Improving the Emergency Medical Service recognition and response for patients who are at imminent risk of out-of-hospital cardiac arrest: The IMARI Study

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A thesis submitted in partial fulfilment of the requirements of the University of the West of England, Bristol for the degree of Doctor of Philosophy.

This research programme was carried out in collaboration with South Western Ambulance NHS Foundation Trust.

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August 2022

Acknowledgements

I would first like to thank my Director of Studies, Professor Jonathan Benger and my supervisor, Professor Sarah Voss for their consistent support and guidance from the initial funding application to thesis submission. I would also like to thank my supervisors, Dr Paul White and Dr Rebecca Barnes for their expertise and guidance in their specialist areas and their encouragement along the way.

I would like to thank the National Institute For Health Research for funding the research fellowship, the Study Steering Committee for their oversight and expertise and the generous support of the South Western Ambulance Service NHS Foundation Trust and the Bristol Out-of-Hospital Cardiac Arrest Research Advisory Group Patient and Public Members. South Western Ambulance Service NHS Foundation Trust sponsored this research and in particular, Dr Sarah Black supported and expertly advised throughout the fellowship. I am also grateful to East Midlands Ambulance Service NHS Trust who have been generous in their support and contributions.

This research would not have been achievable without the contributions of the research participants, and I am grateful for their time, generosity and expertise during a global pandemic. I am also grateful for the permission to use anonymised patient data and to the patients who it relates to. Lastly, I would like to thank my family and friends for listening, supporting, being there and continuing to make me laugh.

Abstract

Current international guidelines and the associated "chain of survival" emphasise the recognition of critically unwell patients in the community followed by an efficient response in the hope of preventing out-of-hospital cardiac arrest, which occurs when the heart stops beating suddenly. This thesis investigates how Emergency Medical (ambulance) Services can improve their recognition and response to patients who are at imminent risk of out-of-hospital cardiac arrest to reduce mortality and improve outcomes.

Four distinct studies were completed:

a) Systematic mixed studies review;
b) Retrospective observational study of Emergency Medical Services call triage and the outcome of patients at imminent risk of out-of-hospital cardiac arrest;
c) Conversation analysis of the Emergency Medical Services call;
d) Interviews with Emergency Operations Centre staff.

This patient group is not well studied in the existing literature, with current research focusing on the recognition and response to individuals who have already suffered a cardiac arrest, even though people at imminent risk have a potentially better chance of survival.

Emergency Medical Dispatcher management of the Emergency Medical Services call is critical in the identification of these high-risk patients. Data analysis showed that Emergency Medical Services respond less urgently to patients at imminent risk of out-of-hospital cardiac arrest in comparison to patients already in cardiac arrest at the time of the call, with a negative impact on patient outcomes. The Emergency Medical Services interaction can be inefficient, leading to lost information.

Emergency Medical Dispatchers require enhanced education and clinical support, and opportunities to monitor deteriorating patients. Members of the public would benefit from education regarding the structure and process of the Emergency Medical Services call.

This thesis describes distinct areas where improvements can be made, and further research undertaken, in the recognition and response to patients in the community who are at imminent risk of out-of-hospital cardiac arrest.

Contents

List of Tables

List of Figures

Glossary of Terms

ARP; Ambulance Response Programme	A national programme to improve the ambulance response to patients requiring urgent and emergency care
AMPDS; Advanced Medical Priority Dispatch System	International scripted Computer Decision Support Software
BLS	Basic Life Support
BCPR	Bystander Cardiopulmonary Resuscitation
CA	Conversation Analysis
CAD	Computer Aided Dispatch
CBD; Criteria-Based Dispatch	Computer decision support software used by clinicians which allows some flexibility to navigate guidelines
CPR; Cardiopulmonary Resuscitation	Pushing up and down on someone's chest, and performing rescue breaths, when that person's heart is believed to have stopped beating
CDSS; Computer Decision Support Software	Computer software designed to assist Emergency Medical Dispatchers to triage ambulance calls
Chain of Survival in out-of-hospital cardiac arrest	Four key sequential and interconnected steps that when delivered effectively optimise the chances of survival from out-of-hospital cardiac arrest
Dispatch on Disposition	Modification to the ambulance call handling process to recognise critical calls immediately and allow extra time to triage and dispatch the correct ambulance resource to a patient
DA-CPR	Dispatcher Assisted-Cardio-Pulmonary Resuscitation
ECS	Electronic Care System
ECCS	Emotional Content and Cooperation Score
EMD; Emergency Medical Dispatcher	Emergency Ambulance '999' Call-Taker
EMS; Emergency Medical Services	Emergency Ambulance '999' Service
Emergency Medical Service witnessed out-of-hospital cardiac arrest	An out-of-hospital cardiac arrest that occurs in the presence of ambulance staff (including first responders)
EOC; Emergency Operations Centre	Ambulance call-centre where ambulance calls are handled
GoodSAM App	An application that alerts volunteers that there is a patient in cardiac arrest nearby so they can volunteer to attend and deliver first aid
HCP	Healthcare Professional
HoB	Hand on Belly
ILCOR	International Liaison Committee on Resuscitation
NHS Pathways	Scripted Computer Decision Support Software owned by the Department of Health and Social Care and used in some services in the UK to triage ambulance calls
Non-Shockable Rhythm	A cardiac rhythm not amenable to defibrillation

OHCA; Out-of-Hospital Cardiac Arrest	Occurs when the heart stops beating, and blood no longer flows around the body, outside a hospital setting
OHCAO Registry; Out-of-Hospital Cardiac Arrest Outcomes Registry	Out-of-hospital cardiac arrest registry maintained by Warwick University
NoC; Nature of Call	A predefined list of problems in the ambulance triage software that are likely to indicate critical illness
PAD; Public Access Defibrillator	A defibrillator freely accessible to the public
PPI	Patient and Public Involvement
PTQ; Pre-Triage Questions	A series of questions at the start of the emergency call-handling process designed to recognise patients in out-of-hospital cardiac arrest
RTA	Reflexive Thematic Analysis
Shockable Rhythm	A cardiac rhythm amenable to defibrillation
SMSR	Systematic Mixed Studies Review
SWASFT	South Western Ambulance Service NHS Foundation Trust
tCPR; Telephone Cardiopulmonary Resuscitation	Emergency 999 call-taker guided cardiopulmonary resuscitation, delivered by telephone
The Circuit	National defibrillator network
Utstein Comparator Group	Bystander witnessed out-of-hospital cardiac arrest presenting with a rhythm amenable to defibrillation

Chapter One: Introduction

1. Chapter Overview

This chapter introduces The IMARI Study and PhD thesis and sets out the importance of the research, the aims and objectives, the reasoning behind the research and the chosen methodology. The focus of my research is out-of-hospital cardiac arrest (OHCA) and the Emergency Medical Service (EMS – often called ambulance service in the United Kingdom) recognition and response to patients at imminent risk of OHCA.

This PhD thesis focuses on improving the recognition and response to patients at imminent risk of OHCA. This is important because OHCA is a catastrophic event requiring immediate intervention if a person is to have any chance of survival. When an EMS call is received regarding a patient who is in OHCA or at imminent risk of OHCA a crucial factor in the patient's survival is the recognition of the severity of the patient's condition. Early recognition by an Emergency Medical Dispatcher (EMD) working in an EMS (ambulance) system that a patient is critically unwell instigates the rapid dispatch of an EMS (ambulance) response. When a patient suffers an OHCA the initial minutes following collapse are critical[1]. Each second without resuscitation decreases that person’s chances of survival[5]. Early intervention by bystanders, guided by EMDs, is imperative and high-quality cardiopulmonary resuscitation (CPR) and bystander defibrillation are dependent on the EMD or bystander recognising that the patient is in OHCA[3]. This PhD thesis will make a novel contribution to the literature in meeting its aims and objectives.

2. Definition of out-of-hospital cardiac arrest (OHCA)

OHCA is defined as ‘the loss of functional cardiac mechanical activity in association with an absence of systemic circulation, occurring outside of a hospital setting’[4]. In simple terms it is when the heart stops beating, and blood no longer flows around the body, and it happens outside of a hospital. OHCA is a leading cause of mortality worldwide[5,6] and despite intensive efforts to improve survival rates from OHCA, they remain relatively unchanged[7]. In the UK survival rates from OHCA are 8.3% in England[8] and are further described in section 5.

A United States report by the Institute of Medicine[9] emphasised the national responsibility to improve the outcomes of patients who suffer an OHCA, this report is relevant worldwide. The report set out a framework which included eight evidence-based recommendation that included enhancement of the capabilities of EMS alongside robust cardiac arrest data collection and dissemination, improvement of the public response, updated national accreditation standards, continuous quality improvement, increases in research funding for resuscitation science research, speeding up the adoption of existing effective cardiac arrest therapies and establishing a new national cardiac arrest collaborative.

3. The chain of survival

The Chain of Survival in OHCA was initially described in 1988 and developed and adapted by the United States Sudden Cardiac Arrest Foundation in 1991. The design has been modified many times since 1991, but has remained unchanged in recent years. The Chain of Survival was published by the European Resuscitation Council in its current format in the 2005 Resuscitation Guidelines[10]. The Chain of Survival in OHCA illustrates the four key sequential and interconnected steps that when delivered effectively optimise the chances of survival from OHCA[11]. These four key steps illustrated in Figure 1 below are; Early recognition and call for help – to prevent OHCA; Early CPR – to buy time; Early defibrillation – to restart the heart and Post resuscitation care – to restore quality of life. These four stages are explained further below.

Figure 1. The chain of survival in out-of-hospital cardiac arrest [11]

(Reproduced with permission)

3.1. Early recognition and call for help

The first step in the Chain of Survival is the 'Early recognition and call for help – to prevent cardiac arrest'. Improving this important first step is the focus of this PhD thesis. In 2005 the Chain of Survival was revised to acknowledge the importance of recognising critical illness and/or angina and cardiac arrest prevention both in and out of hospital. Experts in the field hoped that this change would prompt earlier recognition of those people at high risk of imminent OHCA, with a subsequent early call for help and the opportunity to prevent the OHCA occurring, if treatment was given early enough[12].

The triage of emergency calls is an important part of the "Chain of Survival" in OHCA[13]. Patients who are identified during the EMS call as having had an OHCA, and those who are critically unwell and at imminent risk of OHCA, should always be allocated the fastest ambulance response (Category 1; target response time 7 minutes). EMDs are trained to assume that a patient is in OHCA, until proven otherwise. Computer Decision Support Software (CDSS) assists EMDs with the task of triaging EMS calls[13] and is further described in section 8.

Deakin[14] demonstrated that not all links in the chain of survival are equal in terms of the numbers progressing through each stage (Figure 2). The contribution of each link in the Chain of Survival decreases rapidly at each stage as the number of patients decreases with progression along the chain[10]. Improving the first link in the chain of survival - early recognition and call for help - has the potential to have the largest impact on survival for OHCA patients due to the larger number of patients at this first stage. Deakin[14] also recognised the potential for the numbers of patients at this stage to increase as recognition improves, resulting in improved patient survival and outcomes. This phenomenon enhances the importance and potential impact of this PhD thesis because improving the first link in the Chain of Survival in OHCA has the potential to benefit the most patients and even prevent the OHCA from occurring[14,15]. This view of the Chain of Survival helps to inform clinicians and researchers where there is the greatest potential to improve outcomes and to focus research[10].

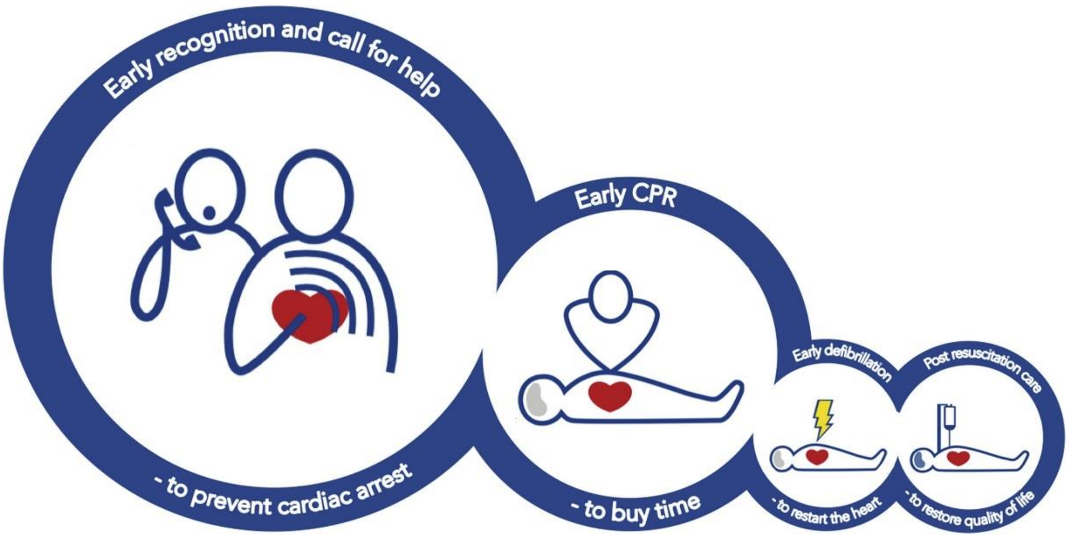

Figure 2. Chain of survival for out-of-hospital cardiac arrest; All links are not equal (Area ratios 1.0,0.47,0.12,0.12)[14] (Reproduced with permission)

3.2. Early CPR to buy time

Cardiopulmonary Resuscitation (CPR) is when a person presses up and down on someone's chest, and performs rescue breaths when that person is believed to have suffered an OHCA, in an attempt to help save their life[16]. Early CPR rapidly restores some blood flow to the heart and brain, and this is critical for survival. Bystanders play a very important role in initiating early CPR[17]. Dispatcher assisted CPR occurs when an EMD directs a caller to perform CPR by providing instruction and encouragement over the phone[18] . Dispatcher assisted CPR, also referred to as telephone CPR (tCPR), has improved rates of bystander CPR[19] and has been shown to improve survival from OHCA by 50% compared to no bystander CPR[20].

EMDs must firstly identify that the patient is in OHCA before instructing the caller how to perform tCPR. It is important that dispatcher assisted CPR is easy to describe and perform correctly; a speaker facility on the phone is very useful in allowing continuous instruction whilst the caller stays on the line[21]. Historically, callers have been reluctant to perform mouth-to-mouth ventilation on patients and there has been a move to instruct callers to deliver compression only CPR to reduce delays to the first chest compression. Compression only CPR has been shown to have better survival rates than standard CPR and is considered a valid alternative in the vast majority of OHCA situations[22–24]. The key to successful dispatcher assisted CPR is early recognition on the EMS call that that patient is in cardiac arrest. The emergency call-taker clearly has an instrumental role in maximising chances of survival in OHCA. Where EMS (ambulance staff) witness an OHCA they can recognise the OHCA and immediately perform effective CPR.

3.3. Early defibrillation to restart the heart

A defibrillator can be used where a patient presents with a cardiac rhythm that is amenable to defibrillation. A defibrillator can restore a patient's normal heartbeat by sending an electric shock through the heart[25]. Early defibrillation is vital to support survival from OHCA and the effectiveness of defibrillation diminishes with time, but timely defibrillation within 3-5 minutes of collapse can lead to survival rates of greater than 50%[26]. Widespread accessibility to defibrillators for use by non-medical volunteers has been found to triple the survival rate in OHCA[27]. When a patient is recognised as being in OHCA on the EMS call, the EMD will direct a caller to obtain a Public Access Defibrillator (PAD), if there is one close by.

3.4. Post resuscitation care to restore quality of life

Post-resuscitation begins immediately after a sustained return of spontaneous circulation (ROSC), this is when the heart restarts, regardless of location[28]. The Resuscitation Council UK Guidleines[28] state that adult patients with non-traumatic OHCA should be transported to a recognised centre of care for appropriate treatment and adult patients with OHCA with presumed cardiac cause should be transported to a hospital that can provide a coronary angiogram.

4. Epidemiology of Out-of-Hospital Cardiac Arrest (OHCA)

4.1. Incidence of out-of-hospital cardiac arrest

In England there are approximately 80,000 OHCA per year and approximately 31,000 of these patients receive a resuscitation attempt by EMS staff[26]. In terms of global figures, Berdowski and colleagues[5] reported an average incidence of 55 adult OHCA of presumed cardiac origin per 100,000 person-years. The incidence of OHCA increases with age and is more common amongst men[29]. The OHCA Overview in England (2020) reported that the sex distribution was 34% females and 66% males[30]. In terms of age distribution in England in 2020, 1.6% of OHCAs were in patients aged less than 15 years old, 39.5% of patients were aged between 15 and 64 and 58.9% of patients were aged 65 years, or over. Rates of OHCA increase with age exponentially in both sexes, apart from in the under-five age group[31]. The majority of OHCAs occur at home with 12.2% occurring in a public place[31]

4.2. Aetiology of out-of-hospital cardiac arrest

4.2.1. Cardiac causes

The majority of OHCAs have a cardiac cause[29] with studies indicating that between 70-85% of OHCAs fall into this category[32]. Cardiac disease is a common cause of OHCA with the predominant diseases being coronary artery disease (when a build-up of fatty substances blocks or interrupts the heart's blood supply) , or structural diseases such as cardiomyopathy (disease of the heart muscle)[33]. As many as 80% of individuals who suffer OHCA have coronary artery disease which increases with age and is more common in men[4]. Studies have indicated that patients dying from a reduction in oxygen to the heart predominantly present with a clot or a disruption to the fatty deposits in blood vessels supplying the heart[34,35]. It is important to consider that OHCA may be the first indication that a person is suffering with cardiovascular disease in as many as 50% of people dying from cardiac causes[33].

4.2.2. Non-cardiac causes

Cardiac arrests of a non-cardiac origin form up to 30% of all OHCAs[36,37]. Patients presenting with an OHCA with a non-cardiac cause are a heterogenous group[36] and can be further split into internal and external causes of OHCA. Internal causes include non-traumatic bleeding, pulmonary embolism, pneumonia, asthma and convulsions. External causes include trauma, choking and intoxication[37]. Engdahl et al.[38] studied non cardiac causes of OHCA over a 20-year period and found that patients in this group were younger, were more likely to be female and were less likely to have a history of cardiovascular disease. OHCA of a non-cardiac cause are also less likely to be witnessed and less likely to be found in a ventricular fibrillation rhythm (shockable rhythm), both of which are associated with lower rates of survival in this group.

4.3. Presenting cardiac rhythm

The presenting cardiac rhythm in OHCA determines the treatment that a patient receives in terms of defibrillation and medical treatments. The presenting cardiac rhythm in OHCA is also an important predictor of short-term survival with patients in a “shockable” rhythm likely to survive if they receive prompt defibrillation[39]. Patients with a “shockable” cardiac rhythm present in ventricular fibrillation or pulseless ventricular tachycardia. These two cardiac rhythms are amenable to defibrillation and have higher survival to hospital discharge rates than “non-shockable” rhythms (pulseless electrical activity or asystole) which are cardiac rhythms not amenable to defibrillation[40]. Where patients survive to hospital discharge, patients with a non-shockable rhythm have higher mortality in the initial four years following OHCA than patients presenting with a shockable rhythm.

In recent decades the proportion of patients presenting with a shockable rhythm has been shown to be in decline and this has been attributed to a reduction in shockable rhythms at the point of collapse, but also to delays in monitoring the rhythm with an electrocardiogram[39] leading to the degeneration of a shockable rhythm into a non-shockable rhythm. One hypothesis regarding the decline in shockable rhythms in cardiovascular disease is that primary and secondary prevention strategies have had a positive impact on heart disease and correspondingly reduced the incidence of shockable rhythms[41]. This decrease in patients presenting with a shockable rhythm is associated with a reduction in chances of survival and highlights the importance of an appropriate EMS response to collapsed patients and those at imminent risk of OHCA.

Patients presenting with a non-shockable rhythm can and do survive to hospital discharge, but this is considerably rarer than in those patients presenting with a shockable rhythm. Patients who present with an initial non-shockable rhythm can also convert into a shockable rhythm. Brown and colleagues[42] reported that 7.4% of patients presenting initially with asystole converted into a shockable rhythm and were defibrillated. Where patients presented with a non-shockable rhythm and were not defibrillated, 1.2% of patients presenting in asystole and 4.2% of patients presenting in pulseless electrical activity survived to hospital discharge.

4.4. Agonal breathing

Agonal breathing is a pattern of breathing that can occur just before, or at the time of OHCA and ceases gradually over a number of minutes[43]. Agonal breathing is common in the early stages of cardiac arrest and is often reported as slow, gasping or noisy breaths[44]. Reports suggest that paramedics witness agonal breathing in up to 50% of OHCAs they attend and that the phenomenon is more common in bystander witnessed OHCA[45]. Agonal breathing is associated with increased survival from OHCA[45]; it has a strong association with ventricular fibrillation arrest (shockable rhythm) and survival to hospital discharge[43]. Where agonal breathing is recognised quickly, leading to the initiation of chest compressions, the patient is likely to continue gasping, providing self-ventilations and enhancing survival[44].

Although the presence of agonal breathing has a positive association with survival from OHCA, the recognition of agonal breathing is problematic. The presence of agonal breathing confuses bystanders and is linked to misinterpretation of a patient's breathing status during an EMS (999) call. OHCA often goes unrecognised where a patient presents with agonal breathing. When an EMD investigates the breathing status of a patient who is agonal breathing on the EMS call, the patient is often reported as breathing, but abnormally. The recognition of agonal breathing by EMDs on the EMS call has improved, but remains problematic. There are a number of different terms used by bystanders to describe agonal respirations[43]; snoring, wheezing, gurgling, weak breathing, laboured breathing, occasional breathing, irregular breathing, difficult breathing, poor breathing, impaired breathing and noisy breathing have all been described[45,46]. The confusion that agonal breathing creates can prevent the recognition of OHCA by the EMD and delay lifesaving actions such as tCPR and bystander defibrillation, detailed in the "chain of survival" in Section 3[44] . The identification of agonal breathing on the EMS call continues to be problematic and a key cause of failure to recognise OHCA during an EMS call[47].

4.5. OHCA witnessed status

Ambulance service witness status is also a predictor of survival. An OHCA can be unwitnessed, witnessed by EMS (ambulance staff) or witnessed by bystanders.

4.5.1. EMS witnessed OHCA

When a patient suffers an OHCA in the presence of EMS (ambulance staff) they receive early treatment (CPR and defibrillation) and have a relatively high chance of survival. In England in 2020 EMS personnel witnessed 13% of OHCA[48] and survival rates in EMS witnessed OHCA have been reported to be as high as 21.8%[49]. A study by Axelsson and colleagues[49] identified that in EMS witnessed OHCA 51% of patients were found to be in a shockable rhythm despite a lower proportion of patients presenting with a presumed cardiac cause and this will be because the cardiac rhythm was assessed early in the collapse. These factors really emphasise the importance of early EMS recognition and response to patients at imminent risk of OHCA.

4.5.2. Bystander witnessed OHCA

In 2020, 50.2% of OHCAs in England were witnessed by a bystander and 5.3% of bystander witnessed OHCAs survived to hospital discharge or 30 days[48]. The best outcomes for bystander witnessed OHCA are achieved where the OHCA occurs in a public place with numerous bystanders, easy access to a PAD and a fast EMS response. A study in an airport in Denmark found that in this setting 56.5% of patients survived to hospital discharge when they suffered a bystander witnessed OHCA. This compared to a survival rate of 14.1% of bystander witnessed OHCA surviving in the Danish Cardiac

Arrest Registry and 45.2% of patients surviving who suffered an OHCA in a public place in Denmark. The figures from Denmark emphasise that improvements can be made in the UK in this group of patients to enhance survival. The difference in survival between EMS witnessed and bystander witnessed OHCA highlights the importance of the EMD, tCPR and PAD in the first links in the chain of survival.

