they felt uncomfortable and for any reason, without having to give a reason. Following this, two consent forms from ERGO and KAIMRC (see Appendix K) were provided for each participant to sign. Participants were made aware that participation was entirely voluntary. Further, no pressure was applied to sign the consent form, and no participant was recruited without this signing.

3.9.3 Anonymity and confidentiality

Confidentiality and anonymity were ensured by adhering to the fundamental principles of anonymity and confidentiality. No personal data were discussed or disclosed to any individual. With regard to the observation of calls study, call recordings were listened to via headphones in a private office at the SRCA. Although personal details were heard during the call (e.g., names and addresses), these data were not recorded during data extraction. Furthermore, the population was sufficiently large, so it was highly unlikely that any individual would be identifiable. Moreover, the call recordings did not leave the premises as all calls were listened to and anonymised data extracted at the central station of the SRCA in Riyadh.

To maintain confidentiality in the before-after simulation study, identifiable participant data were stored securely and only shared among those identified in the ethical approvals (the research team). Further, no extracted information was sufficiently detailed to identify individuals (e.g., department where the staff work or the speciality studied by the students). Linked anonymity was used for the participants' files—both audio and video recordings.

Anonymised ID numbers were used in the transcribed documents and subsequent analysis. In this thesis and in publications resulting from this PhD project work, words and phrases will be anonymously quoted.

During the simulation itself, only the participant, the MD, and I (in addition to the female chaperone when the participant was female) were present, minimising the opportunity for the participant to be seen taking part in the study. Similarly, the interviews were conducted in a quiet space with only the participant and me present.

3.9.4 Data storage and management

All data were collected in Saudi Arabia, but stored in the secure University of Southampton filestore via the Southampton Virtual Environment (SVE), which gives access to the University Windows desktop from any location. A virtual private network (Global Protect) was used when working with secure electronic data stored on the University of Southampton server.

Electronic data were kept on a password-protected Southampton University server. Paper documents with identifiable information (consent forms) were scanned and kept on the Southampton University server, after which the paper documents were shredded. Video and audio recordings were transcribed and kept on the same server.

The data will be kept for the duration of the PhD programme. Following completion of this PhD, data will be kept on a university password-protected computer for a duration of ten years by my supervisors in compliance with the university data retention policy.

3.10 Summary

This PhD project used a sequential mixed-method study design, which consisted of an observation of calls to understand current practice and a before-after simulation study. A sequential design was selected so that findings from earlier study components could inform the simulation study.

Moreover, the observation of calls study used a retrospective mixed method design aiming to investigate the nature of OHCA calls and the T-CPR protocol in the current practice in Saudi Arabia. This was followed by a before-after simulation study that examined the Saudi T-CPR protocol, explored possible modifications, then developed the enhanced T-CPR protocol, and tested it using a prospective mixed-method design.

The initial version of the enhanced T-CPR protocol was developed based on three resources drawn from findings of observation of calls, findings from the before stage of the before-after simulation study, and supported evidence from the literature. The initial version was then reviewed by medical and language experts and validated using PPI.

All quantitative data were analysed using SPSS, while the qualitative data were analysed using inductive thematic analysis. Additionally, all ethical approvals were obtained prior to conducting the studies and all participants signed the required consent forms before taking part.

Chapter 4 Findings: observation of calls study

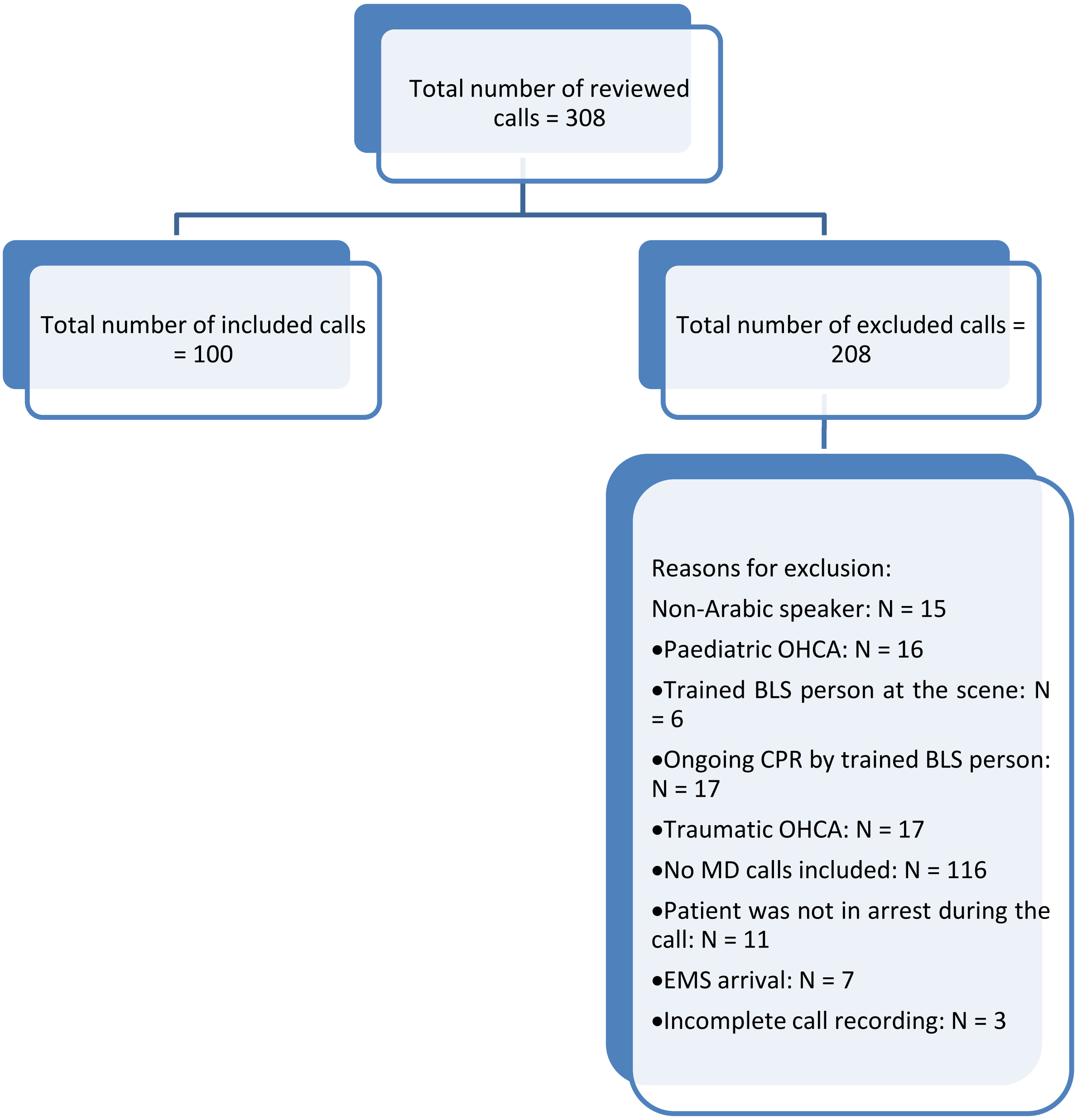
4.1 Introduction

This chapter presents the results from the observation of calls study describing the nature of OHCA calls and T-CPR protocol in current practice in Saudi Arabia. This chapter begins by presenting the characteristics of OHCA calls to set up the context of the calls. Further, time to first chest compression and the proportion of misrecognised OHCAs are presented to establish the baseline performance of T-CPR in current practice and compare them with the AHA standards. Next, qualitative observations are analysed to provide a possible explanation for the delays in time to first chest compression and misrecognition of OHCA. Observations of the language used in the communication are then examined to highlight the preferred form of the Arabic language that the callers used to communicate. Finally, the key findings as well as implications of the before-after simulation study and the development of the enhanced T-CPR protocol are presented in the summary section.

4.2 Baseline characteristics of OHCA calls

A sample size of 100 consecutive calls was included after applying the inclusion and exclusion criteria. To include the first 100 consecutive calls meeting the inclusion and exclusion criteria, a total of 308 calls were reviewed (see Figure 11). A brief summary of the total reviewed OHCA calls (N = 308) highlighted that most callers (N = 293; 95%) were Arabic speakers. Here, only 15 callers (5%) were excluded due to their speaking of other languages. Moreover, as the T-CPR protocol is aimed at untrained BLS callers, 23 calls (7.4%) were excluded for the following reasons: 17 callers (5.5%) had already started CPR prior to contacting the EMS; and the six other callers (1.9%) reported having BLS training, and thus, there was no need for CPR instructions.

Figure 11. A flow diagram of the included and excluded OHCA calls.



The details of the patients' and callers' characteristics in the included 100 OHCA calls are presented in Table 6. More calls to the service were made by men, but 24 calls (24%) were made by women, showing that women do report OHCA cases. Further, of the 100 callers, 83% were Saudi callers, and 72% of calls were made on behalf of a relative (e.g., parents, spouse and siblings). Demographic characteristics of the callers and patients are presented in Table 6.

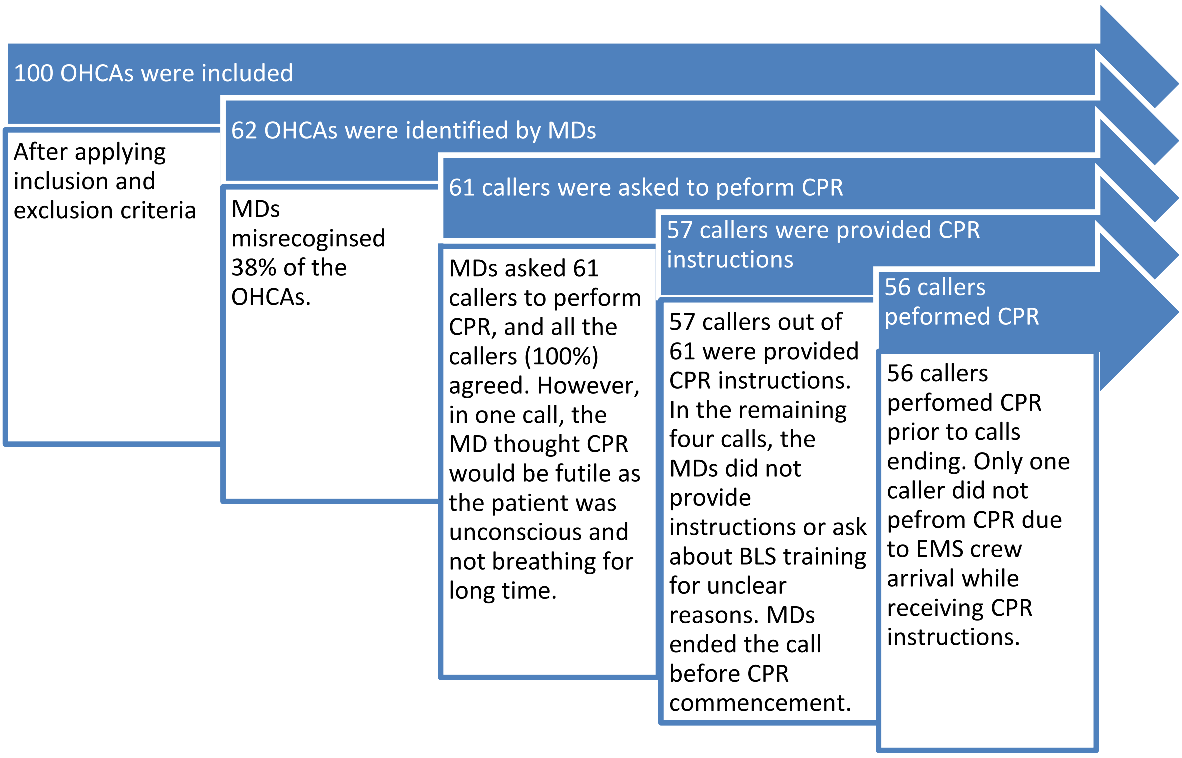
Table 6. Baseline demographic characteristics of the OHCA callers and patients.

Demographic characteristics	Caller N (%)	Patient N (%)
Gender:		
Male	76 (76%)	60 (60%)
Female	24 (24%)	40 (40%)
Nationality:		
Saudi	83 (83%)	80 (80%)
Other Arabic countries	17 (17%)	20 (20%)
Calls made by relatives*:		
Relatives	72 (72%)	
Nonrelatives	26 (26%)	
Unknown	2 (2%)	

*Relatives include parents, spouse, siblings, and other relations considered as relatives in Saudi culture including uncles and grandmothers.

Out of the 100 included OHCAs, 62 cardiac arrests (62%) were identified (see section 4.3.1), and subsequently, the MDs asked 61 callers (61%) to perform CPR. Here, one caller was not asked to perform CPR, as the MD on the call thought CPR would be futile as the patient was unconscious and had not been breathing for a long time. Meanwhile, all 61 callers (100%) agreed to perform CPR. However, the MDs provided CPR instructions to 57 callers (93.4%) with no clear reasons as to why the remaining four callers did not receive them. Subsequently, 56 callers (91.8%) performed CPR, while the MD was on the phone, and one caller did not start CPR as the ambulance crew had arrived. Figure 12 summarises these stages of callers' CPR rates. Moreover, patients' ROSC rate was found to be low at 10% to hospital arrival. However, after using the non-parametric Mann Whitney U test, it was found that there was no significant difference between patients who received CPR and those who did not ($p = 0.29$).

Figure 12. Illustration of callers' CPR rates in OHCA calls.



4.3 OHCA recognition and time to starting first chest compression: compliance with AHA standards and factors influencing them

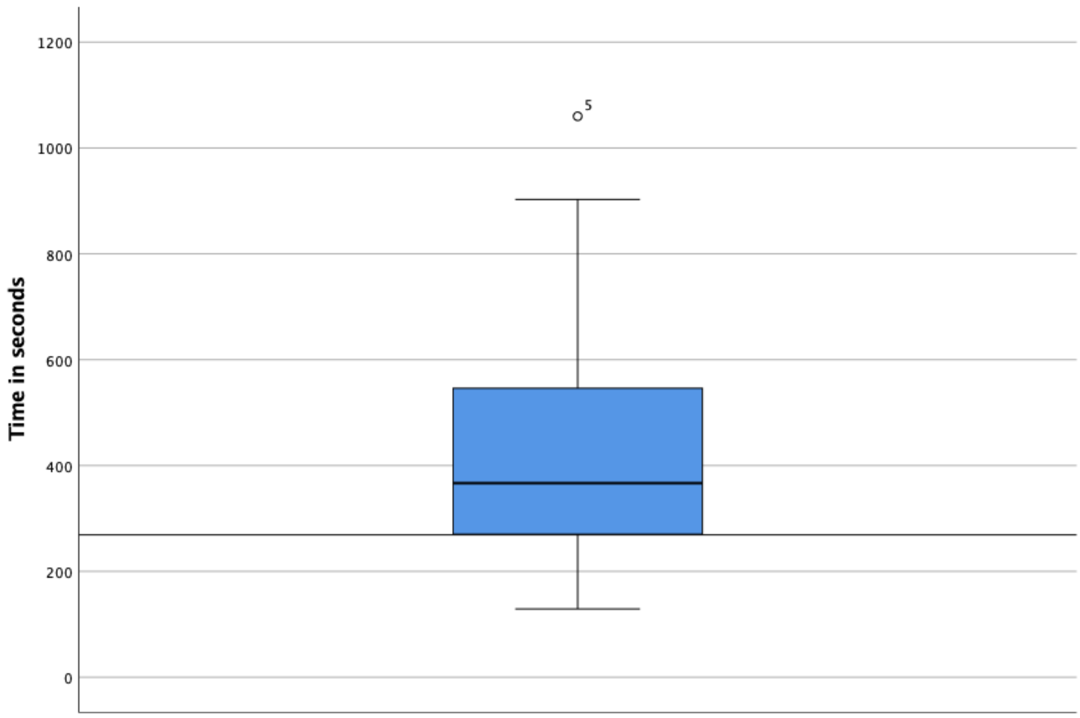
The proportion of OHCA identification and the time taken from EMS call receipt to starting of first chest compression were measured and then compared with the AHA standards to determine whether they met them. Qualitative observations of the calls provided insight into factors that are associated with the OHCA recognition and the time to first compression.

4.3.1 Baseline performance and comparison with the AHA standards

Not all OHCAs were correctly identified by the MDs, and subsequently, no CPR was performed in the unrecognised cases. In the 100 included OHCAs, the MDs successfully identified 62 cardiac arrests (62%). This falls short of the AHA standards, which state that 75% of the total OHCAs be correctly identified. Even though it can be challenging to identify all OHCAs, the MDs fell short by 13% of the AHA recommendation.

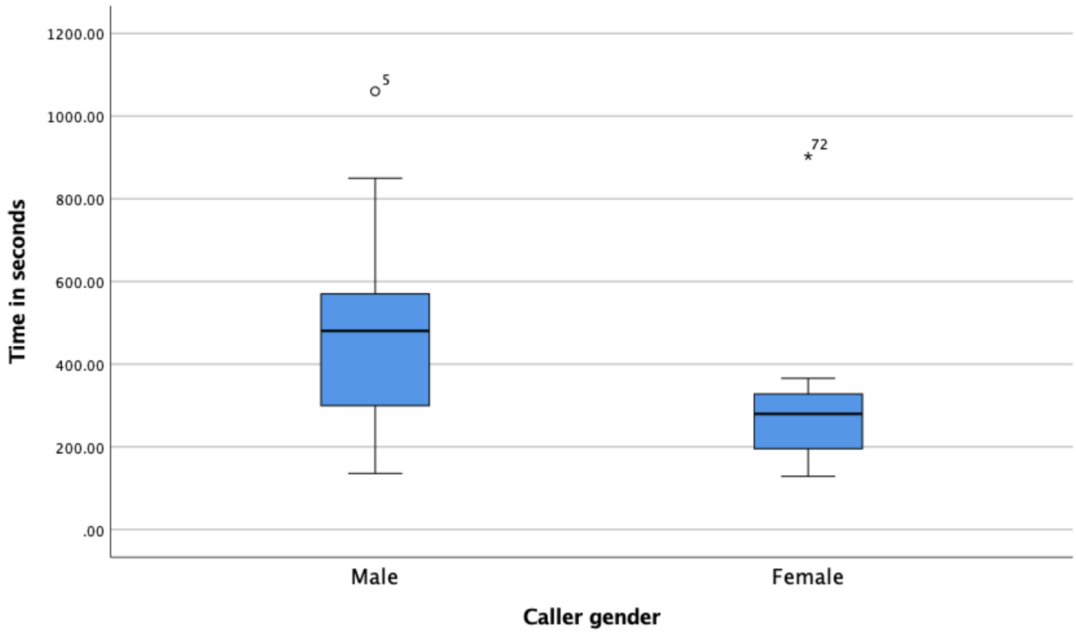
In the identified OHCA calls where CPR was performed (N=56), the time to first chest compression was longer what is recommended by the AHA standards. The callers (N = 56) started chest compressions with a median time of 367 s from the EMS call receipt. This exceeded the minimum acceptable and high AHA standards by 217 and 277 s, respectively (see Figure 13). Moreover, none of the callers performed the first compression within the high AHA standard, and only two callers (3.57%) reached the minimum AHA standard.

Figure 13. A Box Whisker plot of the time from EMS call receipt to the start of first chest compression.



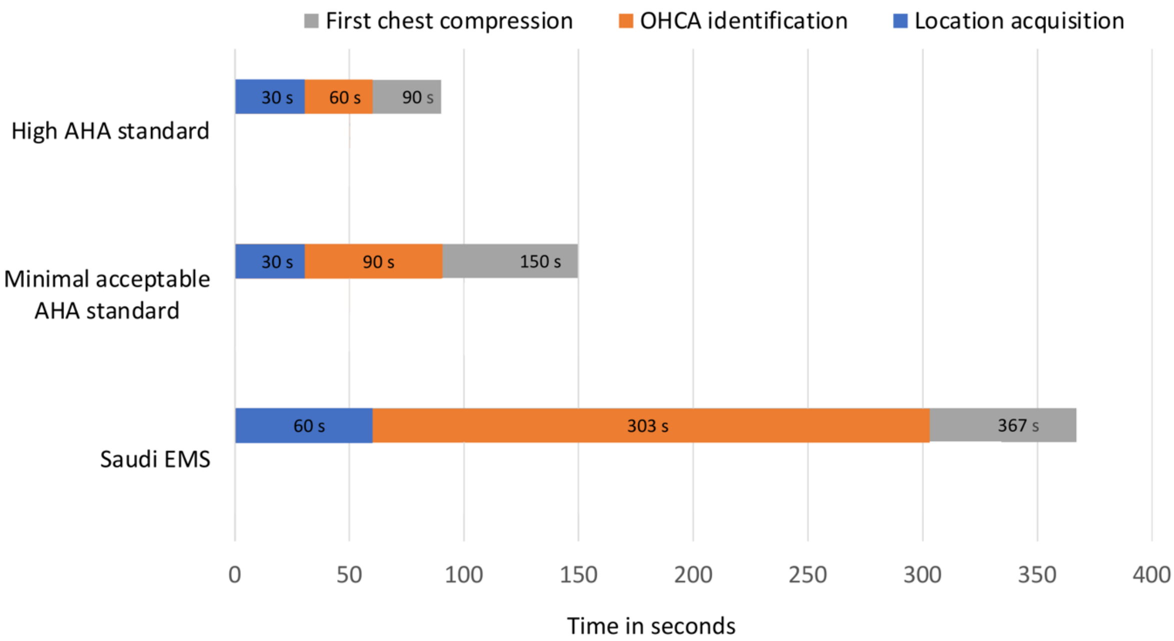
Using a non-parametric Mann-Whitney U test showed that female callers significantly (p =.002) commenced chest compressions faster than male callers, with the median times at 280 and 480.5 s, respectively. Figure 14 presents the differences between female and male chest compressions initiation times.

Figure 14. A Box Whisker plot of the time from EMS call receipt to the start of first chest compression by gender.



The delayed time to first compression could be influenced by how the call is processed from the time of the EMS call receipt until the callers started chest compressions. Prior to starting chest compressions, the call location has to be identified by the call takers, the call has to be transferred to an MD, and then, OHCA has to be identified by the MD (as indicated in Chapter 1 section 1.5.3.1). The time taken to complete each of these steps is summarised and compared with the AHA standards in Figure 15.

Figure 15. OHCA call processing from the EMS call receipt until first chest compression and comparison with the AHA standards.



As seen in Figure 15, the call takers took a median time of 60 s from the EMS call receipt to identify patients' location, which is double that of the AHA recommendations (the minimum and high targets are the same). This delay might be due to the callers having to describe their locations as the calls tracking system does not accurately identify location (as described in section 1.5.3.1).

Meanwhile, call processing in SRCA requires call takers to transfer urgent calls, including suspected OHCA calls, after acquiring the location to the MD to continue with triage and advice (as described in section 1.5.3.1). MD call transfer took a median of 231.5 s from the EMS call receipt until the MD answered the call.

Following this, OHCA identification by the MD took additional time, leading to the median of 303 s from the EMS call receipt. This exceeds the minimum and high AHA standards by 213 and 243 s, respectively. Thus, the delay in location acquisition, the MD call transfer, and OHCA identification have influenced the time to first chest compression. Table 7 presents details of the time taken and a comparison with the AHA standards.

Table 7. Time intervals in the OHCA call process.

Parameters	N	Median	IQR	Compliance with the high AHA standards N (%)	Compliance with the minimal acceptable AHA standards N (%)	Test for normality	
						Shapiro-Wilk (p value)	Distribution
Time to first chest compression (s)	56	367	266.75–550.5	0 (0%)	2 (3.57%)	.004	abnormal
Time to OHCA identification (s)	62	303	177.75–496.25	0 (0%)	1 (1.61%)	.001	abnormal
Time to MD call (s)	100	231.5	131.5–413	N/A	N/A	<.001	abnormal
Time to location acquisition (s)	99 *	60	34–91	21 (21.21%)	21 (21.21%)	<.001	abnormal

* Time to location acquisition in one call was not recorded in the EMS calls system, but the reasons for this are unknown.

Further analysis of the time taken during the call process showed that there is a median of 171.5 s between accomplishment of the location acquisition and the MD starting to talk to the caller. During this time, the ambulance is being dispatched, but the caller is free and waiting for the MD to contact him/her. Also, further analysis of time between OHCA identification and first compression showed that the callers (N = 56) performed the first chest compression at a median of 50.5 s after the MDs had identified cardiac arrests. This time interval meets the minimum acceptable AHA standard, which recommends the first compression commences less than 60 s following OHCA identification. Of the 56 callers who performed CPR, 33 (58.92%) commenced the first compression within the minimum AHA standard, and 13 callers (23.21%) performed it within the high standard. However, 43 (76.78%) and 23 (41.07%) callers performed first chest compression below the high and minimum AHA standards, respectively.

The qualitative observations were analysed to provide a further possible explanation of factors that were associated with the OHCA misrecognition and the time to chest compressions (see section 4.3.2).

4.3.2 Factors that influence OHCA recognition and the time to first chest compression

The quantitative analysis showed that OHCA recognition and the time of initiation of chest compression were below the AHA standards, while the qualitative analysis of the observations identified possible factors associated with the low performance. There are a number of factors that relate to how language is used in T-CPR protocol instructions. Such factors could be improved by enhancing the language and T-CPR protocol, which is the focus of this thesis. However, it is also important to describe the wider context of OHCA calls in which T-CPR takes place. T-CPR is a complex task where a broad set of factors (e.g., emotional distress, physical barriers to performing CPR) also influence OHCA recognition and time to first compression. These broader contextual factors are likely to not be directly addressed by enhancing the language and T-CPR protocol. However, simplifying the language in the protocol could help ameliorate the impact of these other factors such as the emotional distress. Table 8 provides descriptions of the two different groups of factors, which are presented in the following sections.

Table 8. Description of factors associated with OHCA misrecognition and time to first chest compression.

Factors	Description
Complexity of the language and T-CPR protocol	Factors relevant to the language and T-CPR protocol can influence OHCA recognition and time to first compression. Such factors are grouped into this overarching theme.

1. Imprecise instructions and caller interpretation	Imprecise instructions can influence the flow of communication. Some instructions were imprecise and presented difficulties for the callers in interpreting them.
2. Difficulties in understanding local dialects	Speaking using local dialects was found to affect the communication. Some dialect terms were used by the MDs and callers, and they were found to be difficult to understand.
3. Variations in language used to describe agonal and abnormal breathing	The callers used different terms and phrases to describe agonal and abnormal breathing. These variations made it difficult for the MDs to identify them.
4. Unnecessary and repeated questions and instructions during T-CPR	Questions and instructions were considered unnecessary when the caller had already confirmed the patient was unconscious with no/abnormal breathing prior to being asked. Repeating questions about consciousness and breathing were considered unnecessary when the callers had clearly answered them already.
5. Involving a third person in the call	The involvement of a third person was the caller's decision but was promoted by the MD's questions and instructions. The third person was involved to assist the caller in answering the MD's question or performing CPR.
Factor	Description
The complex context of OHCA calls	The context of OHCA calls, when T-CPR protocol is provided, is associated with OHCA misrecognition and delay in time to chest compression. Relevant factors are grouped in this overarching theme.
1. Emotional distress as a barrier to communication and starting CPR	The callers' emotions (e.g., distress) influenced their ability to cooperate with the MDs and to

	comprehend the MDs' questions and instructions.
2. Cultural and gender considerations	Occasions when the MDs asked female callers to hand the phone to a male caller or when male callers refused to assess or perform CPR on nonrelative female patients.
3. Barriers to physically accessing patient	Lack of access to patients was due to the callers being in a different place and the need for e-positioning patients to the correct position for chest compressions.
4. Incomplete calls	The MDs losing connection with the caller was observed when the callers left or ended the call (and then returned), the MDs left the phone (and then returned), and the call signal quality was poor.
5. Legal barriers to providing CPR instructions	The MDs suspected a crime and Do Not Resuscitate (DNR) order and then, asked further questions to ensure the legality of providing CPR instructions.
6. Suspected of seizure and choking	Patients' conditions as described by the callers could be misleading, causing the suspicion of other medical diagnoses.

4.3.2.1 Complexity of the language and T-CPR protocol

The T-CPR instructions and the wording of these instructions, and the language/words used in communication between the callers and MDs were associated with a delay in time to first compression and misrecognising the cardiac arrest. The factors included providing imprecise CPR instructions, using local dialects, using different words and phrases to describe agonal breathing, asking unnecessary questions, and involving a third person in the calls. These factors could be addressed by enhancing T-CPR protocol and the language being used.

4.3.2.1.1 Imprecise instructions and caller interpretation

The clarity of CPR instructions given to callers influences how promptly they are able to commence chest compressions. Thus, some callers found it difficult to understand and interpret some of the instructions provided by the MDs. This was indicated by the caller asking for further clarifications about the instructions.

The MDs often used wording that was different to what was written in the Saudi T-CPR protocol, which are explored in section 4.4. This resulted in varying wording and phrasing used by different MDs (see section 4.4). Some callers had difficulty in interpreting some instructions because the instructions were imprecise. For example, when the callers were guided to place their hands on the patient's sternum or the middle of the chest, some did not know where to place their hands. This required the caller to ask for further clarification, causing a delay. In the call detailed below, the caller could not identify the middle of the chest from the instructions.

MD: You will push using your two hands ... [the dots refer to a short pause in this thesis] and your hands flat on the middle of the chest.

The caller: In the middle of the chest? What do you mean?

MD: Exactly at the centre of the chest ... 100 compressions in every minute.

The caller: OK.

MD: OK. (call number 55)

4.3.2.1.2 Difficulties in understanding local dialects

Simplicity and clarity of the language spoken between the callers and MDs facilitate the flow of information, which leads to the prompt initiation of chest compressions. However, some MDs and callers experienced difficulty in communication due to the usage of some local dialect words or terms during the call. The difficulty was indicated when either the MD or caller had to repeat their questions, answers, or instructions, or ask for further clarification.

The callers and MDs showed a preference for communicating using simple language that is easily comprehended by the public (see section 4.4). However, in some calls, local dialects were used, which impacted the understanding of both MDs and callers and required them to clarify what had been said. Consequently, such misunderstandings in communication, along with the need for clarifications, influenced the flow of communication, which introduced delays. In the two calls below, the MD and caller both spoke Arabic as a first language, but they most likely came from different countries, which have different dialects, and this led to a misunderstanding.

MD: Where is he [referring to the patient] laying down? On the floor?

Caller: He is laying on his back ['his back' was said using a dialect term].

MD: Laying on what?

Caller: On his back ['his back' was said using an alternative familiar term] ... his back is down and he is laying to the front [meaning that his face is to the front].

MD: OK, so he is laying on his back. (call number 26)

Caller: completely unconscious and not responding to us but his eyes are open and they look [a dialect term].

MD: what do you mean by they look [the dialect term]?

Later on the same call, MD: have you previously seen basic life support?

Caller: yes [‘yes' was said using a dialect term], I saw.

MD: did you see it? Or did not you see it? [MD did not understand the answer]

Caller: I saw. (call number 32)

4.3.2.1.3 Variations in language used to describe agonal and abnormal breathing

Agonal and abnormal breathing were observed in the OHCA calls and were described in different ways by the callers. In this context, using different terms and phrases could have made it difficult for the MDs to identify the agonal and the abnormal breathing. The misrecognition of agonal or abnormal breathing could lead to a misrecognised OHCA or a delay in recognising cardiac arrests and consequently, the time to chest compressions.

Callers who are untrained in BLS are not familiar with agonal breathing, which makes it difficult for them to accurately describe it when patients were experiencing it. Here, the callers used different terms and phrases to describe this breathing including ‘snoring’ and ‘taking big gasps’ as well as simulating the agonal breathing by saying ‘akkh akkh’. These descriptions were provided in addition to the absence of patient’s consciousness. The variations in the language (terms and phrases) describing agonal breathing made it difficult for the MDs to recognise it. The MDs seemed to not be familiar with the different ways in which the callers described agonal breathing, leading to the misrecognition of agonal breathing. This resulted in them having to ask additional questions (e.g., about the patient’s past medical history) to further clarify the patients’ condition, causing further delays. When patients stopped agonal breathing, the MDs were able to identify the cardiac arrest, thus causing a delay in the commencing of chest compressions. On the other hand, if agonal breathing was persistent, cardiac arrest was misrecognised.

Caller: I went to him then I saw his face became yellow then he suddenly gasps then be quiet! I do not know what is the problem!

MD: So, he does not respond to you if you talk to him?

Caller: No, he does not respond at all.

MD: But he is breathing, right?

Caller: No, his breathing is suddenly being quiet, then gasping a strong gasp and then, stop!