4.5.3. Non-witnessed OHCA

The Out-of-Hospital Cardiac Arrest Outcomes (OHCAO) Registry, an OHCA registry maintained by Warwick Univeristy[50] identified that in 2020 36.8% of OHCAs were unwitnessed and 1.3% of unwitnessed OHCA events survived to hospital discharge or 30 days[48]. In unwitnessed OHCA the chain of survival cannot be activated unless EMS is contacted, and the critical nature of the situation is recognised. Improving survival in this group relies on early reporting of warning symptoms prior to the patient's collapse. Where an EMS call is made by these patients, improving the recognition that these patients are at imminent risk of OHCA is imperative to improve their chances of survival. Technology such as wearables, mobile devices and artificial intelligence technology have the potential to be used to activate the Chain of Survival in this patient group[51].

4.6. Bystander interventions

4.6.1. Bystander CPR

Early bystander CPR in OHCA is of vital importance if the patient is to have any chance of survival[52,53]. There is evidence that bystander CPR can improve the chances of survival in OHCA between twofold and fourfold[15,54]. The time to initiation of bystander CPR is critical; EMS rarely reach a patient who has collapsed due to OHCA in time to initiate lifesaving CPR in the first few minutes after OHCA[15]. Where a patient suffers OHCA and is in a rhythm amenable to defibrillation, every one minute delay in CPR decreases survival by 7-10%[53].

Rates of bystander CPR differ substantially between countries. The proportion of OHCA patients receiving bystander CPR range from 5-20% in most countries to 60-80% in some countries[55]. Current rates of bystander CPR in the UK have been found to be as low as 40-50% which is significantly lower than Norway, which demonstrates bystander CPR rates of 73%[15]. In 2018, World Restart a Heart Day was launched with the aim to empower as many bystanders as possible to perform chest compressions where they witness an OHCA[55].

The 2013 Cardiovascular Disease Outcomes Strategy is best practice guidance aiming to improve outcomes from cardiovascular disease. Included in the strategy is a goal to improve outcomes from OHCA by improving rates of bystander CPR. There is also a belief that improvements in bystander CPR will in turn have a positive impact on the 'early call for help' in the first link in the chain of survival through better education of lay people [15]. There was positive news in January 2019 when the UK government announced that CPR and first aid training were to be included in the national school curriculum following a campaign from the Resuscitation Council UK[56] . This change will improve awareness and skills and will undoubtedly save lives [56]. The NHS Long Term Plan[57] states that a national network of community first responders will help to save up to 4000 lives a year by 2028. This target will be supported by education of the general public in recognising and responding to OHCA.

4.6.2. Bystander defibrillation

In OHCA, one of the most critical factors in determining survival is early debrillation[46] and for every minute defibrillation is delayed, survival decreases by 10%[58]. Approximately 80% of OHCAs occur in the home, with 20% occurring in public places and early use of PAD needs to occur more frequently[59]. PAD use in England is reported to be 5.4% in bystander witnessed cases of OHCA and 4.6% in unwitnessed cases of OHCA[48]. Low use has been attributed to a lack of bystander confidence related to the location of PADs and how to use them. The implementation of a PAD programme in the UK has the potential to double survival from OHCA, but such programmes also require an effective community response[58]. In the UK there are plans to facilitate a national database of PADs and to integrate it with mobile phone technology so that EMDs can easily direct members of the public to the nearest PAD[15]. The Circuit is a national defibrillator network linked to ambulance services across the UK. The Circuit has been initiated by the British Heart Foundation, Resuscitation Council UK, St John Ambulance and the Association of Ambulance Chief Executives to register PADs on a national database[60] and it is hoped that the registration of thousands of ‘unknown’ PADs will improve their use in the community when a patient suffers an OHCA and consequently improve survival.

5. Clinical outcomes in OHCA

5.1. Utstein comparator group

An important comparator group for survival in OHCA is the Utstein comparator group. Utstein reporting originated following a multidisciplinary meeting of experts in the Utstein Abbey, Stavanger, Norway in 1990 and is known for establishing consensus in reporting for resuscitation[61]. The Utstein guidelines allow uniform reporting of data relevant to resuscitation[62]. The Utstein reporting templates provide a structured framework to compare systems of care for OHCA[63]. The aim of uniform reporting in OHCA is to allow comparisons between EMS systems, an understanding of the epidemiology of OHCA and to drive quality improvement and research[61]. Ideally Utstein reporting would compare OHCA of a cardiac origin, where the initial rhythm is a shockable rhythm and the OHCA was witnessed by a bystander. This was because it was agreed that a comparator should be robust in its endpoint and eliminate variables that influence outcome as far as possible[62]. However, there are difficulties in separating OHCA of presumed cardiac origin from other causes of OHCA. Because of this, the recommended primary reporting by EMS systems should state the outcomes of all EMS-treated OHCA, measuring system effectiveness, and also those that are bystander witnessed and where the first monitored rhythm is shockable, measuring system efficacy[61].

5.2. OHCA survival

OHCA will always lead to death unless rapid action is taken[64]. As a consequence, survival rates in OHCA are poor and survival to hospital discharge following OHCA varies globally with 11.7% of patients surviving to hospital discharge in Europe compared to 4.5% of patients in Asia[65]. There are EMS systems internationally with higher survival rates from OHCA. Survival rates in Holland and Norway are 21% and 25% respectively[66] and King County, Seattle is widely reported to have the highest OHCA survival rates internationally. In 2018 King County, Seattle reported 21% of patients surviving who suffered an OHCA before EMS arrival and 29% surviving who suffered an OHCA after EMS arrival. In the same year, the Utstein comparator group in King County, Seattle had a survival rate of 56%[64].

The OHCAO epidemiology report produced in 2020 indicated that the survival to discharge rate for OHCA in England was 8.3% for all cause cardiac arrests and 25.3% for the Utstein comparator group. Myat and colleagues[4] report systems committed to quality measures can achieve an all-rhythm survival of 12% and an Utstein survival of 35%; substantially higher than current figures in the UK.

In terms of EMS response, Holmen and colleagues[67] found that survival to 30 days after a witnessed OHCA decreased as EMS response time increased; this finding was independent of presenting cardiac rhythm and whether CPR was performed prior to EMS arrival. These findings are corroborated by Huang and colleagues[68] who conducted a retrospective registry study investigating response time threshold for survival to hospital discharge following OHCA under different conditions. The optimal time for survival to discharge was found to be 6.2 minutes. Where a patient was in a public area the threshold was extended to 7.2 minutes and where there was bystander CPR the threshold was 6.3 minutes. These studies indicate that EMS response time to OHCA is closely related to patient survival.

5.3. Data collection

Until recently, in England each ambulance service in the UK has collected data for audit purposes and there has been no national surveillance system in OHCA to establish the burden of the disease, to identify factors that may increase survival and assess quality improvement strategies[48]. The Out of Hospital Cardiac Arrest Outcomes Project (OHCAO Project) is hosted by the University of Warwick; the focus of the project is an OHCA registry and the aim of the project is to collect data from English ambulance services to establish the epidemiology and outcomes of OHCA[50]. The OHCAO Project publishes annual epidemiology reports for England which can be found via the research website: https://warwick.ac.uk/fac/sci/med/research/ctu/trials/ohcao/.

The OHCAO Project is driven by the fact that differences in the way data is collected can substantially impact on reported outcomes. Rates of OHCA survival are derived by the number of people that survive divided by the number of resuscitation attempts. Exploratory work in the UK found five different ways in which UK ambulance services identify cases of OHCA. Some services only include cases dispatched as OHCA and do not include 'missed' cases[50]. Berdowski and colleagues[5] on investigation of the global incidence of OHCA reported a tenfold global variation in the reporting of incidence and outcomes of OHCA. The researchers recognised that there are international differences in the way that OHCA cases are defined alongside diverse EMS systems and differing research methodologies used between studies. These factors will lead to artificial differences between study findings, but true differences will also exist.

The Utstein comparator group (bystander witnessed, ventricular fibrillation OHCA) allows for some adjustment in case mix, but it is likely that this only accounts for 40% of the variation[69]. There are many other variations in case mix; age, sex, body mass index, to name a few. In addition to case mix, there are also structural factors to consider, e.g. community initiatives, PAD uptake and also process variables such as EMS response time and time to first shock alongside individual variables such as CPR quality[50]. The OHCAO Registry is continuing in its second stage, the prospective collection of cases of OHCA and is collecting OHCA data on patient information, patient characteristics, event data/clinical information, EMS response variable/interventions and outcome variables and is focused on developing a reliable and reproduceable system for collecting OHCA data in the UK[70].

There are other OHCA registries around the world, such as the Resuscitation Outcomes Consortium (ROC) Cardiac Epidemiologic Registry[71] based in North America. There have also been studies such as EuReCa Two[72] that compares results from international European registries using the Utstein Template to detail epidemiology and outcomes of OHCA in Europe. OHCAO is a positive initiative in the UK that has potential to provide surveillance and support research to improve outcomes for OHCA.

6. Previous initiatives to improve the recognition and response to OHCA

There are ongoing initiatives to improve survival from OHCA. Europe is adopting a system level approach to OHCA emphasising the interconnectedness between communities and EMS, with every step in the system being important. "Systems saving lives 2021"[10] emphasised the following aspects; Raising awareness about the importance of CPR and defibrillation; Use of technology to engage communities; Kids save lives; Cardiac arrest centres; Dispatch assistance during CPR[10]. King County Seattle describe the treatment of OHCA as "the ultimate team sport" which includes laypeople, telecommunicators, law enforcement and EMS personnel[64].

6.1. The Ambulance Response Programme

Previous initiatives to improve the recognition and response to OHCA in the UK include the Ambulance Response Programme (ARP) initiated in 2015 that aimed to review ambulance response performance standards, reduce operational inefficiencies and improve the quality of care for patients[73]. ARP incorporated Dispatch on Disposition (DoD) which modified the call handling process so that the most urgent calls could be recognised immediately and extra time could be allowed to support targeting the right resource to the right patient[73]. Part of DoD was the introduction of a set of initial Pre-Triage Questions (PTQ) and Nature of Call identification (NoC) at the very start of the EMS call triage. The aim of the PTQ and NoC was to identify patients with immediately life-threatening conditions so that an appropriate resource could be dispatched immediately. Patients who have suffered an OHCA and patients who are at imminent risk of OHCA would clearly fall into the category of patient that require immediate identification by the EMD so that an optimal ambulance response can be initiated. The PTQ focus on establishing the status of a patients' breathing and consciousness and are illustrated in Figure 3 below. An EMS call designated a Category 1 response (7-minute response target time) is the quickest ambulance response. As illustrated in Figure 3, if a patient is not breathing, or is not awake and with noisy breathing then a Category 1 response is immediately initiated. The third PTQ focused on noisy breathing is designed to recognise those patients that are agonal breathing early in the EMS call.

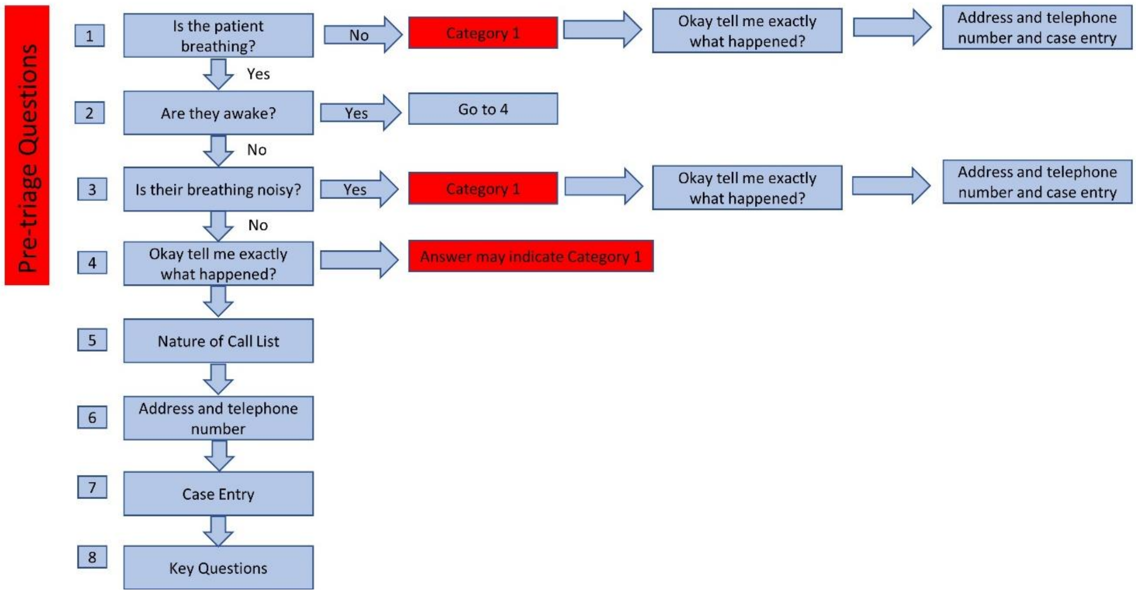

Figure 3. Pre-Triage Questions

At step 5 in Figure 3 is the NoC list. The NoC list includes a predefined list of problems that are likely to indicate critical illness. Where a patient is identified as suffering from a condition in the NoC list, they are allocated a Category 1 response.

ARP identified that OHCA is a rare event with only 0.6% of EMS calls for a patient in OHCA and only 8% of EMS calls identified as OHCA being for patients in OHCA. Data analysis during ARP indicated that 70% of OHCA received a Category 1 response and 91.6% a Category 1 or Category 2 response, but accurate pre-ARP data was not available for comparison. Staff surveyed during ARP did comment that NoC was working to identify patients just about to go into OHCA, but also that many calls for unconscious and noisy breathing were for intoxicated people[73].

The British Heart Foundation have initiated a “Call Push Rescue Programme” that enables teachers, leaders and volunteers to train secondary school children in CPR. This initiative has grown in scope and now there is an annual Restart a Heart Day where key stakeholders in resuscitation raise awareness about OHCA and educate people in first aid and CPR[74].

6.2. Smartphone Apps

In the UK there has been ongoing adoption of mobile phone applications such as GoodSAM[75] (GOODSAM Limited, London) to alert nearby trained volunteers to OHCA. When an EMD suspects OHCA, a relevant response code is applied to the patient, and this can automatically alert a volunteer via the GoodSAM app (GOODSAM Limited, London) that there is a patient in OHCA nearby. The volunteer can then choose to accept the alert and respond to that patient to provide initial first aid. Where a trained volunteer accepts an alert from GoodSAM (GOODSAM Limited, London) there is improved survival to hospital discharge, however alert acceptances are low and there is an opportunity to increase the number of GoodSAM (GOODSAM Limited, London) volunteers[76] to maximise the impact of this technology.

6.3. The Circuit

In section 4.6.2 I described the ongoing initiative by a collaboration between the Association of Ambulance Chief Executives, Resuscitation Council UK and St John Ambulance which aims to register all PADs on a national defibrillator network and connect PADs to NHS services[60].

7. Patients at imminent risk of OHCA

The majority of the focus in the literature relating to EMS recognition and response to OHCA relates to patients already in OHCA, and/or agonal breathing when the EMS call is made and not to patients who are not yet in OHCA, but suffer an OHCA before they reach hospital. The Chain of Survival in OHCA identifies the importance of the recognition, during the EMS call, of patients who are at imminent risk of OHCA so that EMS staff can be dispatched to arrive as quickly as possible to either treat the cardiac arrest as soon as it occurs or, better still, prevent it from happening through the provision of early treatment[15].

There is little known about the symptoms of patients who are at imminent risk of OHCA when EMS is contacted. Research indicates that patients contacting EMS within 0-7 days prior to OHCA mostly present with ‘Other’ symptoms (30%), indicating diverse symptoms, followed by Central Nervous System issues/unconsciousness(17%) and breathing problems (11%)[77]. Another study by Nishiyama and collegaues[78] identified that 40% of victims of OHCA displayed symptoms prior to their arrest. In OHCA of cardiac origin the most frequent symptoms prior to OHCA were breathing problems, followed by chest pain and fainting. In OHCA of non-cardiac origin the most common symptoms prior to OHCA were breathing difficulties with chest pain rarely presented. In this study early contact with EMS was associated with better neurological outcomes.

Nehme and colleagues[79] looked at the specific group of EMS witnessed OHCA of presumed cardiac cause. Of the 515 patients included, 41.5% complained of breathlessness and 29.2% with arm, or shoulder pain prior to collapse. Delays in activating EMS following the onset of symptoms was associated with a reduction in patient survival. These findings corroborate the findings of Nishiyama and collegues[78]. The authors recognised the requirement for public health campaigns that encourage patients to contact EMS as soon as they begin to display prodromal symptoms.

When a patient at imminent risk of OHCA presents to EMS, the challenge is to recognise that the patient is at imminent risk of OHCA. The PTQ detailed in Section 8.2.1 are focused on those patients in OHCA already, or those patients agonal breathing. The NoC list is more useful for identifying those patients at imminent risk of OHCA. When an EMD does recognise a critically unwell patient during the call, they should be able to use the CDSS to allocate a Category One response. Part of this response may be for a community first responder to attend the address of the incident to offer first aid prior to the arrival of the ambulance. In addition, the EMD can maintain contact with the patient or caller whilst the ambulance is en route and guide the caller to assist the patient and, if necessary, provide tCPR instructions over the phone. This offers critically ill patients, and patients who deteriorate into cardiac arrest, the best possible chance of survival[3].

8. Description of EMS organisation and response to OHCA

8.1. Recognition and response to OHCA by Emergency Medical Dispatchers (EMDs)

The EMS Dispatch team have multiple roles as the first EMS contact for a patient in OHCA. These roles include recognising the OHCA, or imminent OHCA, triaging the EMS call appropriately, dispatching an emergency ambulance with a defibrillator, instructing a bystander to retrieve a PAD and supporting bystanders to perform tCPR through the use of approved pre-arrival instructions[46].

Recognising OHCA and imminent OHCA on the EMS call is challenging and a systematic review by Vaillancourt and colleagues[80] found that enquires into patient breathing and consciousness status gave a moderate sensitivity for OHCA recognition of 38-97% and a high specificity of 95%-99%. Watkins and colleagues[81] found that in some cases symptoms of OHCA are described, but not acted on by the EMD. The following sections will describe the way the EMS call is processed.

8.2. The EMS system for triaging EMS calls

8.2.1.Dispatch Systems

Internationally EMS use different systems for managing EMS (999) calls and dispatching response vehicles (ambulances). In the majority of systems the EMD uses scripted telephone triage to assess and categorise the EMS call [21]. Anglo-Saxon countries tend to use a system called Advanced Medical Priority Dispatch System (AMPDS) which is a scripted protocol guiding the EMD through key questions regarding the patient's condition[82]. A system called Criteria-Based Dispatch (CBD) is utilised in Nordic and European countries[83,84] and is used by registered clinicians that can navigate guidelines and prompts allowing more freedom and the application of professional experience[82].

In the UK there are two dispatch systems used and these are NHS Pathways and AMPDS. NHS Pathways is a CDSS owned by the Department of Health and social Care and the system is an interlinked series of algorithms that connect clinical questions and care advice. Non-clinicians triage the calls based on the answers given by the caller and an appropriate clinical response is initiated[85]. AMPDS is an international dispatch system developed in the United States. AMPDS consists of 36 protocols and EMDs use scripted caller interrogation based around these protocols to provide symptom based information to prioritise calls[86]. In both AMPDS and NHS Pathways the scripted triage begins by asking the caller about breathing and consciousness so that OHCA can be identified as a priority at the earliest possible stage in the EMS call.

The planned research will be completed in ambulance trusts that use AMPDS, and a more in-depth description of the process is detailed here. AMPDS uses a set of key questions, pre-arrival instructions and dispatch priorities which are set out in algorithms. It is the role of the EMD to use AMPDS to triage the EMS call. The reported advantage of using AMPDS is that it reduces reliance on the judgement of the EMD and reduces bias and errors by using a structured script. The use of AMPDS is reported to allow easy audit of the process and reduces stress on EMDs[84] .

In the UK when a caller contacts the EMS (ambulance service) for a patient in OHCA the call is answered by a general call centre who then puts the call through to a specific EMS call-centre. In the EMS call centre, also known as the Emergency Operations Centre (EOC), the call is handled by an EMD who triages the call[87]. In the UK EMDs are non-clinically trained members of the EMS team who receive training on first aid, advice giving and the CDSS. The objective is for the EMD is to use the information gained on the telephone call to identify which category of response is required, at what priority that resource should be dispatched and to provide first aid advice. The challenge here is to allocate limited EMS resources whilst at the same time ensuring the safety of patients[83].

During the EMS call taking process the EMD takes the caller through a scripted dispatch protocol beginning with the PTQ focused on identifying patients in OHCA[88] and illustrated in Figure 3. The EMDs must comply with the dispatch protocol as it is a licensing requirement. If the patient is assessed as being in OHCA during the PTQ a category one response (mean 7-minute response time) is automatically allocated, and the address details are taken. The EMD proceeds to ask the caller the reason for the call. Where the incident has not been allocated a category one response and the caller then indicates that the patient is critically unwell the EMD can quickly allocate a category one response using NoC. The EMD continues to take the caller through a structured series of questions which are dependent on the reason for the call; during this phase the EMS call is categorised, if it has not been already. Following triage, the EMD can stay on the line and monitor the patient, or they may disconnect the call ready to triage another EMS call.

8.3. Response times

In the UK EMS calls are categorised to one of five categories, Category one being the fastest ambulance response:

- Category 1 – Calls from people with life-threatening illnesses of injuries (average response time 7 minutes)
- Category 2 – Emergency calls (average response time 18 minutes)
- Category 3 – Urgent calls (average response time 90% within 120 minutes)
- Category 4- Less urgent calls (average response time 90% within 180 minutes)
- Category 5 – Hear and treat

Allocation of the fastest ambulance response to a critically unwell patient and those who are in need of resuscitation does not always occur. In 2018/19 London Ambulance Service allocated 76.1% of patients who suffered an OHCA the highest priority ambulance response (Category 1), 19.8% the second highest priority response (Category 2) and 4.1% a lower priority response (Category 3, 4 or 5)[89]. Similarly, scoping work, completed in 2016, that reviewed calls in South Western Ambulance Service NHS Foundation Trust (SWASFT) found that approximately 27% of patients who subsequently deteriorate and suffer an OHCA, who are alive when the EMS call is made, receive a lower priority ambulance response than Category 1. If these patients could be identified more effectively during the EMS call, then these individuals who are critically unwell and at imminent risk of OHCA would receive a Category 1 response, saving lives and improving patient outcomes.

Studies have indicated that call triage in EMS may trigger a suboptimal response to some patients with life threatening conditions[90]. Previous observational research has highlighted communication problems between the caller and EMD attributable to the emotional state of the caller, confusion over medical terminology and the EMD talking too quickly and without clarity[91]. Any miscommunication during the EMS call will interfere with the activation of the optimum ambulance response to that patient. A previous conversation analysis and linguistic analysis study of EMS calls completed in Australia aimed to improve the identification of patients already in OHCA. Findings indicated that changing the wording of a key question to: “Tell me exactly what’s happened?” instead of “What happened?” in the dispatch protocol, changed the response of the caller so that they gave an informative short report rather than using a longer narrative format. A short report format of dialogue is preferable for EMDs because it allows them to prioritise the call in a more timely manner[92].

9. Knowledge gap addressed by this PhD thesis

The initial link in the chain of survival; the 'early recognition and call for help – to prevent cardiac arrest' is the element of the chain of survival that has the potential to benefit the most people[14]. In the existing literature there is a focus on patients who are already in OHCA at the time of the EMS call and recognising these patients as effectively as possible[80,93,94]. There is little focus on patients who contact the EMS service who are not yet in OHCA and then proceed to suffer an OHCA before they reach hospital.

Patients who are not yet in OHCA at the time of the EMS call have a higher chance of surviving the OHCA. As described previously, initial OHCA survival is focused on early CPR and defibrillation where a patient presents in a shockable rhythm. Recognising that a patient is at imminent risk of OHCA before they suffer the OHCA provides critical minutes for an EMS resource to be dispatched and reach the patient before they progress to OHCA. This substantially increases the patient's chance of surviving their OHCA, or may even prevent the OHCA from happening in the first place. When an EMD recognises that a patient is at imminent risk of OHCA they can categorise the patient as requiring the fastest ambulance response, a category one response (mean 7-minute response time). The EMD can also stay connected to the caller on the telephone so that if the patient does suffer an OHCA on the EMS call they can coach the caller to provide tCPR and direct the retrieval of a PAD, if appropriate. The EMD can also instigate a community first responder to attend the scene to provide initial first aid before the ambulance arrives.

Little is known about the epidemiology of patients who suffer an OHCA after the EMS call is connected and little is understood concerning the recognition and response to this patient group and how it can be improved. There is an opportunity to improve outcomes from OHCA through understanding how EMS can recognise these patients more effectively, enabling the provision of an optimum ambulance response. This PhD thesis aims to address this gap in the literature to inform future studies and guidelines.

10. Aims and objectives

10.1. Aim

The overarching aim is to contribute to improving outcomes in OHCA by improving the recognition and response for patients who are at imminent risk of OHCA. The more focused aim for this research is:

To understand how to improve the early identification of patients contacting Emergency Medical Services who are at imminent risk of cardiac arrest, in order to provide the most timely and effective response possible, thereby reducing mortality and improving clinical outcomes in this high-risk patient group.

10.2. Objectives

- Objective A: To complete a systematic review of primary research investigating the features of an EMS call interaction that facilitate EMD recognition of patients who are in OHCA, or at imminent risk of OHCA.
- Objective B: To understand the current EMS emergency call triage, EMS response and survival of patients at imminent risk of OHCA.
- Objective C: Conversation Analysis of the EMD and caller interaction on the emergency call to identify call features that may facilitate recognition of patients who are critically unwell and at imminent risk of OHCA.
- Objective D: To conduct focus groups and interviews with Emergency Operations Centre employees to gather and understand their views on how the findings of this PhD thesis can be used to improve the recognition and response to patients who are at imminent risk of OHCA.

11. Overall methodological approach

Four research objectives have been identified and each objective will be addressed sequentially using methodologies appropriate for each research question. The Discussion in Chapter Six synthesises the four research objectives as a whole to generate new knowledge and insights.

11.1. Objective A: Systematic Mixed Studies Review

Objective A (systematic mixed studies review) will investigate theory from the literature regarding patients who are at imminent risk of OHCA and patients already in OHCA at the time of the EMS call and the EMS call interaction.

11.2. Objective B: Retrospective Observational Study

Objective B (data analysis) stems from a positivist philosophy of science. This objective will use a hypothetico-deductive method to investigate hypotheses[95] and identify explanatory associations or causal relationships. The ontology is that a single tangible reality exists, and this reality can be understood, identified, and measured. The epistemology is that knowledge is developed objectively; there is absolute separation between the researcher and the data, referred to as dualism[95].

11.3. Objective C: Conversation Analysis (CA) of EMS calls

The method of CA was chosen over discourse analysis because CA examines the organisation and ordering of talk in interaction and examines language as social interaction whereas discourse analysis is concerned with the variation in language use and the context of language production and the functions it performs[96]. Discourse analysis is employed to understand the meaning of what people say and how they say it[97]. My research is concerned with the structure of the EMS call and the order of the verbal interaction related to it. CA is concerned with how order is created and sustained on a micro interactional level and the 'how' of participant interaction; because of this it is the method suitable to meet Objective C of my research[98].

CA is an approach that studies human interaction and an underlying assumption is that language is a co-present interaction with a structure that has adapted to its environment; interaction is the arena for human action[99]. CA is inspired by ethnomethodology and is usually treated as a self-sufficient approach to studying the world. CA has two areas where there is a clear conflict with alternative approaches. Firstly, CA rejects that psychosocial features can be attributed to human behaviour and secondly it asserts that what people say about the world can be relied on for analytical purposes[100]. Actors are viewed by conversation analysts as acting in a way that does not relate to anything specific about them; they do what any actor would, or could, do. CA relies on the analysis of transcribed talk rather than any exploration of the orientation of actors[100].

11.4. Objective D: Interviews and focus group

Objective D (interviews) is based in the paradigm of social constructivism. Like positivism, social constructivism employs observations to gather information, but in social constructivism the researcher is a part of what is being observed[101]. Reality is constructed through human behaviour; social constructionists acknowledge that "truth" varies, is socially constructed and is ever-changing. People create their reality and social context and interaction frame peoples' realities[102]. In terms of epistemology, constructivists believe that knowledge is something that is socially constructed and that truth lies within the human experience; findings are culturally bound and context dependent[103].

My thesis is based around four objectives which detail a series of interlinking studies that use different research paradigms to answer distinct research questions. The synthesis of these four objectives brings together the findings from the different approaches utilised to generate new knowledge concerning the issue of improving the EMS recognition and response to patients at imminent risk of OHCA.

12. Research governance and ethics

The sponsor for the research was South Western Ambulance Service NHS Foundation Trust. Health Research Authority (HRA) approval was sought for Objectives B-D and approval was granted on 20th September 2019 and included in Appendix 10 An HRA amendment was sought in March 2021 and approval was granted and included in Appendix 10. This amendment was to allow for the interviews in Objective D to take place virtually, as well as face to face and was a change made to accommodate the COVID-19 pandemic. NHS ethical approval was not required for this study. Confirmation of Capacity and Capability was sought from participating NHS Trusts and was granted and included in Appendix 10. As a PhD candidate of University of the West of England (UWE) I was required to obtain UWE ethical approvals and full ethical approval was granted on 22nd June 2020 is included in Appendix 10.

The most prominent ethical issues in this research were the potential for the transcription of the EMS calls to cause distress to the transcriber in Objective C. To mitigate this risk I was very clear with the transcriber regarding the content of the calls and the potential for distress. An agreement was in place where the transcriber would make contact if the content of the audio recordings caused distress. In addition, I checked in with the transcriber after each transcribed call to check whether any distress was caused. The transcriber did not report distress, but if they had I would have been able to signpost them to well-being services within SWASFT, or UWE.

An additional risk was the potential for interviewees to become distressed during the interviews in Objective D when reflecting on emotive EMS calls. The Participant Information Sheet highlighted the risk of taking part in the study and signposted individuals to their NHS Trust research teams in the first instance so that staff could be directed to their individual NHS Trust's health and well-being support teams. During the research there were no reports of any individuals becoming distressed due to their participation in this research.

13. Patient and Public Involvement

Patient and Public Involvement (PPI) in research is research that is done 'with' or 'by' the public. People with the relevant experience contribute to the design, conduct and dissemination of research[104]. The effectiveness of PPI is best when patients who have experience of the condition being studied are involved as research partners[105]. This is potentially challenging in OHCA as the vast majority of patients that suffer an OHCA do not survive. In my case I was fortunate to have access to two PPI groups where there were members who had experience of OHCA, or experience assisting someone who had suffered an OHCA. The UK Standards for Public Involvement centre around six main elements: Communications; Governance; Impact; Working Together; Support and Learning; Inclusive opportunities[106]. The idea is that researchers do not have to consistently meet these standards, rather that they are improving and working towards these standards.

In the planning phase of this research, I formulated a South Western Ambulance Service Patient Involvement in Research Group consisting of 13 people. The group developed and supported this work as well as other ambulance related projects. In addition to this group the project has benefitted from access to a well-established group of OHCA survivors and their close friends/relatives, based in Bristol who have also supported this project since the initial planning stages. Both PPI groups have contributed to the design, analysis, presentation, and dissemination of the work. In addition to these groups, at times I have been fortunate to receive input from an ambulance research group attached to Sheffield University. The PPI groups recognise the importance of this work in improving the chain of survival in OHCA and improving the chances of survival where patients are at imminent risk of OHCA.

13.1. Design

This research was a long time in the planning stage. My PPI contributors provided their experiences of accessing EMS in the context of OHCA and provided a valuable perspective from personal insights. The members assisted with simplifying the use of technical language so that I was able to explain my planned research in a way that audiences not expert in the field of OHCA could understand. They also provided their expertise in writing for the 'lay' audience and this input was invaluable.

There were some ethical issues associated with my planned research that I was wary that members might not fully support. My data in Objectives B and C consisted of data relating to anonymised OHCA patients and OHCA EMS calls. I was concerned that the members might object to the use of anonymised data in this context. However, the members were very supportive as they understood the value of the research and were committed to supporting the improvement of outcomes in OHCA.

13.2. Analysis

At each stage of my research, I was able to discuss the ongoing analysis with PPI members. Members had been involved with the data analysis planning, so no changes were made to this aspect; rather members fed back on the way data analysis was presented so that it was clear and visually acceptable. Graphs and tables were redrafted following members' comments. Also, any information was checked with members for understanding and revised following any feedback.

13.3. Dissemination

Members have reviewed and supported the development of clear dissemination materials. The main element that the PPI members assisted with was the design of a short film describing the research and the outcomes to date. Members watched the film and fed back about the timings in the film and accessible content and terminology used. The film was revised several times in response to comments. This process is likely to continue as I add more aspects of the study to the film and ask members to review it.

14. Guide to the thesis

The following chapters present each element of the research individually and concludes with a discussion chapter that synthesises the research findings together as a whole. Chapter Two (Objective A) presents the Systematic Mixed Studies Review (SMSR) which focuses on investigating the features of an EMS call interaction that facilitates EMD recognition of patients who are in OHCA, or at imminent risk of OHCA. Chapter Three (Objective B) presents the retrospective observational data analysis of cardiac arrest registry data linked to computer aided dispatch data to provide an understanding of the current EMS emergency call triage, EMS response and survival of patients at imminent risk of OHCA. Chapter Three (Objective B) also identifies the two cohorts of OHCA patients to be used in Chapter Four (Objective C). These cohorts of patients are: cohort one; those that were triaged as requiring the highest priority EMS response (Category 1), and cohort two; those that were triaged as requiring a lower priority EMS response (Categories 2-5).

Chapter Four (Objective C) proceeds to present the findings of the conversation analysis of the EMD and caller interaction during the EMS call to identify call features that may facilitate recognition of patients who are critically unwell and at imminent risk of OHCA. Chapter Five (Objective D) reports the findings from interviews and a focus group with employees from the Emergency Operations Centre of two English EMS (ambulance services) that aimed to understand their views on how the findings of this PhD thesis can be used to improve the recognition and response to patients who are at imminent risk of OHCA. Finally, Chapter Six, the discussion chapter, synthesises the body of research and clearly demonstrates the contribution of this thesis, building on existing literature to identify new findings and areas of knowledge. Chapter Six also considers the strengths and weaknesses of the thesis, and makes recommendations for further research in this field.

15. Chapter summary

This chapter describes the background to OHCA and the opportunities to improve outcomes. I have set out the importance of my planned research focussed on improving the EMS recognition of, and response to, patients who are at imminent risk of OHCA to improve survival. My second chapter will report the findings from my first piece of original research, a systematic mixed studies review investigating the features of an EMS call interaction that facilitate EMD recognition of patients who are in OHCA, or at imminent risk of OHCA.

Chapter Two: A systematic mixed studies review of the literature focused on features of Emergency Medical Service calls that facilitate or inhibit Emergency Medical Dispatcher recognition that a patient is in, or at risk of, cardiac arrest

1. Chapter Overview

In this chapter I review the evidence focused on the features of Emergency Medical Service (EMS) calls that facilitate, or inhibit the Emergency Medical Dispatcher (EMD) in recognising that a patient is either in out-of-hospital cardiac arrest (OHCA), or at imminent risk of OHCA. My research is focused on patients at imminent risk of OHCA, but a preliminary scoping review of the literature identified that there was an absence of research focused on this specific topic area, in relation to patients at imminent risk of OHCA. Because of this the population was broadened to include patients who were already in OHCA at the time of the EMS call.

2. Introduction

The International Liaison Committee on Resuscitation (ILCOR)[107] recognise studies which address knowledge gaps associated with OHCA recognition to be both high impact and high priority. ILCOR note that an area that requires further research is the optimal questions and instructional sequences to provide to callers to enhance recognition of OHCA and provision of CPR. Other systematic reviews have been completed in this area. Drennan et al.[108] reviewed quantitative papers concerning patients presumed to be in OHCA. The authors evaluated the diagnostic accuracy of dispatch centres to diagnose OHCA and investigated EMS call characteristics that impact on the ability of EMDs to diagnose OHCA. Findings indicated variance in the sensitivity and specificity of OHCA recognition across dispatch centres with no difference in accuracy between dispatch criteria/algorithm or with the level of education of the EMDs. Vaillancourt and colleagues[109] aimed to determine whether descriptions of specific symptoms by the caller improved the accuracy of the identification of OHCA by systematically reviewing interventional and observational studies. Findings indicated the importance of enquiry regarding consciousness and breathing to determine OHCA. In addition, the review highlighted that abnormal breathing is a significant barrier to recognition of OHCA and the presence of seizures can be an indication of OHCA.

To date no systematic review has reviewed and synthesised all the available evidence regarding features of an EMS call that facilitate or inhibit recognition by the EMD that a patient is in cardiac arrest, or at imminent risk of OHCA. The inclusion of diverse forms of evidence and the inclusion of quantitative, qualitative and mixed methods research is known to maximise review findings[110]. These findings can then be used to inform practice and inform future service improvements. This systematic mixed studies review (SMSR) aims to investigate the features of an EMS call that facilitate the recognition by the EMD that a patient is in cardiac arrest, or at imminent risk of OHCA. Synthesising all the available evidence has the potential to provide a foundation on which to develop an intervention. This intervention could be aimed at improving the early identification on the EMS call of a patient who has suffered an OHCA, or who is at imminent risk of OHCA. A successful intervention of this nature would have strong potential to improve patient outcomes in this extremely high-risk patient group.

3. Research Question

What are the features of an EMS call interaction that facilitate, or inhibit, the recognition by a EMD that a patient is in cardiac arrest, or at imminent risk of cardiac arrest?

4. Objective

To systematically identify and appraise evidence relating to the features of an EMS call interaction that enable, or inhibit, an Emergency Medical Dispatcher's recognition that a patient is in out-of-hospital cardiac arrest, or at imminent risk of out-of-hospital cardiac arrest.

5. PICOS (Population, Indicator, Comparison, Outcome, Study)

P [adults and children in out-of-hospital cardiac arrest, or at imminent risk of out-of-hospital cardiac arrest] I [not applicable] C [not applicable] O [Features of an EMS EMD/caller interaction that facilitate, or inhibit, the recognition by the EMD that a patient is in out-of-hospital cardiac arrest, or at imminent risk of out-of-hospital cardiac arrest] S [quantitative, qualitative studies or mixed methods studies].

6. Method

This SMSR set out to synthesise data and results produced from studies with diverse designs to include quantitative, qualitative and mixed methods designs[111,112]. A segregated mixed research synthesis approach as introduced by Sandelowski et al.[113] and reproduced in Table 1, was the underlying method used to integrate the findings from both qualitative and quantitative research studies.

Table 1: Segregated design for mixed research synthesis[113] (reproduced with permission)

Qualitative research question		Quantitative research question
Retrieval of qualitative studies		Retrieval of quantitative studies
Qualitative analysis of findings		Quantitative analysis of findings
Qualitative synthesis of findings		Quantitative synthesis of findings
	Mixed research synthesis (configuration)	

The segregated design recognises the distinct differences between qualitative and quantitative research. The segregated design requires separate analysis of the quantitative and qualitative findings before synthesising into a set of conclusions. This design was appropriate to use in the context of this SMSR because the research found during the literature search was complementing rather than confirming, or refuting. The mixed research synthesis was defined as the configuration rather than the assimilation of research findings as described in Sandelowski et al.'s work[113,114]. Configuration in research synthesis in the context of SMSR is the organisation of theoretically diverse findings. These findings are not perceived to lend themselves to pooling, but rather to contradict, expand and explain each other. The findings are linked through abductive reasoning and a top-down approach as depicted by Sandelowski et al.[114] in an effort to capture the strength in diverse approaches and findings.

An alternative approach that might have been considered would be the integrated or contingent design, also developed by Sandelowski[113]. The integrated design minimises the differences between quantitative and qualitative findings and assumes that any differences between research approach do not require a separate analysis of findings and can be assimilated rather than configured. Lastly, the contingent design proposed by Sandelowski et al.[113] occurs when a group of studies is reviewed to answer a research question which then determines a second research question to be answered by a further group of studies. A contingent design may follow a segregated or a contingent approach in a systematic review cycle designed to produce a synthesis of research that answers the researcher's objectives. Following a review of the findings of this literature search the segregated design was identified as the most appropriate design for this work. The reasons for this are set out in Table 2, below.

Table 2: Reasons for study design choice

Study Design	Features	Reasoning for using/not using
Chosen: Segregated Design	Recognises the distinct differences between quantitative and qualitative research. Requires separate analysis before synthesis.	Research identified and included is complementing rather than confirming, or refuting.
Configuration of findings	The organisation of theoretically diverse findings.	Findings do not lend themselves to pooling, but rather to contradict, expand and explain each other.
Integrated Design	Methodological differences between designs are minimised. Separate analyses are not considered to be required.	Considered unsuitable as findings from included studies do not confirm, extend, or refute.
Assimilation of findings	Findings grouped where answering the same research question, or phenomenon, not by method.	Findings considered diverse and not suitable for this type of synthesis

Contingent Design	A designated group of studies is synthesized to answer a specific research question and then a second group of studies is designated to answer another question in a cycle of reviews until a comprehensive research synthesis can be presented.	Results not considered suitable for answering a number of research questions.
Configuration or Assimilation	Type of synthesis chosen is dependent on studies included.	
(Sandelowski et al., 2006)[113]		

Building on Sandelowski et al's previous work[113,114], a review of SMSRs was published by Hong et al.[115] and sought to provide guidance on the conduct and reporting of SMSRs. The review identified two main types of synthesis design in use in SMSRs; convergent and sequential synthesis design. In convergent design synthesis occurs at the same time and corresponds to both Sandelowski et al.'s segregated and integrated designs, but with the analysis in the segregated design being completed separately and the analysis in the integrated design being completed concurrently[116]. Sequential design describes a situation in which synthesis occurs one after the other,[117] as in Sandelowski et al.'s contingent design[113]. The convergent and sequential design use found by Hong et al.[118] indicate that SMSR reviewers are applying the segregated and integrated synthesis designs first designed by Sandelowski et al.[113] and applied to this review.

Frantzen and Fetters[116] devised practical guidance and principles for configuring data in mixed methods research synthesis and developed the concept of 'meta-integration'. Most SMSRs use the basic convergent design, where there is no transformation of one type of data into another, for example, qualitative data to quantitative data, or vice versa. For the purposes of this review the basic convergent design was used. The two mixed methods studies identified during the search phase were fractionated, as described by Frantzen and Fetters[116] into qualitative and quantitative data.

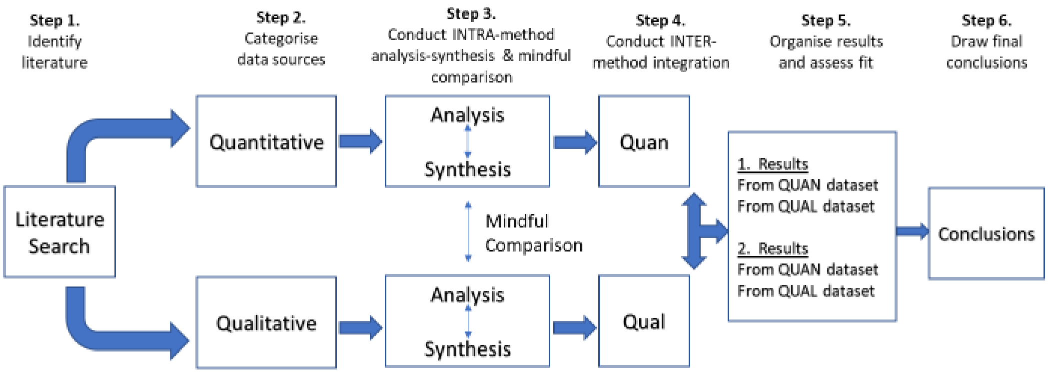

Figure 4. Basic convergent meta-integration[116] (reproduced with permission)

An alternative design would be a 'Basic convergent QUALITATIVE meta integration' or a 'Basic convergent QUANTITATIVE meta integration'. In these designs quantitative data is transformed into qualitative data, or qualitative data is transformed into quantitative data respectively[116]. Neither of these approaches were deemed relevant for use during this SMSR as the data was not congruent with this design.

6.1. Eligibility Criteria

Table 3:Eligibility criteria

Inclusion	**Exclusion**
Studies investigating adults and children who are in out-of-hospital cardiac arrest, or at imminent risk of out-of-hospital cardiac arrest	Review papers
Investigation of the features of an EMS EMD/caller interaction that facilitate, or inhibit, the recognition by the EMD that a patient is in out-of-hospital cardiac arrest, or at	Protocol papers

imminent risk of out-of-hospital cardiac	
English language studies	
Primary quantitative, qualitative and mixed methods research	
Grey Literature	
Date of publication 1990 – May 2021	
Published in the English language	

6.2. Justification for eligibility criteria

The papers reviewed were limited to English language studies due to resource restrictions and the cost of translation. All relevant non-English language studies were identified, documented and had 'language' recorded as the reason for exclusion. The systematic review included a broad range of primary research as a prior scoping review established limited research in this area. A systematic search of the grey literature allowed any relevant unpublished research to be included for analysis. Limiting the search period to 1990 was likely to identify all but a small minority of research completed before this time.

6.3. Search Strategy

6.3.1. Information sources

Databases

Medline, BNI, CINAHL, EMBASE, PubMed, Cochrane Database of Systematic Reviews, AMED, OpenGrey.

Forward and backward citation searching.

Stakeholder Resources

International Liaison Committee on Resuscitation

International Academies of Emergency Dispatch

NHS England

Resuscitation Experts

Professor Charles Deakin (Honorary Professor of Resuscitation and Emergency Medicine - UK)

Professor Judith Finn (Research Professor in Prehospital, Resuscitation and Emergency Care Research – Australia)

Dr Benjamin Leong (Senior Consultant in Emergency Medicine, Deputy Director Unit for Prehospital Care - Singapore)

Dr Freddy Lippert (Clinical Associate Professor & Director Emergency Medical Services – Denmark)

6.3.2.Justification for Information Source

The database resources were selected because they include the main medical databases and the inclusion of the Cochrane Databases of Systematic Reviews ensured that any prior Cochrane Review in this area was identified. OpenGrey was used as the source for grey literature as it covers the relevant subject areas for this review and has open access to over 700,000 bibliographic references.

The key stakeholders that openly publish resources have been listed. These stakeholder resources were accessed and reviewed for relevant information.

Resuscitation experts, with an interest in Emergency Medical Service dispatch, were identified to review the results of the systematic literature searches and provide expert opinion on any relevant additional resources that were not already identified during the search process.

Any eligible literature was hand searched to ensure any relevant backward citations were identified from the papers.