MD: OK brother … are you close to him?

Caller: I am now close to him.

MD: Look at his breathing, how often does he breathe?

Caller: He takes a while … around seconds then he gasps a strong gasp.

Later on the same call, MD: Place him on his right side so his breathing becomes better until the ambulance arrives [guiding the caller to the recovery position].

Caller: I already placed him ... and his face became yellow and his eyes [unclear word], and there is no response ... nothing.

MD: Is he not moving at all, brother?

Caller: At all.

MD: Look at his chest, does it move with the breathing?

Caller: He has no sound ... there is no breathing!

MD: There is no breathing?

Caller: No, it looks like there is no breathing at all. (call number 80)

Along similar lines, callers used different terms and phrases to describe the breathing quality making it difficult for MD to differentiate between normal and abnormal breathing. The descriptions included shortness of breath as well as weak and heavy breathing. These descriptions were provided in addition to the absence of patient's consciousness. However, they could have influenced how the MDs assessed 'breathing quality'. The abnormal breathing was misrecognised, which led to misrecognising OHCA.

MD: Is she breathing or not? Now, look at her come closer to her.

Caller: Very weak, I feel weak breathing, which might not be counted ... but I feel it.

MD: Is she now completely unconscious?

Caller: She is completely unconscious.

MD: OK, how is the breathing now?

Caller: Very weak I feel very weak breathing.

The MD then provided recovery position instructions, and the call then ended. (call number 27)

4.3.2.1.4 Unnecessary and repeated questions and instructions during T-CPR

The goal of T-CPR is to quickly elicit relevant data about the condition of patients. However, in some calls, there were questions and instructions that were unnecessary for patients in cardiac arrest. The unnecessary and repeated questions were asked prior to identifying the cardiac arrest as well as providing CPR instructions. Questions defined as 'unnecessary' included those focusing on past medical history, eliciting answers on the last time the patient had seemed normal, body temperature, face colour, and the caller/patient relationship. Despite such questions being asked to further investigate the patients' condition to decide on the correct intervention, they are considered unnecessary as they were asked after the callers had confirmed that the patient was unconscious with no/abnormal breathing; in such cases, OHCA should be suspected as per the ILCOR recommendations (see section 1.4.2). The answers to these types of questions will not change the decision to suspect OHCA and provide CPR instructions. Thus, they were associated with delays in the commencement of chest compressions. MDs also sometimes repeated necessary questions, about patient's consciousness and breathing condition. However, repeating them when they had received a clear answer from the caller could cause a further delay. While some unnecessary and repeated questions could have only caused minimal delay, further delay was caused when the callers did not know the answer and sought information from a third person (see section 4.3.2.1.5).

> *MD: OK my brother, is the patient responding to you?*
>
> *Caller: He is not moving at all, and there is no breathing.*
>
> *MD: OK he is not breathing my brother … when was the last time you saw him conscious? I mean did it happen in front of you or when?*
>
> *Caller: Around half an hour.*
>
> *MD: OK my brother, place him on his back. (call number 48)*

Similarly, unnecessary instructions were guided by the MDs to specifically clarify the presence of the patients' consciousness and breathing. The instructions were defined as unnecessary, as the callers had already provided clear answers about patients being unconscious with no/abnormal breathing prior to receiving those instructions. However, some MDs preferred to investigate consciousness and breathing further, with no clear reason, to confirm cardiac arrest. Such unnecessary instructions included guidance to open patients' airways, feel or listen for air movements, feel for carotid and radial pulse, monitor chest rising, perform painful stimuli to check consciousness, and open patients' eyes to check responses. The callers' application of these instructions (e.g., checking the carotid pulse) required time, which added further delay. Such instructions could have been avoided, especially when there were clear answers from the callers regarding the consciousness and breathing conditions. Additionally, in one call, the unnecessary instructions influenced OHCA recognition. In this one call, an MD asked a caller to check for a carotid pulse even though the caller had confirmed that the patient was unconscious and not breathing, which are circumstances in which OHCA should be suspected. Deciding whether a patient has a carotid pulse needs CPR-related experience, and therefore, this is an unreliable method of checking by people with no CPR background (per the recommendation of ILCOR – see section 1.4.2). The callers receiving T-CPR instructions do not have CPR training, are unlikely to be able to correctly decide if there is a carotid pulse and provide an accurate answer. Call 23 shows that applying the unnecessary instructions would require time from callers leading to delay in CPR commencement.

Caller: Now, he is on the floor and unconscious.

MD: Is his chest moving up and down?

Caller: No.

MD: OK place your two fingers on his neck and check if there is pulse or not ... on the trachea try to feel it you might feel it.

The caller left the phone to perform it and then came back: I do not feel anything. (call number 23)

4.3.2.1.5 Involving a third person in the call

Involving a third person during the call—which was a response by the callers to the MDs' questions and instructions—disrupted the flow of information in the communication between a caller and MD. Involvement of, for example, additional family members who were present at the scene could prolong the call, as the caller relayed information to other people at the scene and then returned information back to the MD. However, this was the callers' decision and was not requested by the MDs. Sometimes, the callers require additional information from a third person to answer the MDs' questions. However, as indicated in section 4.3.2.1.4, some questions were unnecessarily asked. Such questions prompted the callers to have discussions with a third person, causing further delays. Here, avoiding asking unnecessary questions can reduce the involvement of the third person.

MD: When was the last time you saw her conscious? At what time, approximately?

[The caller has a discussion with a third person on the last time they saw the patient conscious, as the caller was not present when the patient collapsed].

Twenty-one seconds later, caller: There was breathing when she was sleeping [referring to the last time the third person saw the patient].

MD: OK and now?

Caller: Now there is no breathing. (call number 3)

While involving a third person was prompted by the asking of unnecessary questions, some calls revealed that the callers involved a third person to assist in undertaking CPR instructions. This included, for example, involving a third person to assist in re-positioning the patient to the correct position to receive chest compressions or to perform chest compressions while the caller receives the instructions. However, it is unclear why the callers decided to involve a third person to assist in performing CPR itself.

MD: Place your hands on the middle of the chest and start chest compressions.

Caller talking to a third person at the scene: Place your hands on the middle of the chest and start chest compressions.

MD: Your right hand over your left hand in the middle of the chest.

Caller talking to the third person: Your right hand over your left hand at the middle of the chest.

MD counting: 1, 2, 3, 4, 5, 6.

Caller counting loudly: 1, 2, 3, 4, 5, 6.

MD: She [refers to the third person] should not stop until the ambulance arrives. (call number 71)

4.3.2.2 The complex context of OHCA calls

The observations of calls found that the complicated context of OHCA is associated with delays in chest compression initiation and OHCA misrecognition, regardless of the language and T-CPR protocol. The act of identifying OHCA then delivering T-CPR instructions and the caller performing CPR take place in a context in which the callers are very often emotionally distressed and are performing a complex and unfamiliar task. In addition, there may be other cultural considerations and barriers to physically accessing the patients that play a role in T-CPR. While these broader factors are not directly addressed by enhancing language and T-CPR protocol, it is important to note their existence. Simplifying language and enhancing communication may help to indirectly ameliorate the influence of some of these wider factors on T-CPR.

4.3.2.2.1 Emotional distress as a barrier to communication and starting CPR

Callers' emotional responses to cardiac arrests appear to affect the way in which they communicated with the MDs. Where callers were emotionally distressed, they were less capable of promptly cooperating with the MDs to identify OHCA and commence chest compressions.

The callers exhibited a range of different emotional responses during calls, including stress, fear (of harming the patient), and crying. This could have influenced their ability to cooperate with the MDs, to understand some of the questions/instructions and to subsequently initiate CPR. When the callers were emotionally distressed, the MDs had to repeat some questions and instructions to facilitate their understanding of instructions or to provide emotional support (e.g., encouragement) to guide them to start CPR. This introduced a delay prior to starting chest compression. However, when the MDs failed to calm the callers down, cardiac arrest was not identified as callers were unable to cooperate. Inability to cooperate was observed, when some callers did not answer the MDs' questions or provided insufficient answers to identify the cardiac arrest (for example, unclear answers about patient's breathing). In the call below, the caller is confused and provides unclear answers. The MD tries to calm the caller down, however, the caller is emotionally distressed and unable to cooperate.

MD: Come closer to your dad and check if he is breathing or not.

Caller: OK [the caller goes closer to her dad as she was not in the same place as him]. My dad died! [people crying in the background]

MD: My sister calm down calm down ... is he not breathing?

Caller: No, my dad died! [with a high tone and crying]

MD: My sister, listen to me ... place him on his back [most likely was going to provide CPR instructions, but the caller interrupted the MD].

Caller: No, he became alive! [very confused] What do I tell him? [referring to her dad].

MD: Talk to him, talk to him.

Caller: He is not talking! I am telling you my dad is [unclear word, as the caller is crying].

MD: Is there breathing?

Caller: There is weak breathing [crying, and her words were unclear].

MD: There is fast breathing? [MD could not hear her as the caller was crying].

Caller: No, I do not know brother! Mercy, mercy! [crying and shouting at the MD]

MD: OK, OK I will ask them to come fast [referring to the ambulance crew]. (call number 1)

4.3.2.2.2 Cultural and gender consideration

Cultural values and practices, particularly relating to gender, influenced the process of the telephone assessment of the patient and subsequent CPR performance. For example, in some calls, the MDs asked female callers to hand the phone to a male caller, and in other calls, male callers refused to assess or perform chest compressions on a female patient who is not a family member.

Asking female callers to give the phone to a male caller increased the time taken to start chest compressions, and there was further delay if a man (the third person) was involved. If there was no man present, then the MDs delivered the CPR instructions to female callers to perform chest compressions, causing minimal delay.

MD, after identifying OHCA: OK, is there a man in the house?

Caller [female]: Yes, here is my brother [referring to her brother].

MD: How old is he?

Caller: 19.

MD: OK, give him the phone.

The third person: Hello [crying].

MD: I need you to do chest compressions in the middle of the chest.

The third person: OK, how, how I do this! [sounding afraid]. (call number 31)

The cultural practices relating to limited interaction between men and women not from the same family also influenced who assessed the patient or performed chest compressions. In one call, the male caller could not assess the patient due to the presence of nonrelative females around the patient. In another call, a male caller could not perform chest compressions on a nonrelative female patient. In these cases, the male callers handed the phone to a relative of the patient or to a female caller. In the call below, the male caller deferred the call to the patient's family member.

MD: I need either you or anyone to do chest compressions until the ambulance arrives. Can you do it?

Caller: No, no I will tell one of her relatives to do it.

MD: No, the one who is going to perform chest compressions … let me talk to him, so I can tell him how to push.

Caller: OK, I will activate the speaker [goes to a family member of the patient]. (call number 15)

4.3.2.2.3 Barriers to physically accessing patients

Callers' access to patients was sometimes limited, influencing the process of assessing the patient or performing chest compressions. This included, for example, the callers not being with the patient when making the call and needing to re-position patients into the correct position for chest compressions.

Callers sometimes did not have immediate access to the patient at the start of the call or had no access at all, which interrupted the flow of communication. Some callers were not located near the patient while receiving instructions and questions from the MDs, which led to more lengthy communication. In two calls, the callers were transporting patients to hospitals by car while making the EMS calls. In one other call, the caller was outside the patient's house, as the caller had left to meet the ambulance crew, as the calls tracking system in the EMS could not identify the caller's location. Here, additional time was needed to establish access (e.g., a caller stopping the car and moving to be with the patient, or providing an MD with the phone number of a person next to the patient to call) leading to a delay in identifying the cardiac arrest and subsequently starting chest compressions. However, this study also revealed that access to the patient could not be established in two calls and subsequently cardiac arrest was misrecognised. In these two calls, the callers were not at the same location as the patient and were waiting for the ambulance crew to come. In these two calls, access to the patients was not possible, which prevented the relevant information about the patients' conditions (e.g., answering the question about breathing quality) being communicated to the MD to diagnose a cardiac arrest and respond accordingly. If there is a person present beside the patient, the caller provides the MD with the third person's phone number, which introduces a delay in cardiac arrest recognition and chest compression initiation.

MD: Is the patient conscious?

Caller: I am not going to lie to you [referring to 'I do not know'] … I went outside waiting for the ambulance.

MD: OK, is it possible to give me a phone number of anyone close to her [referring to the patient], so I can call to check on her?

Caller: OK, but can you call me when I arrive at the house?

MD: OK.

The caller did not provide the MD with a phone number of a person close to the patient, and the call ended with no recognition of OHCA (call number 52).

In some calls, the caller was near the patient but had limited access to their chest to perform chest compressions, as the patient's positioning was not suitable. Here, placing the patient in the correct supine position to perform chest compressions was also associated with the increase in time to chest compressions. For example, the callers had to re-position patients where patients were sitting on a chair or sleeping on a soft bed.

MD: Is she laying on her back now?

Caller: No, she is on a chair.

MD: Can you not place her on her back on the ground?

Caller: Yes, I can I can.

MD: OK, place her, and stay with me to tell you what to do.

Caller: OK, OK [goes to change the patient's position]. (call number 43)

4.3.2.2.4 Incomplete calls

Incomplete calls influenced the flow of negotiation about the patient's condition to then identify the cardiac arrest and later provide CPR instructions. These included calls where the callers left the call (and then returned) or ended the call (and then, the MD called back). On occasion, the MDs also left the call and returned. Meanwhile, in a small number of calls, the quality of the call signal was poor.

The reasons for why the callers or MDs left or ended the call were mostly unclear. Nevertheless, in two calls, the emotional distress of the callers might account for why they left the phone as there were people crying in the background. In such calls, the MDs and callers returned and the communication continued. Additionally, the quality of call signals was low in four calls, which impacted the MDs and callers from hearing each other and required them to repeat themselves. This affected the exchange of data, which disrupted the ability of the MDs to promptly identify cardiac arrests and subsequently, guide the callers to commence chest compressions. This can be seen in call 54, where the MD asks the caller to repeat what he/she says as the voice is not clear, resulting in a delay in identifying the cardiac arrest.

Caller: I have a patient who has [unclear voice due to bad signal].

MD: He has what?

Caller: [unclear voice due to bad signal].

MD: My sister, your voice is not clear.

Caller: My brother, he has [unclear voice due to bad signal] diabetes [the caller got upset].

MD: Diabetic patient?

Caller: [unclear voice due to bad signal].

MD: Hello!

Caller: Yes, he is not breathing!! He has no [unclear voice due to bad signal] breath. (call number 54)

4.3.2.2.5 Legal barriers to providing CPR instructions

EMS calls are received from general public, which could involve legal issues that need further investigation, thus influencing the flow of communication. In some cases, the MDs need to ask further questions about the case to ensure that the call and CPR performance are legal, resulting in a lengthy communication. Suspicion of a crime and the presence of a Do Not Resuscitate (DNR) order were observed in two calls in this study. The MD recognised the OHCA but had to clarify the situation by asking further questions prior to providing CPR instructions. In call 97, the MD was very strict about receiving a clear answer about the DNR order prior to providing CPR instructions to ensure it is legal. The caller apparently does not know the answer causing a drawn-out negotiation.

MD: Did the hospital sign DNR for him? That you don't do resuscitation?

Caller: No, no they did not sign for him this thing [the caller seems unaware of DNR].

MD interrupted caller: DNR is that you do not do resuscitation if the breathing and the heart stop.

Caller: No, this is the first time to stop, usually he does not collapse.

MD: So, they did not do DNR for him in the hospital?

Caller: No, in the past they did in the past they did but no.

MD interrupted caller: So, he had DNR in the past?

Caller: Yes.

MD: So, he had it?

Caller: Yes.

MD: DNR is not about the past ... DNR stays with you forever.

Caller: What does this mean! [with a shocked voice].

MD: Did you sign the DNR in a hospital? That you do not do resuscitation for him?

Caller: One minute, one minute ... mum mum [goes to her/his mother]. (call number 97)

4.3.2.2.6 Suspected seizure and choking

Identifying OHCA through telephone conversation relies on the data transferred by callers, which might sometimes be misleading to the MDs and cause them to suspect other medical issues. In this context, seizures and choking were the two diagnoses mistakenly suspected by the MDs in this study.

In three calls, the MDs did not ask callers about patients' consciousness and breathing quality, except in one call the caller reported that the patient was having weak breathing, and therefore the MD misrecognised the cardiac arrest. Although the reasons for misrecognising the arrest are not well identified, it could be due to the data provided by callers that could be misleading. In two calls the callers informed MDs that the patients were having cramps, so the MDs started to ask seizure-related questions and then seizure was suspected. In another call, the caller described the patient's chief complaint as suddenly choking after finishing eating soup, so the MD suspected that it was a case of choking. Here, the MDs did not ask further questions to investigate more about the patients' consciousness and breathing quality for unknown reasons. Alternatively, first aid guidance for seizure and choking were provided, and cardiac arrest was not suspected.

Caller: There is a man who is cramping and not talking [unclear voice due to bad signal] and collapsed.

MD: Is he collapsed? [the caller interrupts the MD].

Caller: And there is blood coming out of his mouth.

MD: Is there froth coming out from his mouth?

Caller: Yes … froth and blood [afraid].

MD: OK, is he an epileptic patient?

Caller: Yes, now he looks like he is cramping.

Seizure instructions were provided by MD, and then the call ended. (call number 21)

4.4 Complexity in modern standard Arabic when communicating CPR instructions

Observation of calls' recordings revealed that OHCA is a stressful situation (see section 4.3.2.2.1) in which the callers and MDs often use language that is more easily comprehensible. Whilst the Saudi T-CPR instructions are written using MSA, this was not used by the callers and MDs during their calls. They tended to communicate using simple and familiar terms that are easier for lay people to understand. However, it was noted earlier that some of their choices of words and phrases were influenced by their local dialects (see section 4.3.2.1.2). The inconsistency between written MSA and spoken Arabic language could influence how T-CPR instructions are provided, which consequently could affect CPR timeliness and quality performance.

None of the MDs gave the CPR instructions exactly as they were worded in the Saudi T-CPR protocol. Instead, they tried to phrase the CPR instructions using their own interpretations of simple and familiar terms. Thus, the T-CPR instructions varied depending on which MD delivered the instructions. Key differences in the CPR instructions included word choices, CPR steps (e.g., not providing depth instructions), and the sequence of the instructions. The following calls show how MDs use different words to phrase the CPR instructions, provide CPR instructions in different order and some do not provide depth instruction as compared to the Saudi T-CPR protocol presented in Appendix C.

MD: Place both your hands on the middle of the chest and start chest compressions ... 100 compressions in a minute ... OK?

Caller: OK.

MD: 1 2 3 4 do not stop the compressions until the ambulance comes to you. (call number 75)

MD: One of them [referring to the people around the caller] sits on the floor on his knees close to the man [referring to the patient] interlocks his hands together and puts them on the middle of the chest on the top ... and pushes hard ... pushes and releases.

Caller: Does he push on the chest or the abdomen?

MD: On the chest on the top ... on the upper chest between the nipples of the breasts ... pushes and releases just like this 1 2 3 4 5 6 [counting aloud] ... when he gets exhausted … anyone reaches the number 100 [referring to 100 compressions], give it to the next person [meaning to swap the compressions performance]. (call number 64)

MD: Interlock your hands together ... sit on your knees close to the man [referring to the patient].

Caller: Yes.

MD: Place your hands on the top of each other ... interlock them in a straight way ... and push in a hard way ... hard and fast compressions on the middle of the chest between the nipples of the breasts.

Caller: OK.

MD: Push around 100 compressions in a minute ... in an effective way, the chest goes down then goes up. (call number 45)

MD: Place the palm of your left hand on his chest in the middle between the breasts.

Caller: OK.

MD: And the right [referring to his right hand] above it in the same position and interlock your fingers together.

Caller: OK.

MD: And start pushing on the chest.

Caller: OK.

MD: Do not stop until the ambulance arrives to you. (call number 18)

MD: Do you see the bone that is in the middle of the chest? [referring to the sternum]

Caller: Yes.

MD: OK, I want you to place your left hand on this bone using the palm.

Caller: OK.

MD: And your right hand above your left hand and interlock your fingers.

Caller: OK.

MD: And keep your hands from the elbow straight ... OK?

Caller: OK.

MD: Do not bend them OK ... keep them straight and lean forward like if you are above him [referring to above the patient].

Caller: OK.

MD: Now I want you to push hard OK and see the chest ... I want it to go down 5 cm in each compression and release your hand slightly so it goes up I mean give it a space to go down and up for these compressions. (call number 86)

4.5 Summary

This chapter presented the findings from the observations of OHCA calls and T-CPR instructions in Saudi Arabia. There were substantial delays in the callers starting chest compressions—a delay by 217 and 277 s—compared to the minimum and high AHA standards, respectively. The median time to first chest compression was 367 s. This time interval has the potential to reduce patients' survival chance by 42.81 to 61.16% as each minute goes by with no CPR and electrical defibrillation decreases the survival chance by 7–10% (Larsen *et al.*, 1993; Valenzuela *et al.*, 1997; Holmberg, Holmberg and Herlitz, 2000). This might provide a possible explanation for the low ROSC rate (10%), which showed no significant difference between patients who received CPR and who did not. Thus, improving the time to chest compression has the potential to improve the survival rates.

The time to chest compression was influenced by factors related to the T-CPR instructions and the language (words, terms) used in the calls. Providing imprecise instructions and using local dialect terms when communicating T-CPR instructions influenced time. Other factors included using different terms and phrases to describe agonal breathing and asking unnecessary questions, which also prompted involving a third person in the call. Improving such factors could improve the time to first chest compressions.

The observation of calls also showed that both the callers and MDs preferred to communicate using simple and familiar terms that are easy for lay callers to understand. MSA language was not used by the MDs or callers, suggesting a preference for simpler, less complex communication, especially in stressful situations such as OHCA. MDs used their experience to change the wording or the T-CPR instructions. The informal process of 'translating' MSA into simpler language during a call could potentially cause delayed time to first compression and influence the quality of CPR. Providing CPR instructions using impromptu formulations by dispatchers and not following scripted CPR instructions has been shown to decrease the quality of CPR performance (Carter *et al.*, 1984).

Therefore, it is crucial to examine how the language used in Saudi T-CPR instructions (clarity, comprehension, and simplicity) could affect CPR timeliness and quality performance. Further, improving CPR timeliness and quality performance has the potential to improve survival rates.

<u>Implications of the before-after simulation study</u>

The before-after simulation study was designed to test whether language changes to the T-CPR instructions improve CPR timeliness and quality performance (see Chapter 5). This observation of calls study was necessary to understand the context of T-CPR in Saudi Arabia and inform the before-after simulation study. This study component helped to inform how Saudi callers would respond to the CPR task and whether they would accept or refuse it, prior to conducting a study to improve their CPR performance. The findings showed that all the callers were willing to perform CPR; however, delays to commencing and conducting CPR were observed. These findings suggest that an enhanced T-CPR protocol could improve CPR timeliness and ensure CPR performance is of high-quality, which will be tested in the before-after simulation study (see Chapter 5).

The findings also informed the design of the before-after simulation study. The cultural and gender considerations observed in this study highlighted the difficulty males and females have in interacting with each other when there is no familial relationship. This raised a question about the feasibility of the recruitment of female participants in the before-after simulation study. The proportion of female callers (about a quarter) found in this study necessitated the importance of involving female participants as they are likely to receive T-CPR instructions. In the design of the before-after simulation study, it was important to use a setting that would maximise the likelihood of females agreeing to participate in research where there would be interactions with a male researcher who they do not know.

Results informing the development of the enhanced T-CPR protocol

The way in which language was used during T-CPR by both callers and MDs informed the development of the enhanced T-CPR protocol. Some callers found it difficult to correctly interpret the T-CPR instructions, which showed delays in the time to first compression. Thus, the findings suggested a need to enhance the clarity and precision of the instructions.

In real-life OHCA experiences, neither the callers or MDs used the more formal, complex MSA language on which the protocol is based. Therefore, it is important to develop a simplified version of the protocol that may improve CPR performance. Therefore, using plain language in the enhanced T-CPR protocol could improve the communication, understanding of instructions, and interpretation, leading to improvements in CPR timeliness and quality performance. This is explored further in Chapter 5

Chapter 5 Findings: before-after simulation study

5.1 Introduction

This chapter presents the findings of the before-after simulation study. The aim of the study was to examine CPR performance using the Saudi T-CPR protocol and explore possible improvements (using a 'before' group of participants), develop an enhanced protocol, and then test it (with an 'after' group). This chapter begins by presenting a baseline of CPR performance using the Saudi T-CPR protocol in the 'before' OHCA simulation component of the study to identify which CPR parameters fall below the ILCOR guidelines. Findings from the participants' interviews, which explored their experiences and views of T-CPR as well as their views about how to enhance the protocol instructions, are then presented. The chapter then explores how the enhanced T-CPR protocol was developed. Subsequently, the results of the CPR performance using the enhanced T-CPR protocol are presented and compared with the Saudi T-CPR protocol findings to identify whether CPR improvement was achieved. Participants' feedback regarding the enhanced protocol is then highlighted to offer possible explanations as to how and why CPR performance could have been improved. Finally, a summary section summarises the key points identified in this chapter.

5.2 Baseline demographic characteristics of the participants

In total, 50 volunteers were recruited to the before group, and a further 50 different volunteers were recruited to the after group from a population sampled from KSAU-HS. The participants were almost equally drawn from male and female academic staff, other staff, and students. This ensured that the sampling included male and female participants from different age groups and levels of education (see Table 9).

Table 9. Baseline demographic characteristics of the participants.

Demographic characteristic	Before group N (%)	After group N (%)
Stratum:		
Academic staff	16 (32%)	16 (32%)
Other staff	18 (36%)	17 (34%)
Students	16 (32%)	17 (34%)
Gender:		
Male	25 (50%)	25 (50%)
Female	25 (50%)	25 (50%)
Nationality:		
Saudi	47 (94%)	46 (92%)
Non-Saudi	3 (6%)	4 (8%)
Age groups:		
Age (15–24)	20 (40%)	19 (38%)
Age (25–54)	30 (60%)	30 (60%)
Age (55 years and above)	0 (0%)	1 (2%)
Levels of education:		
PhD	2 (4%)	4 (8%)
Masters/ high diploma	12 (24%)	10 (20%)
Bachelor's	14 (28%)	15 (30%)
Diploma	6 (12%)	3 (6%)
Secondary school	16 (32%)	18 (36%)

The diversity in the participants' demographics was aimed at representing a wider population, and specifically was aimed to encourage women to take part. Consequently, half of the participants in both groups were female. The participants showed variations in their levels of education ranging from PhD to secondary school degrees. To avoid any bias in the CPR performance, the participants were untrained in CPR and all spoke Arabic as a first language to be consistent with the T-CPR protocol language.

5.3 CPR performance using the Saudi T-CPR protocol

Participants' CPR performance was measured using the Saudi T-CPR protocol in OHCA simulation sessions (before group) to establish a baseline performance. Following the CPR simulation, the participants were asked to reflect on their experiences and explore the Saudi T-CPR instructions in semi-structured interviews. The quantitative data collected in the simulation (see section 5.3.1) identified performance in terms of CPR timeliness and quality (e.g., rate and depth), while the qualitative analysis from the interviews (see section 5.3.2) explored the factors that could affect CPR performance. Additionally, participants' views on how to enhance CPR instructions were also explored.

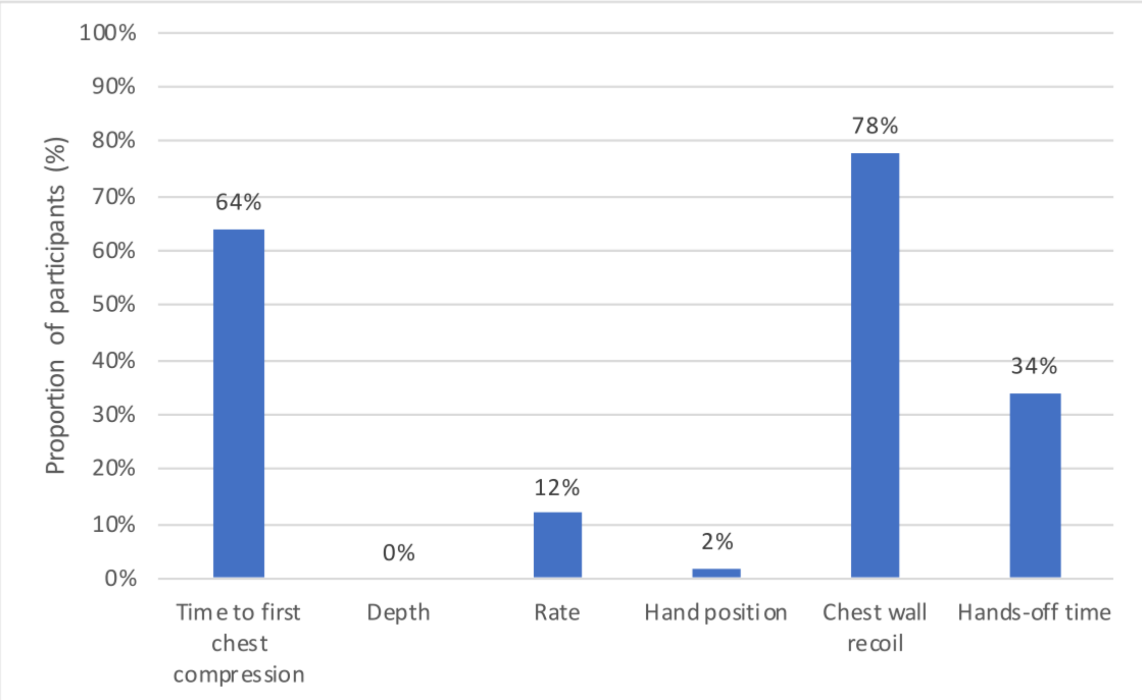
5.3.1 CPR timeliness and quality performance to establish a baseline performance

None of the participants performed chest compressions that met the quality standards recommended by ILCOR and the time recommended by AHA. Following the two-minute continuous chest compressions, the overall performance of the participants was below the ILCOR and AHA recommendations (see Table 10 and Figure 16).

Table 10. CPR timeliness and quality performance following the Saudi T-CPR protocol.

Parameters	Median	IQR	ILCOR and AHA recommendations	Test for normality	
				Shapiro Wilk (p value)	Distribution
Time to first chest compression (s)	110	99.75–125.5	<60 / <120	<.001	abnormal
Depth (mm)	30	21–35.25	50–60	.313	normal
Rate (c/m)	94.5	71.1–127.25	100–120	.017	abnormal
Hand position (%)	86.5	75–93	100	<.001	abnormal
Chest wall recoil (%)	100	100–100	100	<.001	abnormal
Hands-off chest time (s)	4.9	0.00–17.87	00	<.001	abnormal

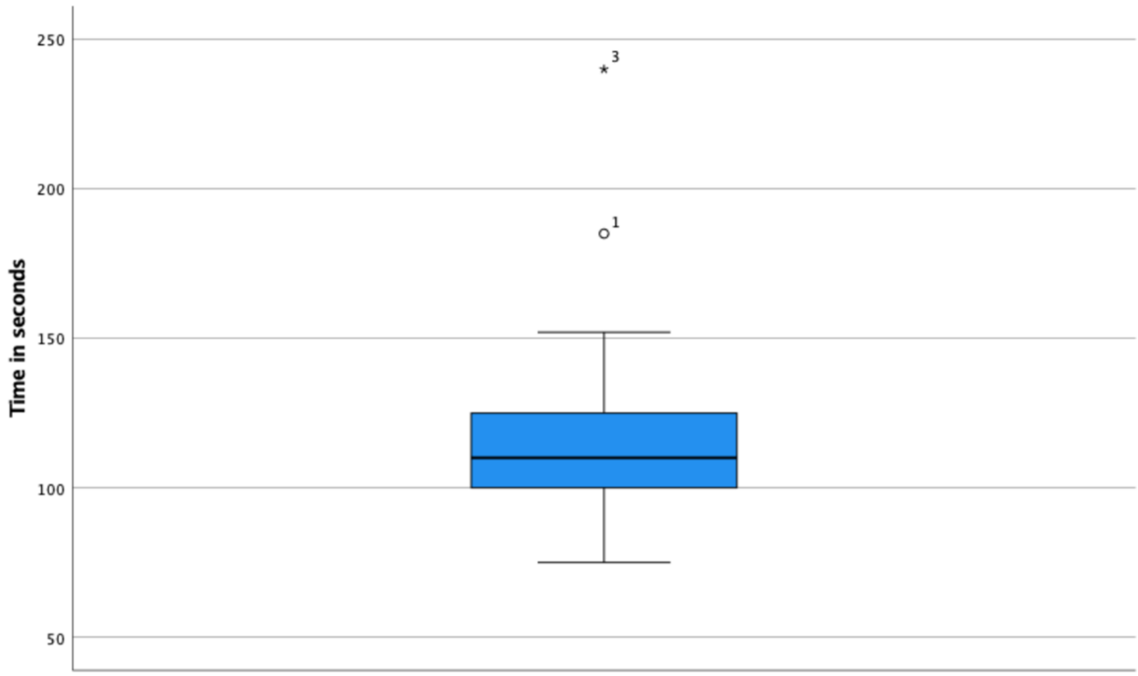
Figure 16. Proportion of participants achieving AHA timeliness (minimum standard) and ILCOR quality performance standards following the Saudi T-CPR protocol.



Here, it is important to note that the AHA recommends chest compressions start within 90 and 150 s from EMS call receipt as the high and minimum standard, respectively. However, these recommendations included an allowance of 30 s for taking callers' information and acquiring their location, which was not part of the OHCA simulation in this study. Therefore, the AHA recommendations were amended for the purposes of this study, and the 30 s were excluded so that standards were adjusted to 60 and 120 s from EMS call receipt to commencing CPR as the high and minimum standards, respectively.

None of the participants started chest compressions within the high AHA standard, while 36% did not start within the minimum AHA standard. The median time to commencing chest compressions was 110 s (IQR 99.75-125.5) (see Figure 17).

Figure 17. A Box Whisker plot of the time from EMS call receipt to the start of first chest compression following Saudi T-CPR protocol.



Further, no participant reached the recommended depth by the ILCOR, and most of the participants (88%) did not reach the recommended rate. The median depth and rate performances were 30 mm and 94.5 c/m, respectively (see Figure 18 and Figure 19), which are below the ILCOR recommendations and could potentially reduce the chances of survival. The other CPR parameters were also below the ILCOR recommendations, and these are summarised in Table 10 and Figure 16.

Figure 18. A Box Whisker plot of depth of compression following Saudi T-CPR protocol.

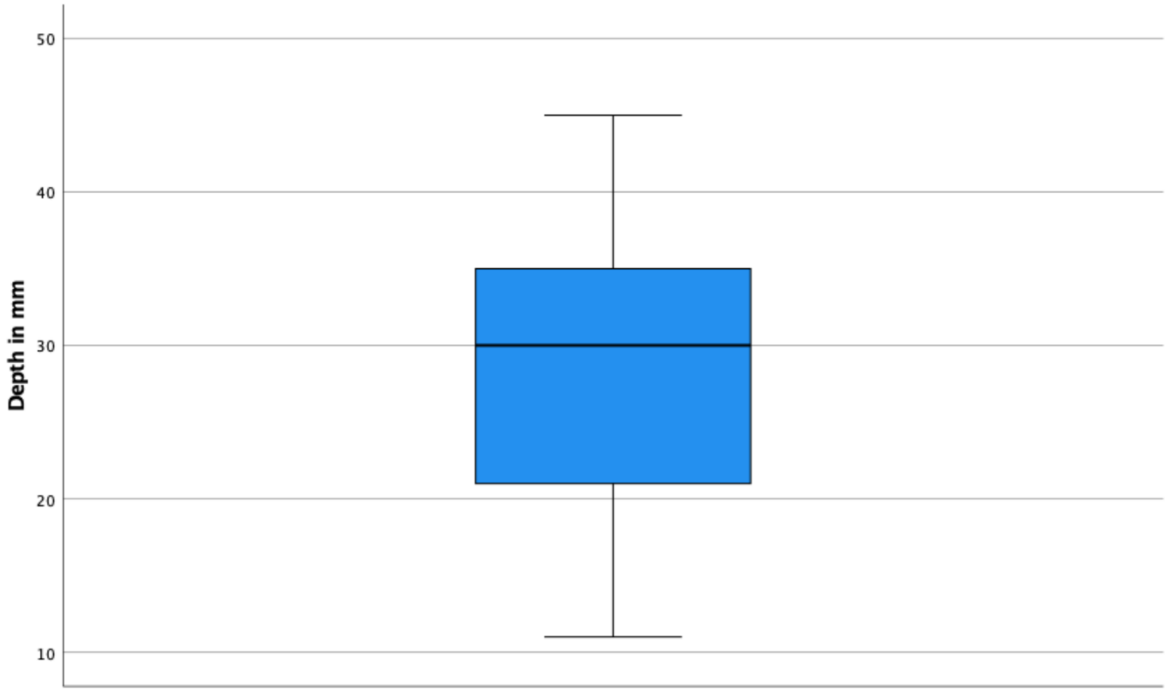
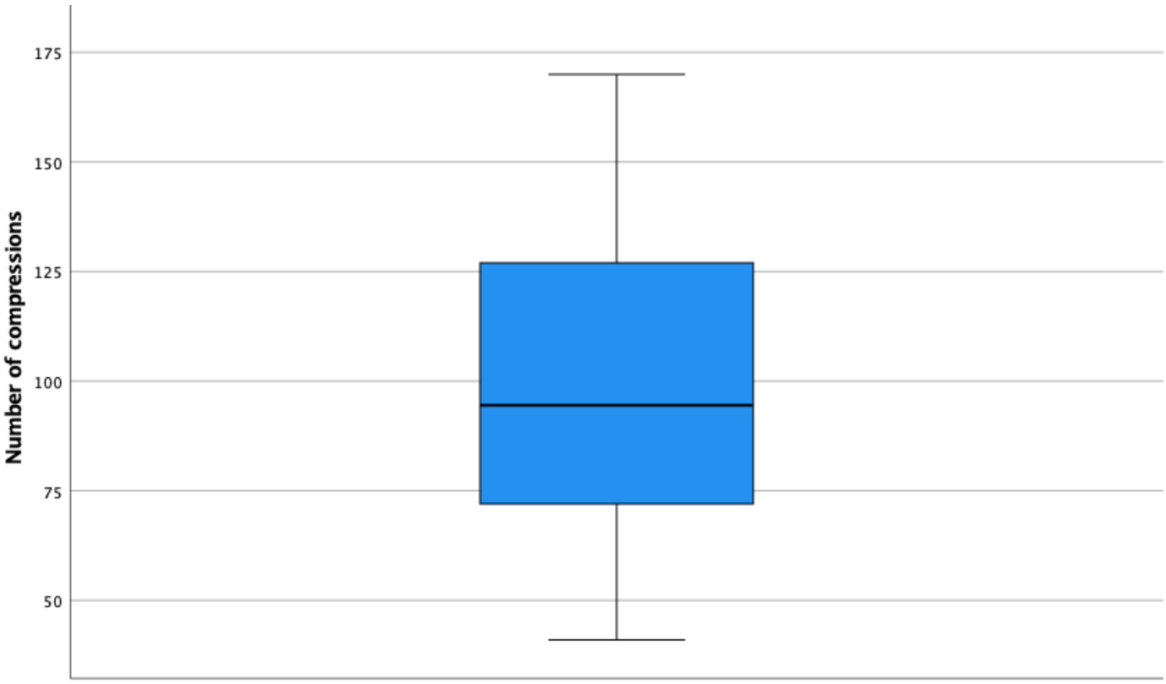


Figure 19. A Box Whisker plot of chest compressions rate per minute following Saudi T-CPR protocol.



Moreover, further analysis using a Mann–Whitney U test revealed significant differences between males and females regarding chest compression performance. Male participants started chest compression significantly earlier than females (median of 101 and 119 s, respectively; $p = 0.011$), delivered more compressions per minute (median of 107 and 83 compressions, respectively; p =

0.010, respectively), and deeper compressions (median of 31.4 and 26.1 mm, respectively; p = 0.032, respectively).

Participant perceptions of how factors relevant to language and T-CPR instructions could have influenced CPR performance are explored in section 5.3.2. Additionally, views about how to improve performance by making language changes to the protocol are presented.

5.3.2 Participant views of factors associated with CPR performance

The quantitative analysis showed that the participants' CPR performance did not meet the ILCOR recommendations (see section 5.3.1). Semi-structured interviews were used to ask participants to reflect on their experiences of performing CPR and the language of the T-CPR instructions they received. They were also asked for their suggestions to improve the T-CPR instructions. Here, they identified a number of factors, which could have impacted their CPR performance, relating to the difficulties in comprehending and interpreting the T-CPR instructions (e.g., where anatomical terms were used). Difficulties in understanding the T-CPR instructions were exacerbated by the context of T-CPR, which is a complex task (e.g., that may require competing cognitive demands), and this further influenced how participants received and interpreted language. Thus, it is important to first explore the context of T-CPR to understand how it impacts the language. Moreover, participants also identified instructions that were impractical to convert into actions (e.g., being able to accurately estimate 5 cm depth) and were associated with the CPR performance. Therefore, they are presented here to facilitate a broader investigation of the T-CPR instructions. Table 11 describes the factors relevant to the context, language, and impracticality.

Table 11. Description of factors influencing CPR performance.

Factors	Description
The complex context of performing CPR via the telephone	This complexity is relevant to the multitasking (the need to simultaneously listen to instructions and perform CPR) and the stress of the OHCA.
Factor	**Description**
Language barriers: comprehension, communication, and interpretation	The language used during T-CPR was found to be difficult for the participants to understand because of the following: the use of MSA as well as anatomical and technical terms; imprecise and unnecessary instructions.

1. Barriers to comprehending and communicating Modern Standard Arabic	MSA is not the everyday language used by the participants, which influenced comprehension and communication. It also requires time to be interpreted and creates barriers in achieving rapport.
2. Barriers to understanding anatomical and technical terms	The use of such terms in T-CPR instructions are difficult to understand and was noted in phrases relevant to 'heel of the hand' and 'allowing full chest recoil'.
3. Imprecise and unnecessary instructions that can lead to different interpretations	The use of imprecise terms and unnecessary information could have negatively influenced how the participants interpreted the instructions.
Factor	Description
Impractical and 'difficult to estimate' instructions and sequence of events	Practicality of the CPR instructions, questions, and sequence can impact its performance. This included participants' struggle to estimate numbers and follow the current instructions order.
1. 'Impractical' instructions and questions: difficulties in estimating parameters	Some instructions and questions were impractical in that they were tasks that most individuals would struggle to achieve. This included estimating 100 c/m, 5 cm depth, and patients' exact age.
2. The complex sequence of the CPR instructions	The order of providing the list of CPR instructions is difficult to follow, which created confusion and consequently, influenced CPR performance.

5.3.2.1 The complex context of performing CPR via the telephone

Participants performing CPR via telephone instructions is a complex task. This complexity contributes to the ways in which the language and instructions can be understood and converted into action by the callers. Further, the task is both cognitively demanding and takes place in an emotionally distressing context.

Preforming CPR while listening to the instructions via telephone is an activity that requires multitasking. In this context, many participants highlighted T-CPR as a complex task in that it required them to simultaneously listen to instructions and perform actions. Moreover, for most people, this is a task of which they had no previous experience. Thus, the participants expressed that it was difficult to listen and act at the same time.

Researcher: OK, was there any difficulty in the process of receiving the instructions? For example, the sound was not clear or the MD was talking too fast?

Participant: No, his talk was ... on speaker It is difficult … it is difficult to manage doing the task and listening at the same time.

Researcher: So, it is difficult to do it [referring to chest compressions] while you are listening?

Participant: Yes. (participant 20)

Participants managed the aforementioned complexity by choosing to focus on one task or the other—either on the CPR performance or paying full attention to listening to the instructions. As a result, some participants missed some instructions when they were focusing on performing CPR performance, while others stopped the chest compressions for several seconds to listen to the instructions.

Researcher: OK, 'Minimise the pauses between compressions to the lowest possible' was it clear to you?

Participant: I did not hear it at all.

Researcher: Why did you not hear it?

Participant: Because I was pushing and when I was pushing, I could not hear clearly. (participant 25)

Meanwhile, some participants highlighted that the volume of complex information was demanding. Decreasing or simplifying the information given could potentially reduce the cognitive demand, allowing them to focus more on the CPR performance.

Researcher: So, there was no noise ... you were hearing clearly ... the sound was clear?

Participant: The sound was clear but the talk was too much … I mean it makes you distracted and at the same time, you are working on a task ... you cannot focus on two tasks together, and this [referring to CPR performance] is considered new for you.

Researcher: You mean you received a lot of instructions?

Participant: Yes, I received the instructions.

Researcher: Information?

Participant: Yes, the information was too much. (participant 30)

Additionally, the complexity of the task was exacerbated by emotional stress. Most participants reflected that undertaking CPR was a stressful experience, which is most likely to be even greater in real OHCA situations. This stress or heightened emotion further impacted their ability to listen, comprehend, and perform the instructions. Thus, some participants reported that they sometimes missed some words and instructions. Meanwhile, others reported that it was difficult to interpret the instructions under stress, which arose because of the recognition that performing CPR has the potential to save someone's life. Further, it was also stressful because the task was unfamiliar, and the participants lacked the related knowledge and experience.

Researcher: How did you do it then?

Participant: The most important thing is to save the patient ... I swear I do not know.

Researcher: So, were you just pushing?

Participant: Yes.

Researcher: Without counting?

Participant: Yes, I did not count.

Researcher: And you did not understand 100 times in a minute [she mentioned it earlier in the interview]?

Participant: No, because I was confused I did not know what to do! (participant 50)

In this context, to manage such stressful situations, the participants showed a preference to receiving reassurance and encouragement from the MD. They highlighted that this would have helped alleviate their stress, thus allowing them to perform better CPR.

Researcher: Do you think there should be any more instruction to simplify performing chest compressions … An instruction that should have been provided?

Participant: No, but you can provide instructions to relieve the stress of the person.

Researcher: Can you provide an example?

Participant: Simple phrases such as 'Do not be stressed … stay with me' or similar. (participant 27)

Thus, this complex context of performing T-CPR influenced how participants received and understood the language. The difficulties that participants experienced with language used in T-CPR (and how it impacts CPR performance) are explored in the following section.

5.3.2.2 Language barriers: comprehension, communication, and interpretation

Using simpler language has the potential to ameliorate the impact of having to perform an unfamiliar and difficult task. However, the language used in the T-CPR protocol was difficult for the participants to comprehend and act upon. Particular challenges were posed from having to comprehend and communicate using MSA, difficulties in understanding anatomical and technical terms, and the misinterpreting of ‘imprecise’ instructions.

5.3.2.2.1 Barriers to comprehending and communicating in Modern Standard Arabic

MSA is the formal written language used in Saudi Arabia; however, it is not the form that is used in everyday communication. Thus, the participants found it difficult to comprehend when it was used in T-CPR instructions. Here, the complexity of language was exacerbated by the complex and stressful context of T-CPR (described in section 5.3.2.1).

> *Participant: The MSA is not good.*
>
> *Researcher: The MSA?*
>
> *Participant: It is not good because it is not common between people to speak using it … and suddenly, someone talks to you using MSA in a stressful situation … the language should be simple, so you can do the task … not to be confused with the meanings of the language. (participant 4)*

Moreover, comprehending instructions in MSA added complexity to the task—and required time to interpret the instructions—since participants were less familiar with hearing and using this form of language in everyday life.

> *Researcher: OK, what do you think about it [referring to the language]?*
>
> *Participant: Not good at all.*
>
> *Researcher: Why?*
>
> *Participant: Because the issue is ... I mean anyone is talking in MSA, you have to listen to what he is saying ... because we do not usually talk using MSA most of the time ... and at this time [referring to OHCA time], it is life or death! I do not have time to think of what he [referring to the MD] is saying I mean, fine talk to me using dialect, where is the problem? We both understand each other. (participant 2)*

MSA was also perceived as impacting on the rapport and flow of communication between the MD and the participants. A couple of participants thought they were listening to a recording of instructions rather than a real MD giving the instructions as the more formal language gave a dehumanised impression. Some participants reported that the use of MSA created barriers to achieving rapport. Use of everyday language was perceived as a way of the MD being able to demonstrate empathy with the caller.

> *Researcher: How was the language in the instructions?*
>
> *Participant: The language … I felt the situation is more critical than someone talking to you using the MSA ... I imagined if I was in the situation [referring to a real OHCA situation] talk to me as I usually talk! I am in an emergency situation, in which I need someone to feel what I am in ... I feel that this language created barriers in communication. (participant 7)*

Moreover, several participants expressed a preference for emotional support, which they believed would alleviate stress and improve their CPR performance (as described in section 5.3.2.1). However, some participants highlighted that the more formal language of MSA was less empathetic, a less human way of communicating.

> *Researcher: OK, let me ask you about the language used in the instructions in the words and questions ... what do you think about them?*
>
> *Participant: It is not … I do not know I mean MSA makes you more confused ... because when you talk in MSA, you feel like you are talking to a machine, and you are in a very critical and emotional situation and you need emotional support.*
>
> *Researcher: You mean you want him [referring to the MD] to be involved with you? As if he is actually with you.*
>
> *Participant: Yes, and emotional support cannot be provided with the MSA I mean he was supposed to say, 'استهدي بالله يا اختي يلا بسم الله يلا توكي على الله يلا اضغطي' [emotional support using Islamic references/terms] like this … do you understand?*
>
> *Researcher: Yes, you mean there should be no barrier?*
>
> *Participant: Yes, there should be no barrier honestly I think it should be like this ... so, imagine that I got confused, while this was not a real patient! What do you think would happen with a real patient? You know what I mean. (participant 14)*

While using dialects was suggested by many participants to improve comprehension and communication, there are difficulties in implementing this suggestion as recognised by some participants. This is because dialect differs between regions and groups of people from the same country who use the same official language (in this case, Arabic). In this context, participant 15 highlighted this issue and therefore, preferred to communicate using MSA rather than dialects.

> *Researcher: So, you prefer the MSA language?*
>
> *Participant: It is better because if he [referring to the MD] speaks in a dialect, some people may not understand it ... for example, someone from Jeddah [a city in the west of Saudi Arabia] may not understand the dialect of people in Riyadh [a city in the central of Saudi Arabia]. (participant 15)*

To avoid the potential difficulties associated with both MSA and dialects, several participants suggested using a simple version of language (plain Arabic) that is not MSA nor dialect. This simple version uses simple and familiar terms that are designed to be understandable for laypeople.

> *Researcher: In the beginning, the language … was it fine for you? The MSA? Do you prefer dialect?*

Participant: It is not as important that it is MSA or dialect as it is important to be simple to comprehend and follow.

Researcher: OK, what do you think MSA or dialect?

Participant: For me personally or in general?

Researcher: For you personally.

Participant: For me personally, the most important is for it to be simple.

Researcher: So, what does fit you? Dialect or MSA?

Participant: I think the language should be simple I mean understandable for everyone.

Researcher: In between dialect and MSA?

Participant: Yes. (participant 20)

Moreover, in addition to using simpler and familiar terms to replace MSA terms, the following themes are the ways in which the language used in T-CPR could be more simplified, so that it could be simplified to plain Arabic.

5.3.2.2.2 Barriers to understanding anatomical and technical terms

Clinical and anatomical words used in T-CPR were sometimes difficult to understand and unfamiliar to participants. This included using the anatomical term 'heel of the hand', which was used to direct participants to perform chest compression to: '*place the heel of one hand on the middle of the chest and place the other one on the top of it, and interlock between their fingers*'. In this context, most participants had difficulty understanding the word 'heel' in relation to their hand, as it is not a common phrase in Arabic. Additionally, some participants also felt that the heel of the hand is a routinely unused body area, and therefore, it is challenging to guide people to identify it. Others were unaware that there is a heel of a hand, as they more commonly understand 'heel' as 'heel of the foot'. Correctly identifying the heel of the hand is crucial in CPR performance, as it is the area of the hand recommended by the ILCOR to be used to best apply pressure to the chest. Failure to identify it could decrease the quality of chest compression performance.

Researcher: You did not understand it ... why you did not understand it?

Participant: I have not heard this word!

Researcher: Why? Is it an MSA term or what?

Participant: Because honestly, I do not know what the name of this is [pointed to the heel of the hand] I mean if you ask me what its name is, I would not know. (participant 10)

Participant: You know ... heel comes to in your mind as heel of the foot as it is common ... I have not been in a situation to call this area with its name [referring to the heel of the hand]. (participant 7)

Thus, using simpler and more familiar terms to describe the heel of the hand area was a preference for the participants. This included using the familiar word ‘palm’ instead of ‘heel’ and providing simple phrases including ‘bottom of the palm’ to describe the heel of the hand area.

> *Researcher: OK, with what should I replace it?*
>
> *Participant: [thinking].*
>
> *Researcher: What do you call this [I pointed to the heel of the hand]?*
>
> *Participant: Palm [thinking] is it called palm?*
>
> *Researcher: No, this is the palm [I pointed to the palm].*
>
> *Participant: Yeah, this is the palm, right? [the participant pointed to the palm]*
>
> *Researcher: Yes.*
>
> *Participant: Bottom of the palm. (participant 31)*

Along similar lines, the participants found that the use of clinical or technical terms were difficult to understand. This included the term ‘*allow full chest recoil between the compressions’*, which most likely would have influenced their chest release performance. Here, participants highlighted their lack of experience in CPR, which impacted their understanding of this technical process. The use of difficult words such as ‘recoil’ also added further difficulty to understanding the technical process of allowing full chest recoil. To improve it, several participants suggested precisely describing the technical process using simpler and more familiar words, as illustrated in the quote below.

> *Researcher: Do you know what allows chest recoil is?*
>
> *Participant: No.*
>
> *Researcher: It means when you push on the chest, you allow the chest to come back to its normal position.*
>
> *Participant: So, when I push, it comes back?*
>
> *Researcher: Yes, you allow it to come back to the normal position.*
>
> *Participant: I honestly have no experience in these areas. (participant 43)*
>
> *Participant: Even the word ‘recoil’, not everyone can comprehend it at this time [referring to OHCA situations] or understand it ... I mean he [referring to the MD] has to simplify it.*
>
> *Researcher: OK, how can you simplify it? You can use a dialect if you want.*
>
> *Participant: We can say ... allow the chest, for example, to return to its normal position ... this can someone comprehend better ... I did not listen well to this instruction because it had a lot of new words. (participant 36)*

Thus, improving the simplicity of the terms can improve the understanding. However, they also have to be adequately precise, so that laypeople can correctly interpret the instructions.

5.3.2.2.3 Imprecise and unnecessary instructions that can lead to different interpretations

Many participants found it difficult to correctly convert the CPR instructions into actions due to 'imprecision' in the language and terms used. Although some terms could be simple to understand, they might not be sufficiently precise to be correctly interpreted. Sitting in the correct place prior to starting CPR (next to the patient's chest) is a vital physical organisational step to perform CPR. However, several participants were unclear about where to sit exactly when they were asked to '*sit on your knees next to the patient*'. Participants interpreted this instruction in different ways and sat in different places, including next to the patient's head, shoulders, or legs. This could delay time to first chest compression, as it would require the need to change their physical orientation (e.g., move closer to the patient's chest) when they were later asked to perform chest compressions. Additionally, performing CPR while sitting away from the patient's chest (e.g., next to the patient's waist) could reduce the quality of chest compressions performed.

> *Researcher: Were there words or questions you did not understand? Or were they difficult for you? Or did you not understand in general?*
>
> *Participant: 'Sit on your knees next to the patient' OK next to the patient ... next to the head! Or next to the chest? Or next [thinking]*
>
> *Researcher: No, I mean to his right or left.*
>
> *Participant: Yes, this was not clear. (participant 11)*

Therefore, several participants preferred to receive instructions that specifically directed them on where to sit next to the patient. Thus, improving precision would save time, which is limited in OHCA calls.

> *Participant: But I was close to the lower abdomen which is almost close to the waist.*
>
> *Researcher: OK, how can I clarify it?*
>
> *Participant: You might say close to the patient's shoulder. (participant 43)*

The next step prior to starting CPR is the instruction to '*place the patient on his/her back on a flat and rigid surface, and take off his/her top clothes and expose his/her chest'*. However, participants reported this to be a rather long and imprecise instruction that included a lot of information to analyse and interpret. Meanwhile, others highlighted that providing a lot of information can cause confusion. For example, there was difficulty in interpreting whether *'rigid and flat surface'* refers to the 'floor' and whether '*take off his/her top clothes and expose his/her chest'* means 'take off the patient's clothes' or just 'expose the patient's chest'. Thus, providing precise but also concise instructions is important, especially in the limited time during OHCA calls. In this context, using simple terms such as 'floor' over 'rigid and flat surface'; deleting the unnecessary information such as ‘take off his/her top clothes’ and only retaining ‘expose his/her chest’ were suggested for improvements.

> *Researcher: OK, ‘place the patient on his/her back on a flat and rigid surface, and take off his top clothes and expose his/her chest’?*
>
> *Participant: This is too much.*
>
> *Researcher: Too much?*
>
> *Participant: Too long.*
>
> *Researcher: OK, how would you like to replace it? It is fine you can use dialect.*
>
> *Participant: Expose his/her chest directly!*
>
> *Researcher: Expose his/her chest ... so, you do not want him to say ‘take off his top clothes’?*
>
> *Participant: Yes, because when you tell me to take off his top clothes ... I thought that I would take the pullover off ... this is what I thought first ... no expose the chest is to open the pullover. (participant 39)*

Moreover, the instruction to place the hands over the patient’s chest was also perceived as an instruction that was open to interpretation. Here, using the term *‘middle of the chest’* was also too imprecise for many participants. The human chest area is quite a large area (with unclear boundaries as to what is defined as ‘chest’), making it difficult to determine the exact middle. Additionally, several participants noted that the term was imprecise as it guides them to the middle in terms of width (from the right to the left side), but does not consider that there is a middle as per the length (the upper and lower side). Therefore, the interpretation of ‘*middle of the chest*’ was dependent on the participants’ perspectives, which were most likely influenced by where they were sat. For example, participants sat next to the patients’ waist were likely to interpret and define *‘middle of the chest’* differently from those next to the shoulder. The participant below highlighted the imprecision in the instruction, showing that it leads to different interpretations that can influence the place of compression (hand position).

> *Researcher: what do you think of the hand position?*
>
> *Participant: The hand position was not described to be honest ... he [referring to the MD] told me in ‘the middle of the chest’ but where in the middle of the chest ... in the upper middle or in the lower middle? He did not say. (participant 15)*

Thus, more precise instructions that would guide people to the middle of the chest were suggested by many participants. Further, the use of precise terms that are not open to different interpretations, such as using obvious anatomical landmarks including the line of the nipples and sternum, was suggested to improve clarity.

> *Researcher: Because your position [referring to hand position] was a bit incorrect.*

Participant: For a person ... I mean to be clearer for a person who does not have … you should say the area between the breasts, for example.

Researcher: Between the breasts or the nipples?

Participant: Or the nipples I mean. (participant 22)

Another example of an instruction opens to different interpretations that guided the participants to be positioned vertically to the patient was: '*make your arms straight and lean forward slightly*'. Here, their positions were impacted by the term '*lean forward slightly*', which was interpreted depending on their perspectives of 'slightly'. Some participants could have interpreted it as leaning forward 30 degrees, while others, 60 degrees. To clarify this, they highlighted the need to use precise terms to describe the physical positioning as well as to ensure using simple words. The suggestions included using simple phrases similar to 'come forward to be directly above the patient' and adding more precision to the phrase using terms similar to 'vertically above the patient'

Researcher: Does this instruction 'make your arms straight and lean forward slightly' represent what I showed you [I showed them how to correctly perform CPR]?

Participant: No, the 'leaning' was not clear ... I do not know what angle I should be leaning. (participant 21)

Researcher: OK, how should this be modified? I mean how should this be clarified for you in the instructions? I want you to do what I did exactly [referring to how I performed it].

Participant: We can add as you showed me ... be above the patient or, for example, the hands are vertical to the patient's chest. (participant 24)

The challenge in any triage instruction is to achieve a balance between providing more information to improve precision and being concise using simple language. An example was found in guiding participants to perform continuous chest compressions using '*minimise the pauses between compressions*'. Some participants falsely interpreted this instruction to mean that they could have very short rests between the compressions. Other participants found conflict between this instruction and the one that followed: '*Do not stop the compressions at all for any reason until ambulance arrival or return of the patient's consciousness*'. Here, many participants highlighted the former instruction as unnecessary guidance, which increased the cognitive demand and also influenced their interpretation. Consequently, removing this instruction to improve precision was suggested. However, a few participants felt that '*minimise the pauses between compressions*' is clear and provides necessary information to maintain continuous chest compressions. Thus, reaching a balance between precision and concision in T-CPR instructions is challenging, considering the importance of fast action during OHCA calls. Participant 13, below, found the instruction unnecessary, and stated that removing it would improve the clarity of the overall instructions. However, participant 23 highlighted the precision and importance of the instruction to improve clarity.

Participant: 'do not stop the compressions at all for any reason' and 'minimise the pauses between the compressions' well, here I feel … I mean one of them is unnecessary, which is 'minimise the pauses' because we ... I told him minimise the pause and then told him not to stop! Right?

Researcher: Yes.

Participant: So, I can just say, 'Do not stop the compressions at all for any reason until ambulance arrival or return of patient's consciousness, and in case you become exhausted, ask for help from attendees'. (participant 13)

Researcher: 'minimise the pauses between compressions to the lowest possible' and then, 'do not stop the compressions at all', were they clear?

Participant: Yes.

Researcher: There is no conflict in meaning? If you prefer, you can modify or merge them together.

Researcher: I see both as important because a person could get exhausted and normally take a rest for 3 or 4 seconds.

Researcher: OK.

Participant: So, it is important to receive information to tell him/her to minimise the rest … and that he/she does not stop at all is important as well … I see them both as important. (participant 23)

5.3.2.3 Impractical and 'difficult to estimate' instructions, questions and sequence of events

Providing instructions and questions that were difficult for participants to estimate impacted how participants performed CPR. Further, the sequence of the CPR instructions was also reported to be complex to follow.

5.3.2.3.1 'Impractical' instructions and questions: difficulties in estimating parameters

Some instructions were impractical in that they were tasks that most individuals would struggle to achieve, even though the participants correctly understood and interpreted these instructions. These included estimating 100 compressions per minute, 5 cm depth in chest compressions, and the patient's exact age.

Guiding participants to estimate the correct rate and depth using '*compress promptly in a rate of at least 100 times/m*' and '*compress hard, so the depth of compression becomes at least 5 cm*' were difficult for participants to accurately perform. Here, the participants reported difficulty in performing 100 c/m as they have no sense of time and therefore, struggled to manage the number of compressions within the specified timeframe. Similarly, '5 cm depth' was found difficult to estimate as they did not know how deep they should go to reach 5 cm.

> *Researcher: OK, and the depth?*
>
> *Participant: No!*
>
> *Researcher: He [referring to the MD] said to you 5 cm.*
>
> *Participant: It is impossible to estimate it in my brain! It is impossible to say 'OK, it is clear this is 5 cm' ... it is impossible ... in fact, my brain will not think of numbers at this time. (participant 4)*

To reach the correct rate and depth, the participants preferred to receive guidance that did not require estimation. Thus, several participants suggested that the MD take the lead by counting loudly and guiding their compression rate until the ambulance arrived (e.g., asking the participant to increase or decrease the pace). However, this is in conflict with how T-CPR is used in current practice, in which the MD ends the call after providing the instructions. Thus, alternatively, participants suggested that difficulties in estimating particular measurements can be improved using simple phrases similar to 'as fast as you can' for the rate and 'as hard as you can' for the depth while providing reassurance that this would not cause harm.

> *Researcher: Would you like to modify it?*
>
> *Participant: I think he [referring to the MD] might say push the deepest you can ... maybe ... I do not know ... the problem with 5 cm is that you cannot estimate*
>
> *Researcher: He can tell you to push as hard as you can.*
>
> *Participant: But the problem is I am afraid that it will harm the patient.*
>
> *Researcher: It is not going to harm the patient.*
>
> *Participant: Not going to harm? Then OK.*
>
> *Researcher: Just minor issues. (participant 41)*

The difficulty in estimating a patient's exact age was also reported based on the question: '*how old is the patient?*' Many participants found it challenging to estimate the exact age by looking at the patient, especially as there was no relationship with the patient. This required the MD to ask more questions to identify the patient's age and provide the appropriate CPR instructions, causing more delay in time to first chest compression. Additionally, this question could have also added further pressure to the participants, as they may find it difficult to trust the instructions received from the MD because they were not certain of their own answer to the question on the patient's age. To avoid estimation, many participants chose to simplify the question using a broader question by asking about the patient's age group (adult, child, or infant) as it is easier to answer.

> *Participant: I cannot estimate the patient's age ... it confuses me a bit.*

Researcher: I am interested in knowing if the patient is an adult or child.