6.3.3. Search Terms

The exact search terms used in the review were developed with a Clinical Research Librarian and reviewed amongst the supervision team and an expert in systematic reviews. The searches were carried out by KK and the Medline search is included in Appendix 1.

The search terms were:

- Developed using MeSh Headings where relevant
- And combined using Boolean Operators

Table 4: Search terms

Out-of-Hospital Cardiac Arrest	**EMS Call**
Out of hospital cardiac arrest	999 call
Heart arrest	112 call
Out-of-hospital heart arrest	911 call
Cardiac arrest	Emergency Call
OHCA	Emergency Medical System Call
OOHCA	Emergency medical call
	Dispatch
	Emergency Medical Service Call

6.4. Research Data Management

6.4.1. Literature Management

Covidence[119] is an online systematic review management system used by The Cochrane Community[120] and designed for efficient systematic review management. Covidence was used to manage study screening and data extraction and used alongside alternative methods of assessing for risk of bias as Covidence is designed for intervention reviews, whereas this systematic review was inclusive of all study types.

6.4.2. Reference Management

Medical databases were searched individually using the National Institute for Health and Care Excellence Healthcare Databases Advanced Search[121] and the search results were imported into Covidence[119]. Any relevant literature identified by the alternative information sources were imported into the Covidence management system. In total 5651 studies from database searching and 25 studies from additional sources were imported into the Covidence systematic review management system for screening.

6.4.3. Selection Process

6.4.3.1. Identifying potentially eligible records and selection for final inclusion

Title and abstract screening were completed by the first reviewer (KK) with a validation sample of 20% independently screened by a second reviewer (SV). This process was repeated when reviewing the full texts. There was an ongoing dialogue between the reviewers to resolve any uncertainties, and there was no disagreement between reviewers regarding the validation sample.

There were two papers Clegg et al.[122] and Riou et al.[92] included for full text review that were later, on reflection, excluded from analysis. At the point of data extraction, it was apparent that these papers did not focus on the correct outcomes; the features of the emergency call. Clegg et al.[122] had a focus on time to complete the various stages of the call and Riou et al.[92] was about the efficiency of the emergency call, rather than the features of the emergency call. A PRISMA flow diagram is shown in Figure 5 below.

PRISMA study flow diagram

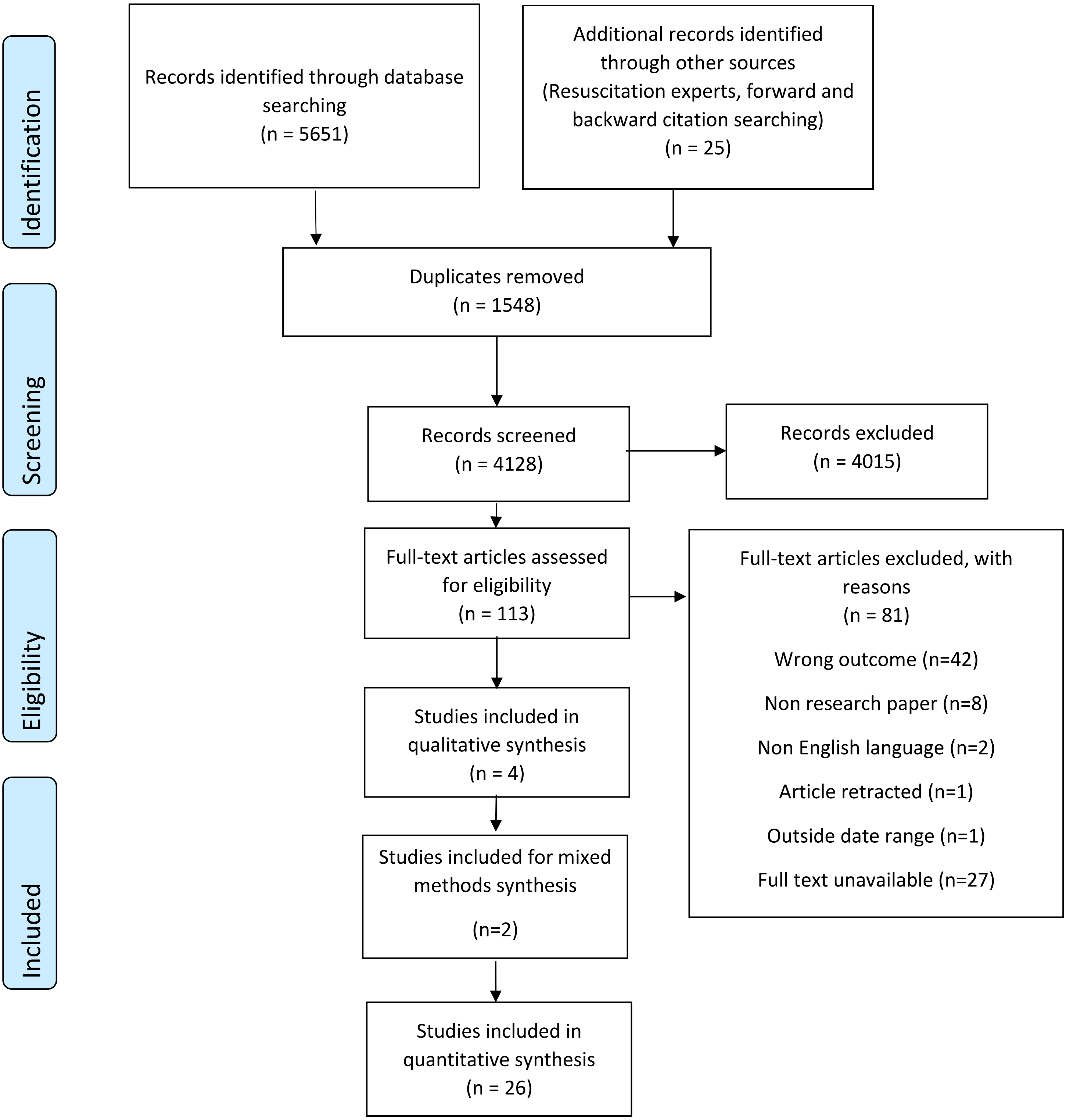

Figure 5. PRISMA study flow diagram

6.4.4. Categorisation

The categorisation phase involved determining whether the papers were qualitative, quantitative, or mixed methods. The studies were split into the five types of study described in the Mixed Methods Appraisal Tool (MMAT)[118]. The decision to categorise the studies in this way was a pragmatic decision based on the intention to use the MMAT to assess the quality of included studies. Table 6 displays the study categorisation data.

6.4.5. Data Extraction

Data were extracted which addressed the features of the EMS call that enable, or inhibit, an Emergency Medical Dispatcher's recognition that a patient is in OHCA, or at imminent risk of OHCA. The first reviewer (KK) extracted data from the categorised studies into a table of findings and into an Excel spreadsheet. The second reviewer (SV) independently validated 20% of data extraction with no disagreement.

6.4.6. Quality Assessment

The Mixed Methods Appraisal Tool (MMAT)[118] has been designed specifically for mixed research synthesis. The MMAT allows the critical appraisal of five types of studies, to include: qualitative research, randomised controlled trials, non-randomised studies, quantitative descriptive studies and mixed methods studies. The MMAT was originally developed in 2006[111], revised in 2011[123] with the present version further revised following a Delphi study, interviews with MMAT users and a literature review of critical appraisal tools[124].

Each paper was scored with the MMAT[118]. Quality scores were calculated by grading the papers from 0%-100% based on the quality criteria met. Grading was completed by KK with 20% of the sample validated by SV, with no disagreement. This type of scoring using the MMAT has been used previously [125–128]. Papers scoring above 80% were graded as high quality, scores of 80% were graded as moderate quality and scores below 80% as low quality. As recommended by Hong et al. [124] the context of individual scoring is included in the limitations sections of the certainty tables. The certainty tables are included in Appendices A2a-A2g.

7. Results

Thirty-two studies were included in the final review and the study flow diagram is shown in Figure 5. These 32 studies were categorised using the MMAT categories[23] and are shown in their categories in Table 5 with the grading of each paper in Table 6. I set out to include all studies that investigated the features of an EMD/caller interaction for both patients already in cardiac arrest ("recognition" studies) and patients at risk of imminent cardiac arrest ("prediction" studies). Unfortunately no "prediction studies" met the inclusion criteria and investigated the features of the EMS call interaction for patients who were unequivocally alive (i.e. definitely not in cardiac arrest) at the time of the EMS call. "Recognition studies" therefore dominated this SMSR, and challenges associated with the recognition of cardiac arrest were apparent. The study characteristics are detailed in Table 7.

Table 5: Categories of study design

Category of Study Design	Number of Papers	References
Qualitative	4	Alfsen et al., 2015[129]; Bång et al., 2002[130]; Jensen et al., 2012[131]; Riou et al., 2018[132]
Quantitative Randomised Controlled Trial	1	Meischke et al.,2017[133]
Quantitative Non-Randomised Controlled Trial	11	Chien et al., 2019[134]; Clawson et al., 2008[135]; Derkenne et al., 2020[136]; Gram et al., 2021[137]; Hardeland et al., 2014[138]; Lewis et al., 2013[139]; Mao et al., 2020[140]; Riou et al., 2021[141]; Roppolo et al., 2009[142]; Schwarzkoph et al., 2020[143]
Quantitative Descriptive	14	Bång et al., 2003[46]; Berdowski et al., 2009[144]; Biancardi et al., 2017[145];

		Bohm et al., 2009[146]; Castrén et al., 2001[147]; Garza et al., 2003[148]; Ma et al., 2007[149]; Mirhaghi et al., 2017[150]; Møller et al., 2016[151]; Nurmi et al., 2006[152]; Riou et al., 2018[153]; Stangenes et al., 2020[154]; Tamminen et al., 2020[155]; Travers et al., 2014[156]
Mixed Methods	2	Hardeland et al., 2016[157]; Watkins C.L. et al.[158]

Table 6:Grading of papers

	High Certainty	Moderate Certainty	Low Certainty
Quantitative	3 papers. Berdowski et al., 2009[144]; Chien et al., 2019[134]; Meischke et al., 2017[159].	21 papers Biancardi et al., 2017[145]; Castrén et al., 2001[147]; Clawson et al., 2008[135]; Derkenne et al., 2020[136]; Garza et al., 2003[148]; Gram et al.,2021[137]; Hardeland et al., 2014[138],2017[160]; Lewis et al., 2013[139]; Ma et al., 2007[149]; Mao et al., 2020[140]; Mirhaghi et al., 2017[150]; Møller et al., 2016[151]; Nurmi et al., 2006[152]; Riou, et al., 2018[153]2021[141]; Roppolo et al., 2009[142]; Schwarzkoph et al., 2020[143]; Stangenes et al., 2020[154]; Tamminen et al., 2020 [155]; Travers et al., 2014[156].	2 papers Bång et al., 2003[46]; Bohm et al., 2009[146].
Qualitative	2 papers Bång et al., 2002[130]; Riou et al., 2018[132]	2 papers Alfsen et al., 2015[129]; Jensen et al., 2012[36]	
Mixed Methods	1 paper Hardeland et al., 2016[157].	1 paper Watkins et al.2021[158].	

The papers were reviewed, described and analysed by type and certainty. Quantitative and qualitative data is synthesised separately before an overall synthesis is completed.

Berdowski e al.[144] investigated all high priority emergency calls in Amsterdam and the surrounding region for 8 months in 2004. The exclusion criteria excluded those calls placed by police officers, fire fighters, or on duty GPs, calls placed by the patient themselves and subsequent calls. Also excluded were calls relating to trauma, calls where the patient was unequivocally conscious and for those where paramedics did not initiate advanced life support. The study investigated 285 OHCAs and found the main reason for unrecognised OHCA on the emergency call was insufficient questioning concerning breathing and limited suspicion of OHCA when the breathing was described as abnormal. If all unconscious patients reported to have abnormal breathing were assumed to be a possible OHCA then OHCA recognition would have been 100%. Where the OHCA was recognised on the emergency call, the patient was more likely to survive. The study team recommend development of a more sophisticated dispatch protocol and training using spontaneous trigger words.

Meischke et al.[159] conducted a prospective randomised controlled trial in the United States and involved EMDs from 13 emergency call centres in Washington, Oregon, Alaska and Arizona. The study aimed to determine whether simulation training could improve EMD recognition of OHCA. 157 EMDs enrolled in the study and randomisation was stratified to account for years of experience. Participants were randomised in a 1:1 ratio to control or intervention arms. The control arm received four 30-minute training sessions over one year. Participants were assessed on three simulated calls using a standardised form evaluating call processing skills and language used. In addition, EMDs were assessed on 'real life' OHCA calls during the study period. Results showed significant improvements between the intervention and control groups in terms of performance in recognising OHCA and responding to the recognition of OHCA on the EMS call. The authors highlighted the importance of using simulation training to improve EMD performance.

Chien et al.[134] investigated the impact of a caller's emotional state on recognition of the OHCA on the EMS call. The study was based in Taiwan. In total 367 cases were included for analysis. Audio files were reviewed independently by two reviewers and verified by a medical director. Callers were assigned an Emotional Content and Cooperation Score (ECCS)[161]. Primary outcomes were the rate of OHCA recognition, the rate of unambiguous caller responses concerning state of consciousness and breathing and the delivery rate of Dispatcher Assisted CPR (DA-CPR) instructions. ECCS was dichotomised to cooperative (ECCS 1-3) and uncooperative (ECCS 4-5). Findings indicated that most callers had manageable emotions and were able to respond to the interrogation effectively. Rate of OHCA recognition was greatest in the ECCS 4-5 group indicating a high ECCS might highlight an OHCA patient. Difficulties in recognising abnormal breathing were highlighted in this research with the most unambiguous responses being received in the mid-range ECCS group and the worst ambiguous responses being in the calmest of callers. The study team found that EMDs tended not to follow the protocol and ask about abnormal breathing and in addition overlooked 30 unambiguous responses to breathing questioning leading to a failure to recognise OHCA.

Castren et al.[147] investigated OHCA cases and divided callers into 3 groups: doctors and nurses, other healthcare professionals, or policemen and laymen. Where the caller was a healthcare professional the EMD refrained from asking further questions and limited interrogation of the caller meaning that important information was lost. There were poor rates of telephone cardiopulmonary resuscitation (tCPR) TCPR in the healthcare professional groups. It was determined that EMDs assume that healthcare professionals can recognise OHCA and are aware of when to commence and continue tCPR. The authors recommend that healthcare professionals be better trained in recognition and reporting of OHCA.

Garza et al.[148] sought to investigate how accurate EMDs are at predicting OHCA and to investigate the effect of the calling party on EMD accuracy. Overall, there was a sensitivity of 68.3% for identifying OHCA with no significant differences for calling party. Dispatch protocol compliance was 85.22% overall with no significant difference found for calling party effect. There was a difference in positive predictive value between calling parties with EMDs able to positively predict OHCA 1.58 times more accurately if talking to first and second party callers compared with third party callers and 1.42 times more accurately if talking to fourth party callers. Appropriateness of EMDs final coding was scored highly at 94.78%, with overall dispatch protocol compliance of 85.22%.

Nurmi et al.[152] assessed the effect of dispatch protocol compliance on the accuracy of OHCA identification by EMDs in Finland. Protocol adherence relating to consciousness and breathing occurred significantly more often in witnessed cases versus unwitnessed cases (72.3% versus 45.0%, $P<0.01$). Interestingly the identification rate of OHCA was not significantly higher when the protocol was adhered to in witnessed cases (80.4% versus 74.4%, $P=0.5111$). In unwitnessed cases the identification rate was lower, but not significantly lower, when the protocol was adhered to (79.7% versus 87.8%, $P=0.0117$). In the group of unrecognised OHCA cases protocol adherence occurred in 60.3% of cases, more often in witnessed versus unwitnessed cases. Protocol adherence led to a shorter delay in vehicle dispatch. Breathing was identified as an important component of the assessment for OHCA. The researchers concluded that despite poor protocol compliance, EMDs achieved high rates of identification of OHCA. The recommendation was for an evaluation of protocols to improve accuracy.

Ma et al.'s [149] study conducted in Taiwan in 2004 systematically reviewed 301 cases of non-traumatic OHCA using a study instrument developed through consensus. The ECCS was low at 1.42 meaning that most callers were calm and cooperative. During the interview, the level of consciousness and breathing status was not interrogated by the EMD in 55% and 32% of cases, respectively. Where the OHCA was not recognised by the EMD 5/6 cases reported the patient to be breathing and it was beyond the scope of this study to determine if the breathing was agonal. The study concluded that callers are in the main calm and cooperative, but that EMD interview skills could be improved and emphasised the importance of continuing education for EMDs.

Clawson and colleagues[135] modified the Advanced Medical Priority Dispatch System (AMPDS) protocol so that a new question about 'regular breathing' was added to the seizure protocol. In a small number of cases OHCA presents as a recovering seizure patient to the EMD. Adding a new question regarding 'breathing regularly' to the AMPDS seizure protocol provides a valuable tool for identifying true cardiac arrest cases. The authors recognised that confounders may have impacted on the study results and recommended larger studies to investigate which conditions effect accurate patient prioritisation at dispatch.

Roppolo et al.[142] aimed to improve EMD identification of agonal breathing during the EMS call by introducing a new breathing assessment protocol that included counting the respiratory rate, holding the phone next to the patient and highlighting identifiers used to describe agonal breathing. The protocol was shown to significantly improve EMD recognition of OHCA and the rate of bystander CPR. The authors recommended that the use of a protocol to detect agonal breathing can increase OHCA recognition and the rates of bystander CPR as a result of dispatchers being able to coach bystanders to begin CPR.

Lewis et al.[139] investigated factors leading to the non-recognition of cardiac arrest by EMDs through completing a retrospective cohort study of OHCAs. The EMD report was reviewed alongside the EMS call recording. The research found that EMDs recognised 80% of OHCAs. Factors leading to non-recognition of OHCA included where the caller gave contradictory information regarding consciousness and most significantly where patients were reported as breathing, or contradictory information was given regarding the patient's breathing status. The authors recommended ongoing training in the recognition of agonal breathing to improve OHCA recognition on the EMS call.

Hardeland et al.[138] compared AMPDS and Criteria Based Dispatch systems between two different countries to examine how they performed in managing OHCA calls. The two systems performed similarly in efficacy and efficiency, but agonal breathing was highlighted as being the main reason that OHCA was not recognised in both systems. The researchers highlight the importance of early identification of OHCA to facilitate bystander CPR.

Travers[156] investigated OHCA detection in Paris in 2014. The team reviewed 82 'detectable' OHCAs over a 2 week period in May 2012 and of these 61% were recognised by the EMD. The study design was such that ventilation assessment was not considered complete until the EMD had asked the bystander to assess breathing by putting their hand on the patient's belly (hand on belly (HoB)) to assess frequency and movement. Where this was completed, no OHCAs went unrecognised. Deficiencies in ventilation assessment and the presence of agonal breathing impacted on the EMDs ability to recognise the OHCA. Also noted was the false reassurance of a bystander's calm voice. The researchers recognised the efficacy of the HoB technique and the importance of a thorough assessment of breathing to improve the detection and prognosis of OHCA.

Moller et al.[151] compared the accuracy of EMD performance in recognition between Sweden and Denmark. Both systems indicated high rates of OHCA recognition by EMDs despite the Danish system consisting of EMDs who are health care professionals and Sweden where the system consists of both healthcare professionals and EMDs with no formal medical education. Breathing difficulties and unconscious adult both appeared as frequent codes in the missed OHCA patient. The study results were limited due to differences in recording practices between countries and the researchers highlighted the need for transparency in reporting on OHCA to improve quality.

Biancardi et al.[145] conducted a simulation study involving two OHCA scenarios. In this Maltese EMS setting EMDs do not have an official OHCA dispatch protocol. EMDs were much more likely to recognise OHCA in the unresponsive patient who is not breathing in comparison to the unresponsive patient with agonal breathing. The authors recommended education and simulation training focused on communication challenges and the identification of breathing patterns to further improve the recognition of OHCA.

Mirhaghi et al.'s [150] Iranian based study developed a checklist for EMDs and then sought to validate it using simulation with EMDs. Using a checklist improved the ability of EMDs to recognise OHCA on the emergency call. The most frequently occurring items on the checklist describing the primary complaint and respiration were ‘collapsed’ and ‘breath does not come up’. Interestingly items removed from the checklist for lack of frequency of occurrence were ‘difficulty in breathing, ‘turning black or blue’, ‘snoring’, ‘seems to be choking’, ‘breathing’, ‘not awake’, ‘feeling unwell’, ‘extremely feeling unwell’, ‘swooned’ and ‘patients having emergency conditions’. The most frequently occurring items on the emergency calls concerning the caller’s tone and background voices were ‘rapid speech’ and ‘worried and afraid’. Fifteen items remained on the checklist and related to the caller’s tone and background noises and the description of primary complaint and respiration. The authors described how decision support tools are vital to aid EMD recognition of OHCA. They also highlighted that extreme emotional distress was helpful for dispatchers and that contextual clues should be considered important to EMDs.

Hardeland et al.[162] set out to investigate whether a targeted simulation and education programme would improve OHCA recognition and tCPR rates. The programme involved lectures focused on agonal breathing and interrogation strategy, simulation training, structured feedback and a web-based tCPR training programme. The research indicated that a training programme of this nature significantly improved the recognition of OHCA by EMDs. The authors concluded the importance of continually measuring key quality metrics to facilitate targeted education and training and to evaluate quality intervention.

Riou et al.’s [153] linguistic analysis identified that when asking callers about breathing in a situation of OHCA 44% of ‘yes’ answers also had a qualification. Qualified yes answers were found to be suggestive of agonal breathing but were treated in the same way as an unqualified yes answer and opportunities to recognise agonal breathing were missed, leading to missed recognition of OHCA. The authors recommended training for EMDs targeted at recognising agonal breathing to include training in recognising qualified answers and their relation to OHCA.

> Examples of a qualified yes answer:
>
> “but gasping”
> “yep just”
> “yes he's snoring**”.**

Derkenne et al.[136] implemented a DA-CPR programme in France in 2012 where less experienced EMDs were tutored by more experienced colleagues and the systematic use of the HoB technique to assess ventilation status was encouraged. There were four periods of analysis between 2012 and

2018. The study demonstrated that the application of a DA-CPR program, with its three components - algorithm, operator training, and performance measurements - could effectively improve the rates of OHCA detection and ongoing CPR at BLS arrival. The HoB was shown to be very effective when used to assess ventilation status and facilitated OHCA detection in this EMS system.

Mao et al. [140] introduced a modified protocol for unconscious patients and completed a before and after study. The modified protocol included a "Hand on Belly" technique for assessing a patient's breathing. The diagnostic accuracy for OHCA improved from 67.5% from 84.4%, but the adherence to the new protocol was only 50.4%. In addition time to tCPR was longer in the group using the modified protocol.

Schwarzkoph et al.[143] completed a retrospective cohort study designed to determine the impact of seizure-like activity among OHCA patients during EMS calls. Where there was seizure-like activity there were delays to the EMDs asking critical breathing and unconsciousness questions. The patient was more likely described as having abnormal breathing and turning blue, purple, or red. It took longer time to establish that the patient was in OHCA in the seizure group. The authors recommended education for EMDs on the possibility of OHCA in patients presenting with seizure-like symptoms. The authors also recommended a reassessment of breathing to establish any abnormalities in breathing and to overcome any caller uncertainty where a patient is unconscious and abnormally breathing following a seizure.

Stangenes et al.[154] investigated caller descriptions of the chief complaint and whether the description delayed EMD recognition of the need for CPR. The authors found that often the EMD will pursue questioning related to a diagnostic condition at the expense of the critical breathing and unconsciousness questions.