Participant: If you are interested in knowing whether it is an adult or a child, then ask me 'is it an adult or child?' that makes it easier for me to decide.

Researcher: Easier for you?

Participant: Because how old is the patient? I feel I cannot … I do not trust the information I gave you.

Researcher: OK.

Participant: It is did I give you [referring to the MD] correct information, so you give me this [referring to the CPR instructions] to do?

Researcher: Will it stress you a bit?

Participant: Yes. (participant 30)

5.3.2.3.2 The complex sequence of the CPR instructions

Several participants found that the order of the current instructions— which is 100 c/m rate, followed by 5 cm depth and then the guidance rhythm—complex to follow. This complexity was reported when participants started chest compressions after receiving the rate instruction, continued while receiving the depth instruction, but suddenly stopped when the MD started to provide the guidance rhythm. This raised confusion, as participants were unaware about whether they were correct in starting at the time of the rate instruction or they had to wait until they received the guidance rhythm.

Researcher: You started with him [referring to the MD] in instruction number 6 [referring to the rate instruction] when he said 'compress promptly', you started.

Participant: Yes.

Researcher: Then, when he said 'compress hard,' you kept pushing ... when he told you 'Now, I will give you the rhythm', you stopped.

Participant: Yes.

Researcher: Why did you stop?

Participant: Because I thought I started it early [referring to chest compressions] I thought I should have listened until he finished talking and then start ... but I started early then when he told me to start again [referring to the guidance rhythm], I started again. (participant 16)

However, there was no consistency in participants' preferences on how to improve the order of instructions. To address the confusion, some participants preferred to receive the rate instruction and guidance rhythm followed by the depth instruction, while others preferred the opposite. The inconsistency in the sequence of instructions is a knowledge gap highlighted by the ILCOR. Participants 2 and 34 expressed the two different preferences for receiving the instructions.

Researcher: When he [referring to the MD] said '1 2 3 4 5 6'?

Participant: No, he should not have said it ... he told me 100 compressions in a minute ... I will start from this moment, and that is why I got confused.

Researcher: Ok, if we move it up for you, compress 100 times in a minute in this rhythm: 1 2 3.

Participant: Yes, this is possible ... but he should tell me the depth and the hand position before telling me this [referring to rate and guidance rhythm]. (participant 2)

Researcher: OK, when he [referring to the MD] gave you the rhythm '1 2 3 4 5 6' was this good for you? Or confused you?

Participant: It was good, but I already started.

Researcher: OK.

Participant: It should be with 'compress promptly with a rate of 100 times in a minute' in this [referring to the rhythm]

Researcher: In this rhythm?

Participant: In this rhythm: 1 2 3.

Researcher: Then, he should tell you the depth of compressions after it?

Participant: Yes, I think this is better. (participant 34)

5.3.2.4 Key findings informing the development of the enhanced T-CPR protocol

Participants reported a range of factors relevant to the language and T-CPR instructions that can act as barriers that inhibit CPR performance. The quantitative findings presented in 5.3.1 showed the low CPR timeliness and quality performance of the participants when using the Saudi T-CPR protocol. This low CPR performance could potentially reduce the survival rates of OHCA patients. Therefore, improving it could subsequently improve the survival rates. In this context, the qualitative findings of post-simulation interviews presented in 5.3.2 suggested recommendations drawn from the participants to develop a protocol that would enhance CPR timeliness and quality performance.

Clearly, there are many possible changes and modifications that could be made to the T-CPR protocol. However, since this PhD study is focused on language, recommendations on developing the enhanced T-CPR protocol that relate to the T-CPR instructions (clarity, precision, simplicity in language) were particularly considered and are summarised in Table 12. There is a set of other findings that were not considered which are summarised in Table 13 along with the reasons why.

Table 12. Key findings considered in the enhanced T-CPR protocol.

The factor	Suggested modification	Reason
Barriers in MSA comprehension and communication	The use of simple language that can be easily comprehended and communicated by laypeople, especially when under stress. The use of simple and familiar terms (plain Arabic) was then suggested to replace MSA terms.	To improve instructions comprehension and call communication
Barriers in understanding anatomical and technical terms	The use of simple and familiar terms to describe the anatomical area and technical process. The suggestions are as follows: • Use 'bottom of the palm'. • Use 'let his/her chest gets back to its normal position'.	To improve understanding of the terms used in the CPR instructions
Imprecise and unnecessary instructions that can lead to different interpretation	The use of precise and simple terms that are not open to different interpretations, and deleting of unnecessary information. The suggestions are as follows: • Use 'sit on your knees close to the patient's chest'. • Use 'place the patient on his/her back on the floor and expose his/her chest'. • Use 'come forward to become vertical to his/her chest'. • Delete 'minimise the pauses between compressions to the lowest as possible'.	To improve instructions interpretation.

'Impractical' instructions and questions: difficulties in estimating parameters	Asking more practical age questions that can be answered without impacting the MD's decisions on which CPR instructions should be provided. The suggestion: • Ask 'Is the patient an adult, a child or an infant?'	To avoid estimation of the exact age

Table 13. Key findings not considered in the enhanced T-CPR protocol.

Factor	Suggested modification	Reason
Imprecise and unnecessary instructions that can lead to different interpretations	The use of precise and simple terms that are not open to different interpretations. The suggestion is as follows: • Use 'between the nipples'.	Although this could improve interpretation of instructions, it lacks support from the literature. Additionally, evidence from the literature suggests that this anatomical landmark can differ between people according to, for example, their gender and age. Therefore, it is not practical to test it using a man-manikin simulator which is used in this PhD project.
'Impractical' instructions and questions: difficulties in estimating parameters	Use simple phrases to improve the practicality in guiding the rate and depth. The suggestions are as follows: • Phrases similar to 'push as hard as you can'. • Phrases similar to 'push as fast as you can'.	These suggestions have been tested several times in the literature. There will be no contribution in testing them again.

Delivering emotional support	Several participants suggested receiving emotional support to alleviate stress and encourage their performance.	The participants reported MSA as not being their everyday language. Therefore, the preferred language should be first identified (e.g., plain Arabic) and tested, after which emotional support could be provided. Additionally, this is not within the scope of this PhD. This recommendation will be suggested for future work.
The complex sequence of the CPR instructions	Some participants suggested receiving rate and guidance rhythm followed by depth instructions. Others suggested receiving depth followed by rate and guidance rhythm instructions.	Although the current instruction sequence in Saudi T-CPR protocol showed not to be optimal, there was no consistency in the suggestions provided by the participants. Additionally, the literature has highlighted this issue as a knoweldge gap in T-CPR protocol. Therefore, future work should investigate the optimal instruction sequence in more depth.
Sending a picture or a video to illustrate how to perform CPR	A couple of participants suggested receiving a picture or a video to illustrate how CPR should be performed.	Sending pictures and videos are not within the scope of this PhD project.

Language modifications to improve the communication of instructions and improve the quality of CPR performance were considered on the basis of the findings presented in Chapter 4 and the qualitative interviews presented in this chapter. Here, it seemed clear that the enhanced protocol should avoid MSA as it is not the daily language used in Saudi Arabia and is difficult to comprehend, especially under stress. Instead, plain language that aims to communicate using simple and familiar terms that are comprehensible to laypeople was recommended. Further, the participants suggested ways in which the T-CPR language can be simplified to 'plain language' including avoiding anatomical, technical, and imprecise terms and phrases as well as removing unnecessary information. In this context, replacing the anatomical and technical terms with simpler and more familiar terms appeared important in making T-CPR instructions more comprehensible to untrained CPR bystanders. Moreover, using imprecise terms and removing unnecessary information was recommended to improve how bystanders interpret CPR instructions. Therefore, the enhanced CPR instructions attempt to achieve a balance between simplicity, precision, and concision. Meanwhile, the participants recommended that the question on the patient's exact age be replaced with a broader question about the age group instead. These language modifications are considered in the enhanced protocol, and improving them could enhance CPR timeliness and quality performance.

The participants also discussed other possible enhancements to the protocol but were not incorporated in developing the enhanced protocol. Improving the precision of 'hand position' guidance using the anatomical land mark of the nipples as a guide lacks support from the literature. Also, the literature suggests that this landmark can differ between people depending on, for example, age and gender. Therefore, testing it in this PhD project which uses a male manikin simulator was not appropriate. Some of the suggestions made by participants have already been intensively tested in the literature (e.g., the instruction to 'push as hard as you can'). This PhD has focused on modifications that have been less well researched. Providing emotional support was suggested to alleviate the stress and improve CPR performance. However, the Saudi T-CPR is written using MSA which is not the everyday language and therefore it was deemed to be difficult to provide emotional support using MSA. Providing emotional support is not within the scope of this PhD project, the aim of which is to focus on the simplicity and clarity of the language of T-CPR instructions. The other suggestions along with the reasons are summarised in Table 13.

5.4 Development and testing of the enhanced T-CPR protocol to improve CPR timeliness and quality performance

The enhanced protocol was developed in three stages: 1) developing the initial version based on recommendations from the 'before group' findings and observation of calls study findings, as supported by evidence from the literature; 2) exploring medical and language experts' opinions on the initial version; and 3) validating the protocol using PPI. The impact of the enhanced protocol was then examined in the 'after' phase of the simulation study. Additionally, post-simulation semi-structured interviews were also used to collect participants' views and experiences of the enhanced protocol.

5.4.1 Development of the enhanced T-CPR protocol

Developing the initial version

The initial version of the protocol was developed based on findings identified in the 'before group' interviews, which are described in Table 12, and are supported by the observation of calls findings (see Chapter 4). These findings were also supported by evidence of using plain language explored in the literature review (see Chapter 2).

Exploring the opinions of medical and language experts

Medical and language experts reviewed a draft of the enhanced version of the T-CPR protocol to ensure that the language was simple and comprehensible, and the modifications did not change the CPR practice. First, the medical experts reviewed the initial version and confirmed that the modifications are consistent with the high clinical performance of CPR, and they do not conflict with the ILCOR recommendations. In the end, no modifications were suggested. Subsequently, the language experts reviewed the plain language used to ensure that it was simple and comprehensible for laypeople. They confirmed the simplicity and familiarity of the terms used for the latter. However, they made simple editing corrections (e.g., similar to apostrophes in English), but these did not change the meaning in Arabic. Further, some also suggested a few alternative word choices to be considered, as they thought they would be simpler and more common for laypeople. The simple editing corrections were made to the enhanced protocol. The suggested word choices were then explored with PPI, as they are the targeted audience, to either make the change or reject it.

Validating the protocol using PPI

Prior to confirming the final version of the enhanced protocol, PPI was conducted to validate it. Here, 10 volunteers, who varied in their levels of education, came from different parts of Saudi Arabia, and age groups, shared their thoughts and reflected on the enhanced protocol. Specifically, the 10 volunteers reflected on the initial version of the protocol and focused specifically on changes made to the language. They were also asked to review the suggested alternatives provided by the language experts. They were asked whether the language would be considered 'plain' (i.e., uses simple and familiar terms that could be understood, and whether there are any vague or imprecise terms). In the end, the volunteers preferred to replace a couple of words from the initial version with the alternatives suggested by the language experts, as they are more commonly used in everyday communication. The final version of the protocol was then revised and agreed upon (the Arabic version is attached in Appendix N). Table 14 compares the translated Saudi and enhanced T-CPR protocols along with the key modifications, which are linked to the factors summarised in Table 12. The aim of Table 14 is to convey a picture of how the enhanced T-CPR protocol was modified, as the exact language modifications (in the exact terms) were conducted in Arabic.

Table 14. Translated Saudi and enhanced T-CPR protocols along with the modifications.

Question and instruction numbers	Saudi T-CPR	Enhanced T-CPR	Factor number
Question 1	How old is the patient?	Is the victim an adult, a child, or an infant?	5.3.2.3.1
Question 2	Are you next to the patient?	Are you close to the victim?	5.3.2.2.1
Question 3	Is the place safe?	Is the place safe?	N/A
Question 4	Is the patient conscious? (Gently shake patient's both shoulders and shout loudly are you fine?)	Is the victim conscious? (Gently shake patient's shoulders and shout are you OK?)	5.3.2.2.1
Question 5	Is the patient breathing in a normal condition?	Is the victim breathing normally?	5.3.2.2.1
Question 6	Have you had previous training on basic life support?	Do you have first aid training?	5.3.2.2.1
Instruction 1	Sit on your knees next to the patient.	Get on your knees close to patient's chest.	5.3.2.2.1 and 5.3.2.2.3
Instruction 2	Put the phone on speaker.	Put the phone on speaker.	N/A
Instruction 3	Place the patient on his/her back on a flat and rigid surface, and take off his/her top clothes and expose the chest.	Place the victim on his/her back on the floor, and expose his/her chest.	5.3.2.2.3

Instruction 4	Place the heel of one hand on the middle of the chest, and place the other one on the top of it and interlock between their fingers.	Place the bottom of your palm on the middle of his/her chest, and place the other one on the top of it and interlock your fingers.	5.3.2.2.1 and 5.3.2.2.2
Instruction 5	Make your arms straight and lean forward slightly.	Make your arms straight and come forward to become vertical to his/her chest.	5.3.2.2.1 and 5.3.2.2.3
Instruction 6	Compress promptly in a rate of at least 100 times/m.	Push fast in at least 100 compressions/m	5.3.2.2.1
Instruction 7	Compress hard, so the depth of compression becomes at least 5 cm, and allow full chest recoil between the compressions without losing contact between your hands and the chest.	Push hard in at least 5 cm depth and let his/her chest gets back to its normal position between the compressions without lifting your hands off his/her chest	5.3.2.2.1 and 5.3.2.2.2
Instruction 8	MDs guide the caller—1-2-3-4-5-6—until taking the right rhythm and monitor him/her.	MDs guide the caller—1-2-3-4-5-6—until taking the right rhythm and monitor him/her.	N/A
Instruction 9	Minimise the pauses between the compressions to the lowest possible	N/A ‘the instruction is deleted’.	5.3.2.2.3
Instruction 10	Do not stop the compressions at all for any reason until ambulance arrival or return of patient’s consciousness, and in case, you become exhausted ask for help from attendees.	Never stop the compressions until ambulance arrives or victim gets conscious, and if you get exhausted, ask for help from people around	5.3.2.2.1 and 5.3.2.2.3

The impact of the final version of the enhanced T-CPR protocol was then examined in OHCA simulation sessions and explored in the post-simulation interviews, which is presented in the following section.

5.5 Measuring the impact of the enhanced T-CPR protocol as compared to the Saudi T-CPR protocol

The impact of the enhanced T-CPR protocol on CPR timeliness and quality performance was measured in an OHCA simulation. Next, semi-structured interviews with the participants asked them to reflect on the protocol. Finally, the findings from the simulation and the semi-structured interviews were compared with the before-group findings, which used the Saudi T-CPR protocol.

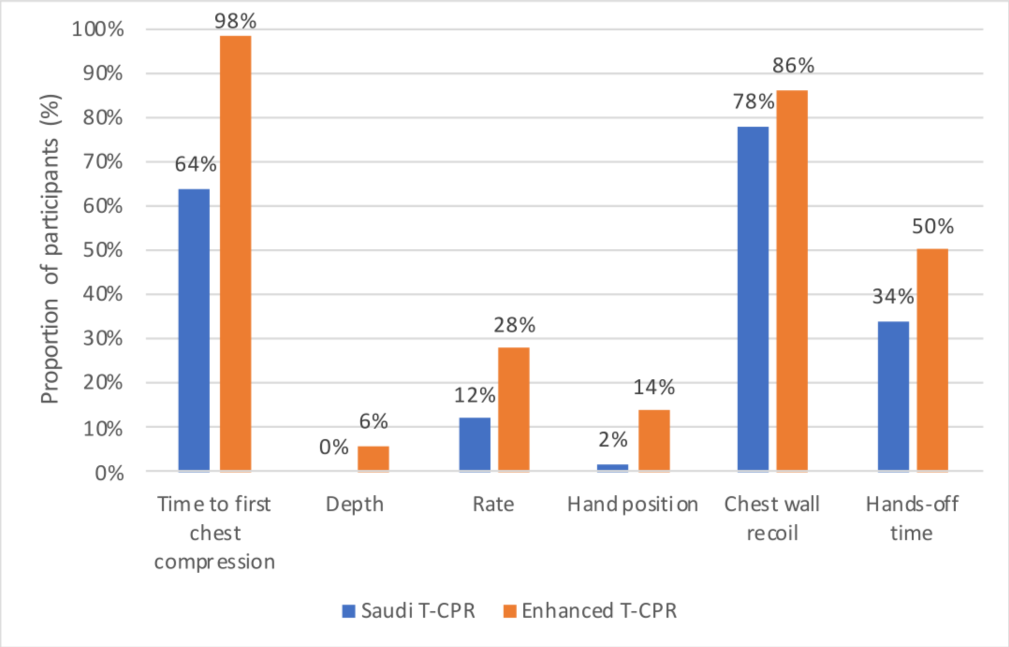
5.5.1 Improving CPR timeliness and quality performance

The enhanced T-CPR protocol enabled participants to perform better quality CPR in a timely manner as compared to the Saudi T-CPR protocol. All CPR quality parameters in the enhanced T-CPR protocol (after group) were improved as compared to the performance following the Saudi T-CPR protocol (before group) (see Table 15). Also, more participants following the enhanced T-CPR protocol reached the AHA timeliness and ILCOR standards as compared to the participants following the Saudi T-CPR protocol (see Figure 20).

Table 15. Comparison of CPR performance between the Saudi and enhanced T-CPR protocol.

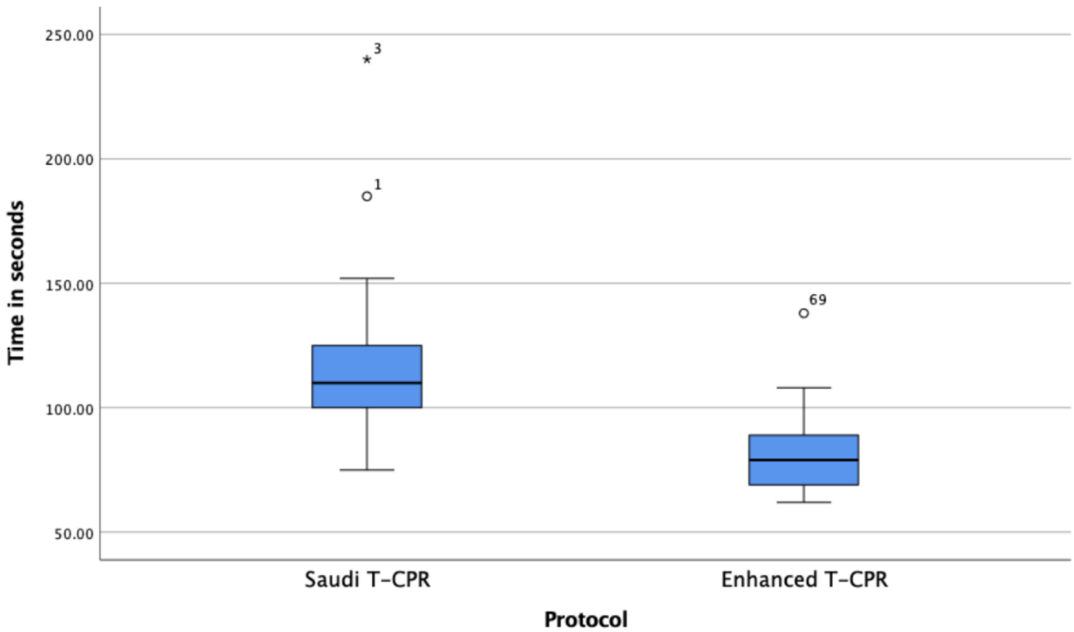
Parameter	Saudi T-CPR (median)	Enhanced T-CPR (median)	Significance (p value)	Effect size
Time to first chest compression (s)	110	79	<.001	0.73
Depth (mm)	30	35	.004	0.29
Rate (c/m)	94.5	105	.202	0.13
Hand position (%)	86.5	95	<.001	0.56
Chest wall recoil (%)	100	100	.318	0.10
Hands-off time (s)	4.9	.9	.007	0.27

Figure 20. Comparison between the Saudi and enhanced T-CPR protocol compliance with AHA timeliness (minimum standard) and ILCOR quality performance standards.



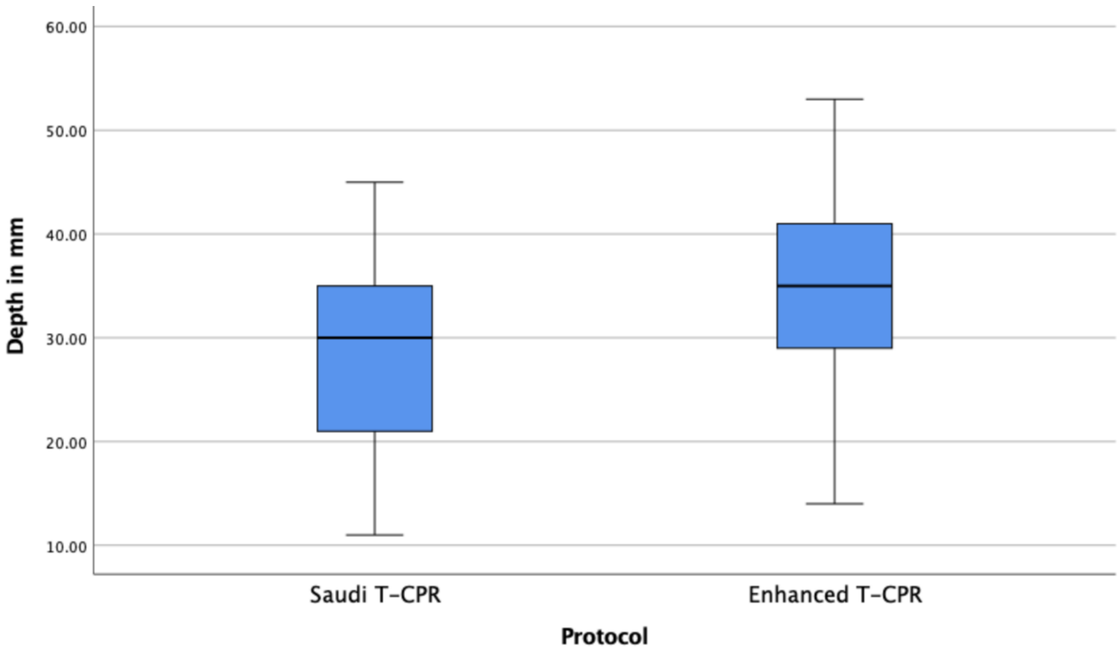
Ninety-eight percent of participants in the after group initiated CPR within the AHA standard compared to the 64% in the before group. The median time to first chest compression was significantly improved from 110 s in the before group to 79 s in the after group ($p < 0.001$) (see Figure 21), which has the potential to increase patients' chances of survival. Calculating the effect size of this improvement is showing a large effect (0.73) of using the enhanced T-CPR protocol.

Figure 21. A Box Whisker plot of the time from EMS call receipt to the first chest compression by the Saudi and enhanced T-CPR protocols.



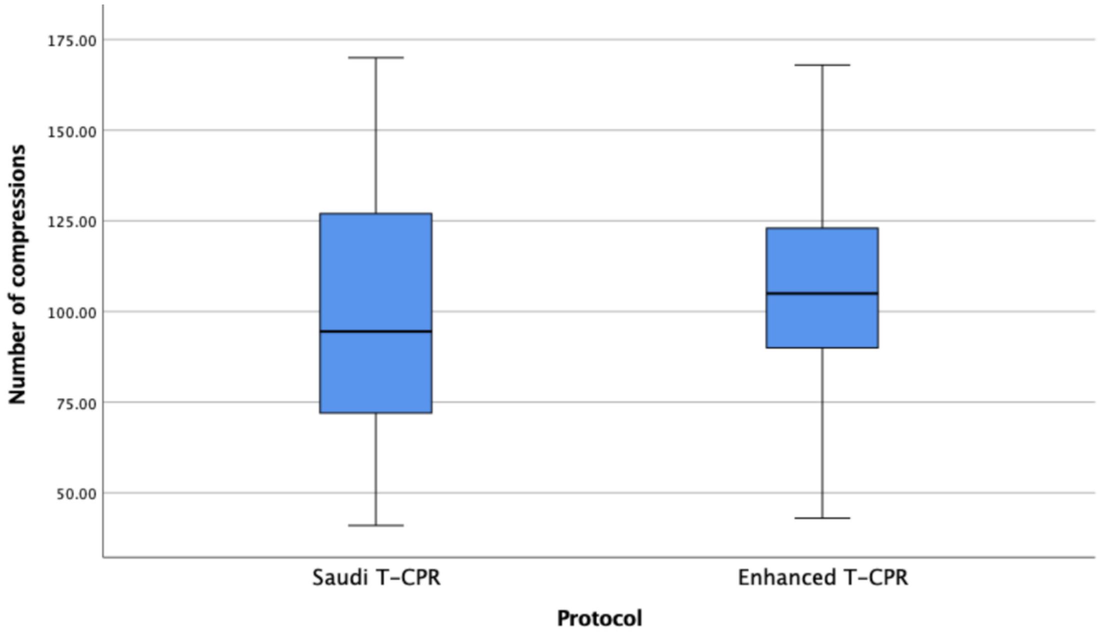
Moreover, the enhanced T-CPR protocol successfully enabled 6% of the participants to perform CPR at the ILCOR recommended depth, which none of the Saudi T-CPR participants achieved in the 'before' simulation. Significant depth improvement was also revealed between the before and after groups at 30 mm and 35 mm respectively (p = 0.004) (see Figure 22). The size of this effect is shown to be medium (0.29) in magnitude.

Figure 22. A Box Whisker plot of the depth of compression by the Saudi and enhanced T-CPR protocol.



Additionally, more participants in the after group performed CPR at the ILCOR recommended rate as compared to the before group at 28% and 12%, respectively. The median chest compression rate also showed improvement from 94.5 c/m to 105 c/m in the before and after groups, respectively (see Figure 23).

Figure 23. A Box Whisker plot of the chest compressions rate per minute by the Saudi and enhanced T-CPR protocol.



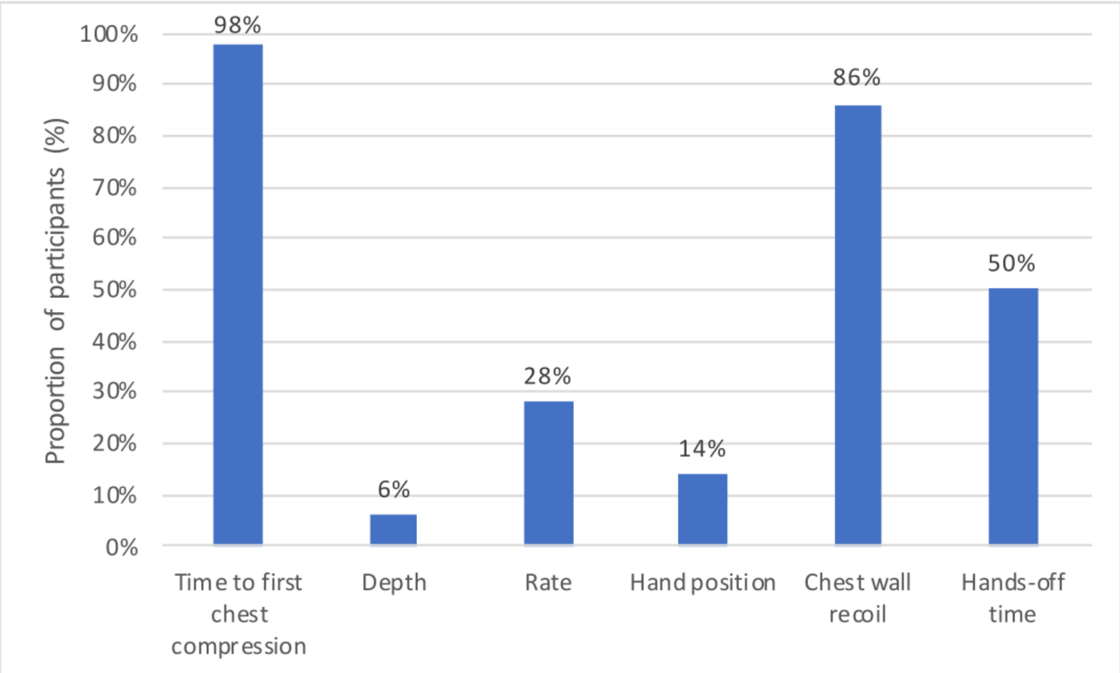
These improvements in CPR commencement time, depth, and rate could have the potential to improve patients' outcomes. Additionally, the other CPR parameters were also improved, and significance was shown in hand position and hands-off chest time (see Table 15), and more participants achieved the ILCOR recommendations in these CPR parameters (see Figure 20). In this context, section 5.5.2 explored the participants' reflections on the enhanced protocol, which provides a possible explanation for the improvement achieved in the CPR performance.

Although the enhanced T-CPR protocol showed improvement as compared to the Saudi T-CPR protocol, CPR performance was still below the ILCOR recommendations (see Table 16 and Figure 24). None of the participants in the enhanced protocol performed CPR that met the recommended ILCOR standard.

Table 16. CPR timeliness and quality performance following the enhanced T-CPR protocol.

Parameter	Median	IQR	ILCOR and AHA recommendations	Test for normality	
				Shapiro Wilk	Distribution
Time to first chest compression (s)	79	69–89.25	<60/<120	<.001	abnormal
Depth (mm)	35	28.75–41	50–60	.669	normal
Rate (c/m)	105	89.5–123.5	100–120	.968	normal
Hand position (%)	95	94–96	100	<.001	abnormal
Chest wall recoil (%)	100	100–100	100	<.001	abnormal
Hands-off time (s)	.91	0.00–5.35	00	<.001	abnormal

Figure 24. Proportion of participants achieving AHA timeliness (minimum standard) and ILCOR quality performance standards following the enhanced T-CPR protocol.



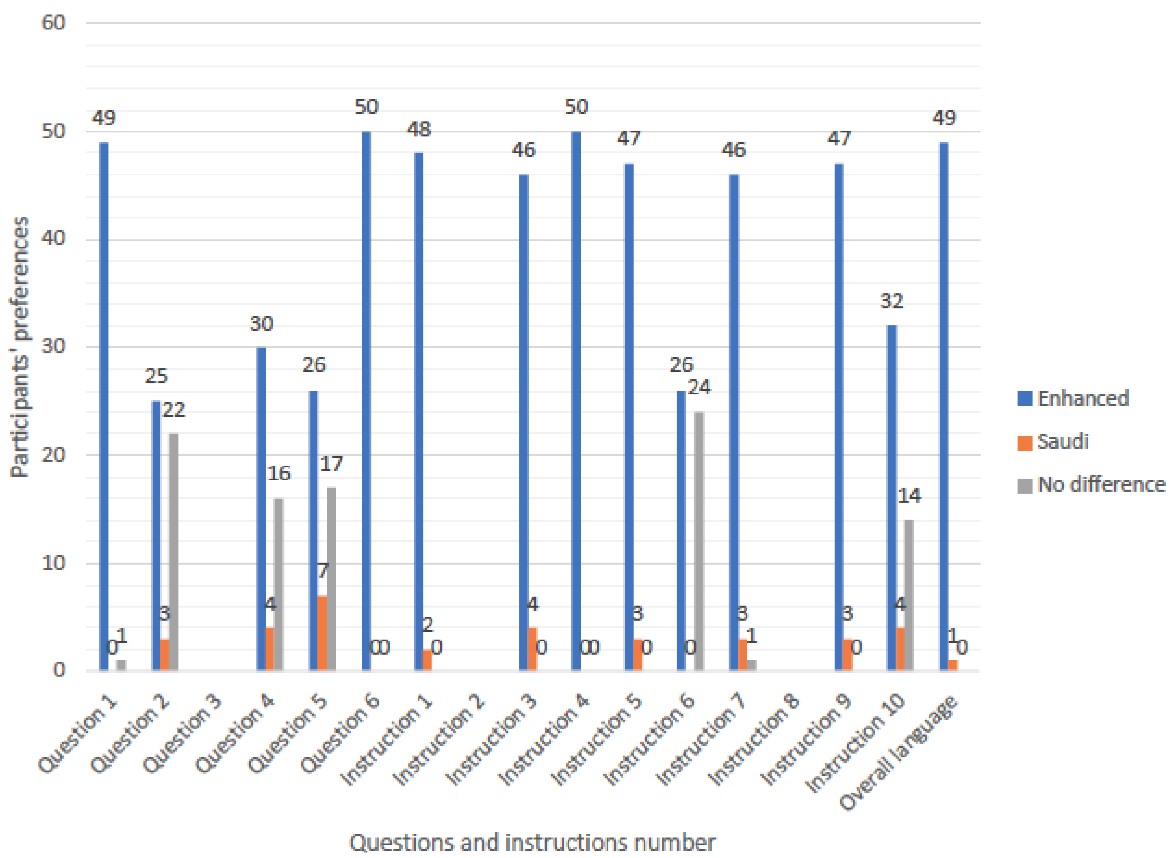
While 98% of the participants starting the first chest compression within the minimum AHA standard, none initiated chest compression within the high standard. Only three (6%) and 14 (28%) participants reached the recommended ILCOR depth and rate, respectively. The participants also showed low performance, compared with the ILCOR standards, in the other CPR parameters (see Table 16 and Figure 24).