Tamminen et al.[155] completed a pilot study investigating 112 OHCAs of which 64% were confirmed as 'true' OHCA and 36% as non OHCA for the association between spontaneous trigger words and OHCA in Finland. The research team identified trigger words more strongly associated with the 'true' OHCA group. The team suggested that subtle changes to the algorithm may improve sensitivity without effecting specificity and suggested that they could be useful for automatic speech recognition.

Gram et al.[137] investigated the impact of an educational intervention on the accuracy of EMDs identifying OHCA. The intervention consisted of the NO-NO-GO-algorithm. When implementing the algorithm, if the patient is not breathing and not conscious then the EMD begins tCPR instructions. Data from voice logs was collected to assess the impact and there was a significant improvement on the accuracy of EMD identification of OHCA after the intervention. There was a 2-year period between pre and post intervention data collection and it was difficult to relate the performance improvement directly to the NO-NO-GO-algorithm.

Riou et al.[141] completed a retrospective cohort study, using EMS call audio recordings, that examined patient declarations of death on delayed recognition of OHCA, caller acceptance to perform CPR, bystander CPR and patient outcomes. All the patients were resuscitated by EMS with a sixth of cases achieving a spontaneous return of circulation. Findings indicated that where a caller made a declaration of death, the event was more likely to be unwitnessed and led to the EMD being more likely to recognise OHCA. However, where a declaration of death was made, the caller was less likely to instigate CPR. The authors recommended that where dispatchers are alert to declarations of death and act on them, there may be an opportunity to increase tCPR and improve patient survival.

Bang et al.[46] reviewed 100 recordings of OHCA in Sweden in 2001 where the patients were admitted to hospital and the quality of the EMD interview was assessed. The study found most callers to be calm and cooperative. 11% of EMD interviews were found to be insufficient and 26% unapproved. Breathing remained unaddressed in a third of cases and consciousness unaddressed in 25% of cases. 17% of cases did not receive a dispatch for OHCA. The study team recommended case analysis and training programmes to improve EMD interview skills in OHCA.

Bohm et al.[146] conducted a before and after study in Sweden investigating whether one day of tuition in agonal breathing improved EMD recognition of OHCA. Results indicated improvements in the rate of tCPR offered in victims with agonal respiration after tuition and in survival rates. The interrogation of callers focusing on breathing patterns was noticeably improved following tuition, but there were still five cases of missed OHCA where the EMD failed to recognise agonal breathing. The authors recommend repeated training in the recognition of agonal breathing at regular intervals

Bang et al.[130] conducted 10 interviews with EMDs to explore the circumstances and factors influencing the identification of OHCA. The results highlighted the relationship between the EMD and the witness and how the EMDs are reliant on the witness's understandings, abilities, interpretations, and communication between the two parties. A particular problem identified by EMDs was the interpretation of the witness's account concerning abnormal breathing.

''The witness can presuppose that the patient does not breathe because they are on edge themselves, or the contrary, that the witness does not want to realise that the patient isn't breathing. The witness can say: ''a little bit'' or speak hesitantly. I want them to state: ''not breathing'' in order to start CPR instructions''. (page 138)

''... really difficult to judge normal breathing, and this is often where I get stuck. If I have a person that is unconscious and has difficulty in breathing then it is really problematic. In which way are they having difficulty in breathing, are they barely breathing or are they breathing shallowly or are they breathing sporadically?'' (page 138)

''... it is difficult to achieve answers on responsiveness. If it is an old person calling, they are generally uncertain, and often mostly afraid! Usually they are also shocked. Usually a good way is to say, ''Can you talk to him?''(Page 137)

''There is often adequate information if you ask the right questions and remain calm''. (Page 139)

''Many dare not, can not and would not. Some dare not even go to have a look. And therein lies the real difficulty in persuading them to check the patient at all''. (Page 138)

The authors also highlight the ongoing need for the EMD to interpret the dynamic situation, be organised and to be mindful of the potential of OHCA in certain situations. This study shows that EMDs do not always act in the same way and provides background to the difficulties the EMDs face when trying to establish whether a patient is in OHCA. The study concludes that are three main functions, the capability of the EMD, the capability of the witness and the interplay between them.

Riou et al.[132] investigated caller pre-emption on the emergency call. Pre-emption in the context of this study is where the caller describes the reason for their call before the EMD prompts them for the reason and an example from the study is included here:

(6) ‘she can’t breathe’ (SJA509)

1.		what is the adDRESS we’re coming to.
2.	C:	uh ((ADDRESS)).
3.		((SNIFF)) and ⌈she can’t breathe. ⌉
4.	CT:	⌊((ADDRESS.)) ⌋
5.		and the phone number?
6.	C:	u:h ((TELEPHONE NUMBER)).
7.	CT:	okay.
8.		that matches thank you,
9.		⌈can you tell me exactly what’s happened? ⌉
10.	C:	⌊%you gotta hurry I don’t know ⌋ what’s wrong with her,%
11.	CT:	what’s happened.
12.	C:	.h she’s just collapsed and she’s making these funny NOI:ses a:nd,
13.	B:	((IN THE BACKGROUND)) having a seizure.
14.	C:	⌈seizure. ⌉
15.	CT:	⌊and are you- ⌋ are you- she’s having a seizure.
16.	C:	yeah a bad one.

// Problem description entered by call-taker: ‘collapsed/ seizure’ //

(Page 9)

The study investigates the disruption that caller pre-emption causes to the trajectory of the emergency call and describes how some EMDs manage this disruption in a positive way using specific strategies. The authors highlight that EMDs act differently which directly impacts the efficiency and efficacy of the call; they also highlight how strategies can be developed and used effectively to manage the impact of disruption in institutional talk. Riou et al.[132] recommend that conversation analysis can produce hypotheses that can be tested in research to identify whether changes in practice impact on outcomes.

Jensen et al.[131] conducted a study in Canada aimed at identifying barriers and facilitators that EMDs face in the recognition of agonal breathing. EMDs described their difficulties in recognising abnormal breathing, meaning that the cardiac arrest protocol could be abandoned. EMDs in this setting also had a lack of awareness that abnormal breathing is a sign of OHCA and described insufficient questioning in the dispatch protocol to identify abnormal breathing and some would like to be able to ask further questions than the protocol allowed. EMDs often stated that the recognition of agonal breathing was a very difficult aspect of the emergency call. The EMDs described the reliance on the witness's description of breathing to determine abnormal breathing. EMDs would welcome more training in the recognition of agonal breathing, to include listening to interaction recordings where abnormal breathing is present.

Alfsen et al.[129] highlight the individual circumstances of each OHCA emergency call and how they can impact on the EMDs ability to recognise OHCA.
The impact of emotional distress:

> [Patient 20]
> Dispatcher: "You need to pay attention; I'm going to ask you some questions. I already sent an ambulance, okay?"
> Caller: "Yes. (…)."
> Dispatcher: "Is he breathing, your husband? "
> Caller: "Yes, I hope (trembling voice)".
> Dispatcher: "What is the colour of his face?" (Interrupting)
> Caller: "Well I can't tell you more, now I have to go. You have to come (loud and determined)". (Interrupting)
> Dispatcher: "No, go and look at his face" (caller hangs up).
> (Page 5)

In some circumstances the dispatch protocol is abandoned when using it appears futile to the EMD. Where a caller was with the patient and able to describe abnormal breathing then the OHCA was recognised early on. The authors recognise the difficulties in identifying abnormal breathing and indicate how this non recognition can lead to the cardiac arrest protocol being abandoned. Responsibility for the trajectory of the call could be transferred to the caller where the caller was a healthcare professional, and this could lead to unrecognised OHCA.

> [Patient 21]
> Caller: "He is fairly unconscious at the moment (…)."
> Dispatcher: "Is he breathing now?"

> Caller: “He is breathing now and then, and then he stops, uhm, it sound like fluids are accumulating (…)”.
> Dispatcher: ”Okay, and now you are telling me that he is unconscious?”
> Caller: “He is unconscious now, yes.”
> Dispatcher: “Yes, okay. And breathing is slower…”
> Caller: “Slower breathing (…)”
> Dispatcher: “Good, then that’s settled, bye.”
> (Page 6)

The researchers identified a triple role of the EMD in obtaining patient information, instructing the caller and calming the caller. They also highlighted the importance of following the dispatch protocol. This study highlights the integral role of the EMD in the chain of survival and the difficulties they face in recognising OHCA on the emergency call.

Hardeland et al.[157] completed a mixed methods study in Norway investigating the issues that impact on the timely allocation of resources to OHCA patients. An evaluation of dispatch performance was completed at three different centres and information-rich cases were selected for in-depth study using qualitative methods, non-participant observations and in-depth interviews. EMDs often deviated from the protocol believing their clinical experience would lead to a better outcome, but the highest performing centre was more protocol compliant. The quantitative data showed significant differences between the three Norwegian sites in terms of performance in managing OHCA calls. Collaboration between the caller and the EMD was considered very important and could be influenced by the emotional state of the caller. Assessments of ‘normal’ breathing were identified as being very challenging with discordance often arising between the caller and the EMD in terms of understanding and interpretation. The authors concluded that agonal breathing remains the main barrier to recognition of OHCA and that EMDs use individual strategies that may impact positively or negatively on the EMDs ability to recognise OHCA. The study team recommend evaluating OHCA cases that are challenging for the system and cases of delayed recognition.

Watkins and colleagues[158] used mixed methods to identify key indicator symptoms and patient factors associated with a correct dispatch allocation in OHCA. The study was retrospective and investigated suspected or confirmed OHCA patients transferred to one acute hospital. Pre-hospital data including call recordings and in-hospital data was analysed. Findings indicated caller reports of effective breathing, abnormal pulse, fluctuating consciousness and female gender decreased the likelihood of OHCA recognition. The results indicated that the EMDs did not always adhere to the dispatch protocol. The authors concluded that the system would lose dispatch specificity if new terms were added to the dispatch protocol. Alternatively, the authors recommended stricter adherence to the current protocol to improve EMDs' recognition of OHCA

Table 7:Study Characteristics

High certainty quantitative papers						
First Author	**Date of data collection/publication**	**Country**	**Design**	**Number and types of participants**	**Main themes identified**	**Quality grade**
Berdowski[144]	2004/2009	Netherlands	Prospective observational study	11,416 high priority emergency, non-traumatic EMS calls	Key features of the EMS call interaction; Managing the emergency call; Patient colour	High
Meischke[133]	2013-2016/2017	United States	A parallel prospective randomised controlled trial	128 Emergency Medical Dispatchers	Managing the emergency call	High
Chien[134]	2015-2016/2019	Taiwan	Retrospective cross-sectional study	424 EMS calls for non-traumatic adult OHCA	Key features of the EMS call interaction; Emotional distress	High
Moderate certainty quantitative papers						

Castren[163]	1996/2001	Finland	Prospective study	328 EMS calls reporting non-traumatic OHCA that were witnessed or had bystander-initiated CPR ongoing.	Managing the emergency call; Emotional distress	Moderate
Garza[164]	2000/2003	US	Retrospective Review of EMS Dispatch Data	520 OHCA EMS calls	Managing the emergency call	Moderate
Nurmi [152]	1996/2006	Finland	Prospective Study	776 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call	Moderate
Ma[149]	2004/2007	Tapei	Retrospective Observational Study	301 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call	Moderate

Clawson[135]	2004-2006/2008	United Kingdom	Retrospective Comparative Study - before and after study	2.33 million EMS calls	Key features of the EMS call interaction; Managing the emergency call	Moderate
Roppolo[142]	Unclear/2009	United States	Prospective before and after study	962 OHCA patients	Key features of the EMS call interaction; Managing the emergency call	Moderate
Lewis[139]	2011/2013	United States	Retrospective cohort study	590 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call	Moderate
Hardeland[165]	2007-2011/2014	Norway	Observational Study.	414 OHCA patients	Key features of the EMS call interaction; Managing the emergency call	Moderate
Travers[156]	2012/2014	France	Prospective Observational Study	144 OHCA patients	Key features of the EMS call interaction; Managing the emergency call	Moderate

Moller[151]	2013/2016	Sweden	Observational Registry Study	930 OHCA patients	Key features of the EMS call interaction; Managing the emergency call	Moderate
Biancardi[145]	Unclear/2017	Malta	Simulation study	52 nurses	Key features of the EMS call interaction; Managing the emergency call	Moderate
Mirhaghi[150]	2015/2017	Iran	Content analysis OHCA emergency calls	80 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call	Moderate
Hardeland[56]	2014/2017	Norway	Prospective, interventional study	561 OHCA calls	Key features of the EMS call interaction; Managing the emergency call	Moderate
Riou[153]	2014-2015/2018	Australia	Retrospective Linguistic Analysis	176 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call	Moderate

Derkenne[166]	2012-2018/2020	France	Repeated cross-sectional study	321 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call	Moderate
Mao[140]	2018/2020	Singapore	Prospective before and after study	513 EMS calls for unconscious patients	Key features of the EMS call interaction; Managing the emergency call	Moderate
Schwarzkoph[143]	2014-2018/2020	United States	Retrospective cohort study	3502 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call; Patient colour	Moderate
Stangenes[154]	Unclear/2020	United States	Analysis OHCA EMS calls	434 OHCA EMS calls	Managing the emergency call	Moderate
Tamminen[155]	2017/2020	Finland	Descriptive pilot study - retrospective registry study	80 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call; Patient colour	Moderate

Gram[137]	2017-2020/2021	Denmark	A quality assessment study	673 OHCA EMS calls	Managing the emergency call	Moderate
Riou[57]	2014-2015,2021	Australia	Retrospective cohort study	422 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call	Moderate
Low certainty quantitative papers						
Bang[46]	2000-2001/2003	Sweden	Prospective study	100 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call; Emotional distress	Low
Bohm[146]	2004-2006/2009	Sweden	Before and after study	570 OHCS EMS calls	Key features of the EMS call interaction; Managing the emergency call	Low
High certainty qualitative papers						

Bang[167]	Unclear/2002	Sweden	Qualitative semi-structured interview study	10 Emergency Medical Dispatch staff	Managing the emergency call	High
Riou[132]	2014-2015/2018	Australia	Conversation Analysis	66 OHCA EMS calls	Managing the emergency call	High
Moderate certainty qualitative papers						
Jensen[131]	2009/2012	Canada	Qualitative telephone interview study using the Theory of Planned Behaviour	24 Ambulance Communication Officers	Key features of the EMS call interaction; Managing the emergency call	Moderate
Alfsen[129]	2021/2015	Denmark	Inductive thematic analysis EMS calls	21 OHCA EMS calls	Managing the emergency call; Emotional distress	Moderate
High certainty mixed methods papers						
Hardeland[157]	2013-2014/2016	Norway	Observational study, non-	1095 OHCA EMS calls, Non-	Key features of the EMS call interaction;	High

			participant observation and in-depth interviews.	participant observations at 3 Emergency Medical Communication Centres, 19 interviews with EMDs	Managing the emergency call	
Moderate certainty mixed methods papers						
Watkins[158]	2013-2014/2021	United Kingdom	Mixed methods retrospective study– qualitative call analysis and OHCA data analysis	39,136 EMS dispatches	Key features of the EMS call interaction; Managing the emergency call	Moderate

8. Discussion

8.1 Synthesis of Findings

Figure 6 shows the mixed methods synthesis of findings and is described further below. There were three main themes:

Key features of the EMS call interaction; Managing the emergency call; Emotional distress.

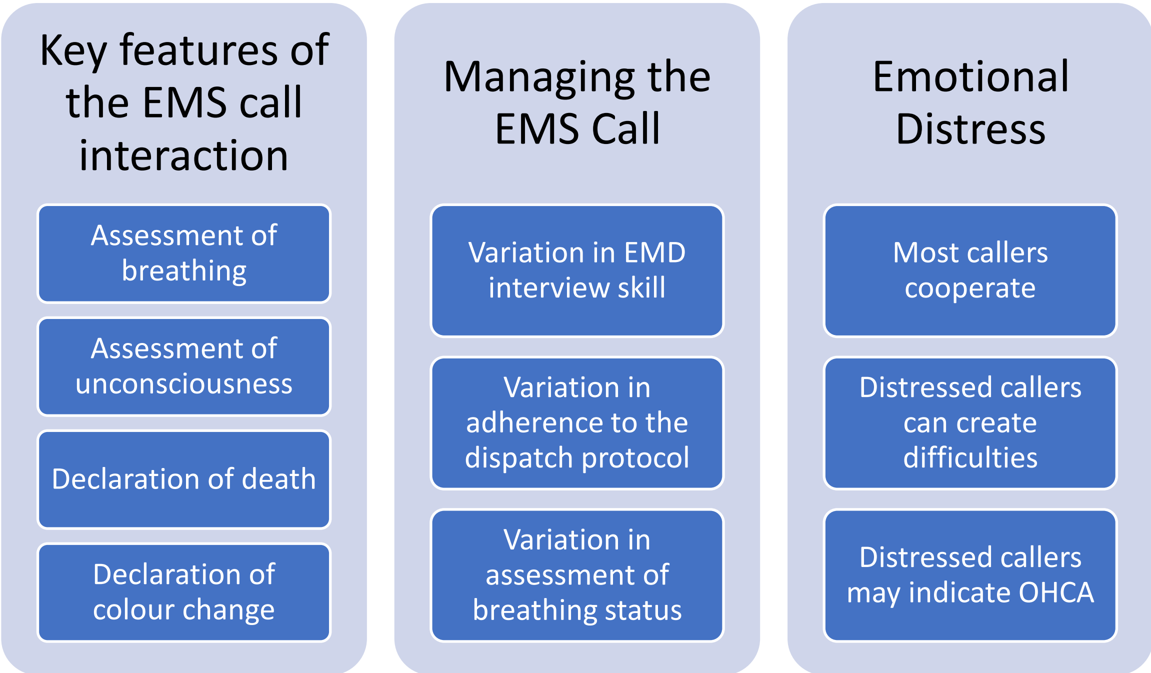

Figure 6. Mixed Methods Synthesis of Findings: Main Themes

8.1.1 Quantitative Synthesis: Key features of the EMS interaction

Assessment of breathing

Recognising abnormal/agonal breathing on the emergency call

Quantitative findings highlight the vital importance of the EMD being able to assess and recognise abnormal/agonal breathing on the EMS call [46,137,144,148,155,156,158]. Bang[46] found that 38% of patients reported as not breathing normally were found to be in respiratory arrest on EMS arrival. Berdowski and colleagues[144] similarly found that the presence of cardiac arrest was 32% where the patient's breathing was described as abnormal and Garza[148] reported that 11.6% of patients found to be in OHCA were coded as respiratory distress on EMS call triage. Lewis and colleagues[139] identified that in cases of unrecognised OHCA the caller was more likely to say the patient was breathing, or give contradictory information[139]. In OHCA, 32% of trigger words were associated with breathing, with the main phrase being, *'is not breathing'*, and *'abnormal breathing'* identified as a significant term[155]. Travers and colleagues[156] in a comparison of detected and undetected OHCAs highlighted differences in assessment of ventilation status and patient outcome and noted that the presence of agonal breathing decreased the likelihood of recognising an OHCA. Assessment of breathing can be delayed in an OHCA presenting with seizure activity and in patients where an incorrect medical condition is described[143,153].

The correct interpretation of the breathing assessment on the EMS call is clearly critical for OHCA recognition. Hardeland[138] in a comparison of MPD and CBD dispatch systems found that the absence of normal breathing was present in 28% and 36% of calls respectively and that the most frequent reason for not identifying OHCA was the misinterpretation of abnormal breathing; this latter finding is supported by Bohm et al.[146] and Watkins et al.[158]. Ma et al.[149] and Chien et al.[134] found that when EMDs asked about the breathing status of the patient it remained unclear in approximately 24% of cases. Nurmi[152] reported that the OHCA identification rate was 69%, 80% and 89% when breathing was not described, described as abnormal and described as absent respectively. These findings are supported by Moller et al.[151] and Travers et al.[156] who found that breathing was addressed more generally and more frequently in recognised OHCA groups. Berdowski[144] investigated cases of unrecognised OHCA; in these cases the caller stated that 20% of patients were breathing and 24% breathing abnormally.

Riou et al[153] used conversation analysis to interrogate the assessment of breathing during the EMS call. The analysis showed that callers answered with a qualified yes in 44% of yes answers. Qualified yes answers to the breathing question were suggestive of agonal breathing, but they were treated similarly to a plain yes answer with 94% being recorded as a plain yes answer. OHCA was recognised in only 36% (18/50) of calls with a qualified yes-answer.

Further research by Hardeland and colleagues[162] introduced an intervention to address the misinterpretation of agonal breathing. Following the intervention recognition of agonal breathing improved from 10% to 25%, ($p<0.001$).

Derkenne and colleagues[136] introduced a Dispatcher Assisted CPR Programme which was assessed over six years. In 2012, dispatchers assessed for breathing in 71% of patients, and this proportion increased to 97% in 2018. Dispatchers correctly identified recognisable OHCA in 54% of cases in 2012 and 93% of cases in 2018. After adjusting for confounders, OHCA detection was associated with breathing assessments, particularly when assessed with a Hand on Belly (HoB) technique (aOR: 13.1 95%CI: 4.8-39.5), during the 2018 period (aOR: 3.4, 95% CI: 1.1-10.8). The sensitivity of HoB for CA detection was measured among patients at 96.2%. The use of HoB technique also improved OHCA detection in Mao et al.'s[140] Singapore study, however poor protocol adherence indicates other factors may have influenced this outcome.

Roppolo[142] found that the introduction of an agonal breathing protocol decreased the percentage of patients who did not have EMD criteria for cardiac arrest, but actually were in cardiac arrest from 28.0% (168/599) to 18.8% (68/362; $p = 0.0012$), a yield of an additional 100 patients over the 4-month follow-up period. Dispatchers found that asking the bystander to say "now" every time they witnessed the patient breathe was most helpful in detecting when these respirations occurred. EMDs reported the use of the 10 s interval, where the time interval between breaths was counted, as very sensitive. All cases identified as having agonal respirations demonstrated a breathing frequency of much less than six per minute (>10second interval between breaths). EMDs did not report finding that putting the phone next to the patient was helpful.

Assessment of unconsciousness

Watkins and colleagues[158] found a description of unconsciousness to have high sensitivity and low specificity for OHCA and that assessing unconsciousness on the EMS call can be problematic. Educational interventions which include unconsciousness in critical questioning improves OHCA detection[137]. Tamminen[155] found 14% of trigger words were focussed on consciousness. A description of a fluctuating level of consciousness decreases the chance of the OHCA being recognised and in 54% of unrecognised cases the caller gave contradictory information regarding patient consciousness[139].

Declarations of death

Riou et al.[141] identified that EMDs were quicker at recognising OHCA where there was a declaration of death, but this was more likely to occur in an unwitnessed event.

Declarations of colour change

When a patient suffers an OHCA the witness may recognise colour changes in the patient. Berdowski et al.[144] found that in 16.5% of OHCAs the witness described a patient's colour as blue/purple and this finding is supported by Tamminen et al.[155] who identified that the description, 'the patient is blue' occurred in 18% of the true cardiac arrest group. Schwarzkoph and colleagues[143] found that patients who have a seizure and OHCA are often described as turning blue, purple or red. Conversely Mirhaghi et al.[150] removed 'turning blue' from their checklist because of a lack of frequency of occurrence, suggesting that there may be ethnic and cultural differences in the way colour change is recognised and reported during an EMS call.

8.1.2 Qualitative Synthesis: Key features of the EMS interaction

Recognising abnormal/agonal breathing on the emergency call

The qualitative findings add context concerning the difficulties in recognising abnormal/agonal breathing on the EMS call that were highlighted in the quantitative analysis. Bang et al.[130], Jensen[131], Alfsen[129], Hardeland[157] and Riou et al's[153] research results all highlight the difficulties that EMDs encounter in recognising agonal breathing on the EMS call which in turn delays or precludes the recognition of OHCA.

The theme 'Attitudes and Behavioural Beliefs' generated in Jensen et al.'s[131] study indicated a lack of awareness amongst EMDs that agonal breathing is a sign of OHCA. Participants in this study also described the witness giving a poor description of breathing to the EMD. Alfsen et al.[129] identify that where a caller is near the patient they are more able to describe any abnormal breathing and assist with recognition of OHCA at an earlier stage than when they are remote from the patient. Hardeland et al.[157] report discrepancies in understanding between the caller and the EMD concerning what constitutes 'normal breathing' which makes interpretation difficult.

Riou et al.[132] highlight how indications for OHCA can be missed by the EMD. Riou et al's[132] study focused on callers pre-empting the reason for the call. In one case the EMD misses the pre-emption regarding the reason for the call where the caller states the patient 'can't breathe'; when asked again later on in the dispatch protocol concerning the reason for the call, the caller treats this as a request for more information and the caller goes on to describe a seizure. The EMD omits to ask if the patient is breathing normally and the OHCA goes unrecognised.

EMDs trust the caller's description of breathing

Jensen et al. [131] and Bang et al.[130] describe findings indicating that EMDs are reliant on the caller's description of a patient's breathing which can be a barrier to recognition of OHCA. EMDs describe taking the caller's description at face value until proven otherwise, even if they doubt the accuracy of the description[131]. The caller will describe the situation they are witnessing based on their interpretation of what is going on and consequently attempt to accurately convey that interpretation to the EMD. The EMD will either then believe that description, or they might have doubts about the accuracy leading them to explore the situation further using techniques they have gained from their experiences. EMDs describe the importance of being open minded and actively listening. Ultimately the EMDs describe requiring a clear statement that breathing is absent to begin tCPR and they clearly convey their frustrations around the difficulties of interpretating caller's descriptions of a breathing assessment to get to this point[130].

8.1.3 Overall synthesis: Key features of the EMS interaction

Assessment of breathing

The recognition of abnormal/agonal breathing is critical in OHCA

Abnormal breathing, or respiratory distress, are indicators for OHCA[46,131,144,148,152,156] with 'not breathing' and 'abnormal breathing' being significant trigger words[155]. Where breathing is adequately addressed on the EMS call an OHCA is more likely to be recognised[136,142,146,151,156].

Abnormal/agonal breathing in out-of-hospital cardiac arrest is ambiguous and easy to misinterpret

A frequent reason for not recognising OHCA on the EMS call is the misinterpretation, or lack of clarity regarding breathing status[134,138,146,149,153,157,162]. EMDs are reliant on the caller's interpretation and communication of the situation[130,131] and EMDs describe trusting the caller's description of breathing until proved inaccurate[131]. However, EMDs also describe working with the descriptions provided by the witness with some EMDs employing personalised intervention-based identification techniques in an attempt to identify abnormal breathing[130]. Where a witness is near to the patient during the EMS call, they can better describe any abnormal breathing and assist the EMD with the recognition of OHCA[129].

Assessment of unconsciousness

A caller description of unconsciousness is predictive of OHCA[158], but unconsciousness is difficult to assess on the EMS call[142,158]. Often where OHCA is unrecognised the caller will have given contradictory information regarding consciousness status[142].

Declaration of death

A declaration of death during the EMS call is indicative of a patient in OHCA, but it is less likely the caller will perform tCPR when initiated by the EMD. A declaration of death is more likely where the event has not been witnessed[153]. This suggests that death may have occurred some time previously, and the patient has little or no chance of survival.

Declaration of colour change

Studies indicate that a patient's colour change can be indicative of OHCA[143,144,155], but that this observation may not be universally accurate[150].

8.1.4 Quantitative Synthesis - Managing the emergency call

Interview Skills

Suboptimal interview skills that hinder OHCA recognition are widely reported in the literature[46,134,144,149–151]. Bang [46] found that in 17% of interviews the caller reported potentially life threatening signs, but the caller was not further interrogated. 11% of interviews were graded as insufficient and 26% of interviews were unapproved as the EMD omitted to ask important questions. Similarly, Berdowski [144] found that in cases of unrecognised OHCA, breathing status was not asked about in 51% of calls, and this differed significantly between recognised and unrecognised calls (<0.001). Stangenes and colleagues[154] found that the description by the caller to the EMD regarding the patient's chief complaint can lead the EMD to pursue questions related to a diagnostic condition at the expense of critical breathing and consciousness questions. Ma et al.[149] report more encouraging findings, with only 17.6% of interviews being classed as suboptimal and 1.5% as unacceptable. Where breathing status was not elicited directly from the interview without the EMD asking, it was not asked about in 32% of cases. EMD assessments for breathing and consciousness are completed more frequently in recognised OHCA when compared to unrecognised OHCA[151,158]. Chien[134] reports that dispatcher error contributed mostly to the reason for non-recognition of OHCA in the low ECCS groups (ECCS 1: 73%, ECCS 2: 77%). Mirhaghi and colleagues[150] developed and introduced a checklist to improve the recognition of OHCA. The use of the checklist improved the recognition of OHCA from 68% to 84%. Gram et al.[137] completed a quality improvement study focussed on the introduction of a 'No,No,Go algorithm' (Not breathing normally, Not awake, Immediate EMS dispatch). The 'No,No,Go algorithm' did not improve time to asking the key questions, but the time to recognition of OHCA did improve.

Dispatch Protocol

Adherence to the dispatch protocol varies between EMDs [148,152,157] and can depend on circumstance[147]. Adherence to the dispatch protocol can be improved with an education programme[162].

Hardeland[157] compared three EMD sites and identified a significant difference in adherence to the algorithm between the three sites with 90%, 96% and 72% of EMDs assessing consciousness and normal breathing $p < 0.001$. Garza [148] found the overall dispatch protocol compliance score was 85.22 % (95% CI 83.33% to 87.10%), meaning the dispatcher followed the protocol according to the EMD standards about 85% of the time.

Castren[147] found differences in adherence to the dispatch protocol where the caller was a healthcare professional (HCP) with further and required questions not asked. The dispatch protocol was adhered to in 42% of calls made by HCPs and 65% of all calls. Interestingly, the dispatch protocol was adhered to in 26% of HCP calls where the OHCA was recognised and 80% of HCP calls where the EMS unit was dispatched with an incorrect code despite the fact that the patient had an OHCA. Nurmi [152] reported findings indicating that information required by the dispatch protocol on consciousness and breathing was only gathered in 52.4% of calls, but found that the OHCA identification rate was not significantly higher when the dispatch protocol was adhered to.

8.1.4 Qualitative Synthesis - Managing the emergency call

Managing the caller

Bang et al.[130] describe EMD reports of intervention-based strategies that EMDs use to confirm normal or abnormal breathing. EMDs guide the caller, personalising the approach to the caller so that the caller can better identify the breathing status of the patient. The EMD participants describe structured ideas on directing the interaction and assessing the circumstances.

Jensen et al.[131] report 63% of respondents highlighting the importance of themselves hearing the breathing to determine if it is abnormal. This requires the caller placing the phone by the patient so the breathing can be heard with EMDs reporting that hearing the breathing allowed them to interpret if it was abnormal.

The dispatch protocol

Research findings describe how the dispatch protocol can be too prescriptive[130], disrupted, or abandoned[129,131,132,157] in certain circumstances, leading to missed cases of OHCA.

In Bång et al's[130] research, EMDs reported requiring a clear description of breathing absence to be able to identify OHCA. Alfsen et al.[129] and Jensen et al.[131] report that an EMD will abandon the dispatch protocol for OHCA when normal breathing is described, leading the triage down a different pathway to the detriment of OHCA recognition. Hardeland[157] reports that EMDs sometimes abandon the dispatch protocol where they think that their experience will lead them to a better patient outcome. The researchers described EMDs expressing that the protocol was most useful for inexperienced EMDs, but more experienced EMDs mixed their clinical knowledge with the protocol to better identify whether a patient was in OHCA. EMDs referred to ‘intuition’ and ‘gut feeling’. Alfsen et al.[129] also found dispatch protocol abandonment where it was clear the caller was remote from the patient and the EMD was unlikely to assess the status of the patient using the protocol. In addition, the EMD might abandon the protocol and have a more relaxed exchange where it becomes clear that the caller is a healthcare professional.

In contrast Jensen et al's[131] study had a finding that EMDs followed dispatch protocol without deviating and that abnormal breathing can be missed due to inadequate questions in the dispatch protocol itself. However, findings from the same study reported that 63% of participants discussed the importance of asking questions outside the dispatch protocol to determine whether abnormal breathing is present. These participants indicated that asking extra questions was allowed, when all the protocol questions had been asked. Some participants desired flexibility in the protocol to change the order of questioning, or to ask extra questions dependent on the quality of the interaction with the caller. EMDs indicate the individuality of each interaction and the importance of being able to adapt to each situation.

Riou et al.[132] investigated the interactions focused on the reason for the call. The research team found that in 33% of cases of OHCA callers did not wait for the prompt later in the dispatch protocol, but disrupted the dispatch protocol much earlier on by stating the reason for the call. This disruption to the dispatch protocol causes problems later during the call. Often when asked for the reason for the call in line with the protocol, the caller does not state the reason as required as they have already given it earlier in the call sequence; instead they expand on the information given previously leading to confusion around the condition of the patient and the potential loss of critical information. Callers may also say 'I don't know' at the request for the reason for the call because they are treating the request following their pre-emption as a request for further information on the reason given previously. Riou et al.[153] found that some EMDs develop strategies to manage caller pre-emption; one method is to deviate from the dispatch protocol and repeat the pre-empted reason for the call preventing the loss of critical information.

8.1.5 Overall synthesis: Managing the Emergency Call

Variation in EMD interview skill

EMDs may not always interview the caller in an optimal way to elicit identification of OHCA[46,132,134,149,150]. Riou et al.[132] highlight the disruption that caller pre-emption causes on the emergency call and the way some EMDs manage this in a positive manner. Riou et al.[132] found that some EMDs employ communication techniques that help them to manage the disruption of caller pre-emption so that vital information is not lost during the call.

Variation in adherence to the dispatch protocol

Significant differences have been found in the way EMDs adhere to the dispatch protocol[157]. Poor adherence to the dispatch protocol has been found to be one of the main reasons why OHCA is not identified[160]. In contrast Nurmi[152] discovered that the dispatch protocol was only followed in relation to consciousness and breathing in 52% of cases, but that OHCA recognition was not higher when the protocol was adhered to. Where the caller is a healthcare professional the dispatch protocol is less likely to be followed and OHCA less likely to be recognised[147]. EMDs have described the inflexibility of the dispatch protocol and the desire to ask additional questions, or to change the ordering of questions based on individual circumstance so that they can better identify OHCA[131].

Variation in assessment of breathing status

The omission of questions about a patient's breathing status was found to be a particular issue contributing to non-identification of OHCA[46,144,149,151]. Some EMDs have been found to use intervention based techniques in an attempt to better identify a patient's breathing status[130,131,156].

8.1.6 Quantitative Synthesis - Emotional Distress

The ECCS score is used as a standard measure of a caller's cooperation with an EMD, but the application of the ECCS should be treated with some caution as the tool has not been thoroughly validated. Research in 2022 by Choisi[168] indicates that there is low inter rater agreement in the ECCS score when the ECCS scoring system is applied. The author recommends that further research is required to investigate a reliable assessment of a caller's emotions and cooperation on the EMS call.

In a Taiwanese study, Chien[134] found that only 8.4% of the callers were rated on the Emotional Content and Cooperation Score (ECCS) as ECCS 4–5 (5, uncontrollable, hysterical; 4, uncooperative, not listening, yelling[169]) . The rate of OHCA recognition was however greatest in the ECCS 4–5 group. Mirhaghi et al.[150] identified *'worried and afraid'* as frequently occurring items and noted the usefulness of high emotional distress as an indication for OHCA. These results suggest that a high ECCS level can be a preliminary clue for the dispatcher in recognising OHCA. Distraught callers made up only a small proportion of the overall number of callers and were not a barrier to OHCA recognition. Travers and colleagues[156] noted that a bystander's calm voice could be falsely reassuring to the EMD. A low ECCS score amongst callers reporting OHCA was also found in Taipei with an average ECCS Score of 1.42[149] and callers were largely reported to be calm and cooperative by Bang[46]. Castren et al.[147] added some context relating to emotional distress and OHCA recognition. The Castren[147] study found that doctors and nurses were able to explain what had happened in 67% of the cases. Where the caller was a total stranger to the victim (25% of the calls), the caller relayed what had happened in 72% of the calls. If the caller were a relative or a friend, they were often so much more upset that they could only state what was wrong in 54% and 48% of cases, respectively.

8.1.7 Qualitative Synthesis – Emotional Distress

Alfsen et al.[129], Bång et al.[170] , Hardeland et al.[157], Mirhaghi et al.[150] and Travers et al.[156] report the effects that an emotionally distressed caller can have on the trajectory of the EMS call.

Bang et al.[130] found that distressed callers create uncertainty on the EMS call, describing that it can be very difficult to interview a person who has 'lost it' and who is unable to engage with the questions. This finding is supported by Alfsen et al.[129] who report that distraught callers create difficulties for the EMD in recognising OHCA. The dispatcher assesses each call individually and may try to calm the caller before asking questions; the EMD may also become affected by the caller's emotional reactions and become distressed themselves.

However, in contrast, Hardeland et al's[157] findings indicate that an overly distressed caller can indicate that the patient is in a critical condition and potentially in OHCA, but the researchers also recognise that the emotional state of the caller can act as a barrier to the recognition of OHCA in concurrence with Bang[46,130] and Alfsen et al[129]. These studies relating to emotional distress were completed in different cultures and regions which may explain some of the contrast in findings.

8.1.8 Overall synthesis: Emotional Distress

Most callers cooperate

In general callers were found to be calm and cooperative on the EMS call [46,134,147,149]. However, relatives of the patient could only adequately describe what had happened in 54% of cases compared to 72% of unrelated callers, where the caller was a doctor or nurse [147].

Distressed callers can create difficulties

Conversely, the emotional response of the caller has been found to create uncertainty for EMDs [46,129,130,157] and make the EMS call very difficult to manage [130].

Distressed callers can indicate OHCA

Chien [134] identified that the rate of OHCA recognition was greatest when the Emotional Content and Cooperation Score (ECCS) was the highest in the ECCS 4-5 group (5- uncontrollable, hysterical; 4 - uncooperative, not listening, yelling [169]), suggesting that a high ECCS may indicate the presence of OHCA. These findings are supported by Hardeland et al.[157] and Mirhaghi[150] who report that callers convey their emotional response to the EMD indicating where the patient is in a critical condition. Conversely a calm caller can create a false reassurance[156].

9 Chapter summary

This systematic mixed studies review (SMSR) set out to identify and appraise the evidence focussing on the features of the EMS call interaction that enable or inhibit an Emergency Medical Dispatcher's recognition of a patient in out-of-hospital cardiac arrest, or at imminent risk of out-of-hospital cardiac arrest. The SMSR reviewed a broad range of evidence identifying three main themes: Key features of the EMS call interaction; Managing the emergency call; Emotional distress.

The studies analysed demonstrate variation in practice and results across EMS systems, however a dominant finding included in the theme, "key features of the EMS call" was the importance of (and difficulty in) recognising abnormal/agonal breathing during the EMS call. Qualitative data provides context to this, describing the barriers that EMDs face in interrogating callers and recognising abnormal/agonal breathing. Qualitative data also indicates variability in practice amongst EMDs, with EMDs describing tailoring an approach to the EMS call dependent on the situation presented. It is interesting to note the focus on difficulties determining breathing status over consciousness status in the published research.

The way in which the EMD manages the EMS call is a critical factor in their ability to recognise OHCA and the deteriorating patient. Adherence to the dispatch protocol and the asking of key questions is variable with associated impacts on triage. The way the caller interacts with the EMD effects the approach of the EMD to managing the EMS call and the subsequent trajectory and outcome. In addition, in some EMS systems there are strategies to clarify breathing status with varying levels of success.

The caller's level of emotional distress impacts on the EMD and their assessment of the EMS call. The majority of callers are calm and cooperative, but high levels of emotional distress may indicate an OHCA and calm callers may create uncertainty. A highly distressed caller can make it challenging for the EMD to manage the EMS call in the most effective way.

The research question included patients who are already in OHCA at the time of the EMS call ("recognition studies"), and those patients who are not in OHCA at the time of the EMS call, but who suffer OHCA subsequently ("prediction studies"). Patients at imminent risk of cardiac arrest may be harder to identify, and it can be difficult to distinguish deteriorating and peri-arrest patients from those already in OHCA. When a patient is reported to be breathing abnormally, they could be in OHCA with agonal breathing, or they might not yet have suffered an OHCA and be breathing abnormally for other reasons. The current European Resuscitation Council Guidelines state that where there is an 'unresponsive person with absent or abnormal breathing' they should be assumed to be in OHCA[171].

Unfortunately, no studies of patients at imminent risk of cardiac arrest ("prediction studies") met the SMSR inclusion criteria. This SMSR therefore comprised studies examining EMD recognition of OHCA where the patient was known to be in cardiac arrest or their status at the time of the call was uncertain ("recognition studies"). This PhD fellowship includes research that examines the features of an Emergency Medicine System call interaction that enable, or inhibit, a call taker's recognition that a patient who is unequivocally alive during the EMS call is at imminent risk of OHCA. This research focus is important because effective identification of a person at imminent risk of OHCA allows EMS to respond in an optimum way, which can improve survival in this important patient group.

Meta-analysis of quantitative findings and meta-synthesis of qualitative findings in systematic reviews consists of well-established methods for combining results and data across studies.[116] Completing systematic reviews where the results of qualitative, quantitative and mixed methods studies are presented in a single systematic review is relatively new and presents the challenge of data integration across these diverse study types[116] . In SMSRs there is methodological diversity, within and between studies[113].

A strength of this SMSR is the diverse range of papers included. Papers were included from a range of different regions, cultures and EMS systems. International EMS systems are adapted to local societal, cultural and financial factors,[158] and some findings may not be generalisable to alternative cultures and EMS settings. The included quantitative papers did not lend themselves to meta-analysis due to heterogeneity of studies. Similarly, qualitative papers did not lend themselves to meta-synthesis. The many different types of studies included in this SMSR reflect the wide range of approaches researchers have taken to generate knowledge in this area. Although challenging, it is important to synthesise all available knowledge so that fully evidence-based recommendations can be made.

Due to the heterogeneity of the studies included, the most recent version of the MMAT[124] was used to critically appraise the included papers. The reliability of the previous MMAT (2011 version)[172] has been appraised by Souto and colleagues and Pace and colleagues[123,173]. This appraisal confirmed the MMAT as an efficient tool, but with improvements required in its reliability. Discrepancies were found in reviewers' interpretations of aspects of the tool. Also, some qualitative research papers had limited mention of some items, including the documentation of reflexivity and how findings relate in the context. In this SMSR there was no disagreement between reviewers regarding quality assessment. The MMAT 2018 has been revised to reflect appraisal of the MMAT 2011, but the authors acknowledge the requirement for further testing of reliability and validity in the future[124].

A quantifiable scale was chosen to score the included papers using the MMAT. However this is discouraged in the MMAT manual, with a preference for reviewers to provide more details of the ratings for each paper[124]. Other SMSR reviewers have set a precedent of scoring using the MMAT in the way that was followed in this review[125–128]. The decision to use quantitative scoring was balanced by providing details of each paper in Appendices A2a-A2g.

A limitation to consider is that this SMSR was confined to English language studies. The PRISMA study flow diagram in Figure 5 indicates that two papers were excluded because they were non-English, and this data has been lost to this review.

10 Conclusions

The first link in the chain of survival; early recognition of OHCA and call for help, is a critical first stage as it enables a sequence of events to be put into action that can ultimately save a person's life. This SMSR reviewed 32 primary research studies. A main finding was the importance of recognising abnormal/agonal breathing and the difficulties that EMDs face in recognising this during the EMS call.

This SMSR highlighted an absence of research examining the EMS call interaction with patients who are not in OHCA when the EMS call is made, but who deteriorate into OHCA subsequently. Recommendations for future research focus on EMD communication strategies, EMD training and the development of interventions that allow EMDs to better predict which patients will deteriorate into OHCA following an EMS call.

In the following chapters of this Thesis I complete a retrospective analysis of OHCA registry data and linked computer aided dispatch data to understand the current EMS call triage, EMS response and survival of patients at imminent risk of OHCA and compare it to patients already in OHCA at the time of the EMS call (Chapter 3). In Chapter 4 I report the use of conversation analysis to investigate EMS call recordings concerning patients who are alive at the time of the EMS call and then subsequently suffer an OHCA. In this work I investigated the caller and EMD interaction on the emergency call to identify call features that may facilitate recognition of patients who are critically unwell and at imminent risk of OHCA. Finally in Chapter 5, I conducted interviews with Emergency Operation Centre staff to understand their views on the findings of objectives A -C. Chapter 6, the discussion chapter synthesises all the evidence of the PhD fellowship and makes recommendations for further research.

Chapter Three: Retrospective Data Analysis of Emergency Medical Service Out-of-Hospital Cardiac Arrest Data

1. Chapter overview

In this chapter I build on the findings from the systematic mixed studies review (SMSR) reported in Chapter Two. The SMSR aimed to investigate the features of an Emergency Medical Service (EMS) call that facilitate the recognition by the Emergency Medical Dispatcher (EMD) that a patient is in cardiac arrest, or at imminent risk of out-of-hospital cardiac arrest (OHCA). The findings from the SMSR indicated the absence of research relating to patients who are alive when the EMS call was made who then subsequently deteriorate into out-of-hospital cardiac arrest (OHCA).

To begin to address this gap in the current research literature this chapter reports a data analysis designed to understand the current ambulance response to OHCA patients resuscitated by EMS staff. UK ambulance Trusts use two assessment systems to triage emergency calls, Advanced Medical Priority Dispatch System (AMPDS) and NHS Pathways[73]. New ambulance standards were implemented in England in 2017[174]. In the UK, Emergency Medical Dispatchers (EMDs) who are not clinicians use AMPDS or NHS Pathways to triage emergency calls. The calls are triaged to one of five categories which have associated response time targets: Category One for people with life threatening injuries and illnesses, average response time target of 7 minutes; Category Two for emergency calls, average response time target of 18 minutes; Category 3 for urgent calls, 90% responded to within 120 minutes, Category 4 for less urgent calls, responded to 90% of the time within 180 minutes (may be given advice or referred to another service e.g. GP)[174] and category 5 which is “hear and treat”, no resource dispatched. In this study AMPDS is the system used; AMPDS uses scripted protocols to assess symptoms and to categorise the patient[86]. Computer-Aided Dispatch (CAD) is then used to dispatch ambulances to an incident.

A retrospective observational study using cardiac arrest data from one ambulance trust linked to CAD data was completed to provide a quantitative understanding of the characteristics of adult patients who suffer an OHCA, and linked patient outcome in terms of survival to hospital discharge. The study aimed to understand the current ambulance emergency call triage, ambulance response and survival of patients at imminent risk of OHCA. The data analysis reports on both the EMS response to patients who had already suffered an OHCA at the time of the EMS call and the EMS response to patients who suffered an OHCA after the EMS call had been initiated.