Additionally, comparisons between male and female performances were measured using a Mann-Whitney U test. Male participants performed significantly deeper chest compressions than female participants (at medians of 36 and 32 mm, respectively; p = 0.006) with shorter hands-off chest times (at medians of .0 and 3.8 s, respectively; p = 0.045).

5.5.2 The use of simple language to comprehend, communicate, and interpret T-CPR instructions

Semi-structured interviews with the participants were conducted to reflect on the enhanced T-CPR protocol and to ask them to compare it with the Saudi T-CPR protocol. Here, most participants preferred to receive the enhanced T-CPR protocol over the Saudi T-CPR protocol (see Figure 25) during OHCA calls. The reason they provided as was the language used, which was simpler for comprehension and communication.

Figure 25. Proportion of participants' preferences of the questions and instructions listed in the enhanced and Saudi T-CPR protocols (the questions and instructions are summarised in Table 14)



*There was no change in question 3 and instructions 2 and 8 between the enhanced and Saudi protocols.

The following sections briefly explores how the enhanced T-CPR language improved the language complexity identified in the before-group component.

Improving call comprehension and communication using plain Arabic

Using plain Arabic was perceived to have the potential to improve comprehension and communication during telephone CPR. Almost all the participants (98%) preferred the plain language used in the enhanced protocol over the MSA used in the Saudi protocol. The only participant who preferred MSA highlighted that he/she was concerned that the MD might use a dialect rather than plain language. Moreover, the issues reported by before-group participants in using MSA (see section 5.3.2.2.1) were successfully improved using plain Arabic. More specifically, many participants highlighted that they are familiar with speaking and hearing this language, and therefore, it is more understandable for laypeople regardless of their levels of education. Further, they emphasised that this form of language is easier to comprehend, especially in stressful situations similar to OHCA, as they do not need to spend time or to completely focus on the language to comprehend it. Additionally, others expressed that it is more familiar and therefore does not create barriers in communication, and thus can improve the flow of communication and achieve rapport. These positive reflections of plain language in terms of increased comprehension and better communication could improve CPR performance.

> *Participant: The plain one.*
>
> *Researcher: Why?*
>
> *Participant: I felt it … more comfortable.*
>
> *Researcher: Do you feel comfortable hearing it?*
>
> *Participant: Yes, I feel comfortable when someone talks using it ... but the MSA, I think, I need time to process it to my language, so I can understand what it means.*
>
> *Researcher: So, you need time to comprehend it [referring to the MSA]?*
>
> *Participant: Yes. (participant 43).*
>
> *Researcher: Do you prefer the MSA? Or the plain one ... the simple language?*
>
> *Participant: Because we are in an emergency situation so the simple language.*
>
> *Researcher: Why?*
>
> *Participant: Because it is the common language, and we are likely to know all the terms used in it, so it is faster to comprehend and apply but here [referring to the Saudi T-CPR], I might wait and think what 'heel of the hand' means.*
>
> *Researcher: So, it is simpler for you because [participant interrupted researcher].*
>
> *Participant: A common language, I know it, and I always hear it, so it is clearer for me. (participant 9).*

<u>Improving understanding of instructions using simple and familiar terms</u>

Avoiding anatomical and technical terms in plain language resulted in improvements in the understanding of instructions. The simple words used to describe the anatomical phrase *'heel of the hand'* and the technical process *'allow full chest recoil'* were found to be easier for almost all the participants to understand (see instructions 4 and 5 in Figure 25). Further, they highlighted that the enhanced protocol used simpler and more familiar terms that did not need CPR background to understand. Participants 13 and 29 expressed how the enhanced protocol improved their understanding using simple and familiar terms.

> *Researcher: Heel of the hand is the bottom of the palm ... do you prefer it or prefer the second one?*
>
> *Participant: No, the second one because it is clear ... most people know what 'palm' is, but 'heel of the hand' is a bit difficult as a language. (participant 13)*
>
> *Participant: Number 2 is clearer its normal position ... allow full chest recoil is difficult to [thinking]*
>
> *Researcher: You previously told me that you did not understand 'allow the chest recoil'?*
>
> *Participant: Yes, it is difficult to understand the process ... so use 'let the chest get back to its normal position' ... it is easier and clearer. (participant 29).*

<u>Improving interpretation of instructions using precise and simple terms and deleting unnecessary information</u>

Using precise, simple and concise terms and phrases in the plain language appeared to improve the interpretation of the instructions and was preferred by most of the participants. They expressed that the enhanced instructions were clearer to interpret than the Saudi T-CPR instructions. Specifically, they reported that the enhanced protocol clarified where they should sit exactly by precisely directing them to sit next to the patient's chest (see instruction 1 in Figure 25). It also improved the precision of *'flat and rigid surface'* by simplifying it to *'floor'* and ensured conciseness in '*take off his top clothes and expose his/her chest'* by deleting the unnecessary information—'*take off his top clothes'* (see instruction 3 in Figure 25). The guidance for physical positioning was also improved by using simple phrase *'come forward to become vertical to his/her chest'* that included the precise word, *'vertical'* (see instruction 5 in Figure 25). Moreover, deleting *'minimise the pauses between compressions'* was agreed upon by most of the participants, as it was unnecessary, and this provided clarity and precision to the overall instructions (see instruction 9 in Figure 25). Improving how participants interpret CPR instructions could improve how they perform CPR. Participants 41 and 15 expressed how the enhanced instructions provided precision.

Researcher: Sit on your knees next to the patient, or sit on your knees close to the patient's chest?

Participant: Close to the patient's chest

Researcher: Why?

Participant: It was clear ... if he [referring to the MD] said 'next to the patient', you would not know ... is it close to his legs [referring to the patient] or from which area you will push? (participant 41)

Researcher: 'Make your arms straight and lean forward slightly' or 'make your arms straight and come forward to become vertical to his/her chest'?

Participant: Two is better ... I mean it has clarification that you will be vertical to his chest [referring to the patient].

Researcher: It tells you where you should stop [referring to the leaning].

Participant: Yes, it is. (participant 15)

Improving question practicality by avoiding the estimation of the patient's exact age

Asking simple questions that can be easily answered was preferred by participants. Here, asking about the patient's age group—'*is the victim an adult, a child or an infant?*'—was easier to answer as compared to their exact age (see question 1 in Figure 25). This broader question provided options that can be easily answered, which decreases the cognitive demand involved in requiring the caller to think about the patient's exact age and leads to a shorter time taken to commence CPR.

Researcher: 'How old is the patient' or is 'the patient an adult, a child or an infant'?

Participant: Version number 2.

Researcher: Why?

Participant: 'how old is the patient?' includes a lot of guessing.

Researcher: OK.

Participant: And it is difficult to decide it in your head ... so, it is easier to decide whether the patient is an adult, child or infant. (participant 46)

Articulating contradicting opinions

Although most participants preferred to receive the instructions listed in the enhanced protocol, a few preferred some in the Saudi protocol, and others showed no preference (see Figure 25). The reason why some participants preferred some instructions from the Saudi protocol was due to their thoughts that those instructions were simpler and clearer to interpret than the enhanced protocol. A couple of participants preferred to receive the instruction '*sit on your knees next to the patient*' as they would immediately interpret it as sitting next to the patient's chest, and therefore, it would save time prior to commencing CPR. Moreover, four participants preferred to receive the deleted '*flat and rigid surface*' and *'take off his/her top clothes,'* as they included necessary information that would add further precision to the instructions. Meanwhile, three participants also preferred to receive the instruction '*lean forward slightly*' as they felt it was precise enough to direct them to be vertically above the patient. Additionally, three participants preferred to receive the technical phrase *'allow full chest recoil'* as it is clearer in describing how to perform the technical process. Finally, three participants preferred to receive the deleted instruction *'minimise the pauses between compressions'* as they felt it includes necessary information that clarifies the need to avoid having rests between the compressions. These differences in participants' preferences could be considered natural, as people are not similar and have different, for example, perspectives, levels of education, cognitive abilities.

> *Participant: Number 1 protocol number 1 [referring to the Saudi T-CPR protocol].*
>
> *Researcher: OK ... until where you come forward in 'lean forward slightly'?*
>
> *Participant: I will move forward a bit I mean I will lean.*
>
> *Researcher: No, I want you to be exactly above the patient.*
>
> *Participant: Yes, above the patient but this is clearer for me.*
>
> *Researcher: Number 1?*
>
> *Participant: Yes. (participant 16)*
>
> *Participant: Number 1.*
>
> *Researcher: Why?*
>
> *Participant: I do not know I feel full recoil [meaning it is better].*
>
> *Researcher: But do you not think the full recoil [referring to the whole instruction] is difficult to understand?*
>
> *Participant: I do not know I mean for a person who understands the Arabic language … I feel it is clearer for me than 'get back to its normal position'. (participant 25).*

5.6 Chapter summary

This chapter presented the findings about CPR timeliness and quality performance using the Saudi T-CPR protocol, after which an enhanced protocol was developed and tested. Here, CPR timeliness and quality performance following the Saudi T-CPR protocol were found to be below the ILCOR and AHA standards. This could reduce patients' chances of survival, and therefore, it is crucial to improve T-CPR. Interviews with the participants provided possible explanations for their CPR performance and how to improve it. The complexity of language in the Saudi T-CPR protocol (e.g., the use of MSA and imprecise terms) was found to influence the communication as well as the understanding and interpretation of instructions. This can impact the CPR performance of participants. Further, the language complexity was exacerbated by the context of T-CPR, which was found to be a stressful and cognitively complex task.

The enhanced T-CPR protocol was developed using plain language, aiming to improve the language complexity to subsequently improve the CPR timeliness and quality performance. The protocol language development was drawn from recommendations received from the before-group and the observation of calls study supported by evidence from the literature. Most importantly, the enhanced protocol resulted in improvements in participants’ CPR timeliness and quality performance as compared to the Saudi T-CPR protocol. This improvement could have the potential to improve the survival rate. Participants’ interviews to reflect on the enhanced protocol highlighted that it involved language that was simpler to comprehend, communicate, and interpret as compared to the Saudi T-CPR protocol. However, CPR performance using the enhanced protocol was still below the ILCOR standards. Thus, further improvement is needed to improve CPR timeliness and quality performance.

Chapter 6 Discussion and conclusion

6.1 Key findings overview and chapter introduction

This PhD project aimed to improve CPR timeliness and quality by investigating the nature of OHCA calls and the T-CPR protocol in current practice in Saudi Arabia and to test and evaluate possible language modifications to T-CPR instructions. This PhD project is the first to use a mixed-method design to investigate OHCA calls in regard to the time to first chest compression. It is also the first study to examine OHCA call characteristics and the use of the T-CPR protocol in current practice in Saudi Arabia. In addition, it is the first study to conduct a detailed investigation and improve language used in T-CPR protocols, drawing upon the knowledge of participants with an experience in applying it.

Following the development of a new, enhanced T-CPR protocol, the time to first chest compression and quality of CPR performance were found to be improved as compared to the Saudi T-CPR protocol. The time to first compression improved from 110 to 79 s, the depth of compression from 30 to 35 mm, and the compression rate from 94.5 to 105 c/m, all of which have the potential to improve survival rate. The language used in the Saudi T-CPR protocol (words and terms) was found by participants as not optimal to communicate with, understand and interpret. Simplifying the language to plain was suggested by the participants which is consistent with evidence from literature and then used in the enhanced T-CPR protocol. The use of plain language in T-CPR noted by the participants to improve communication as well as the understanding and interpretation of instructions, which subsequently improved their CPR timeliness and quality performance.

Meanwhile, the observation of calls study in the current practice found the ROSC rate to be low by only 10%. This low rate could be attributed to the delayed time to first chest compression from the EMS call receipt. Further, time to start of first chest compression was found to be prolonged with a median of 367 s, which exceeds the AHA recommendation by 217 s. These key findings are explored in the following section.

This chapter starts by discussing the key findings identified in this PhD, which are relevant to the characteristics of OHCA and T-CPR in current practice, the language and communication, and the influence of using plain language. Additionally, strengths and limitations of this PhD are also highlighted. This is followed by implications, further recommendations, and dissemination of the findings. Finally, the conclusion section summarises this PhD project and highlights the key findings and contributions to the current literature.

6.2 Discussion of the main findings

This PhD aimed to improve CPR timeliness and quality by investigating the nature of OHCA calls and T-CPR protocol in current practice in Saudi Arabia and to test and evaluate modifications to T-CPR instructions language. The key themes in this discussion in the following sections are: the characteristics of OHCA and T-CPR protocol in current practice; the language of and communication using the T-CPR protocol; and how plain language influences CPR timeliness and quality performance.

6.2.1 Characteristics of OHCA calls and the use of T-CPR protocol in current practice in Saudi Arabia

This PhD project is the first to investigate OHCA calls and the use of the T-CPR protocol in current practice in Saudi Arabia. The findings discussed in this section address the PhD objectives of describing the characteristics of OHCA calls and assessing the quality of the T-CPR protocol, while also investigating possible factors influencing the quality of T-CPR.

Due to the lack of studies reported in the literature on OHCA calls in Saudi Arabia, callers' basic characteristics were explored to understand the context of T-CPR practice. More specifically, observations of OHCA calls revealed that the majority of callers were male (76%). Here, the lower proportion of female callers (24%) in this study contrasts with findings from other countries that female callers typically make more OHCA calls (Bergner and Eisenberg, 1982; de Vreede-Swagemakers *et al.*, 1997; Dorph, Wik and Steen, 2003; Ma *et al.*, 2007). However, this could be attributed to the cultural considerations regarding gender roles, where males in Saudi Arabia typically take the responsibility to take action (Almalki, 2020). Further, in Kuwait, a Gulf country that shares a similar culture to Saudi Arabia, women also accounted for a lower proportion of callers in a before-and-after (36% and 28.9%, respectively) T-CPR protocol implementation study (Al Hasan *et al.*, 2019).

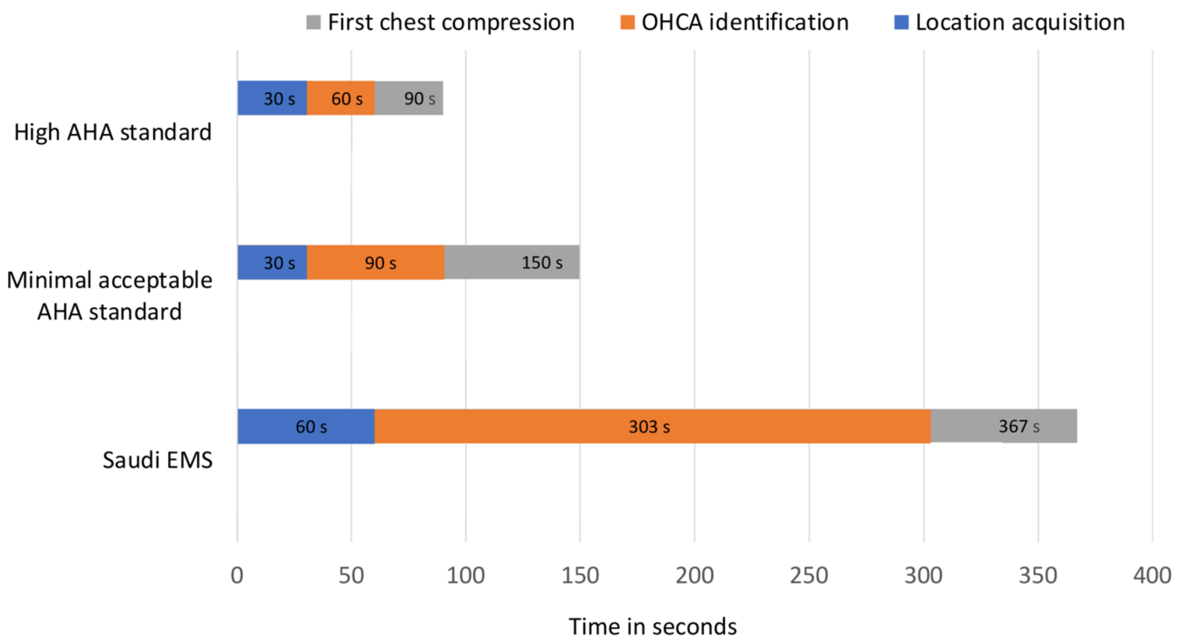
A further observation is that most OHCA callers (72%) shared a family relationship with the patients. This finding is important, as family members undertaking CPR has been reported to be proportionally declining as compared to stranger bystanders (Casper *et al.*, 2003; Fujie *et al.*, 2014; Sato *et al.*, 2020). This could be due to the psychological factors influencing bystanders to perform CPR to one of their family members (Dwyer, 2008). However, in Saudi Arabia, the family relationship was not a barrier influencing family members callers from performing CPR. The observations revealed that none of the callers declined performing CPR when asked by the MD. This could indicate that how callers respond to OHCA calls and T-CPR tasks might vary between communities.

Despite the high proportion of callers performing CPR when asked, at 10%, the ROSC to hospital arrival was found to be less than half of that reported in the literature. A systematic review conducted by Sasson *et al.* (2010) concluded that 23.8% of overall OHCA patients survived to hospital admission. However, in terms of the regional area, Saudi Arabia was similar or better than other Gulf countries—Kuwait and the Emirates showed 1.6%–6% and 9.2% pre-hospital ROSC, respectively (Al Hasan *et al.*, 2019; Alqahtani *et al.*, 2019), while Qatar had 13% ROSC at hospital admission (Irfan *et al.*, 2016). The low ROSC in Saudi Arabia and the Gulf countries needs urgent intervention to investigate the possible reasons and how they can be improved to subsequently improve the survival rate.

The time to first chest compression (median 367 s, IQR 266.75–550.5 s) was prolonged and fell well below the AHA recommendations, which is likely to detrimentally the impact on ROSC. This time interval exceeds the minimum acceptable (<150 s) and high quality (<90 s) AHA standards by 217 and 277 s, respectively. In this context, time to start of CPR is crucial in OHCA patients' survival, as its early initiation can double or quadrable the survival rate (Valenzuela *et al.*, 1997; Holmberg *et al.*, 1998; Holmberg, Holmberg and Herlitz for the Swedish Cardiac Arrest Registry, 2001; Waalewijn, Tijssen and Koster, 2001; Wissenberg *et al.*, 2013; Hasselqvist-Ax *et al.*, 2015). Moreover, the median time to start CPR found in current practice, which is 367 s, has the potential to decrease the survival rate by 42.81 to 61.16%, as evidence from literature suggests that for each minute that goes by with no CPR and the use of electrical defibrillation decreases the survival chance by 7–10% (Larsen *et al.*, 1993; Valenzuela *et al.*, 1997; Holmberg, Holmberg and Herlitz, 2000). Here, after considering the literature, two studies were found to meet the AHA standards with times from EMS call receipt to first chest compression at 145 and 148 s, respectively (Plodr *et al.*, 2016; Gram *et al.*, 2021). However, there is no clear explanation for why these studies achieved the AHA standard. Importantly, Plodr *et al.* (2016) demonstrated an improvement in ROSC to hospital admission from 31.9% to 45.6% when the time to first chest compression improved. Meanwhile, the majority of the studies in the literature showed delayed time to first chest compression, which ranged from 168 to 330 s (Hauff *et al.*, 2003; Heward, Donohoe and Whitbread, 2004; O'Neill and Deakin, 2007; Van Vleet and Hubble, 2012; Lewis, Stubbs and Eisenberg, 2013; Clegg *et al.*, 2014; Dameff *et al.*, 2014; Hardeland *et al.*, 2014; Stipulante *et al.*, 2014; Travers *et al.*, 2014; Dami *et al.*, 2015; Hardeland *et al.*, 2016; Ho *et al.*, 2016; Oman and Bury, 2016; Hardeland *et al.*, 2017; Huang *et al.*, 2017; Shah *et al.*, 2017; Michiels *et al.*, 2020; Zhang *et al.*, 2020). However, time to first compression in current practice in Saudi Arabia is below the wider literature.

The manner in which the OHCA call is processed in current practice has been found to contribute to delaying first chest compressions. Figure 26 shows how a significant amount of time is spent on identifying OHCA and on the calls being processed.

Figure 26. The OHCA call processing from EMS call receipt until first chest compression and comparison with the AHA standards.



The MDs identified OHCA in 303 s from EMS call receipt, which is 213 s short of what the AHA recommends. This delayed OHCA recognition and time to first chest compression could be attributed to how calls are processed in the SRCA. The main difference in the SRCA is that suspected urgent calls, such as OHCA, are transferred to an MD to assess and advise the caller. There was a median of 231.5 s between the call receipt and the MD answering the call. More specifically, 171.5 s was spent waiting for the call to be transferred to the MD (measured as starting from the identification of the location by the call taker until the MD answered the call). This additional step of transferring some types of calls is not present in other commonly used EMS dispatching systems, such as MPDS (Bohm and Kurland, 2018) and CBD (Baabdullah *et al.*, 2020). Routinely the dispatcher who receives the EMS call is the one to identify OHCA and provide T-CPR instructions (Kurz *et al.*, 2020). Thus, avoiding unnecessary transfers in calls can improve the time to first chest compression.

Moreover, the median time taken to identify the location was 60 s from call receipt, which is double that of the AHA recommendation (Kurz *et al.*, 2020). The current T-CPR protocol requires call takers to ask callers to describe their locations because calls tracking systems at the SRCA do not automatically track call locations in many cases. Further, Saudi Arabia does not use postal codes to identify location, and this added made it harder for callers to describe their location.

However, location acquisition has been reported in the literature to impact the time to first chest compression. More specifically, the study by O'Neill and Deakin (2007) found that after the call receipt, 73 s was spent to establish the location. However, no clarification was provided as to why the location was difficult to identify. Thus, having a well-designed call tracking system (see implications in section 6.4) could reduce the time wasted prior to starting chest compressions.

Additionally, this study found that MDs asking callers, who report OHCAs, unnecessary questions impact the time to first chest compression. Some MDs asked callers further questions about the patient's condition, such as past medical history, to further investigate the case even though the callers confirmed unconsciousness with abnormal/no breathing. As they were asked after this confirmation, these questions are considered unnecessary. Here, providing CPR guidance is the recommendation by the ILCOR to reduce the time to first chest compression (Perkins *et al.*, 2015c). Further, the AHA highlighted the importance of dispatcher protocols to identify OHCA as soon as possible and noted that asking questions about past medical history or acute conditions might delay CPR performance (Lerner *et al.*, 2012). In this context, asking such questions was shown to add further delay when callers did not know the answer and had to find a third person to assist, as seen in this study. Looking at the relevant literature, the unnecessary questions reduced time to first compression (Lewis, Stubbs and Eisenberg, 2013; Travers *et al.*, 2014; Oman and Bury, 2016; Michiels *et al.*, 2020). Therefore, omitting unnecessary questions from T-CPR protocols and training MDs to comply with the protocols could reduce the time spent prior to starting chest compression and thus, improve the survival rate. Further, Lewis, Stubbs and Eisenberg (2013) also highlighted the need to train dispatchers to avoid asking unnecessary questions, as it has the potential to improve the survival rate by reducing time to first compression.

Another explanation for the delayed time to commence chest compression can be related to Saudi cultural norms about gender. Male callers refused to assess or perform CPR on an nonrelated female patient when asked by the MD, as shown in this study. This is likely due to sex segregation in Saudi Arabia, as men do not routinely interact with nonrelative women due to cultural norms (Almalki, 2020). Alternatively, male callers preferred to hand the phone to a family member of the female patient to speak to the MD, causing further delays. Gender also played a role in some calls where the callers were female, and the MDs asked if there was a male (a third person) they could talk to. The reasons for responding differently to male and female callers are unknown, as this is not the standard practice. Wider literature from non-Arabic speaking countries has also reported that females are less likely to receive bystander CPR (Blom *et al.*, 2019) and PAD (Matsui *et al.*, 2019; Kiyohara *et al.*, 2020) in OHCAs. This suggests that there are gender differences in other cultures worldwide due to possible social norms. Despite this, gender difference has not been reported in the literature as a factor influencing the time to first chest compression during T-CPR.

The language used in the T-CPR instructions, such as providing imprecise instructions, was found by this study to prolong the time to first chest compression. Providing such instructions was found to be difficult for callers to interpret and resulted in them asking for further clarification, which influenced the communication. The language complexity and how it impacts communication during T-CPR is discussed in section 6.2.2.

6.2.1.1 Qualitative observations with potential influence on survival rate

Due to the lack of qualitative observations investigating OHCA calls, observations of MDs and callers communication during the calls is discussed. These observations provide insight into aspects of OHCA calls that could have the potential influence on survival chances.

Observations in current practice revealed that multiple factors can be influenced by a common underlying cause. As discussed in 6.2, asking unnecessary questions can cause delay in time to chest compression, but can also cause misrecognised OHCA. Unnecessarily asking callers to check the carotid pulse of unconscious and not/abnormally breathing patients to identify OHCA was found to influence the identification. This technique has been highlighted as inaccurate when being performed by those untrained in CPR (Bahr *et al.*, 1997; Moule, 2000; Nyman and Sihvonen, 2000; Tibballs and Russell, 2009; Tibballs and Weeranatna, 2010). Thus, omitting unnecessary questions from the T-CPR protocol and providing training to MDs can improve the time to first compression, as discussed in 6.2, but it can also improve OHCA recognition.

A further observation in this study was found in emotionally distressed callers and how MDs treated them. Here, callers were emotionally distressed and therefore, unable to cooperate with the MDs' questions. The latter providing encouragements to calm the former down improved their cooperation, but delayed the initiation of chest compressions. On the other hand, when MDs were unable to calm callers down, they were unable to cooperate, and thus, OHCA was misrecognised. In this context, other studies have found that callers being emotionally distressed prolongs the time to first chest compression (Lewis, Stubbs and Eisenberg, 2013; Nuño *et al.*, 2017; Chien *et al.*, 2019; Michiels *et al.*, 2020) and causes the misrecognition of OHCA (Eisenberg *et al.*, 1986; Weslien *et al.*, 2005; Swor *et al.*, 2006; Alfsen *et al.*, 2015). Thus, the ability of MDs to treat emotionally distressed callers is crucial in improving time to first compression and ensuring OHCA recognition, which can subsequently improve survival rate.

Along similar lines, the presence of agonal breathing was found to cause either delayed chest compression initiation or OHCA misrecognition. In this study, callers described agonal breathing (in addition to the absence of consciousness) during calls; however, the MDs did not recognise it. When the callers later reported in the same calls that patients had stopped breathing, the MDs then identified OHCA, thus causing a delay in time to first chest compression. However, when the call ended and callers had only provided agonal breathing descriptions, OHCA was misrecognised. Here, the inability of MDs to recognise agonal breathing could be attributed to the language (word choices) callers used to describe it, which varied and included snoring and taking big gasps as well as simulating it by saying 'akkh akkh'. Fukushima and Bolstad (2020) highlighted that the description of agonal breathing often differs according to the language or culture of the callers, and therefore, it is recommended for each local EMS agency to investigate how callers are likely to describe it. In this context, this PhD is the first study to provide information on how OHCA callers describe agonal breathing in the Saudi context and in Arabic. Improving the ability of MDs to identify different descriptions of agonal breathing provided by callers can be beneficial in minimising the time to first compression and also improving OHCA recognition.

The findings from the current practice in Saudi Arabia showed that MDs routinely end calls following initial chest compressions. However, maintaining contact with callers is important since they are emotionally stressed. Further, they have highlighted that their stress is not relieved until the ambulance crew arrives and takes responsibility for the patient (Bremer, Dahlberg and Sandman, 2009; Nord-Ljungquist *et al.*, 2020). In this context, dispatchers staying on the phone until ambulance arrival to guide the caller has been introduced in T-CPR protocols in some EMS systems (Birkenes *et al.*, 2015). This can include providing emotional support for emotionally distressed callers, regular encouragement, and feedback to improve callers' performance as well as any necessary help during the call (Park *et al.*, 2013; Birkenes *et al.*, 2014; Rasmussen *et al.*, 2017; Rasmussen *et al.*, 2020). Therefore, ensuring contact between MDs and callers, to provide any necessary help, until ambulance arrival is crucial in OHCA calls.

6.2.2 People's experiences of T-CPR language and communication

This PhD project is the first to explore participants' views and reflections on the language of T-CPR instructions and communication. It is also the first to investigate T-CPR protocol written in Arabic. This section discusses this project's specific objective about language challenges, such as complexity and using anatomical terms, and how they might influence CPR timeliness and quality performance.

This PhD project found that the language used in T-CPR instructions—the terms and phrases—are difficult to understand and interpret. The Arabic terms used to describe anatomical parts or technical concepts, such as 'heel of the hand' in the instructions, were difficult for the participants in the before-after simulation study to understand. The difficulty was also noticed when the instructions lacked precision. Using imprecise phrases similar to 'lean forward slightly' and 'middle of the chest' were open to different interpretations and were therefore interpreted incorrectly by the participants. The lack of CPR training of the participants was also found to exacerbate the understanding and interpretation of the T-CPR language. However, T-CPR instructions are targeted at people who are untrained in CPR (Soar *et al.*, 2019). Thus, they are important to be written in a language that those untrained in CPR find simple to comprehend. Looking at similar literature, the language used in the healthcare context was found difficult for laypeople and patients to comprehend, as it included anatomical, technical, and imprecise phrases (Chapple, Campion and May, 1997; Cooke *et al.*, 2000; Higgins *et al.*, 2001; Wolf *et al.*, 2007; Pieterse *et al.*, 2013; Barker, Reid and Minns Lowe, 2014; Rancher *et al.*, 2016; Gunn *et al.*, 2017; von Itzstein *et al.*, 2020; Weetman *et al.*, 2020). More specifically to CPR, resuscitation terminologies were also reported to be difficult for those untrained in CPR to understand (Trethewey *et al.*, 2019; Lee, Yang and Oh, 2020). Also, Higgins *et al.* (2001) found that using medical and technical terms such as 'unconscious' by EMS dispatchers was confusing for callers to understand and therefore, increased the complexity of communication.

Along similar lines, the language complexity of CPR instructions was also noticed in the observation of calls study and subsequently, impacted the time to first compression. Using imprecise phrases similar to 'middle of the chest' was found difficult for callers to interpret, and therefore callers asked the MD for further clarification, causing a delay. Similarly, some studies in the literature reported a lack of language comprehension by callers as a factor that impacted the time to first chest compression (Lewis, Stubbs and Eisenberg, 2013; Case *et al.*, 2018; Michiels *et al.*, 2020). However, these studies did not provide qualitative analysis to explore what aspects of language (e.g., using anatomical terms or lack of spoken language proficiency) were difficult to comprehend so that they can be improved. Meanwhile, the post-simulation interviews with the participants highlighted the language complexities of using anatomical, technical, and imprecise terms as a factor that impacted their CPR performance. This is supported by the evidence that the performance of CPR by untrained laypeople depends on their ability to understand and interpret instructions and successfully convert them into CPR performance (Deakin *et al.*, 2007). As a possible solution, this PhD project found simplifying the language of T-CPR instructions into plain language can potentially improve understanding and interpretation of the instructions, leading to better CPR timeliness and quality performance (see section 6.2.3).

Further, T-CPR language and communication were also found to be influenced by the provision of unnecessary information. The before-after simulation study concluded that providing a lot of information during T-CPR increased the cognitive demands of the participants, which subsequently influenced how they interpreted the instructions. This also influenced the communication, as more time was needed to receive and process the information by the participant, when time in OHCA is precious for patient survival. Leong *et al.* (2020) highlighted that transferring a lot of information to OHCA callers could lead to information overload. Thus, avoiding unnecessary information was found to be a potential suggestion to improve CPR language and communication with the aim of decreasing cognitive demands and improving the interpretation of instructions. This, for example, included asking callers to 'expose the patient's chest' rather than to 'take off his/her upper clothes and expose his/her chest'. A scoping literature review of strategies to improve telephone communication, including T-CPR, suggested the use of concise instructions when providing guidance to callers (Hampton *et al.*, 2020). However, here, there could be a risk of not delivering sufficient information needed to provide precise instructions to perform CPR. This was found with the participants in the before-after simulation study when some of them preferred not to use guidance similar to '*minimise the pauses between compressions*', while others emphasised its importance as it provided precision in terms of the need to avoid resting during the compressions. Although it is challenging to keep the T-CPR instructions precise but concise, this PhD project found it to be important to achieve this balance.

The participants and callers in this study did not prefer the use of MSA, which is the formal written language in Saudi Arabia, to communicate during T-CPR. Instead, the callers and MDs in current practice tended to use simple and familiar terms that are easily comprehended by laypeople during communication. More specifically, the participants in the post-simulation interviews commented that MSA is difficult to comprehend and use to communicate. The interviews with the participants found the reason to be connected to the minimal use of MSA in daily communication, which could explain why the callers and MDs did not use it during OHCA calls in current practice. The literature supports this finding and shows that MSA is not used in everyday communication and that its use is very limited, including within educational initiations (Al-Amer *et al.*, 2016; Muhammed, 2016; Guellil *et al.*, 2019; الحسن, 2019). Further, the participants noted that the use of terms and phrases from such an unfamiliar language in writing T-CPR instructions required more time for comprehension when time is already limited during OHCA, which impacted the flow of communication. In this context, it is important to note that T-CPR requires effective communication between dispatchers and callers, and the terms used are important in the communication (Leong *et al.*, 2020). The lack of familiarity with MSA was also found to contribute to creating barriers in achieving rapport in communication. Gerwing and Indseth (2016) highlighted that when dispatchers and callers have a language barrier, including not sharing the native language or unfamiliar accents, communication will be disrupted due to a lack of mutual understanding. Thus, the findings relating to the complexity of communicating and comprehending MSA is crucial, as effective communication between dispatchers and callers is important in the identification of OHCA and the delivery of understandable T-CPR instructions (Sasson *et al.*, 2013; Meischke *et al.*, 2015). The difficulty in communicating with and comprehending CPR instructions written in MSA terms and phrases impacted the CPR performance of the participants in this study. Simplifying these terms (using simpler and familiar terms) was a suggested language modification to simplify T-CPR instructions into plain language, with the aim of improving comprehension and communication, to subsequently improve CPR timeliness and quality performance. The influence of this language modification is discussed in 6.2.3.

Performing T-CPR was found to be a cognitively complex task that impacted communication and exacerbated language complexity. More specifically, performing CPR while listening to instructions via telephone was found to involve complex multitasking for the participants in the before-after simulation study. As a result, some participants focused on performing CPR but not the MD's guidance, while others delayed the initiation of CPR to listen and focus on the guidance. This resulted in participants missing instructions, as they were focused on performing chest compressions. This could also explain why some callers in the current practice involved a third person to perform compressions while they paid complete focus to receiving the instructions and communicating with the MDs. This finding in line with Nord-Ljungquist *et al.* (2020) study that interviewed callers who reported life-threatening cases, including suspected OHCA, and the callers highlighted difficulties in concentrating on responding to the dispatcher whilst acting and helping the patient. In multitasking, performing one task showed to have the potential to influence the performance of the other task due to cognitive demands (Dzubak, 2008). Thus, the before-after simulation study found that participants preferred to receive instructions in simple language to decrease their cognitive demands and pay more attention to CPR performance.

In this PhD project, the stress of being in an OHCA situation was also revealed to impact language comprehension. The before-after simulation study participants noted that they were stressed due to the recognition of their responsibility to save the patient's life, which has been reported elsewhere (Axelsson, Herlitz and Fridlund, 2000; Bremer, Dahlberg and Sandman, 2009; Nord-Ljungquist *et al.*, 2020). Further, the stress was also found to impact participants' ability to communicate with the MD and understand the instructions, even though it was in a simulation setting where the stress is less than what it would have been in a real-life OHCA situation. Similarly, the observation of calls study found that language understanding was impacted when the OHCA callers in current practice were emotionally distressed. Some were so distressed that they were unable to comprehend the instructions, causing the MDs had to repeat themselves to ensure understanding. This language complexity resulted in delayed time to first chest compression in the current practice, as time was spent on repeating what had been said. However, here, a possible explanation is that stress has the potential to influence people's cognitive ability in any given circumstance (Mendl, 1999; Cibrian-Llanderal, Melgarejo-Gutierrez and Hernandez-Baltazar, 2018). This potential influence of stress on language comprehension supports the need to use plain language T-CPR instructions.

6.2.3 The influence of plain versus standard language in T-CPR

This is the first study to develop and test an enhanced T-CPR protocol based on observations from the current practice and interviews with laypeople who have been through a simulated T-CPR experience. This section discusses the PhD objectives regarding the use of plain language in the enhanced T-CPR protocol and how it improved baseline CPR performance in Saudi Arabia.

Using plain language in the enhanced T-CPR instructions was found by the participants to improve their understanding and interpretations of the instructions. As discussed in 6.2.2, T-CPR instructions are health-related instructions that were found to be challenging. To improve the understanding and interpretation of the instructions, the participants in the 'before group' suggested simplifying the instructions into plain language. In this context, the use of plain language being used within health-related contexts has also been reported in other studies (Jefford and Moore, 2008; Rancher *et al.*, 2016; Williams, Moeller and Willis, 2018; Elliott *et al.*, 2020; Tammy *et al.*, 2020; Weetman *et al.*, 2020). To simplify the instructions into plain language, this PhD project found that the instructions needed to be simple, precise, and concise. This included avoiding anatomical and technical terms, imprecise terms (open to interpretation), and removing unnecessary information. These language modifications appeared to improve the understanding and interpretation of enhanced T-CPR instructions by participants when compared to the Saudi T-CPR instructions. This finding is consistent with other studies in the literature that simplified healthcare contents, including consent forms and medication instructions, to plain language and reported improvement in the understandings of laypeople and patients (Young, Hooker and Freeberg, 1990; Wolf *et al.*, 2010; You *et al.*, 2011; Mohan *et al.*, 2014; Kim and Kim, 2015; McCormack *et al.*, 2016; Ancker *et al.*, 2017). However, this is the first study to simplify these language complexities to plain T-CPR instructions.

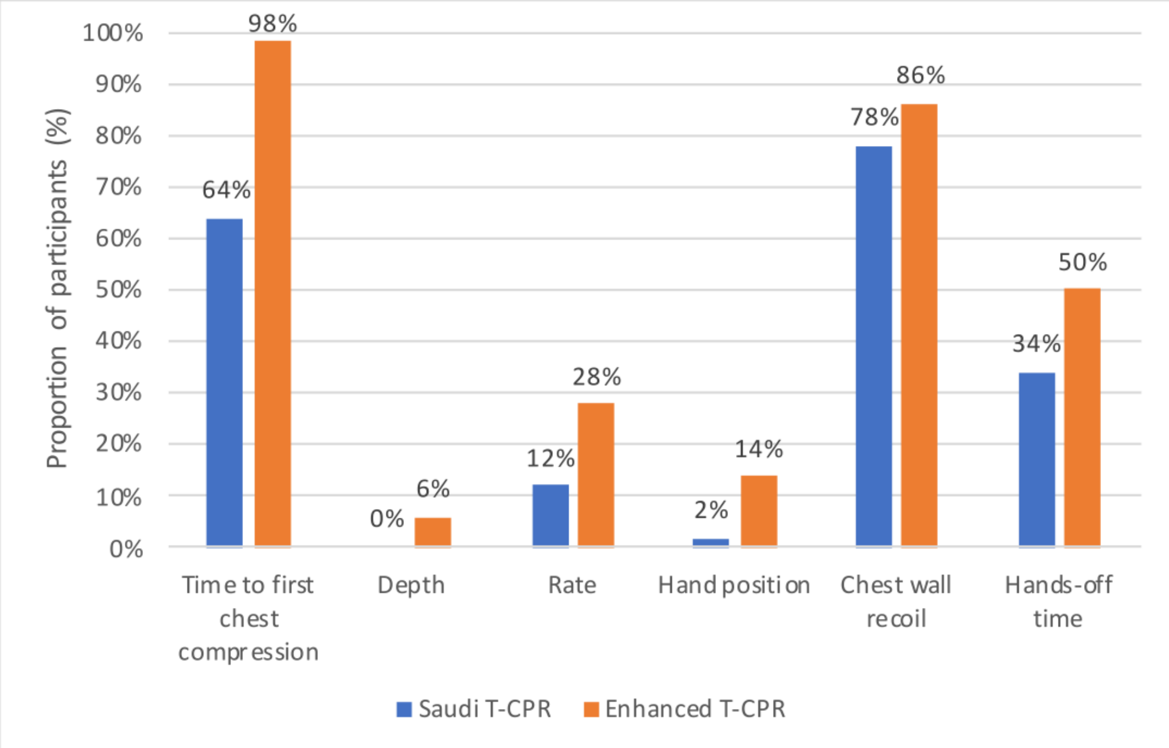
As part of simplifying the T-CPR instructions to plain language, the MSA terms were replaced with more familiar and simpler terms to ensure understanding, as suggested by the participants in the before-after simulation study. This was found to improve the comprehension of the instructions as well as the overall communication, as the participants highlighted their familiarity in hearing and speaking using this language. This finding is consistent with the aim of plain language, which aims to improve communication using simple and familiar terms for the audience (US Plain Language, 2004a). As a result of using more familiar and simpler language, this was found to improve the creation of rapport between participants and the MD and to allow the former to pay more focus on performing CPR rather than the language. Additionally, using such language can improve the mutual understanding between dispatchers and callers, which subsequently improves communication (Gerwing and Indseth, 2016). The improvement in communication and language after the use of plain language showed the potential of improving CPR timeliness and quality performance, which is discussed below.

Using plain language in T-CPR instructions was found to improve CPR timeliness and quality performance. The enhanced T-CPR protocol improved all CPR parameters as compared to the Saudi T-CPR protocol with significant improvements in time to first compression, depth, hand position, and hands-off time (see Table 17). It also helped more participants to reach the resuscitation standards regarding time to start chest compression, depth of compression, and compression rate (see Figure 27).

Table 17. Comparison of CPR performance between the Saudi and enhanced T-CPR protocols

Parameters	Saudi T-CPR (median)	Enhanced T-CPR (median)	Significance (p value)	Effect size
Time to first chest compression (s)	110	79	< .001	0.73
Depth (mm)	30	35	.004	0.29
Rate (c/m)	94.5	105	.202	0.13
Hand position (%)	86.5	95	<.001	0.56
Chest wall recoil (%)	100	100	.318	0.10
Hands-off time (s)	4.9	.9	.007	0.27

Figure 27. Comparison between the Saudi and enhanced T-CPR protocols compliance with AHA timeliness (minimum standard) and ILCOR quality performance standards.



Improving CPR timeliness and quality performance has the potential to improve survival rate (Van Hoeyweghen *et al.*, 1993; Wik, Steen and Bircher, 1994; Gallagher and Lombardi, 1995; Valenzuela *et al.*, 1997; Holmberg *et al.*, 1998; Holmberg, Holmberg and Herlitz for the Swedish Cardiac Arrest Registry, 2001; Waalewijn, Tijssen and Koster, 2001; Wissenberg *et al.*, 2013; Hasselqvist-Ax *et al.*, 2015). In this PhD project, the improvement of CPR performance is most likely attributed to the use of plain language, which improved communication and the participants' understanding and interpretation of the instructions. Most participants in the 'after' group of the before-after simulation study preferred to receive instructions in the plain language, as they found it to be simpler to communicate with, understand, and interpret. This is supported by evidence in the literature that improving the terminologies used in CPR instructions can improve CPR timeliness and quality performance (Lerner *et al.*, 2012; Trethewey *et al.*, 2019). This improvement is also consistent with the study by Smith and Wallace (2013), which reported significant improvements in laypeople's understanding of medication instructions and subsequently, in the self-injection of a medical drug after the instructions were revised to plain language. Thus, using plain language improves CPR timeliness and quality performance, which has the potential to then improve survival rate.

In a comparison with the wider literature that modified the T-CPR language, the enhanced T-CPR protocol is within the range in terms of the CPR timeliness and quality performance. Table 18 summarises CPR timeliness and quality performance before and after language modifications.

Table 18. Comparison of the average performance of CPR timeliness and quality performance.

Study	Time to first compression (s)		Rate (c/m)		Depth (mm)		Hand position (%)		Chest wall recoil (%)		Hands-off chest time (s)	
	Standard	Modified	Standard	Modified	Standard	Modified	Standard	Modified	Standard	Modified	Standard	Modified
Before-after simulation study	110.0*	79.0**	94.5**	105.0**	30.0**	35.0**	86.5**	95.0**	100.0**	100.0**	4.9**	0.9**
(van Tulder *et al.*, 2014a)	N/A	N/A	88.1*	94.5 *	44.1*	46.1*	N/A	N/A	N/A	N/A	1.9*	2.0*
(Rasmussen *et al.*, 2017)	72.0**	65.0**	110.0*	114.0*	52.0*	58.0*	N/A	N/A	N/A	N/A	1.0**	6.0**
(Deakin *et al.*, 2007)	163.0**	148.0 **	52.1**	81.0 **	32.0**	20.0 **	70.0 **	70.0 **	N/A	N/A	N/A	N/A
(Painter *et al.*, 2014)	123.0*	99.0 *	93.0*	102.0*	25.0*	32.0*	86.0*	63.0*	92.0*	89.0*	41.0*	39.0*
(van Tulder *et al.*, 2014b)	52.0 and 50.0 *	47.0 and 60.0*	93.0 and 89.0*	93.0 and 101.0 *	43.0 and 40.0*	34.0 and 45.0 *	N/A	N/A	N/A	N/A	N/A	N/A

(Dias *et al.*, 2007)	78.6*	60.0*	94.0*	104.0*	N/A	N/A	N/A	N/A	N/A	N/A	95.0**	69.0**
(Trethewey *et al.*, 2019)	N/A	N/A	At least 5 cm: 83.7* Approx. 5 cm: 71.2*	98.9*	At least 5 cm: 40.9* Approx. 5 cm: 35.4*	46.8*	N/A	N/A	N/A	N/A	N/A	N/A
(Leong *et al.*, 2020)	240.7*	229.8*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
(Woollard *et al.*, 2003)	245.0**	184.0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

*Refers to the mean.

**Refers to the median.

Thus, modifying the language significantly improved CPR timeliness and quality performance in the literature, which is consistent with the findings in this PhD project. However, no protocol has yet met the AHA timeliness and ILCOR CPR quality recommendations. Therefore, further modifications to the language are needed to improve CPR performance. However, none of the reported studies in Table 18 interviewed participants to investigate possible language difficulties that influenced their performance and how to improve them. This limited the guidance that could be provided on how to amend the language with the aim of improving the CPR. This could provide a possible explanation for the differences in the CPR timeliness and quality performance in the reported studies, as described in Table 18. Meanwhile, this PhD project is the first study to investigate the possible language difficulties that the participants faced and provide suggestions for improvement. Thus, this project's findings can be used as guidance to further modify the T-CPR language.

The enhanced protocol did not modify all the T-CPR protocol issues found in this PhD project. This was due to, for example, this PhD is focused on testing language modifications that have been less researched in the literature. More specifically, replacing the complex instructions of 'push fast with a rate of 100 times/min at least' and 'push hard so the depth of the compression becomes 5 cm at least' with simple phrases similar to 'push as hard as you can' and using a metronome as suggested in this PhD project was not modified in the enhanced T-CPR protocol. Meanwhile, the literature showed a significant improvement in using 'push as hard as you can' and the metronome (Park *et al.*, 2013; Trethewey *et al.*, 2019). Therefore, merging some of the language modifications that already showed improvement in the literature with those identified in this PhD project might further improve CPR timeliness and quality performance. This is recommended for future research in section 6.5.

6.3 Strengths, limitations, and challenges

This PhD project has some strengths, limitations, and challenges that should be clearly highlighted. Here, it should be noted that all the necessary steps were taken to minimise and mitigate the influence of the limitations.

6.3.1 Strengths

First, this PhD project used a mixed-method design that provided the needed depth of investigation to achieve the overall aim. Using a mixed-methods design provides insights into the investigated issues that are unavailable when quantitative and qualitative studies are conducted independently (O'Cathain, Murphy and Nicholl, 2007). Additionally, mixed-methods studies can balance the limitations of one methodological approach by using the strength of the other approach to provide a deeper understanding (Services and Board, 2000; Thurmond, 2001). More specifically, this PhD project needed to collect quantitative data to establish the baseline performance and the compliance with the AHA and ILCOR standards to identify the weaknesses (e.g., low quality chest compression performance by participants). Meanwhile, the qualitative data were also required to explain the quantitative data (e.g., the use of imprecise T-CPR instructions impacted the chest compression performance) and explore how to improve the weaknesses (e.g., simplify T-CPR to plain language). Thus, the combination of the quantitative and qualitative data in this study provided detailed investigation.

Second, the enhanced T-CPR protocol was developed using a novel research design. The Saudi T-CPR protocol was examined in the current practice and then in a simulation study. This allowed a thorough investigation to identify the weaknesses in the Saudi T-CPR protocol and how it could be improved, which were supported by the use of mixed methods. Moreover, as the modifications to the enhanced T-CPR protocol were relevant to the language, the ‘end users’ of the T-CPR protocol were involved in amending the language. Their involvement took place in the post-simulation interviews in the before-after simulation study and PPI. In this context, the importance of involving ‘end users’ in simplifying instructions to plain language has been reported in several studies (Davis *et al.*, 1998; Smith and Wallace, 2013; Kim and Kim, 2015). The scoping literature review by Hampton *et al.* (2020) also suggested receiving input on telephone protocols, including T-CPR, from end users to improve the value of the instructions. However, this is the first study to involve participants who have been through a T-CPR simulation experience to inform the development of a T-CPR protocol. Meanwhile, Painter *et al.* (2014) conducted a focus group to inform modifications to the T-CPR protocol, but the focus group had not had T-CPR experience. Additionally, the focus group was not conducted with the ‘end users’ as they were at a low level of English proficiency, but the protocol was examined using fluent English speakers. These could have influenced their input. Therefore, the enhanced T-CPR protocol was developed using a novel research design.

Third, a further strength of this project was the validation of the research materials prior to conducting the studies. Piloting was conducted for the calls observations as well as the before and after stages of the before-after simulation study prior to the data collection. This ensured that the data collected would be sufficient to meet the aim and objectives of this PhD project. Moreover, the enhanced T-CPR protocol was also validated using the PPI prior to testing it in the before-after simulation study. PPI can be used in PhD projects for different purposes, including the development of research materials (Brett *et al.*, 2014). Thus, the aforementioned piloting and PPI work ensured the validation of the research materials, which minimised any unforeseen limitations.

Fourth, another strength is that the observation of calls study was conducted in the SRCA, which is the main EMS in Saudi Arabia. As indicated in the introduction chapter (see section 1.5.3), some medical city hospitals and large companies have EMS departments that respond to their employees and residents. However, as they are not the public EMS, they will most likely not represent the wider OHCA calls in Saudi Arabia, including the callers. Therefore, collecting data from the SRCA provided findings about wider OHCA calls in current practice. Further, this calls observations study is also the first in Saudi Arabia to provide qualitative data about EMS calls, either relevant or irrelevant to OHCA. Therefore, the findings can provide possible implications for Saudi EMS calls in general (the possible implications are discussed in 6.4).

6.3.2 Limitations

The main limitation of this PhD project is that the participants in the before-after simulation study might not have been fully representative of the wider population of Saudi Arabia. However, this setting was chosen to encourage more females to take part. Here, it is important to note that women represent the majority of OHCA callers (Bergner and Eisenberg, 1982; de Vreede-Swagemakers *et al.*, 1997; Dorph, Wik and Steen, 2003), and 24% in Saudi Arabia, as shown in this PhD study. Therefore, it is crucial to ensure that women are included in this research. However, Saudi Arabia is a conservative country where sex segregation is present in daily life activities, including at schools, universities, and workplaces (Almalki, 2020). Thus, Saudi women do not usually interact with men whom they do not know (Altorki, 1986; AlMunajjed, 1997; Le Renard, 2008). Therefore, the setting of KSAU-HS, where males and females commonly work together, was chosen to ensure the recruitment of female participants.

Another limitation is the nature of the data in the observations of calls study. These data were extracted based on audio recordings. The reported time to OHCA identification and start of first chest compression might have a few seconds of difference from the actual time. For example, the time to OHCA identification was considered complete once the MD confirmed it or started to provide CPR instructions. However, as the MDs did not always provide verbal confirmation of OHCA identification, a difference of a couple of seconds might exist. Nevertheless, this difference of a couple of seconds is unlikely to influence the findings, as the time to identify OHCA was found to be below the minimum AHA recommendation by 213 s. Additionally, the nature of the data might have also added some subjectivity to the collected data. The presence of agonal breathing was based on subjective judgment, according to the presentations provided by the callers.

However, this is the only way to measure the time associated with the events and the presence of agonal breathing in the OHCA calls, which is consistent with similar studies in the literature.

A further limitation is that a ‘before-after’ study design does not allow for cause and effect conclusions. Whilst this design can include the random selection of participants, it lacks the random assignment of those participants to either the control or intervention group. This lack of random assignment could introduce a risk of bias and influence unidentified confounding variables (Cook, Campbell and Shadish, 2002; Eliopoulos *et al.*, 2004), which could subsequently influence the conclusion about whether the outcome is caused due to the intervention. However, a ‘before-after’ study design can establish an association effect between the intervention and the outcome (Stratton, 2019).

This study is limited by a lack of an inter-rater check on both the quantitative and qualitative data. Involving a trained person to check the data collection and analysis in a research study can enhance rigour and transparency to the findings (O’Connor and Joffe, 2020). However, in this doctoral thesis, the data collection and analysis were limited to a single researcher. Nevertheless, steps were taken to minimise bias where possible such as conducting data analysis rigorously to avoid any subjectivity in the analysis.

Bias may have been introduced by using a single MD in the before-after simulation study who conducted both the ‘before’ and ‘after’ stages. As such, the MD was not blinded from the purpose of the ‘after’ stage, which thus might have influenced his behaviour. To minimise any bias, the MD was instructed to follow the T-CPR protocol. Indeed, piloting was conducted to ensure that the MD followed the protocol to minimise any influence by the study aim. Whilst there are some drawbacks to using a single MD, this was a deliberate study design choice to attempt to minimise the influence of the MD on the findings when the performance between ‘before’ and ‘after’ groups were later compared. Using a different MD for the ‘after’ stage could have influenced CPR performance, as he/she may have exhibited different behaviour compared with the ‘before’ stage MD.

There is a risk of type II error in the before-after simulation study given the sample size. The sample size was calculated using 80% power to detect a significance difference. However, there is a 20% probability that a true difference was not identified, if it existed, between the Saudi and enhanced T-CPR protocols in the before-after simulation study. Increasing the power can reduce the risk of type II error (Jones, Carley and Harrison, 2003). However, to do so would have involved a larger sample size, which is not feasible to control for in a PhD project, considering the costs and time needed. Thus, it is acknowledged as a limitation.

6.3.3 Challenges

Writing this PhD thesis in English, while the original data were collected in Arabic was challenging. All data in this PhD project were collected and analysed in Arabic, but were discussed and presented in this thesis using English. Translations are therefore illustrative and likely to have some semantic differences. Thus, the English versions of the protocols presented here are not intended to exactly represent the Arabic versions. However, this was not an aim.

A further challenge was the Covid-19 pandemic. Even though it did not influence the data collection, it significantly influenced the time needed to complete the analysis and write this PhD thesis. Travel restrictions from Saudi Arabia to the UK (after completion of data collection in Saudi Arabia), the lockdown, no physical access to the university, and no meetings with other PhD colleagues also influenced the progress of the analysis and write-up.

6.4 Implications for healthcare delivery, clinical practice and patient care

The findings of this PhD have implications for healthcare delivery, clinical practice and patient care both in Saudi Arabia and internationally. These are discussed in this section, whilst recommendations for future research are examined afterward.

6.4.1 International implications

First, this PhD project has shown that there is potential to improve callers' CPR timeliness and the quality of their performance by making language modifications to the verbal instructions given using a T-CPR protocol. CPR timeliness and quality performance are significantly linked with OHCA survival and neurogenic outcomes (Van Hoeyweghen *et al.*, 1993; Wik, Steen and Bircher, 1994; Gallagher and Lombardi, 1995; Valenzuela *et al.*, 1997; Holmberg *et al.*, 1998; Holmberg, Holmberg and Herlitz for the Swedish Cardiac Arrest Registry, 2001; Waalewijn, Tijssen and Koster, 2001; Wissenberg *et al.*, 2013; Hasselqvist-Ax *et al.*, 2015). Whilst CPR performance using the enhanced T-CPR protocol still did not meet the ILCOR recommendations, it significantly improved the CPR timeliness and quality performance when compared to the T-CPR protocol currently used in Saudi Arabia. This improvement was due to using 'easier to understand' language (plain language) to ensure lay understanding and interpretation of CPR instructions. Therefore, one of this study's key recommendations for health organisations and policymakers worldwide is to focus on developing and using 'simple language' to ensure understanding and interpretation and, in turn, deliver quicker and higher-quality CPR. In particular, this study informs the knowledge gap, highlighted by the ILCOR, to demonstrate how language may influence T-CPR performance. This study found that the use of anatomical, technical and imprecise terms as well as unnecessary information in T-CPR instructions made them difficult for laypeople to understand and interpret, and that replacing such language with simple, concise and precise terms improved understanding and interpretation and subsequently CPR timeliness and quality performance.

Second, this PhD project showed the value of involving the target audience in the development of plain language instructions to better tailor them to their potential recipients. This is particularly significant in the context of this study, since most health literature, particularly that on T-CPR protocols, is based on the English language and data from Western regions. It is important for non-English-speaking countries and non-Western regions to develop protocols and health instructions that better reflect the local language and context. This also suggests that the ILCOR should more comprehensively consider the influence of context and population on T-CPR language understanding and interpretation and subsequently CPR timeliness and quality performance (see the 'Recommendations for further research' section below).

Third, it is recommended that EMS dispatching centres and policy makers focus more on the language used when developing EMS pre-arrival instructions. This PhD research showed the significance of using plain language in providing scripted pre-arrival T-CPR instructions to callers reporting OHCAs. However, what is plain language for one group of people may not be for another (US Plain Language, 2004b); callers come from varied backgrounds and use different dialects, meaning that identifying instructions that are comprehensible to all callers may be challenging. Hence, it is unclear whether strictly following the exact instructions scripted in pre-arrival protocols would be preferable to a more flexible approach, for example, the flexibility to amend the instructions according to callers' dialects and responses. Emergency dispatch systems vary in the degree to which they are scripted; for example, the MPDS dispatching system strictly follows scripted protocols in questioning callers (Baabdullah *et al.*, 2020), whilst the CBD system is more flexible and relies on the dispatcher's experience (Bohm and Kurland, 2018). Hardeland *et al.* (2014) compared MPDS and CBD in terms of the time to first compression and showed that the latter was faster, but that the time difference was not significant. A further simulation study showed that there was a significantly shorter time taken to identify OHCA using the MPDS system, as compared to CBD (Perry *et al.*, 2019). However, these two studies did not focus on measuring the influence of language. Following the exact wording in a scripted dispatcher protocol ensures standardisations so that the same quality of service is delivered regardless of the dispatchers (Ornato, 2009). However, where instructions are not understood by, or familiar to, a caller, amending them might be necessary. Conversely, not following the exact wording in a scripted protocol can be influenced by the dispatcher who is handling the call (Ornato, 2009). Therefore, it is unclear how the choice between strictly following the scripted terms in pre-arrival instructions or being flexible in choosing and amending the terms influences T-CPR performance. This may suggest a knowledge gap to be investigated by ILCOR and protocol developers when developing a T-CPR protocol to further improve the performance (see the ‘Recommendations for further research’ section below).

Fourth, EMS dispatchers (and MDs in Saudi Arabia) should be trained to identify agonal breathing when described by callers. This study showed that MDs in current practice misrecognised agonal breathing in several cases, which influenced OHCA recognition and the time to chest compression. Agonal breathing is common in OHCA cases and might be present in up to 40% of the cases (Clark *et al.*, 1992; Lewis, Stubbs and Eisenberg, 2013). Patients who experience agonal breathing are reported to have better survival rate compared to those with no agonal breathing when patients received CPR (Clark *et al.*, 1992; Lewis, Stubbs and Eisenberg, 2013). Thus, it is important to identify agonal breathing to improve survival rate. However, callers in current practice described agonal breathing differently. Therefore, regular training in how callers use the terms and phrases to describe agonal breathing is recommended. This could improve the OHCA recognition and time to first compression, which have the potential to improve the survival rate. The ILCOR highlighted the essential elements that are needed to be included in the dispatchers’ training programme for T-CPR as a knowledge gap; the need to train dispatchers in how callers use their language (terms and phrases) to describe agonal breathing can be one of those essential elements.

Fifth, EMS dispatchers (and MDs in Saudi Arabia) should avoid asking ‘unnecessary questions’ during T-CPR, as this can influence OHCA recognition and time to first compression. Therefore, avoiding asking unnecessary questions and being more consistent with the use of T-CPR protocol could have the potential to improve the proportions of OHCA identification and time to callers commencing CPR. Thus, training dispatchers to avoid asking unnecessary questions during T-CPR is recommended as part of the training programme for dispatchers, thereby providing another of the essential elements highlighted by the ILCOR.

It is important that EMS dispatchers (and MDs in Saudi Arabia) provide encouragement and emotional support to callers. The findings of this study demonstrated that (even in a simulation) OHCA is a stressful situation, and callers experience intense emotions that can limit their ability to cooperate and follow the instructions. Emotional response was also found to influence OHCA recognition and time to first compression. The findings from the observation of calls showed that when MDs offered encouragement or emotional support, this helped the callers to be more willing to perform CPR. However, some callers were extremely distressed and could not be encouraged. Thus, providing training to dispatchers and offering them regular feedback in the form of expert review of some of the calls in which callers needed emotional support could improve dispatchers' ability to persuade callers to cooperate and follow instructions. This could result in improving of the OHCA recognition rate, time to first compression, and caller CPR rate, which could also improve the survival rate.

A further implication is that EMS dispatching centres should have well-designed call-tracking systems. The AHA has recommended that a call location should be identified within 30 s of receipt by EMS (Kurz *et al.*, 2020). This PhD project showed that location acquisition delayed the time to first compression and influenced OHCA recognition when callers were unable to describe the location and then, left the patient to meet the ambulance crew. Therefore, the use of a well-designed call tracking system by the EMS has the potential to improve OHCA recognition and the time to first compression.

Finally, establishing a quality improvement programme for EMS, including dispatching centres, is recommended. The quality of T-CPR recommended by the AHA is based on the proportion of correct OHCA recognition (75%), timely recognition of OHCA (<90 s), time to first chest compression (<150 s), and the proportion of callers successfully guided to perform CPR (75%). However, this PhD project found that it was difficult to meet these standards. Thus, it is recommended that a quality improvement programme be established. This can include providing training to dispatchers and reviewing OHCA calls for quality assessment (Kurz *et al.*, 2020). This recommendation also includes the need to establish quality improvement initiatives for EMS in different areas, such as ambulance response time, to meet quality standards.

6.4.2 National implications

In addition to the international implications discussed above, this research also has several specific implications for Saudi Arabia.

First, this PhD project showed that there was a low survival rate post OHCA and that the enhanced T-CPR protocol has the potential to improve callers' CPR timeliness and the quality of their performance. Compared with the Saudi T-CPR protocol, the enhanced T-CPR protocol significantly improved CPR timeliness and quality performance, which have the potential to improve the survival rate. Additionally, the improvement was established using a relatively simple small-scale modification, in amending the language. Such modifications are not costly, but could save lives, and can be implemented in practice relatively easily. Therefore, further testing of the enhanced T-CPR protocol in in current practice in Saudi Arabia and measurement of its influence on patient survival is recommended (see the 'Recommendations for further research' section below).

An additional implication is for SRCA dispatching centres to omit any unnecessary transfers in EMS calls. There are differences in dispatching systems and how they are organised across countries; in some, different systems are used in different regions within a country (Langhelle *et al.*, 2004; Pozner *et al.*, 2004). However, this PhD showed that transferring OHCA calls, and potential other urgent calls, to a medical expert to follow the T-CPR protocol added avoidable delays. The commonly used EMS dispatching systems, such as MPDS (Bohm and Kurland, 2018) and CBD (Baabdullah *et al.*, 2020), do not have this additional call transfer. Time is critical for OHCA patients, and losing time prior to initiating chest compression has the potential to influence their survival chances. Therefore, avoiding any unnecessary transfers is recommended during OHCA calls to save time prior to the start of chest compressions. Whilst this is recommended for SRCA, there may be other international EMS dispatching centres that might also have unnecessary call transfers.