2. Methods

South Western Ambulance Service NHS Foundation Trust (SWASFT) routinely collects a comprehensive cardiac arrest registry data set, including survival status, for all OHCA patients where a resuscitation attempt occurs. The SWASFT OHCA data set uses both the CAD data and Electronic Care System (ECS) data in a tried and tested automated service. Survival is collected from summary care record outcome data via lead data owners within each receiving hospital. The SWASFT data set contributes in turn to the National Ambulance Quality Indicator set and National OHCA Outcomes Registry based at Warwick University[48]. Two years of SWASFT OHCA cardiac arrest registry data (1st January 2018 to 31st December 2019) were linked to CAD data. Data was cleaned and coded in Excel[175] before import into IBM SPSS 26[176]. Appendix 3 details the data fields extracted from the SWASFT dataset to be imported into SPSS.

2.1. Defining patient groups

Using SPSS (SPSS Statistics for Windows, version 28 (SPSS Inc., Chicago, USA) patients were allocated into groups for analysis. The data was divided into three main patient groups, designated as Groups 1, 2 and 3. Group 1 was further divided into two subgroups. This created a total of 4 patient groups (Table 8) and Figure 7.

Table 8: Patient Groups

Groups	*Description*
Group 1 (G1)	Patients who were not in cardiac arrest at the time the EMS call was answered
Group 1 Subset 1 (G1a)	Patients who were not in cardiac arrest at the time the EMS call was answered, and who went on to have an OHCA after the arrival of EMS staff (OHCA witnessed by EMS staff)
Group 1 Subset 2 (G1b)	Patients who were not in cardiac arrest at the time the EMS call was answered, and who went on to have an OHCA before the arrival of EMS staff (OHCA not witnessed by EMS staff)
Group 2 (G2)	Patients who were already in cardiac arrest at the time the EMS call was answered
Group 3 (G3)	Status unknown as the time of cardiac arrest was not recorded in the data set

Table 8 describes how the patient groups were defined. However, allocating patients to specific groups was not straightforward. The recording of the time of the OHCA by EMS is not always accurate due to the often-chaotic scene of an OHCA, the time of OHCA being unwitnessed and unknown and due to uncertainty amongst bystanders as to when an OHCA definitively occurred. This inaccuracy in recording of the time of OHCA was expected in the data and required careful consideration as this time was used to determine whether patients had suffered an OHCA before or after the EMS call. To account for some potential inaccuracies in recording the exact time of OHCA, and subsequent potential inaccuracies concerned with grouping patients who were or were not in OHCA at the time the EMS call was answered, a decision was made to allow some flexibility in the boundaries between Group 1b and Group 2. Patients were included as being alive at the time of the EMS call where their OHCA was recorded as being equal to, or greater than, three minutes after the time the EMS call was answered, and this decision affected both Group 1b and Group 2. Where the OHCA was witnessed by EMS staff there was no doubt that this group was alive at the time of the EMS call, because EMS witnessed OHCA is accurately recorded. The cut-off time of three minutes was chosen because it was judged to have the best chance of allocating patients to the right groups, but also because under "dispatch on disposition" which was introduced during the Ambulance Response Programme (ARP), it was the maximum time between call connect and response time clock start[88]. The way patients were allocated to groups is defined in Table 9 and the potential for overlap between groups is illustrated in Figure 7.

Table 9: Defining the patient groups

Group	*Group Definition*	*Methods for defining the groups from the data*
Group 1	Patients who were not in cardiac arrest at the time the EMS call was answered	EMS witnessed patients and those patients who had a time of cardiac arrest recorded as ≥ 3 minutes after the EMS call was answered.
Group 1a (Subgroup -EMS witnessed)	Patients who were not in cardiac arrest at the time the EMS call was answered, and who went on to have an OHCA after the arrival of EMS staff (OHCA witnessed by EMS staff)	OHCA recorded as witnessed by EMS staff.
Group 1b (Subgroup-not EMS witnessed)	Patients who were not in cardiac arrest at the time the EMS call was answered, and who went on to have an OHCA before the arrival of EMS staff (OHCA not witnessed by EMS staff)	Time of cardiac arrest recorded as ≥3 minutes after the EMS call was answered and not witnessed by EMS staff.
Group 2	Patients who were already in cardiac arrest at the time the EMS call was answered	Time of cardiac arrest recorded as being ≤3 minutes after the EMS call was answered.
Group 3	Arrest status unknown at the time the EMS call was answered	Time of cardiac arrest not recorded.

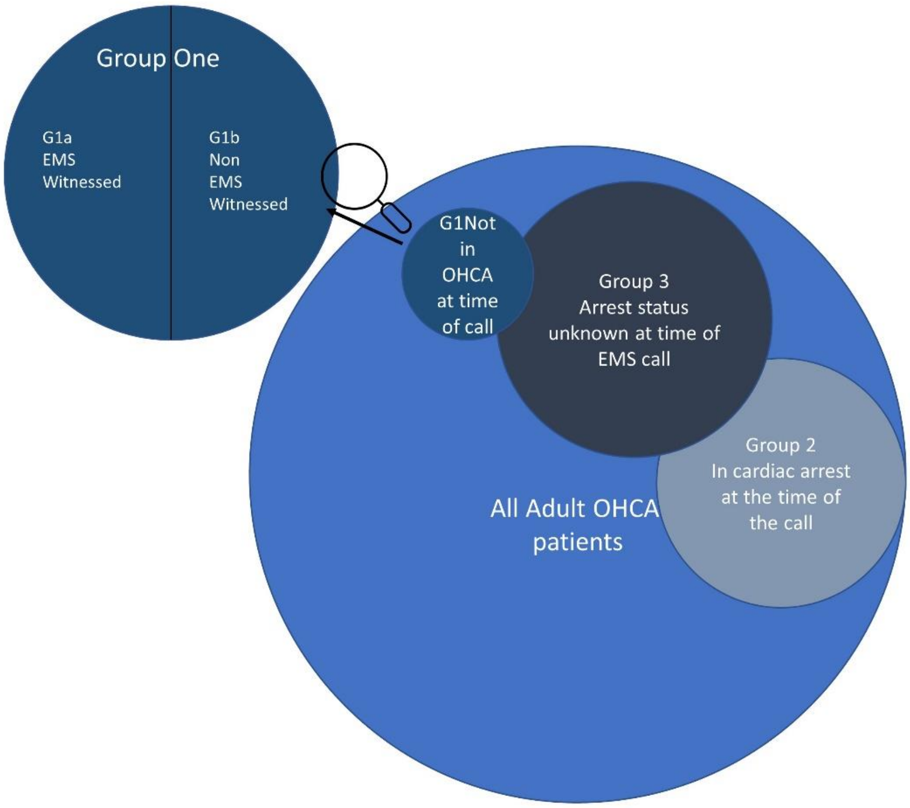

Figure 7. Patient Groups N.B Emergency Medical Service (EMS), out-of-hospital cardiac arrest (OHCA)

2.2. Group 3

Group 3 did not have the time of the OHCA recorded in the data, so it was impossible to ascertain whether this group was alive at the time of the EMS call or not. Compared to the other groups, Group 3 had the highest proportion of unwitnessed OHCAs (61%) which explains in part the missing 'time of OHCA' data as the time of the OHCA would have been unknown. It is likely that Group 3 is a mixture of G2 and G1b (see Figure 7) and including Group 3 in comparison with Groups 1 and 2 would confuse the data analysis. Group 3 was therefore removed from the analysis when examining and comparing the groups in detail.

2.3. Data reporting

Data was presented, aligned to the Utstein Reporting Guidelines, in two main tables, Tables 10 and 11. Data was reported according to the Strobe criteria and a Strobe checklist is included in Appendix 4.

2.4. Sensitivity Analysis

In recognition of this potential for 'blurring' of boundaries between two of the patient groups (Group 1b and Group 2), a sensitivity analysis was conducted. The sensitivity analyses was designed to assess the impact of key assumptions or variations[177] and in this analysis it was used to assess the impact of changes in assumptions on the reliability of the conclusions. The sensitivity analyses investigated the robustness of the findings where the 3-minute cut off was applied. In addition to the 3 minutes time point, analyses were completed at 0 minutes and 10 minutes after the time the EMS call was answered, and this is illustrated in Figure 8. The sensitivity analyses were applied to results where there was not a big difference between the groups to test the robustness of the conclusions made.

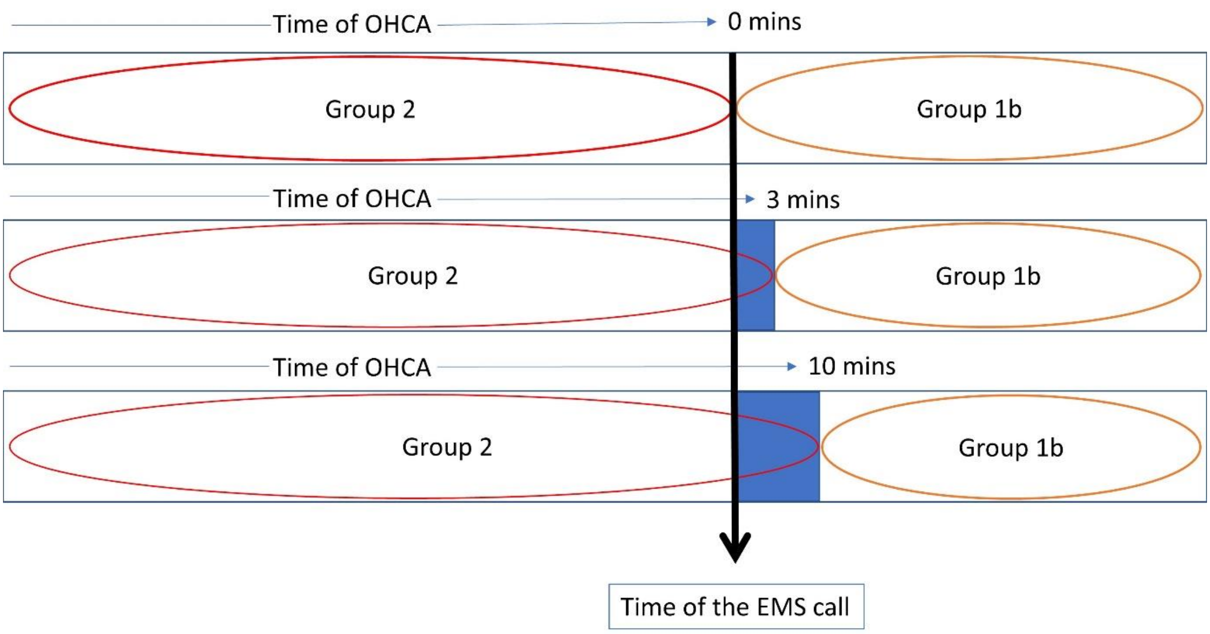

Figure 8. Description of the sensitivity analyses

2.5. Data Analysis

The data is predominantly categorical data. For this reason, the data analysis involved interrogating the dataset using descriptive statistics including percentages and chi square analysis for associations. Chi square analysis involved testing the null hypothesis that there was no difference between groups in each variable investigated and is based on the differences between the observed frequencies and the expected frequencies under a tentative assumption of the null hypothesis being true[178]. Cramer's V was used to quantify effect size along with the odds ratio for 2 by 2 cross-tabulations. Cohen[179] proffered lower bound thresholds of $V = .1$ (small), $V = .30$ (medium), $V = .50$

(large) for one degree of freedom; V = .07 (small), V = .21 (medium), V = .35 (large) for two degrees of freedom; V = .06 (small), V = .17 (medium), and V = .29 (large) for three degrees of freedom and V = .05 (small), V = .15 (medium), and V = .25 (large) for four degrees of freedom.

The study population was analysed as a whole before analysing the patient groups. In the group analyses the patients who were alive at the time of the EMS call (Group 1) were compared with patients who were not alive at the time of the EMS call (Group 2). This was followed by further analysis of the two subgroups of Group 1 (G1a and G1b) in comparison to Group 2. The groups and subgroups are referred to as G1a, G1b and G2.

2.6. Inclusion/Exclusion Criteria

Patients aged 18 years and over were included for analysis with no exclusions.

3. Results

Two years of SWASFT OHCA cardiac arrest registry data (1st January 2018 to 31st December 2019) were linked to CAD data and all patients aged 18 years, or older were included. In total there were 7,491 patients in the SWASFT OHCA registry and 7,302 patients who were aged 18 years, or over and included for analysis.

3.1. Characteristics and outcomes of the study population

Table 10 Characteristics and outcomes of the study population

NB Out-of-Hospital Cardiac Arrest (OHCA); Nursing/Residential (N/R); Overdose (OD)

Characteristics of the study population		
Variables		
Patient Variables		
Sex n(%)	Female	2421(33.2)
	Male	4872(66.7)
	Missing	9 (0.1)
Age n; mean SD	7302; 68.1 SD 16.7	
Presenting cardiac rhythm n(%)	Shockable	1921 (26.3)
	Non-shock	5119 (70.1)
	Other	262 (3.6)
OHCA location n(%)	Home	5115 (70.0)
	Public Place	1427 (19.5)
	N/R Home	286(3.9)
	Other	144 (2.0)
	Healthcare fac	79 (1.2)
	On ambulance	251 (3.4)
OHCA aetiology n(%)	Asphyxia	196 (2.7)
	Drowning	15 (0.2)
	Drug OD	169 (2.3)
	Medical	6389 (87.5)
	Other	214(2.9)
	Trauma	273 (3.7)
	Missing	46 (0.6)
Witnessed n(%)	Bystander	3963 (54.3)
	EMS	978 (13.4)
	Unwitnessed	2319 (31.7)
	Unknown	Missing (0.6)
Bystander CPR (BCPR) n(%)	BCPR	4849 (66.4)
	No BCPR	2408 (33.0)
	Missing	45 (0.6)
Utstein comparator group n(%)	Utstein	1283 (22.3)
	Non-Utstein	5677 (77.7)
OHCA outcomes		
Survival to hospital discharge n(%)	Yes	739 (10.1)
	No	6476 (88.7)
	Missing	87 (1.2)
Survival to 30 days n(%)	Yes	692 (9.5)
	No	6473 (88.6)
	Missing	137 (1.9)
Utstein survival to hospital discharge n(%)	Yes	329 (25.6)
	No	926 (72.2)
	Missing	28 (2.2)

Utstein survival to 30 days n(%)	Yes No Missing	317 (24.7) 926 (72.2) 40 (3.1)
EMS Process		
Response time	Mean Minimum Maximum 25th percentile 50th percentile 75th percentile	00:12:00 00:00:00 05:21:25 00:04:54 00:07:57 00:13:16
Initial categorisation n(%)	Category 1 Category 2 Category 3 Category 4 Category 5 Missing	4898 (67.1) 1773 (24.3) 174 (2.4) 53 (0.7) 58 (0.8) 346 (4.7)
Final categorisation	Category 1 Category 2 Category 3 Category 4 Category 5 Missing	5753 (78.8) 1362 (18.7) 130 (1.8) 21 (0.3) 29 (0.4) 7 (0.1)

3.1.1.Patient characteristics

The sex of the study population was unevenly distributed. Of the study population, 66.7% were male and 33.2% were female. The mean age of patients within the study population was 68.1 with a standard deviation of 16.7. The median age was 71 years old.

3.1.2.Out-of-hospital cardiac arrest characteristics

Throughout this chapter I use the term “shockable” as the term to reflect a cardiac rhythm amenable to defibrillation.

The OHCA characteristics of the study population were that 26.3% of patients in the dataset had a rhythm that was shockable and 70.1% of patients did not have a shockable rhythm. The remaining 3.6% were grouped into “other” and included missing data and paced rhythm from the ambulance registry dataset. The location of the OHCA was predominantly in the home with 70% of patients having their OHCA at home. The distribution of location of OHCA within the study population is further illustrated in Figure 9 below.

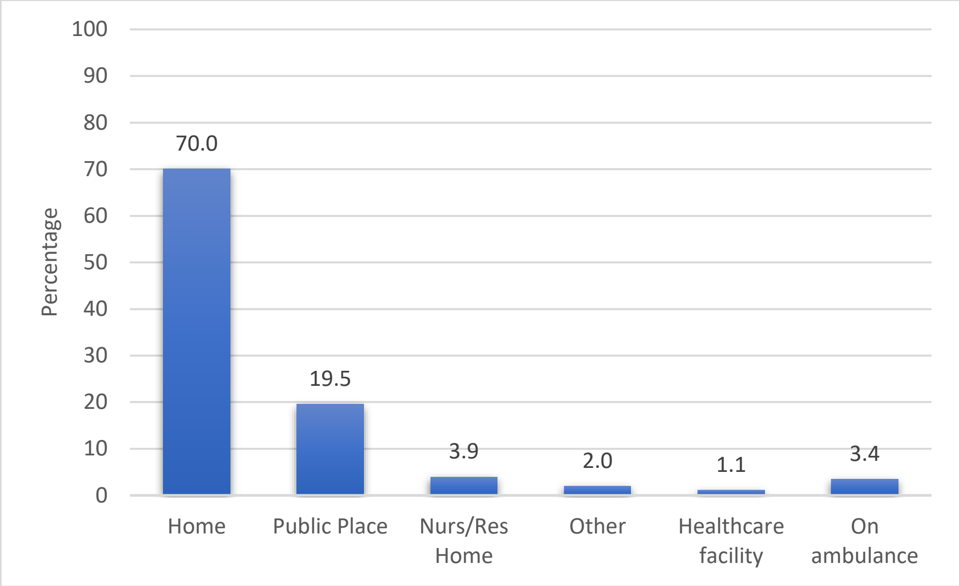

Figure 9. Location of OHCA within the study population

Figure 10 illustrates that the vast majority of OHCAs in the study population, 87.5%, were of a medical cause.

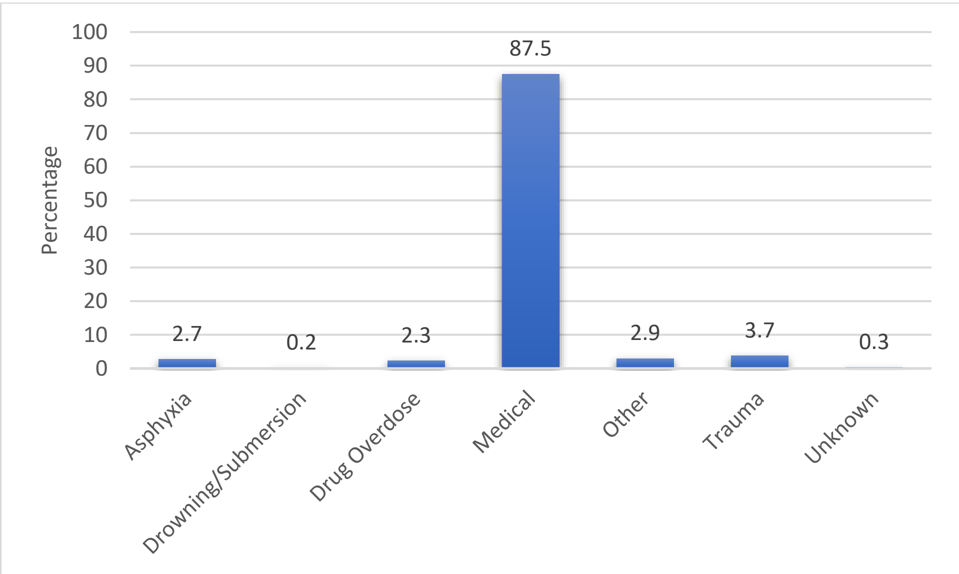

Figure 10 Aetiology of OHCA within the study population

Figure 11 indicates that 54.3 % of OHCAs were witnessed by a bystander, 31.8% were unwitnessed and 13.4% of OHCAs were witnessed by EMS.

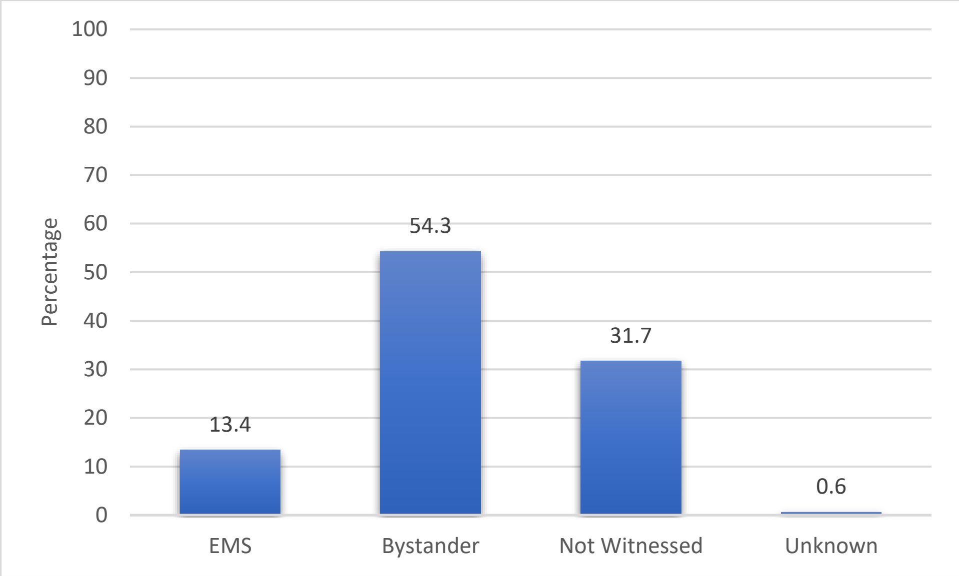

Figure 11. OHCA witnessed status within the study population N.B Emergency Medical Service (EMS)

In terms of bystander CPR status, 66.4% of OHCA patients in the study population received bystander CPR and 33.0% received no bystander CPR.

The Utstein template describes a standardised approach to the reporting of OHCA research and the associated outcomes. The aim of uniform reporting in OHCA is to allow comparisons between EMS systems, an understanding of the epidemiology of OHCA and to drive quality improvement and research[61].

Ideally Utstein reporting would compare OHCA of a cardiac origin, where the initial rhythm is a shockable rhythm and the OHCA was witnessed by a bystander. However, there are difficulties in separating OHCA of presumed cardiac origin from other causes of OHCA. Because of this, the recommended primary reporting by EMS systems should state the outcomes of all EMS-treated OHCA, measuring system effectiveness, and also those that are bystander witnessed and the first monitored rhythm is shockable, measuring system efficacy[61]. The proportion of patients in the study population who were bystander witnessed and where the first monitored rhythm was shockable was 22.3% and these patients are defined as the Utstein comparator group.

3.1.3.Out-of-hospital cardiac arrest outcomes

Figure 12 illustrates the outcomes of OHCA patients. Survival to hospital discharge is 10.1% and survival to 30 days is 9.5%. Figure 13 demonstrates that survival to hospital discharge is 25.6% and survival to 30 days is 24.7% in the Utstein Comparator Group. Further analyses of the data indicates that of the conveyed patients in the study population 23.9% survive to hospital discharge. This compares to 39.4% of patients who are conveyed to hospital surviving to hospital discharge in the Utstein comparator group.