Finally, some cultural considerations should be taken under consideration. Saudi Arabia has a set of cultural norms and traditions. Common to many Arabic speaking countries, segregation of men and women means that men do not routinely interact with women that are not relatives. This research showed that this, as well as differences in gender roles (e.g., who talks to the MD), influenced the time to first chest compression in the current practice, which in turn may influence the survival rate. In urgent or life-threatening cases, men and women ideally should interact such that, for example, men could assess women who are unrelated to them. However, such a recommendation would require a large social shift in attitudes to change cultural practices such as these. This is unlikely to be feasible at this point of time.

6.5 Recommendations for further research

The findings of this PhD project provide directions and recommendations for further research, which are examined in this section.

First, the Saudi T-CPR protocol was found to be difficult to understand and resulted in low CPR timeliness and quality performance. On the other hand, the enhanced T-CPR protocol showed significant improvement in CPR timeliness and quality performance, which has the potential to improve survival rate. Consequently, the next step to measure the influence of the enhanced T-CPR protocol on patient’s survival is recommended: testing these modifications on current practice and measuring their influence on patient’s survival.

Second, the enhanced T-CPR protocol did not include all suggestions for improvement identified in this PhD project. Thus, a future study should incorporate all modifications in one T-CPR protocol, with support from the literature, and test the effect of the new protocol on improving

CPR timeliness and quality performance. This could further improve CPR performance to ensure that it meets the ILCOR quality recommendations and AHA timeliness standards.

Third, this PhD project highlighted the difficulty in the T-CPR instructions sequence. However, it could not provide recommendations on how to amend this sequence as the participants in the before-after simulation study showed inconsistency in their preferences. Thus, it is unclear as to the order in which the T-CPR instructions be given. The ILCOR highlighted this as a knowledge gap in T-CPR (Soar *et al.*, 2019). Therefore, it is recommended that the instruction sequence be investigated in more depth and its influence on CPR timeliness and quality performance be measured.

Fourth, this PhD project highlighted the need to provide emotional support, including encouragement, to OHCA callers. However, it is unclear how these can be best provided in a conservative country, such as Saudi Arabia, due to cultural considerations. Bobrow, Eisenberg and Panczyk (2014) also highlighted the need to identify tactics to calm panicked OHCA callers to correctly identify OHCA, start chest compressions, and perform continuous CPR. Thus, it is recommended to investigate how emotional support can be provided, especially in the presence of cultural considerations regarding gender.

Fifth, this study showed the value of involving the target audience in developing T-CPR instructions to make them more comprehensible for potential recipients. It is important to consider the context and population amongst which T-CPR instructions would be implemented when developing them. However, most of the health literature, and specifically T-CPR, are based on the English language and data coming from Western regions. Thus, investigation of the influence of context and population on T-CPR instructions language understanding and interpretation, and how it impacts CPR timeliness and quality performance is recommended.

Finally, this PhD project showed the significance of using plain language in a scripted T-CPR protocol. However, language that is plain for one group of people may not be so for another, and identifying optimal terms might be difficult. Thus, it is unclear whether it is preferable for dispatchers to strictly follow the exact terms scripted in a T-CPR protocol, or to be flexible in choosing and amending terms according to, for example, caller responses. Therefore, investigation of the optimal method for developing T-CPR protocols and how it influences CPR timeliness and quality performance is recommended.

6.6 Research dissemination and output

This PhD project is aimed to be published in peer reviewed journals. It is anticipated that the targeted journals will include the Resuscitation Journal and Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine. Moreover, till date, two poster presentations have been presented at international conferences, and the abstracts were successfully published. The findings from the observation of calls study regarding time to first compression and ROSC were presented as a poster at the London Trauma Conference and Cardiac Arrest Symposium. This poster was successfully published in the Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine (Avery *et al.*, 2020). The second poster showing the results of the improvements in time to first compression and depth of compression in the before-after simulation study was presented at the European Resuscitation Council Congress. This poster was also successfully published in the Resuscitation Journal (Hotan *et al.*, 2020). Nevertheless, two complete papers will be submitted as publications to disseminate the findings of this PhD project.

Additionally, the SRCA showed interest in the work conducted in this PhD project. Consequently, a meeting with the SRCA took place, and preliminary findings were discussed. They appreciated the work conducted in this PhD and requested a copy of the final findings. Thus, it was agreed that a copy of this completed thesis will be provided to the SRCA with the aim of improving the quality of the T-CPR protocol and dispatching system.

Furthermore, contact with the research team that is establishing the national registry of OHCA in Saudi Arabia has been made in the course of this PhD. As indicated in the introduction chapter (section 1.5.3), Saudi Arabia still do not have a national registry of OHCA. However, the grant for establishing the national registry has been recently received and the national registry is being established. A meeting was conducted with the research team discussing issues relevant to OHCAs in Saudi Arabia and seeking how to establish the national registry. An invitation to join the research team after completion of this PhD project was offered.

6.7 Conclusion

This PhD project aimed to improve CPR timeliness and quality by investigating the nature of OHCA calls and the T-CPR protocol in current practice in Saudi Arabia and to test and evaluate possible language modifications to T-CPR instructions. Survival rate of OHCA patients is low worldwide, and improving CPR timeliness and quality performance has the potential to improve survival rate. In this context, the use of the T-CPR protocol showed the potential to improve CPR timeliness and quality performance. However, they are still below the resuscitation recommendations, and further improvements are needed. Language modifications to T-CPR were shown to be one of the modifiable factors in T-CPR to improve timeliness and quality performance. Although the attempts to simplify the phrases used in the T-CPR language improved the timeliness and quality performance, they still did not reach the resuscitation recommendations. Additionally, none of the attempts used an Arabic T-CPR protocol, which is a knowledge gap. The current T-CPR literature lacks qualitative data investigating the language factors influencing lay callers' ability to convert T-CPR instructions to the recommended CPR performance. It also lacks guidance on how to simplify the T-CPR instructions in a language suitable for laypeople with no CPR background. Therefore, detailed investigation on T-CPR language, including quantitative and qualitative data, was required to improve CPR timeliness and quality performance. Saudi Arabia showed limited OHCA survival data, with only two studies reporting low survival rates. Moreover, while the SRCA delivers T-CPR protocol, its quality in identifying OHCA and guiding callers to perform chest compression promptly has still not been investigated. Also, the ability of callers to understand the Saudi T-CPR instructions and convert them to the recommended CPR timeliness and quality performance is still unknown. These are knowledge gaps in the current literature. These knowledge gaps have been addressed in this PhD project.

This is the first study to provide detailed investigation (using mixed methods) of factors influencing time to first chest compression in current practice in the literature. It is also the first to examine characteristics of OHCA calls and T-CPR protocol in current practice in Saudi Arabia. This study found a low ROSC of OHCA patients to hospital arrival, which could be attributed to the delayed time to first chest compression as it is significantly linked with the survival rate. The time to commence chest compression was influenced by how the call was processed, including the time needed to identify patient location, transfer the call to an MD, and identify OHCA. The qualitative observations found that the time delay was associated with the language and T-CPR protocol. This included, for example, providing imprecise T-CPR instructions, using dialect languages and asking unnecessary questions. The qualitative observations also provided insight into the broader contextual factors, including the cultural considerations regarding gender differences in Saudi Arabia and callers being physically away from patients. Improving these factors by, for example, improving the clarity of T-CPR instructions, omitting unnecessary questions from the T-CPR protocol, and removing unnecessary transfers in the calls (e.g., MD call transfer) could improve time to first chest compression. Contributing these detailed observations to the literature provides insight into why time to first compression did not meet the AHA standards and how to improve it and subsequently, the survival rate.

In addition, it is the first study to conduct a detailed investigation (using mixed methods) and improve language used in T-CPR protocols, drawing upon the knowledge of participants with an experience in applying it. Additionally, it is the first attempt in the literature to improve an Arabic T-CPR protocol. Here, using imprecise, anatomical, and technical terms in T-CPR instructions was found to be difficult for untrained CPR laypeople to understand and interpret. Providing unnecessary information in the T-CPR protocol was also reported to increase the cognitive demands on people, thus influencing their communication with the MDs and the subsequent clarity of the instructions. In this context, MSA, which is not the everyday language in Saudi Arabia, was also found to be difficult to communicate with and understand. Using such a language influenced the communication, as it needed more time to be analysed and contributed to creating barriers to achieving a rapport with the MDs. These language issues showed to impact the CPR performance. Also, all these language issues were exacerbated by the context complexity of T-CPR task. The need to simultaneously listen to the MDs and perform CPR in a stressful event was found to exhaust the cognitive abilities of callers, resulting in further difficulties in language comprehension and communication. These findings contribute to the current literature by explaining the low CPR timeliness and quality performance following receiving T-CPR instructions and how they can be better improved.

This PhD found the need to simplify T-CPR instructions to plain language to improve callers' understanding and interpretations of the instructions and subsequently, their CPR performance. To simplify the CPR instructions into plain language, the instructions found the need to be simple, precise, and concise. This included avoiding anatomical, technical, and imprecise terms as well as unnecessary information. Based on these findings, the enhanced T-CPR protocol was developed aiming to improve CPR performance. As a result, the enhanced T-CPR protocol showed to improve the CPR timeliness and quality performance which has the potential to improve survival rate. These improvements are attributed to the use of plain language in the CPR instructions. This contributes to the current literature by showing how the use of plain language T-CPR instructions can improve CPR performance, which has the potential to improve survival rate.

The findings of this PhD project have implications for healthcare delivery, clinical practice and patient care. Using language modifications to simplify T-CPR instructions into plain language showed the potential to improve laypeople's understanding and interpretations of the instructions and subsequently their CPR timeliness and quality performance, which have the potential to improve the survival rate. Thus, it is recommended for health organisations and policymakers worldwide to use plain language when developing instructions. Further, the findings showed the value of involving the target audience in the development of plain language instructions to make them more comprehensible. Thus, it is important for health organisations and policymakers to consider involving the target audience and develop instructions that reflect the local language and context in which the instructions are going to be implemented. This is more important for non-English-speaking countries and non-Western regions, as the majority of health literature, and particularly T-CPR, is based on the English language and data from Western regions. The findings also highlighted the significance of dispatchers not asking unnecessary questions during OHCA calls and correctly identifying agonal breathing for OHCA recognition and time to first compression. Thus, regular training of dispatchers is recommended. Such training can help to fill the knowledge gap highlighted by the ILCOR regarding the essential elements of the dispatcher-training programme for T-CPR. Additionally, EMS dispatching centres are also recommended to have a well-designed call tracking system, as this has been shown to influence time to first compression and OHCA recognition. Finally, achieving the AHA standards regarding the quality of the T-CPR protocol was found to be challenging; therefore, establishing a quality improvement programme to evaluate and assess the performance of T-CPR and other EMS areas is recommended for achieving the quality standards.

The findings of this study also provide specific implications for Saudi Arabia. Use of the enhanced T-CPR protocol showed improvements in CPR timeliness and quality performance, which are linked with the survival rate. This was achieved using the simple technique of amending word choices to make them suitable for lay callers. Such modifications are not costly but could save lives and can be implemented in practice relatively easily. Therefore, testing the enhanced T-CPR protocol in current practice in Saudi Arabia is recommended as a next step. Further, based on the findings, it is recommended that SRCA dispatching centres omit unnecessary transfers in EMS calls, as they influenced time to OHCA recognition and first chest compression. Moreover, some cultural considerations, such as sex segregation and differences in gender roles, were found to influence the time to first chest compression. However, changing these sorts of cultural considerations would require a large social shift in attitudes that is unlikely to be feasible at this point.

Based on the findings of this PhD project, there are certain recommendations for further research that can be made. First, using the enhanced T-CPR protocol significantly improved CPR timeliness and quality performance as compared to the Saudi protocol; therefore, the next recommended step is to test the enhanced protocol in current practice. Second, this PhD project provided several suggested modifications to improve the T-CPR protocol, but did not test all of them. Therefore, a future study is recommended to test the other suggested modifications found in this PhD project with the supported evidence from the literature to further improve the T-CPR protocol. Third, this PhD project highlighted the difficulties associated with the T-CPR instruction sequence, but could not provide suggestions on how to improve it. Thus, further investigation into improving the instruction sequence and measuring its impact on CPR timeliness and quality performance is recommended. Fourth, this PhD project showed the significance of providing emotional support to OHCA callers. However, it lacked clarity in how to verbally phrase and deliver this support, especially in conservative countries such as Saudi Arabia. Therefore, it is recommended that how emotional support should be provided in OHCA calls be investigated. Additionally, this study showed the significance of involving the target audience in developing T-CPR protocols so as to serve the population amongst which they will be implemented. Therefore, investigation of the influence of context and population on T-CPR instructions language understanding and interpretation, and how it influences CPR timeliness and quality performance is recommended. Furthermore, this study showed the value of using plain language in a scripted T-CPR protocol. However, plain language for one group of people might not be plain for another, so it is unclear whether dispatchers should strictly follow the exact scripted terms or be flexible in choosing and amending them. Thus, further research into the optimal method for developing a T-CPR protocol and how it impacts CPR timeliness and quality performance is recommended.

Appendix A Chest compressions only CPR steps. Reproduced from (Perkins *et al.*, 2015a)

CIRCULATION **Start chest compressions**		Kneel by the side of the victim Place the heel of one hand in the centre of the victim's chest; (which is the lower half of the victim's breastbone (sternum))
		Place the heel of your other hand on top of the first hand Interlock the fingers of your hands and ensure that pressure is not applied over the victim's ribs Keep your arms straight Do not apply any pressure over the upper abdomen or the bottom end of the bony sternum (breastbone)
		Position yourself vertically above the victim's chest and press down on the sternum approximately 5 cm (but not more than 6 cm) After each compression, release all the pressure on the chest without losing contact between your hands and the sternum Repeat at a rate of 100-120 min^{-1}

Appendix B Examples of T-CPR protocols

B.1 First example of T-CPR protocol used in Seattle and King county in Washington. Reproduced from (Painter *et al.*, 2014).

- What are you reporting?
- What is the address of the patient?
- What is the patient’s age? Gender?
- What is the telephone number you are calling from?
- What is your name?
- Is the person conscious (awake, responding to you)?
- Is the person breathing normally? If patient is not conscious and not breathing normally, begin CPR.
- Does anyone there know CPR? (Trained bystanders may still need instructions. Ask!)
- Get the phone NEXT to the person.
- Listen carefully. I’ll tell you what to do.
- Get them FLAT on their back on the floor.
- BARE the chest.
- KNEEL by their side.
- Put the HEEL of your HAND on the CENTER of their CHEST, right BETWEEN the NIPPLES.
- Put your OTHER HAND ON TOP of THAT hand.
- PUSH DOWN FIRMLY, ONLY on the HEELS of your hands, 2 inches.
- Do it 50 times, just like you’re PUMPING the chest. Count OUTLOUD 1-2-3….50 (correct rate if needed).
- KEEP DOING IT: KEEP PUMPING the CHEST UNTIL HELP TAKES OVER. I’ll stay on the line.

B.2 Second example of T-CPR protocol used in Ireland’s National Ambulance Service. Reproduced from (Oman and Bury, 2016)

General assessment:

- Tell me exactly what happened?
- Confirm details.
- Advise that the ambulance is being dispatched.
- Are you with the patient now?

Appendix B

- How old is the patient?
- Is he awake?
- Is he breathing normally?
- Is he changing colour?
- Did you see what happened?
- Is there a defibrillator available?

Breathing assessment:

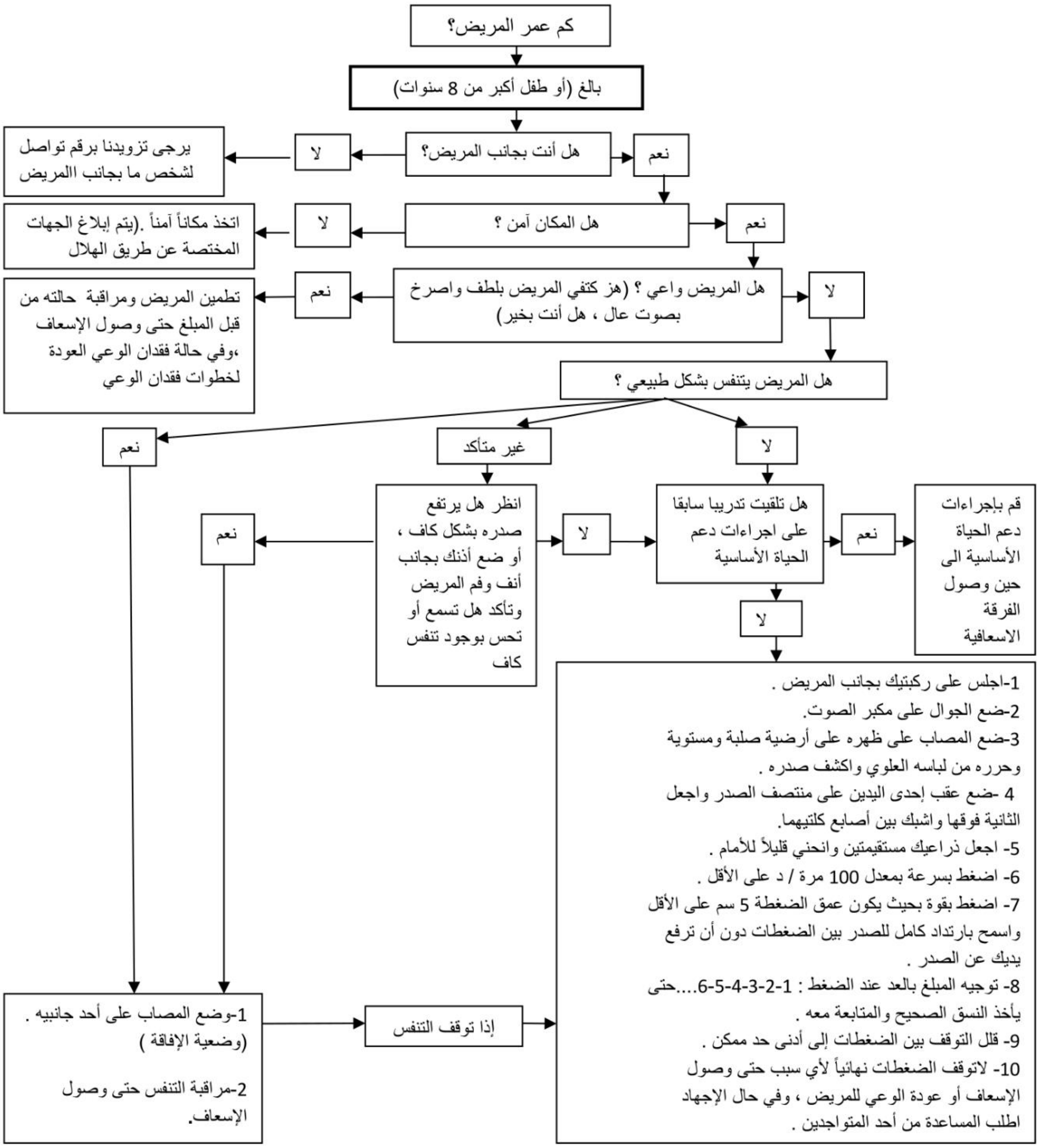
- Lie the patient for on his back and remove any pillows.
- Kneel next to him and check in his mouth for food or vomit?
- Place your hand on his forehead and the other hand on his neck and tilt his head back
- Put your ear close to his mouth.
- Can you hear any breathing?

CPR instructions:

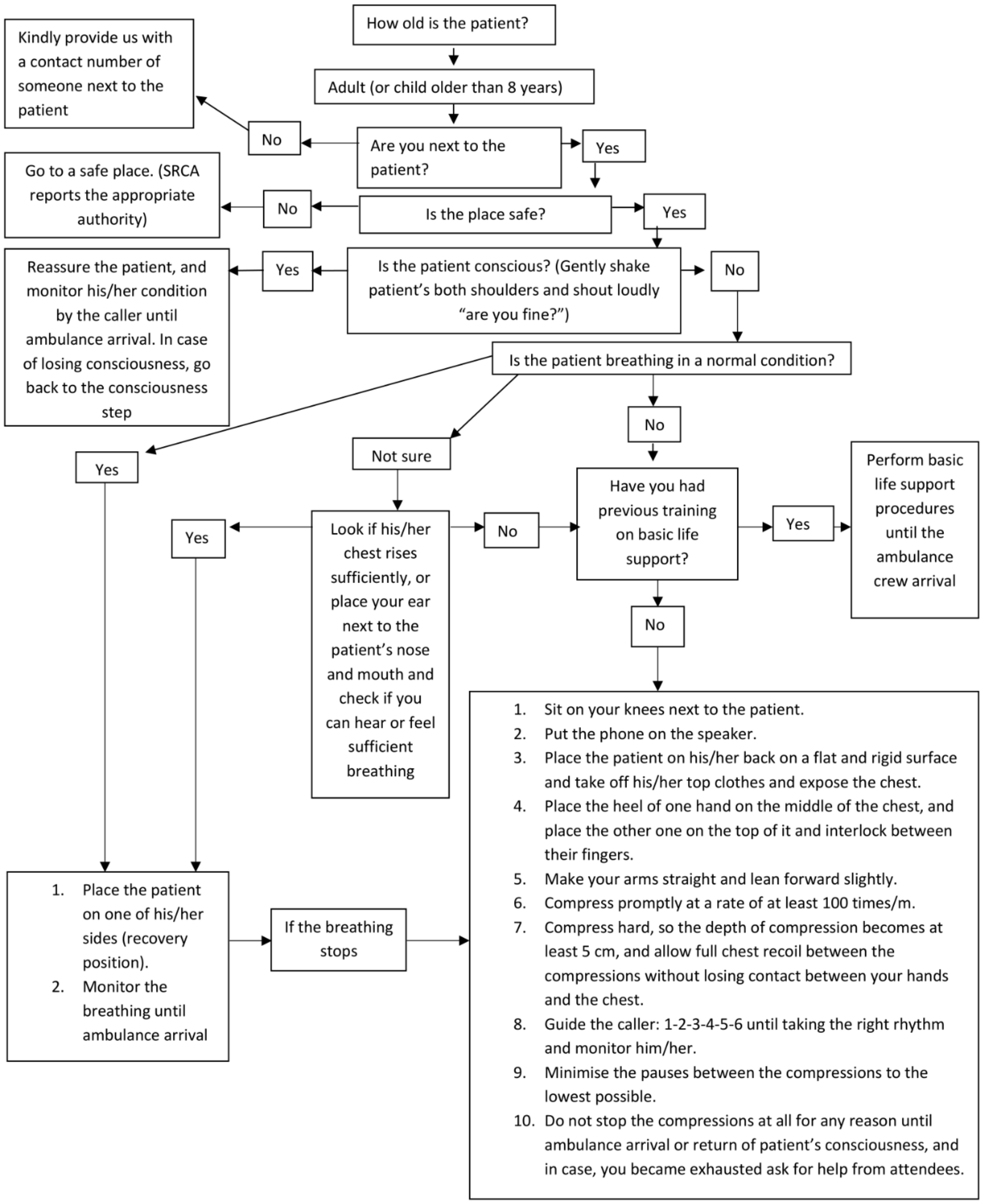
- I will tell you how to do resuscitation.
- Place the heel of your hand on the breast bone in the centre of the chest between the nipples.
- Put the other hand on top of that hand, push down firmly 2 inches with only the heel of your lower hand. Push the chest hard and fast at least twice per second. Let the chest come all the way back. Count out loud so I can count with you.

Appendix C **Saudi T-CPR protocol**

C.1 Arabic version



C.2 English version



Appendix D **Keywords used in plain language literature search**

SPICE model	Keyword	Embase synonyms	Cinahl synonyms	Medline synonyms
Setting	Healthcare, Telemedicine, emergency medical dispatch, out of hospital cardiac arrest	exp health care/ healthcare*.mp. exp telemedicine/ telemed*.mp. emergency medical dispatch.mp. or exp emergency health service/ or exp emergency medical dispatch/ out of hospital cardiac arrest.mp. or exp heart arrest/ or exp "out of hospital cardiac arrest"/ or exp resuscitation/	(MH "Health Care Delivery, Integrated") OR "healthcare" healthcare* (MH "Telemedicine+") OR "telemedicine" OR (MH "Telehealth+") telemed* (MH "Emergency Medical Service Communication Systems") OR (MH "Emergency Medical Services+") OR "emergency medical dispatch" (MH "Heart Arrest+") OR "out of hospital cardiac arrest"	(MH "Delivery of Health Care+") OR "healthcare" healthcare* (MH "Telemedicine+") OR "telemedicine" OR (MH "Remote Consultation+") telemed* (MH "Emergency Medical Dispatch") OR "emergency medical dispatch" OR (MH "Emergency Medical Services+") OR (MH "Emergency Medical Service Communication Systems") (MH "Out-of-Hospital Cardiac Arrest") OR (MH "Heart Arrest+") OR "out of hospital cardiac arrest"
Perspective	Health personnel/ patient/	health personnel.mp. or exp health care personnel/	(MH "Health Personnel+") OR "health personnel" OR (MH "Allied Health Personnel+")	(MH "Health Personnel") OR "health personnel" OR (MH "Allied Health Personnel+")

	dispatcher / caller	patient*.mp. or exp patient/ dispatcher*.mp. or exp emergency medical dispatcher/ caller*.mp.	patient* dispatcher* caller*	patient* (MH "Emergency Medical Dispatcher") OR "dispatcher" dispatcher* caller*
Intervention	Plain language Lay language Simplified language Simple language	plain languag*.mp. lay language.mp. simplified language.mp. simple language.mp.	plain languag* lay languag* simplified languag* simple languag*	plain languag* lay languag* simplified languag* simple languag*
Comparison	None	None	None	None
Evaluation	Understanding Comprehension communication	understand*.mp. comprehension/ or comprehen*.mp. exp interpersonal communication/ communicat*.mp.	understand* comprehen* (MH "Communication+") OR "communication" OR (MH "Communication Barriers+") communicat*	understand* comprehen* (MH "Comprehension") OR "comprehension" (MH "Communication+") OR "communication" OR (MH "Communication Barriers+") communicat*

Appendix E Keywords used in T-CPR language modifications literature search

Keywords	Synonyms
Dispatch*	Telephon*, phon*, mobil*
Cardiopulmonary resuscitat*	CPR, chest compress*
Instruct*	Protocol*, transcript*, guid*

Appendix F **Quality assessment table of plain language literature**

Study	Setting	Study design	Outcome	Sample size	Modifications	Results	Strengths and limitations
McCormack et al. (2016)	USA	Randomised controlled trial	To understand how adults differ in their comprehension, need and preferences of safety information of prescription drugs.	1244 (620 for control group and 624 for intervention)	Language: followed plain language recommendations highlighted by US Plain Language (2004b) and simplified the reading level (e.g., by using short sentences). Others: enhanced design (e.g., for clearer communication) and format.	More participants significantly comprehended the revised form and agreed with the clarity of the form compared with the standard one.	The study design was optimal to establish a causal effect relationship. However, the study lacked details about how the plain language was modified. The changes made to plain language are unclear (e.g., using familiar terms).
Michie and Lester (2005)	United Kingdom	Randomised controlled trial	To investigate the influence of plain language and behavioural specificity on 1) satisfaction and perceived comprehension, and 2) cognitive predictors and behaviour.	84 (42 for each group)	Language: avoided highly technical terms, avoided negative approach, used active verbs and personalised the message. Others: used headings, bullet points, and boxes with key points.	No improvement in comprehension was found. However, the participants showed more attention to use the plain language form in the future and found it more helpful in decision making compared with the standard form.	The study design was optimal for measuring the effect of the plain language. However, the study provided little detail about exactly how the plain language was modified—for example, it lacked information about how highly technical terms were identified and where the alternative terminologies were drawn from, which

							might not be the optimal options for the target audience. Also, the participants might not be representative of the target population, as none of them had been diagnosed with schizophrenia (the issue investigated in this study). This might have influenced the extent to which the participants understood the two different forms of language.
Kim and Kim (2015)	South Korea	Randomised clinical trial	To evaluate the efficacy of a simplified consent form for a cancer clinical trial, regarding actual and perceived understanding	150 (75 for each group)	Language: used plain language which included using fewer words, sentences and characters compared with the standard one. Other: used wider line spacing, larger font size, more pictures and diagrams, as well as formatting techniques such as bullet points.	The simplified form significantly improved the actual and perceived understanding compared with the standard form.	The plain language form was validated by three expert investigators in chemotherapy and two members of an ethical review board. Feedback from the target audience was received to amend and confirm the form. However, the simplified form included several changes irrelevant to the language, which might have influenced the findings. Also, the participants were not cancer patients, who the form had been designed for.

							Also, the participants were not approached randomly, which might have introduced bias.
(Young, Hooker and Freeberg, 1990)	USA	Observational study	To assess the influence of a low reading level consent form on comprehension and participants' intention to participate in a research study.	661 (333 for control group and 328 for intervention)	Language: used more familiar lay terminology, avoided jargon and used shorter sentences. Others: improved the layout.	The amended form was easier to understand and showed significant improvement in comprehension compared with the standard one.	The study design was observational, therefore a casual effect cannot be concluded. No randomisation was conducted, which could have introduced bias.
Davis *et al.* (1998)	USA	Observational study	To measure the impact of a simplified consent form on participants' comprehension and attitude (e.g., preference and comfortability) toward the consent form.	183 (69 for control group and 114 for intervention)	Language: was brief, direct, avoided jargon and was written in plain English. Others: improved the clarity of the format (e.g., coloured headers and graphics)	No difference in comprehension was found between the two groups. However, more participants preferred the simplified form and found it easier to read.	The modified form received input from the target population. However, the study did not include patients with breast cancer, who were the target population, which might limit the applicability. The study design was observational, therefore a causal effect was not concluded. Also, there was no randomisation, which might have introduced bias. The validity of the tools (questions) used to measure the comprehension was not

							tested, which could have influenced the findings.
Ancker *et al.* (2017)	USA	Randomised experiment	To assess if wording changes according to the best practices for plain language would improve comprehension of medication instructions.	951 (480 for control group and 471 for intervention)	Language: plain language changes included 1) replacing unfamiliar terms, jargon and abbreviations with familiar terms and explaining unreplaced medical terms; 2) performing computation (e.g., replacing 'every X hours' with recurrent events such as in the morning or at mealtimes); 3) breaking down the complex sentences that contained multiple instructions; 4) using the active voice; and 5) using illustrations.	The plain language form significantly improved comprehension compared with the standard one. Also, significant reduction in responses leading to the risk of underdosing (but not overdosing) was found when the plain language instructions were followed, as compared to the standard instructions.	The study did not explain where the alternative familiar terms were drawn from and how complex sentences in the standard version were identified. The study tool (questionnaire) was not tested to ensure that it measured comprehension, which could have influenced the findings.
(Wolf *et al.*, 2010)	USA	3 arm cross-sectional study	To evaluate the efficacy of enhanced drug warning labels, which were rewritten in plain language with/ without icons,	500 (the number per group is unclear)	Language: improved clarity, concision and explicitly.	Using plain language with or without icons showed to significantly improve participants comprehension of the	Patients' input was used to amend the warning labels. Three physician raters checked the participants responses, which improved the validity of the findings.

			on participants comprehension compared with the standard warning labels.		Others: enhanced the icons and design (e.g., removal of the use of colour and optimising the font size).	drugs warnings compared with the standard one.	However, the study design did not allow a causal relationship. The participants' health information (who were actual patients) was not reviewed to check if they had experience in medication use, which might have introduced bias. The participants were not randomly assigned, which could have introduced bias. The participants were mainly African American and female, which could limit the generalisability of the findings.
(You *et al.*, 2011)	USA	3 arm cross-sectional study	To evaluate the efficacy of enhanced drug warning labelling, which were amended to plain language with and without icons, on patients' comprehension.	132 (50 for control group, 49 for plain language form group and 33 for plain language with icons form group).	Language: improved clarity, concision and explicitly. Others: enhanced the icons and design (e.g., removal of the use of colour and optimising the font size).	Enhancing drug labels using plain language + icons found to improve the comprehension of drug warnings compared with using only plain language label or the standard label.	This study conducted a secondary analysis from Wolf *et al.* (2010) study. Patients' input was used to amend the warning labels. Three physician raters checked the participants responses, which improved the validity to the findings. However, the study design did not allow a causal relationship. The generalisability of the findings is limited, as the participants were only

							females. Also, the study aimed to measure the influence of plain language + icon labels, but it did not measure the influence of only using plain language label compared with the standard label.
(Mohan *et al.*, 2014)	USA	Randomised controlled trial	To evaluate the efficacy of an amended medications list compared with the standard list regarding understanding of medication, satisfaction and self-reported adherence.	200 (101 for control group and 99 for intervention)	Language: was written in plain English and plain Spanish (depending on the participants' spoken language). Others: the frequency of medication was amended to a specific time in a day (e.g., in the morning or in evening), included a picture of each medication and included an icon showing the purpose of each medication.	The amended medications list improved the understanding of medications compared with the standard list. Participants who received the amended list were very satisfied and nearly all of them found it clear and easy to read. However, there was no difference in self-reported adherence.	The study design was feasible to achieve the aim. However, the research staff and participants were not blinded from the randomisation, which might have introduced bias. The study lacked details about how the plain language was amended. Also, the amended list included several other changes irrelevant to language, including pictures and icons, which might have influenced the findings about the language. Also, the participants were recruited from a single clinic which could limit generalisability.
Smith and Wallace (2013)	USA	Randomised clinical trial	To compare participants' comprehension and	50 (26 for control and 24	Language: the plain language used shorter instructions and	Participants following the plain language form showed	The study received input from the target audience regarding how to amend the

			ability to use an auto injector following receiving standard instructions guidance and plain language instructions guidance.	for intervention)	included only the most pertinent instructions and information.	significantly better understanding of how to prepare and self-administer the auto injector compared with the standard form. The participants given the plain language form were also better at demonstrating how to self-inject compared with the standard group.	language. However, it lacked detail of how the plain language was amended (e.g., word choices). Also, the sample size was not statistically calculated to detect the significant difference, which might influence the internal validity of the findings. The research assistant (who approached the participants) was not blinded from the two different forms of instructions, which might have introduced bias.

Appendix G **Quality assessment table of language modifications to T-CPR instructions literature**

Study	Setting	Design	Outcomes	Sample size	Standard protocol	Modifications	How modified	Result	Strengths and limitations
(Woollard *et al.*, 2003)	United Kingdom	Randomised controlled simulation study	Primary outcome was: to evaluate the effect of eliminating ventilation instructions from scripted telephone CPR directions delivered to untrained lay responders	60 (31 for control group and 29 for interventional group)	N/A	The modified protocol deleted the Instruction to ventilate and simplified hand position instruction to 'place your hands in the middle of her/his chest'.	Previous studies suggested that many lay responders are reluctant to give rescue breaths, so it was removed in this study.	The modified protocol improved time to first compression but decreased hand position.	The study design was optimal to establish a cause-and-effect relationship. However, the standard hand position instruction was not defined, in order to be compared with the modified one. The sample size was also small, which could have influenced the precision of the findings.
(Deakin *et al.*, 2007)	United Kingdom	Prospective observational simulation study	Primary outcomes are: To measure adequate airway opening, time to first ventilation, inspiratory time of each breath, tidal volume, time to first cardiac	101 (50 for control group and 51 for interventional group)	AMPDS V. 11.1	The phrase ''Put the phone down, and come back when you have done it,'' was added. The standard phrase ''under the neck'' was modified to ''behind the neck'' (for opening the airway). The standard phrase ''two deep breaths of air into lungs, just like you are blowing up a big balloon'' was modified to	Based on video recordings analysis of a before-study using the standard protocol.	The modified protocol significantly improved rate and time to first chest compressions but also significantly decreased the depth of the compression	The study assessed a wide range of CPR quality parameters, including the time to first chest compression to measure all of the influences. However, the participants were not selected randomly, which could have introduced bias. The T-CPR protocols (the standard and simplified

			compression, depth and rate of each chest compression and hand positioning. Secondary outcomes are: to measure the number of individuals correctly identifying respiratory arrest in the manikin and the percentage of time actually spent delivering chest compressions.			‘‘force two big breaths into the lungs’’. The standard term ‘‘heel’’ of the hand was replaced with the ‘‘palm’’ of the hand. The phrase ‘‘right between the nipples’’ was removed. Reinforcement statements were omitted in order to reduce the amount of time spent giving instructions. The standard phrase “Push down firmly 2 in. (5 cm)” was modified to ‘‘Push down as hard as you can’’. The standard phrase for rate ‘‘pumping their chest twice a second’’ was modified to ‘‘pumping her/his chest at this speed’’ (the dispatcher then counts from one to five at the correct rate, using a metronome for assistance).		compared with the standard protocol.	one) included giving 2 rescue breaths, which is not recommended anymore in T-CPR, which limits applicability of the study. Also, the sample size was not calculated statistically to measure a significant difference.
(Dias *et al.*, 2007)	USA	Randomised double blinded controlled	Primary outcomes are: to measures chest compression	117 (59 for control group and 58 for interventional group).	MPDS version 11.2.	Deleting some phrases and instructions from the standard protocol. Modifying rate and depth instructions “twice per	By the research team.	The modified protocol significantly improved depth, time to	The study design was optimal to measure a causal effect. Also, the study assessed a wide range of CPR quality

		simulation study	rate, depth, hand position, full release, overall proportion of compressions without error, time to start of CPR and total hands-off chest time. In addition, proportion of correct compressions based on depth, release and hand position was provided by the simulated manikin.			second and 2 inches" in the standard protocol to "a rate of 100 per minute and as hard as you can".		first compression and hands-off time compared with the standard protocol. However, the modified protocol significantly decreased hand position.	parameters including time to first chest compression, to measure all of the influences. However, the standard protocol was aimed for standard CPR (chest compression + ventilation) while the simplified one aimed for only chest compression CPR, which could have influenced the time to first chest compression finding. In addition, the simulated dispatcher was acted by a research assistant who had not received formal dispatch training, which could have influenced the findings.
(Birkenes, Myklebust and Kramer-Johansen, 2013)	Norway	Randomised simulation study	The study aimed to measure hand position.	36 (18 for each group).	The standard hand position instruction from ERC	Modifying the standard instruction "Kneel down beside the chest. Place one hand in the centre of the victim's chest and the other on top" to the instruction "Lay the	N/A	The modified instruction resulted in less caudal hand placement with	The study was performed with only one adult male acting as the patient. Peoples' chests are different in terms of shape and size, and this could have limited the

						patient's arm which is closest to you, straight out from the body. Kneel down by the patient and place one knee on each side of the arm. Find the midpoint between the nipples and place your hands on top of each other".		participant placed his/her hands in the abdominal region compared with 5 followed the standard instruction.	generalisability of the findings. The amended instruction was more detailed and longer than the standard instruction, however, time to start chest compression was not measured. It is expected that the amended instruction would have delayed the time to first chest compression. Furthermore, the hand position was measured without performing CPR, and therefore it is unknown if the participants would maintain the same hand position during performing CPR.
(van Tulder *et al.*, 2014a)	Austria	Investigator blinded, randomized, parallel group simulation design	Primary outcome: to examine mean chest-compression Depth.	26 (13 per group)	MPDS V12.0	Modifying the standard phrase ''push down firmly 5 cm'' to ''push as hard as you can''	N/A	No difference in compression depth, quality of CPR, or physical strain on lay rescuers	The study design was optimal to achieve the study's aim. However, almost all participants had BLS training, which could have influenced the findings.

			Secondary outcomes: to investigate physical strain on the compression only CPR provider (data evaluating chest compression containing total number, accurate performance, hand position, recoiling, compression/ relaxation ratio, and hands-off times)					between the two protocols.	
(Painter *et al.*, 2014)	USA	Randomised controlled simulation	Primary outcomes are: to measure the time interval from call receipt to the first chest compression and the core	75 (36 for control group and 39 for interventional group).	Criteria Based Dispatch (CBD).	Changes included that 1) callers were no longer asked if they wanted to do CPR prior to beginning to provide CPR instructions, 2) callers counted in cycles of 50 (1, 2, 3. . ..49, 50) was changed to cycles of 10 (1, 2, 3. . ..9, 10) and 3)	Using focus group with limited English proficiency speakers (Mandarin, Cantonese and Spanish) to determine	The modified protocol significantly improved time to first compression and depth of compression compared	The study design was optimal to establish a cause-and-effect relationship. Also, the study assessed a wide range of CPR quality parameters and time to first chest compression, to measure all of the

			metrics of chest compression (depth, rate, release, interruptions and hand position).			terms such as "bare the chest" and "push 2 inches" were replaced with "open the shirt," and "using straight arms, push as hard as you can,". Apart from CPR instructions: the call questions were re-sequenced the cardiac arrest questions before less urgent questions to improve time to first compression.	challenging words/ phrases and alternatives. Also, conducting interviews with dispatchers about their perception of word and phrases that challenged callers.	with the standard protocol. However, hand position was significantly decreased in the modified protocol compared with the standard protocol. No significant changes in compression rate, complete release, number of hands-off periods, or total hands-off time.	influences. However, the language was amended using input from English speakers of a limited proficiency, but then examined in this study using primary English speakers. This could have influenced the findings. Also, the amended protocol included amending the sequence of the call questions and therefore the influence of the amended language on the findings is unclear. The improvement in time to first compression is likely to be attributed to the amended call questions sequence rather than the language. The participants were informed that the patient (simulated manikin) is unconscious and not breathing prior to starting the simulation, which could also have influenced the time to first compression findings.

(van Tulder *et al.*, 2014b)	Austria.	investigator-blinded, 4-armed, randomized, factorial simulation trial	Primary outcomes are: to measure relative chest compression depth which represents the absolute compression depth minus the leaning depth in millimetres. Secondary outcomes are: to measure the absolute distance (compression depth × compression per Minute × 10 min in metres), hands-off time to CPR start and cumulative hands-off times (seconds per 10	32 (8 for each group).	MPDS protocol version 12.2.	Two modifications and a combination of both versus the standard instruction were measured in four distinct study groups. First modification was comprised of an intensified wording prompted: "It is very important to push down the chest firmly 5 cm every time!". The second modification was repeating the instruction every 20s.	N/A	Repeating the target depth every 20 s and/or using an intensified wording for compression depth instruction did not improve compression depth and significantly worsened the depth of compression compared with the standard instruction. Repeating incorrectly interpreted instructions would not improve the task performance.	Almost all of the participants had previous CPR training and some of them had taken part in recent training (within the last 2 years), which could have influenced the findings, as they already had CPR skills. Selection bias could also have been introduced, due to the lack of randomisation.

			min) and changes in participants' vital signs reflecting physical strain.						
(Rasmussen *et al.*, 2017)	Denmark	Randomised controlled simulation	primary outcome: to composite outcome score based on time to first compression, hand position, chest compression depth and rate and hands-off time. Proportion of compressions without total recoil and participants' evaluation of the dispatcher assistance, inter- and intra-observer	124 (62 each group)	Danish T-CPR protocol.	Asking for activation of mobile phone speaker was scripted, hand position was instructed using "Place one hand in the centre of the chest, right between the nipples, and the other on top", chest compression depth was instructed using "Push as hard as you can", chest compression rate was instructed by saying "push, push, push..." and concurrent guiding using a metronome, encouragements were provided every 15th seconds, participants were instructed to have a 10-s rest each minute and redundant words or sentences from the	Based on findings of previous studies in the literature and pilot studies.	The modified protocol significantly improved CPR quality score measured using a developed assessing form compared with Danish protocol. The modified protocol improved hand position and time to first compression compared with Danish protocol. However, the	The study design is optimal to measure a cause-and-effect relationship. Also, the study assessed a wide range of CPR quality parameters and time to first chest compression, to measure all of the influences. However, the assessment tool to measure the overall CPR performance was not validated. Both the standard and amended protocol reached the recommended rate and depth by ILCOR, which could indicate that the study population or people in Denmark were likely to have CPR skills, and therefore might limit the generalisability.

			variability of the primary endpoint and dispatchers' protocol compliance were reported.			standard protocol were omitted.		modified protocol was associated with longer hands-off time. Both groups performed chest compression depth and rate within guideline recommendation, but participants guided with the modified protocol performed both deeper and more compressions.	
(Trethewey *et al.*, 2019)	United Kingdom	Randomised controlled simulation design	The primary outcome was: to measure the mean chest compression depth.	330 participants distributed almost equally in three study groups.	T-CPR protocol used in the UK.	Three study groups received the same T-CPR instructions except the depth instruction. One group received the instruction used in resuscitation council of	N/A	The phrase "hard and fast" delivered the highest quality chest compressions	The study design was optimal for measuring a causal effect. However, the study did not simulate a real T-CPR scenario, as the participants did not communicate with a

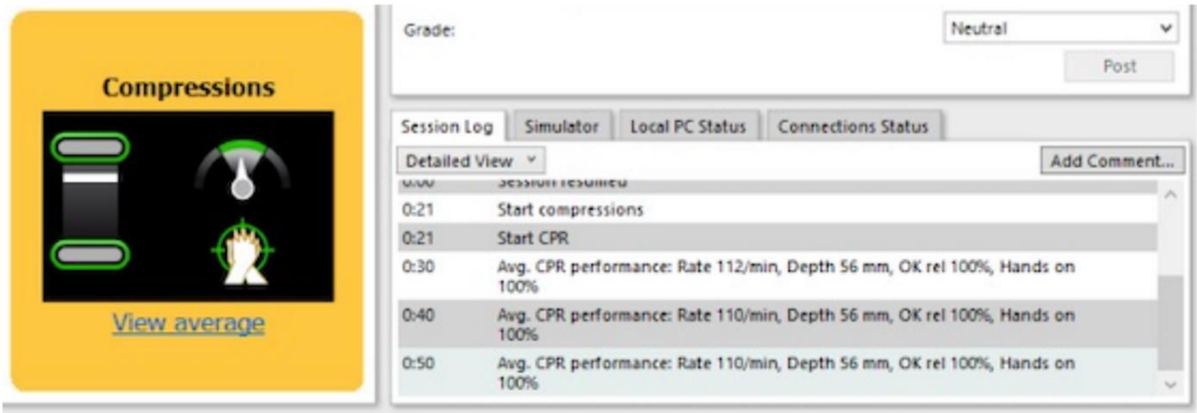
			Secondary outcomes were: to measure chest compression rate, chest compression count, proportion of chest compressions in the recommended rate (100-120 per minute), proportion of chest compressions in the recommended depth (50 mm), and proportion of delivery of good quality CPR (defined as percentage compressions with complete release and of adequate			Asia “approximately 5 cm”, another group received the instruction used in AHA and ERC “at least 5 cm” and the last one received the instruction used in high-profile media campaigns by the AHA and the BHF “hard and fast”.		in terms of chest compressions depth, chest compression rate and delivery of good quality compressions compared with the resuscitation guidelines terminologies.	dispatcher to receive the instructions, but instead listened to audio recorders. This could have influenced the findings, as the complexity of performing CPR while talking to a dispatcher was not included. In addition, the recruitment took place in a hospital setting, which could also limit the generalisability of the findings.

			depth and rate).						
(Leong *et al.*, 2020)	Singapore	Before-after observational study	Primary outcome was: to measure time intervals between instructions and compressions. Secondary outcomes were: to measure overall time to first compression and the need for further paraphrasing of the CPR instructions when delivered to the callers.	506 calls (282 for control group and 224 for interventional group)	Standard T-CPR protocol in Singapore.	Modifying the rate and depth phrase "push 100 times a minute 5 cm deep" in the standard protocol to "push hard and fast"	N/A	The simplified instruction was associated with a shorter interval between time of instruction and first compression. The need for paraphrasing occurred in more calls using the modified instruction than the standard instruction.	It is the first study to measure the influence of simplified phrasing in real OHCAs, rather than in a simulation. However, the dispatchers in the 'before' stage had poor compliance with the protocol. Also, the dispatchers were not blinded from the purpose of the study, which could have influenced their behaviour, and therefore introduced bias. Finally, the 'after' stage had the higher proportion of true OHCAs, compared with 'before' stage, which could have influenced the callers' reaction and initiation of prompt CPR.

Appendix H **Observation of calls study data extraction form**

Call ID number: …………	Date: □□/□□/□□□□
Gender of the caller: Male. □ Female. □	Gender of the patient: Male. □ Female. □
Nationality: Saudi. □ Non- Saudi. □	Did the MD recognise OHCA? Yes. □ No. □
Time to identify the location: □□:□□	Time to transfer the call to MD: □□:□□
Time to OHCA recognition: □□:□□	Time to start chest compressions: □□:□□
Did the MD offer CPR instructions? Yes. □ No. □	Did the caller perform chest compressions? Yes. □ No. □
Are the caller and patient family members? Yes. □ No. □	Did the patient have ROSC? Yes. □ No. □

Appendix I A 3G SimMan simulator from Laerdal (reproduced from (Laerdal, 2016)) and the control panel of CPR performance



Appendix J Before-after simulation study data extraction form

<table>
<tr><td colspan="2">Participant ID number: ……………</td><td>Date: □□/□□/□□□□</td></tr>
<tr><td>Gender:
Male. □
Female. □</td><td>Nationality:
Saudi. □
Non-Saudi. □</td><td>Occupation:
Academic staff. □
Other staff. □
Student. □</td></tr>
<tr><td colspan="2">Age:
15-24. □
25-54. □
55-64. □
Above 64. □</td><td>Level of education:
1. PhD. □ 2. Master's/high diploma. □
3. Bachelor's. □ 4. Diploma. □
5. Secondary school. □ 6. Elementary school. □
7. Primary school. □ 8. Less than these. □</td></tr>
<tr><td colspan="2">Time to start first chest compression:
□□:□□</td><td>Chest compressions per minute: ……………….</td></tr>
<tr><td colspan="2">Chest compression depth:
……………….</td><td>Hand position: ……………….</td></tr>
<tr><td colspan="2">Chest wall recoil: ……………….</td><td>Hands off chest time: □□:□□</td></tr>
</table>

Appendix K Consent forms

K.1 Consent form from ERGO for the before-after simulation study

UNIVERSITY OF Southampton

CONSENT FORM

Study title:
Telephone Dispatcher Assisted Cardiopulmonary Resuscitation: An analysis of Out of Hospital Cardiac Arrest Simulations for Cardiopulmonary Resuscitation Quality Performance
Researcher name: Meshary Bin Hotan
ERGO number: 47622

Please initial the box(es) if you agree with the statement(s):

I have read and understood the information sheet (*dated on 11/03/2019 version no. 2*) and have had the opportunity to ask questions about the study.	
I agree to take part in this research project and agree for my data to be used for the purpose of this study.	
I understand my participation is voluntary and I may withdraw at any time for any reason without my participation rights being affected.	
I understand that data pertaining to my academic and demographic background as explained in the information sheet will be collated for the purposes of this research study. I give permission that any anonymised data may be used in the study reports.	
I understand that taking part in the study involves audio and video recording which will be transcribed and then destroyed for the purposes set out in the participation information sheet.	
I agree to take part in the interview and simulation session for the purposes set out in the participation information sheet and understand that these will be recorded using audio and video recordings.	
I understand that the collected data may be viewed by the study supervisors/ investigators. I give permission for these individuals to access my data.	
I understand that I may be quoted directly in reports of the research and in presentation of the findings but that I will not be directly identified (e.g. that my name will not be used) and the quotes will be anonymised.	
I understand that the data collected from me for this study will be retained by the University of Southampton for ten years in line with the university policy.	

Name of participant (print name)……………………………………………………………………………
Signature of participant………………………………………………………………………………….
Date……………………………………………………………………………………..…………………….
Name of researcher (print name)……………………………………………………………………………
Signature of researcher ………………………………………………………………………………….
Date………..

K.2 Consent form from KAIMRC for the before-after simulation study

Kingdom of Saudi Arabia
Ministry of National Guard - Health Affairs

المملكة العربية السعودية
وزارة الحرس الوطني – الشؤون الصحية

إقرار موافقة للمشاركة بدراسة بحثية - دراسة غير اجرائية

عنوان الدراسة : **الإنعاش القلبي الرئوي بمساعدة هاتفية من المرحل: تحليل لمحاكاة توقف القلب خارج المستشفى لتقييم جوده الإنعاش القلبي الرئوي**

رقم الدراسة : **SP19/050/R**

الباحث الرئيسي :

1. أهداف الدراسة

أنت مدعو للإنضمام طواعية لدراسة بحثية الهدف من اجراءها هو تقييم مهارات الإسعافات الاولية بناءاً على تعليمات مستلمه من مزود الخدمات الإسعافية الطارئة من خلال الهاتف للتعرف على كيفية تطوير هذه التعليمات. نتائج هذا البحث سوف تساعد (بمشيئة الله) في تقليل عدد الوفيات للمرضى الذين يحتاجون تدخل سريع وهم خارج المستشفى في انتظار وصول الإسعاف.

2. مدة المشاركة بهذه الدراسة:

مدة مشاركتك بهذه الدراسة من 30-40 دقيقة (5 دقائق للمحاكاة و15-30 دقيقة مقابلة شخصية)

3. عدد المشاركين بهذه الدراسة/موقع الدراسة

العدد الكلي المتوقع للمشاركين بهذه الدراسة سيكون 50 مشارك، ستجرى هذه الدراسة في مختبر المحاكاة في قسم الخدمات الطبية الطارئة في كلية العلوم الطبية التطبيقية في جامعة الملك سعود بن عبدالعزيز للعلوم الصحية.

4. خطوات الدراسة

اذا وافقت في المشاركة في الدراسة فسيتم ترتيب وقت مناسب لك لكي تشارك. سيطلب منك المشاركة في محاكاة للإسعافات اولية لمدة لا تزيد عن 5 دقائق. بعد ذلك سيطلب منك حضور مقابلة شخصية مع الباحث للتحدث عن تجربتك بعمل الإسعافات الاولية .

قبل المشاركة في الإسعافات الاولية سيتم اعطائك سيناريو (محاكاة) عن شخص ساقط (تمثال على شكل انسان) وسيطلب منك الاتصال بالإسعاف (اخصائي خدمات إسعافيه طارئة جالس ينتظر في الغرفة المجاورة) عند الوصول للمريض. مستقبل الاتصال سوف يقودك لعمل الإسعافات الاولية لمدة دقيقتين. بعد موافقتك سيتم تسجيل المحاكاة بالصوت والصورة لكي نستطيع تقييم فعالية التعليمات في تمكين المتصل من عمل الإسعافات الاولية.

بعد المحاكاة سيقوم الباحث بإجراء مقابله معك للتحدث عن تجربتك في عمل الإسعافات الاولية. خلال المقابلة سيتم سؤالك عن التعليمات التي استلمتها لكي نتعرف على أماكن الخلل في التعليمات. بعد موافقتك سيتم تسجيل المقابلة صوتياً.

5. المخاطر والاعراض الجانبية و الانزعاجات

ليس هناك أي مخاطر عند المشاركة في الدراسة. ومع ذلك إذا كان لديك تجربة سابقه سيئة في عمل الإسعافات الاولية في الحياة الحقيقة (ليس في المحاكاة) يمكن لهذه الدراسة فقط ان تحفز هذه ذكرى السيئة. ان حدث ذلك تستطيع انهاء مشاركتك في الدراسة في أي وقت ويمكننا ايضاً ترتيب موعد لك مع شخص متخصص طبياً للتحدث معه عن هذه التجربة بكل سرية اذا اردت ذلك.
سيتم إبلاغك بأي معلومات جديدة قد تأثر على رغبتك في بدء أو إستكمال الدراسة.

6. التكاليف والتعويض عن المشاركة في هذه الدراسة

لا يوجد تكاليف مالية لقاء المشاركة في هذه الدراسة ولا يوجد أي تكاليف لأي أدوية أو فحص طبي أو إجراءات خاصة بالبحث (قد يتم تعويضك لقاء مصاريف تنقلاتك خلال الدراسة إن أمكن ذلك). لن يكون هناك أي تكاليف ماليه عليك عند المشاركة في البحث.

7. الفوائد

بالرغم من انه لا توجد فائدة مباشره لك من خلال المشاركة في هذه الدراسة الا ان هذه الدراسة تهدف الى زيادة فرصة الحياة للمرضى خارج المستشفى ويعانون من مشكله قلبيه حاده.
أيضا سيقدم لك فرصه لحضور دورة تدريبية عن الإسعافات الاولية مجاناً مقدمة من اخصائي خدمات إسعافيه طارئة نظير مشاركتك في الدراسة.

8. معلومات حول المشاركة

إن مشاركتك في هذه الدراسة تطوعية، لك الحق التام في الإنسحاب من الدراسة في أي وقت تشاء بدون إبداء الأسباب، و لن يؤثر ذلك على العناية الطبية المقدمة لك. إذا قررت إنهاء مشاركتك عليك إخبار الباحث الرئيسي للدراسة بذلك.
يحق للباحث الرئيسي للدراسة أو الممول أنهاء مشاركتك في هذه الدراسة وذلك بناءاً على حالتك الصحية.
اذا رغبت في المشاركة يرجى التواصل مع منسق الدراسة مشاري الحوتان من خلال الإيميل m.s.bin-hotan@soton.ac.uk

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9. السرية والتخويل لجمع واستخدام والكشف عن المعلومات الطبية الشخصية

جميع المعلومات التي تم جمعها عن طريق طبيب الدراسه أو منسق البحث سواء كانت شخصية أو طبية، تعتبر سرية و لا يحق لأحد الإطلاع عليها عدا ممثلين مصرح لهم كطبيب الدراسة، و موظفي مركز الملك عبدالله العالمي للأبحاث الطبية، و ممثلين عن ممول الدراسة، واللجنة الأخلاقية، و اللجنة العلمية , إضافة ألى و ليس حصرا: مفتشي هيئة الصحة، و مفتشي ممول الدراسة وأيضاً الأشخاص المصرح لهم بالدخول للملفات الطبية أو مراجعة وتحليل البيانات ويشمل ذلك أي جهة تقدم شهادات اعتماد .

البيانات التي يتم جمعها من ملفات المشاركين بالدراسة هي ملك لمركز الملك عبدالله العالمي للأبحاث الطبية أو (ممول الدراسة)، في حال تم نشر نتائج الدراسة، لن تكون معلوماتك الشخصية مذكورة مطلقاً، و لكن من الممكن أن يشار إليها برموز غير معروفة إلا لدى فريق البحث.

10. الاتصالات

إذا كان لديك أي استفسارات تتعلق بالبحث أو بالرعاية الطبية المتوفرة من خلال البحث، أو إذا كنت تظن أنك واجهت إصابة أو حالة طارئة متعلقة بالبحث، يمكن الاتصال على الباحث الرئيسي في الدراسة: (مشاري بن حوتان). (رقم هاتف الباحث الرئيس:٠٥٠٠٠٣٠٨٦٠)

إذا كانت لديك أي استفسارات عن حقوقك كمشارك يمكنك الاتصال باللجنة الأخلاقية على الرقم: 8011111 ، فرعي: 14572 .

لقد أعُطيت الفرصة لمناقشة أسئلتي حول المشاركة في هذه الدراسة، ولقد تم الإجابة عليها من قبل فريق البحث، و إذا كان لدي أي أسئلة أخرى سأقوم بالاتصال على مشاري بن حوتان

- أفهم أن مشاركتي في هذا البحث تطوعية، و أعلم أنه يحق لي الإنسحاب متى قررت ذلك دون أن يؤثر ذلك على الرعاية الطبية التي أتلقاها بشكل طبيعي .
- أفهم أنه يحق لباحث الدراسة الرئيس إنهاء مشاركتي حسب ما يراه مناسباً لي.
- أفهم أن عدم الإلتزام بإجراءات البحث و مواعيد الزيارات قد يتسبب في إنهاء مشاركتي في الدراسة .

بتوقيعي على هذة الموافقة المبنية على الإطلاع، أقر بأني لم أتنازل عن أي من حقوقي القانونية، و أؤكد بأنني تلقيت معلومات كافية عن الدراسة، وأنني قد قرأت وفهمت المعلومات الموجودة في هذه الموافقة المبنية على الاطلاع وأتيحت لي الفرصة لمناقشة الدراسة وطرح الأسئلة وقد كنت راضٍ عن التفسيرات التي تلقيتها.

أفهم أنه بعد التوقيع على هذه الموافقة المبنية على الإطلاع سوف أحصل على نسخة موقعة و مؤرخة.

من خلال توقيع وتاريخ هذه الموافقة المبنية على الاطلاع، أنا أوافق على المشاركة في هذه الدراسة البحثية.

اسم المشارك	**التوقيع**	**التاريخ**
اسم ولي الأمر أو الوصي القانوني (إذا كان المشارك قاصراً ، أقل من 18 سنة)	**التوقيع**	**التاريخ**
اسم الشاهد (إذا كان المشارك غير قادر/قادرة على القراءة والكتابة)	**التوقيع**	**التاريخ**
اسم الباحث الرئيسي	**التوقيع**	**التاريخ**
اسم الباحث الرئيس أو منسق الدراسة	**التوقيع**	**التاريخ**

Appendix L The standard simulation scenario for participants in before-after simulation study

There is a collapsed patient (simulator) in the simulation room and you are alone in helping him. Once you arrive the patient, call 997 from the contact list using the mobile phone you were provided. An acting EMS MD will answer the call then provide you with first aid instructions which will require performing first aid skills. Please imagine the scenario as a real case and the simulator as a real patient and follow the MD instructions as possible.

Appendix M Interview guide of the before-after simulation study

Interview Guide

Introduction:

- This study is part of my PhD study carried at the University of Southampton in the United Kingdom.
- This study aims to examine CPR performance of participants receiving DA-CPR instructions currently used in SRCA and investigate these CPR instructions in more depth to identify the possible weaknesses in which improving them will improve OHCA survival rate.
- In this discussion I will ask about your opinion about the DA-CPR protocol you received to identify the weaknesses then explore suggestions for improvement.
-

Opening questions:

- Where are you from?
- How old are you?
- What is your level of education?
- What is your educational background?
- What is your job?

Main interview questions (identifying the potential weaknesses in the DA-CPR protocol):

- How did you feel about performing the chest compressions?
    - Explore if the participant found it easy/challenging, comfortable/worrying etc.
- What did you think about the instructions that were given to you over the telephone?
- Prompts:
    - How easy or difficult you think was performing CPR based on the CPR instructions you received? And why?
    - Were there any difficulties in the process of receiving the CPR instructions via telephone? If so, can you describe them? (e.g. dispatcher's voice tone, speed of delivering the instructions)
    - Did you feel that you performed the CPR correctly? Why/why not?
    - Did you feel the instructions enabled you to perform CPR well? Why / why not?
- Explore views about each of these aspects in turn (this will be guided by what I have observed in the simulation task).
    - Chest compression rate.
    - Depth.
    - Hands position.
    - Hands off time.
    - Chest wall recoil.
- How did you feel about the language that was used in the instructions given to you?
    - Words.
    - Instructions.
    - Questions.
- Were there any words, instructions or questions you did not understand or found difficult to understand? if so,
    - What were they?
    - Why? (e.g. was it a new word for you, the accent of dispatcher was not clear).
    - What words, instructions or questions would have been helpful for you to perform CPR?
- Do you think the instructions could be changed or improved in anyway?
- What instructions do you think need to be given to enable you to perform CPR?

Note: additional follow up questions and probes might be asked, if necessary, depending on the participants' answers.

Appendix N **The enhanced T-CPR protocol (Arabic version)**

البروتوكول المطور
هل المريض بالغ، أو طفل، أو رضيع؟
هل أنت جنب المريض؟
هل المكان آمن؟
هل المريض واعي؟ (هز أكتاف المريض بلطف، واصرخ، هل أنت بخير؟)
هل المريض يتنفس طبيعي؟
هل عندك تدريب على الإسعافات الأولية؟
1. اجلس على ركبتيك جنب صدر المريض.
2. ضع الجوال على مكبر الصوت.
3. ضع المريض على ظهره على الأرض واكشف صدره.
4. ضع أسفل راحة يدك على منتصف صدره و ضع يدك الثانية فوقها واشبك اصابعك.
5. اجعل ذراعيك مستقيمتين وتقدم للأمام حتى تكون عمودي على صدره.
6. اضغط بسرعة بمعدل 100 ضغطه في الدقيقة على الأقل
7. اضغط بقوة، بعمق 5 سم على الأقل واترك صدره يرجع لمكانه الطبيعي بين الضغطات بدون ما تشيل يدينك عن صدره
8. توجيه المبلغ بالعد عند الضغط: 1-2-3-4-5-6 حتى يأخذ النسق الصحيح والمتابعة معه
9. ---
10. لا توقف الضغطات أبدا حتى يوصل الإسعاف أو يرجع الوعي للمريض، وإذا تعبت اطلب المساعدة من أحد المتواجدين.

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