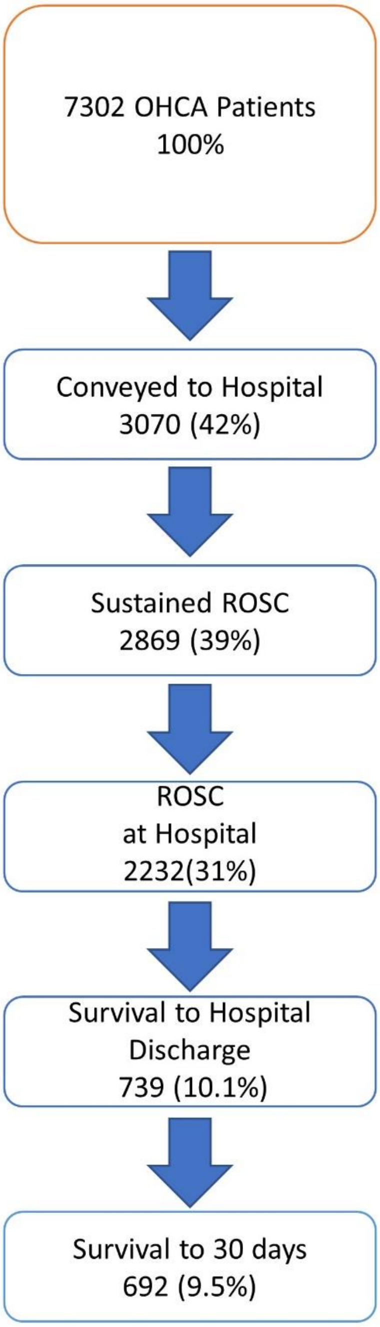

Figure 12. Patient flow chart for the study population NB out-of-hospital cardiac arrest (OHCA); return of spontaneous circulation (ROSC)

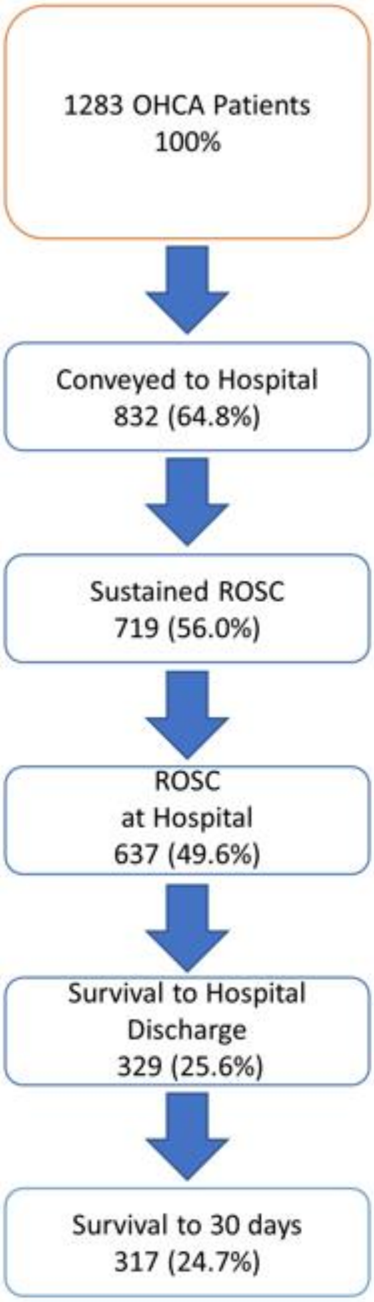

Figure 13. Patient flow chart Utstein Comparator Group N.B out-of-hospital cardiac arrest (OHCA); return of spontaneous circulation (ROSC)

3.1.4. EMS call outcomes

Response times for the study population are displayed in Table 10. The mean response time was 12 seconds with a maximum response time of more than five hours.

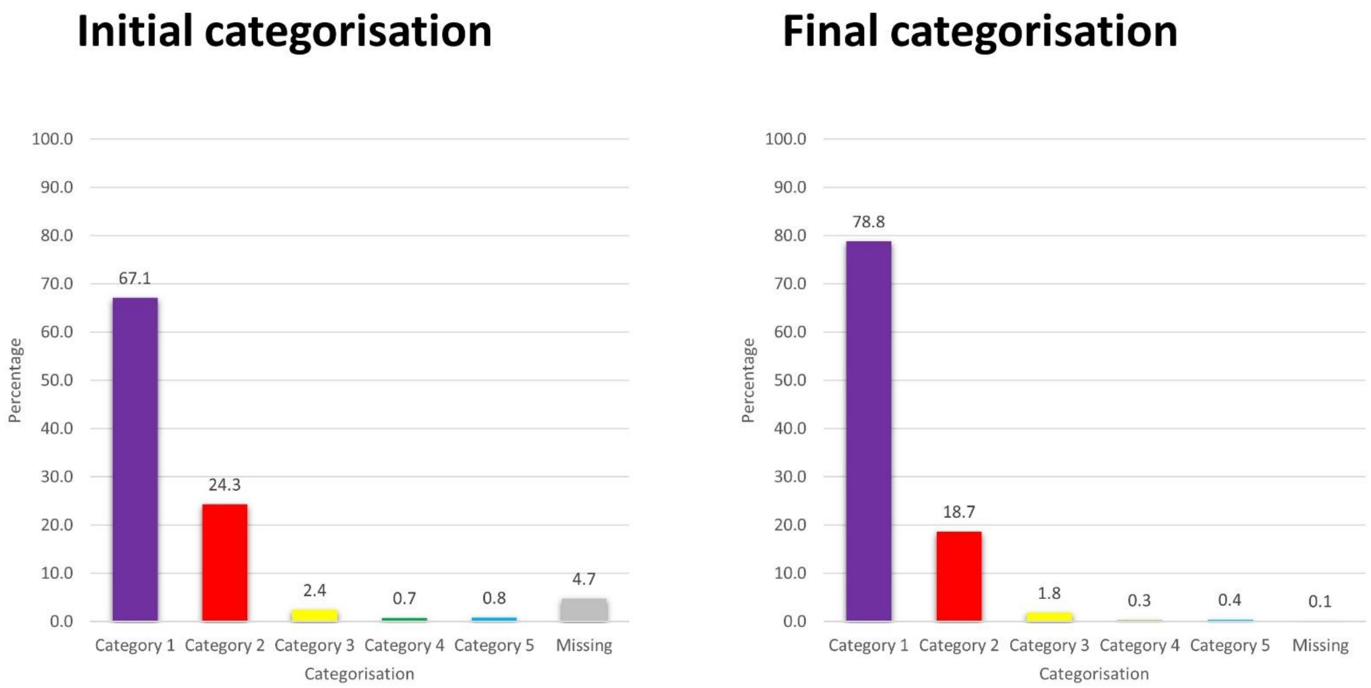

Figure 14. Response category at first categorisation (T5) and final categorisation for the study population

Figure 14 shows that 67.1% of the study population initially received a category one response and 24.3% received a category two response with a very small percentage of patients receiving a response between category three to category five. The final response category changes slightly with 78.8% of patients categorised as category one and 18.7% receiving a category two response. A very small number of patients continue to receive a category three to five response.

AMPDS consists of 36 main protocols and patients are triaged to one of these protocols based on their clinical symptoms[180]. These protocols define the line of further questioning by the EMD. Figure 15 indicates that 50% of AMPDS protocols at categorisation were for cardiac or respiratory arrest/death, with 10.6 % of cards coding as Unconscious/fainting.

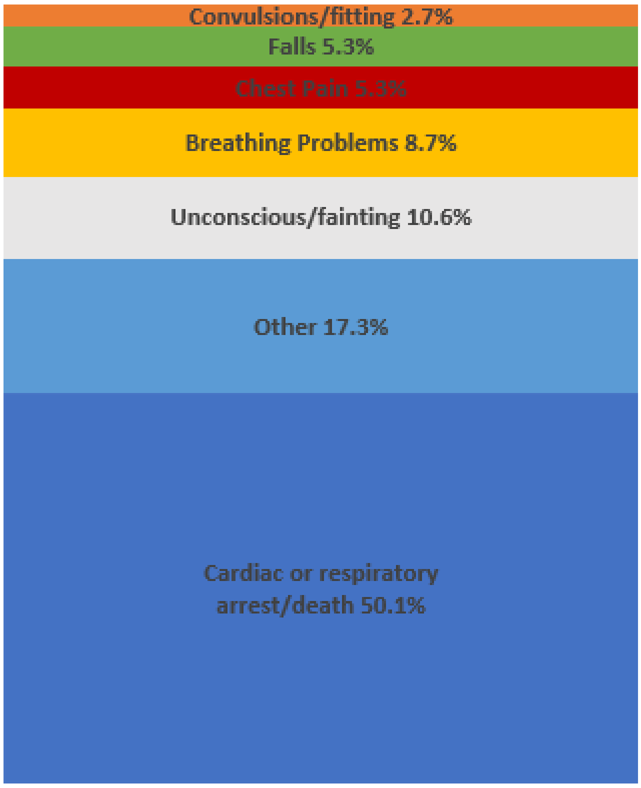

Figure 15. Most common AMPDS cards at categorisation

When looking further in-depth at the study population AMPDS coding, 40% of AMPDS card descriptions are coded as a cardiac/respiratory arrest-not breathing at all, with 10% coded as cardiac/respiratory arrest-breathing uncertain (agonal).

3.2. Characteristics and outcomes of the study groups

Table 11 Characteristics and outcomes of the study groups NB Out-of-Hospital Cardiac Arrest (OHCA); Nursing/Residential (N/R); Overdose (OD)

	Group 1		Group G1a		Group 1b		**Group 2**		**Group 3**	
Number of patients n(%)	1451 (20)		978 (13)		473 (7)		2794 (38)		3057(42)	
Patient variables										
Sex n(%)	Female	546 (37.6)	Female	361(36.9)	Female	185(39.1)	Female	860 (30.8)	Female	1015(33.2)
	Male	904 (62.3)	Male	617(63.1)	Male	287(60.7)	Male	1929(69.0)	Male	2039(66.7)
	Missing	1(0.1)	Missing	0(0)	Missing	1(0.2)	Missing	5(0.2)	Missing	3(0.1)
76Age n; mean SD	1451; 70.12 SD 15.553		978; 69.33 SD 16.055		473; 71.44 SD 14.908		2794; 69.31 SD 16.038		3057; 66.01 SD 17.43	
Presenting cardiac rhythm n(%)	Shock	448(30.9)	Shock	342(35.0)	Shock	106(22.4)	Shock	858(30.7)	Shock	615(20.1)
	Non -shock	940(64.8)	Non -shock	584(59.7)	Non -shock	356(75.3)	Non -shock	1861(66.6)	Non -shock	2432(79.6)
	Missing	63(4.3)	Missing	11(2.3)	Missing	11(2.3)	Missing	75(2.7)	Missing	8(0.3)
OHCA location n(%)	Home	940 (78.0)	Home	589(80.4)	Home	351(74.4)	Home	1917(68.7)	Home	2258(73.9)
	Public Place	165(13.7)	Public Place	80(10.9)	Public Place	85(18)	Public Place	663(23.7)	Public Place	599(19.6)
	N/R home	50(4.1)	N/R home	26(3.5)	N/R home	24(5.1)	N/R home	127(4.5)	N/R home	109(3.6)
	Other	21(1.7)	Other	13(1.8)	Other	8(1.7)	Other	63(2.3)	Other	54(1.8)

	Healthcare fac.	29 (2.4)	Healthcare fac.	25(3.4)	Healthcare fac.	4(0.8)	Healthcare fac.	21(0.8)	Healthcare fac.	29(0.9)
	Missing	0 (0)	Missing	0(0)	Missing	0(0)	Missing	1(0)	Missing	5(0.2)
OHCA aetiology n(%)	Asphyxia	14(1.0)	Asphyxia	11(1.1)	Asphyxia	3(0.6)	Asphyxia	64(2.3)	Asphyxia	118(3.9)
	Drowning	0(0)	Drowning	0(0)	Drowning	0(0)	Drowning	2.0(0.1	Drowning	13(0.4)
	Drug OD	18(1.2	Drug OD	12(1.2)	Drug OD	6(1.3)	Drug OD	59(2.1)	Drug OD	92(3.0)
	Medical	1353(93.2)	Medical	907(92.9)	Medical	446(94.3)	Medical	2485(89.2)	Medical	2551(83.4)
	Other	21(3.0)	Other	17(1.7)	Other	4(0.8)	Other	78(2.8)	Other	115(3.8)
	Trauma	43(3.2)	Trauma	29(3.0)	Trauma	14(3.0)	Trauma	90(3.2)	Trauma	140(4.6)
	Missing	2(0.1)	Missing	2(0)	Missing	0(0)	Missing	16(0.6)	Missing	28(0.9)
Witnessed n(%)	Bystander	437(30.1)	Bystander	0(0)	Bystander	437(92.4)	Bystander	2360(84.5)	Bystander	1166(38.1)
	EMS	978(67.4)	EMS	978(100)	EMS	0(0)	EMS	0(0)	EMS	0()0)
	Not witnessed	34(2.3)	Not witnessed	0(0)	Not witnessed	34(7.2)	Not witnessed	419(15.0)	Not witnessed	1866(61.0)
	Missing	2(0)	Missing	0(0)	Missing	2 (0.4)	Missing	15(0.5)	Missing	25(0.8)
Bystander CPR (BCPR) n(%)	BCPR		BCPR		BCPR	350(74.0)	BCPR	2240(80.2)	BCPR	2214(72.4)
	No BCPR		No BCPR		No BCPR	122(25.8)	No BCPR	535(19.1)	No BCPR	810(26.5)
	Missing		Missing		Missing	1(0.2)	Missing	19(0.7)	Missing	33(1.1)
Utstein comparator group n(%)	Utstein	103(7.1)	Utstein	0(0)	Utstein	103(21.8)	Utstein	790(28.3)	Utstein	390(12.8)
	Non-Utstein	1348(92.9)	Non-Utstein	978 (100)	Non-Utstein	370(78.2)	Non-Utstein	2004(71.7	Non-Utstein	2667(87.2)
OHCA outcomes										

Hospital Conveyance n(%)	Conveyed Non-convey	860 (59.3) 591 (40.7)	Conveyed Non-convey	672(68.7) 306(31.3)	Conveyed Non-convey	188(39.7) 285(60.3)	Conveyed Non-convey	1131(40.5) 1663(59.5	Conveyed Non-convey	1079(35.3) 1978(64.7)
Sustained return of spontaneous circulation n(%)	Sustained ROSC No sustained ROSC Missing	782(53.9) 667(46) 2(0.1)	Sustained ROSC No sustained ROSC Missing	574(58.7) 402(41.1) 2 (0.2)	Sustained ROSC No sustained ROSC Missing	208(44) 265(56) 0(0)	Sustained ROSC No sustained ROSC Missing	1092(39.1) 1695(60.7) 7(0.3)	Sustained ROSC No sustained ROSC Missing	995(32.5) 2053(67.2) 9(0.3)
Survival to hospital discharge n(%)	Yes No Missing	275(19) 1155(79.6) 21(1.5)	Yes No Missing	242(24.7) 719(73.5) 17(1.7)	Yes No Missing	33(7) 436(92.2) 4(0.8)	Yes No Missing	254(9.1) 2503(89.6) 37(1.3)	Yes No Missing	210(6.9) 2818(92.2) 29(1.0)
Survival to 30 days n(%)	Yes No Missing	253(17.4) 1157(79.7) 41(2.8)	Yes No Missing	220(22.5) 722(73.8) 36(3.7)	Yes No Missing	33(7.0) 435(92.0) 5(0.1)	Yes No Missing	224(8.0) 2507(89.7) 63(2.3)	Yes No Missing	215(7.0) 2809(91.9) 33(1.1)
Utstein survival to hospital discharge n(%)					Yes No Missing	23(23) 75(75) 2(2)	Yes No Missing	184(24) 564(73.5) 19(2.5)	Yes No Missing	117(28.5) 267(65.0) 27(6.6)
Utstein survival to 30 days n(%)					Yes No Missing	23(23) 74(74) 3(3)	Yes No Missing	170(22.2) 566(73.8) 1(0.1)	Yes No Missing	119(30.6) 266(68.4) 4(1.0)
EMS Process										

Response time	Mean	0:22:21	Mean	00:23:50	Mean	00:19:17	Mean	00:09:05	Mean	00:09:45
	Minimum	0:00:00	Minimum	00:00:00	Minimum	00:01:05	Minimum	00:00:00	Minimum	00:00:00
	Maximum	5:21:25	Maximum	05:21:25	Maximum	03:53:17	Maximum	01:57:03	Maximum	03:36:36
	25^{th} percentile	0:07:24	25^{th} percentile	00:07:06	25^{th} percentile	00:08:06	25^{th} percentile	00:04:46	25^{th} percentile	00:04:29
	50^{th} percentile	0:13:38	50^{th} percentile	00:13:57	50^{th} percentile	00:13:09	50^{th} percentile	00:07:26	50^{th} percentile	00:07:03
	75^{th} percentile	0:26:16	75^{th} percentile	00:28:10	75^{th} percentile	00:22:56	75^{th} percentile	00:11:24	75^{th} percentile	00:11:34
Initial categorisation n(%)	Category 1	408(28.1)	Category 1	194(19.8)	Category 1	214(45.2)	Category 1	2130(76.2)	Category 1	2360(77.2)
	Category 2	801(55.2)	Category 2	594(60.7)	Category 2	207(43.8)	Category 2	504(18.0)	Category 2	468(15.3)
	Category 3	82(5.7)	Category 3	61(6.2)	Category 3	21(4.4)	Category 3	36(1.3)	Category 3	56(1.8)
	Category 4	28(1.9)	Category 4	19(1.9)	Category 4	9(1.9)	Category 4	6(0.2)	Category 4	19(0.6)
	Category 5	25(1.7)	Category 5	20(2.0)	Category 5	5(1.1)	Category 5	18(0.6)	Category 5	15(0.5)
	Missing	107(7.4)	Missing	90(9.2)	Missing	17(3.6)	Missing	100(3.6)	Missing	139(4.5)
Final categorisation n(%)	Category 1	495(34.1)	Category 1	229(23.4)	Category 1	266(56.2)	Category 1	2558(91.6)	Category 1	2700(88.3)
	Category 2	863(59.5)	Category 2	679(69.4)	Category 2	184(38.9)	Category 2	212(7.6%)	Category 2	287(9.4)
	Category 3	70(4.8)	Category 3	54(5.5)	Category 3	16(3.4)	Category 3	16(0.6)	Category 3	44(1.4)
	Category 4	11(0.8)	Category 4	10(1)	Category 4	1(0.2)	Category 4	3(0.1)	Category 4	7(0.2)
	Category 5	10(0.7)	Category 5	5(0.5)	Category 5	5(1.1)	Category 5	4(0.1)	Category 5	15(0.5)
	Missing	2(0.1)	Missing	1(0.1)	Missing	7(0.1)	Missing	1(0)	Missing	4(0.1)

3.2.1. Numbers of patients in each group

Figure 16 illustrates the numbers and percentage of patients allocated to each group.

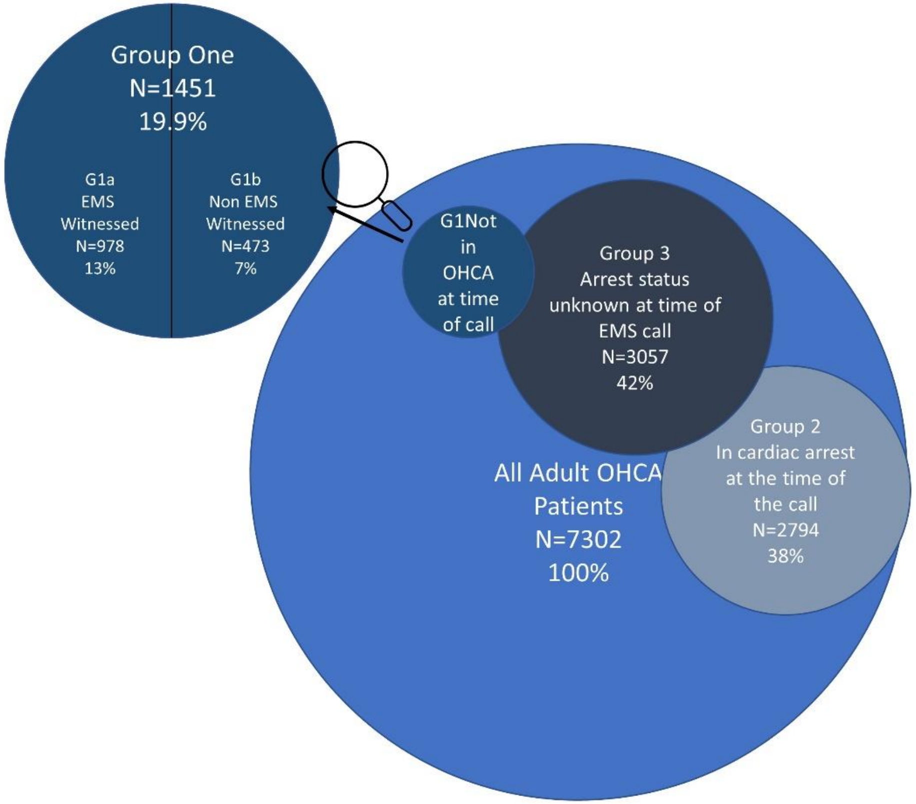

Figure 16. Patient and number of patients within each patient group

3.2.2.Sex

There is a greater number of males than females in both G1 and G2, and the percentage of females in G2 (30.8%) is lower than the corresponding percentage of females in G1 (37.6%) and this data is displayed in Appendix A4a. When G1 was split into the subgroups and compared to G2 the sex proportions for G1a, G1b and G2 were 36.9%, 39.1% and 30.8% female respectively as shown in Appendix A5a.

Table 12: Cross tabulation of sex in groups

Sex	Female		Male	
Group		%		%
G1	Observed	37.6	Observed	62.3
	Expected	33.1	Expected	66.7
	Difference	**4.5**	**Difference**	**-4.4**
G1a	Observed	36.9	Observed	63.1
	Expected	33.1	Expected	66.7
	Difference	**3.8**	**Difference**	**-3.6**
G1b	Observed	39.2	Observed	60.8
	Expected	33.1	Expected	66.7
	Difference	**6.1**	**Difference**	**-5.9**
G2	Observed	30.8	Observed	69.2
	Expected	33.1	Expected	66.7
	Difference	**-2.3**	**Difference**	**2.5**

There was evidence of an unequal sex distribution between groups. The Pearson-chi square test showed a statistically significant association (χ^2 = 22.594, *df* = 4, *N* = 4245, *p* < .001) . The Cramers V effect size was 0.052, which is small. There were more women in Group 1 (not in cardiac arrest at the time of the EMS call), most noticeably in the G1b group (not in cardiac arrest at the time of the EMS call and not witnessed by EMS staff) in comparison to the percentage of women in Group 2.

3.2.3. Age

The age range of included groups was between 18 and 102 with a mean age of 70 years and a median age of 72 years. The mean age of patients in the groups was between 69 and 71 years of age. The oldest patients were in G1b with a mean age of 71 years.

3.3. Out-of-hospital cardiac arrest characteristics

3.3.1. Initial presenting rhythm

The presenting rhythm data was categorised into three groups, ‘rhythms shockable’, ‘rhythms not shockable’ and ‘other’. Other included these groupings from the ambulance dataset, unknown (25, 0.6%), paced rhythm (1, 0%), other (36, 0.8%), no rhythm recorded (77, 1.8%). ‘Other’ consisted of 139 patients (3.3%) and was excluded from the analysis as it was not a clearly defined group.

G1 and G2 have the same proportions of patients presenting with a rhythm shockable. However, when G1 is split into the subgroups G1a and G1b there are more patients presenting in a rhythm shockable in G1a (35.0%) than G1b(22.4%).

Figure 17 Initial presenting rhythm G1a,G1b and G2

Table 13: Rhythm distribution by group, G1a, G1b and G2

Presenting Rhythm	Shockable		Non-shockable	
Group		%		%
G1a	Observed	36.9	Observed	63.1
	Expected	31.8	Expected	68.2
	Difference	**5.1**	**Difference**	**-5.1**
G1b	Observed	22.9	Observed	77.1
	Expected	31.8	Expected	68.2
	Difference	**-8.9**	**Difference**	**8.9**
G2	Observed	31.6	Observed	68.4
	Expected	31.8	Expected	68.2
	Difference	**-0.2**	**Difference**	**0.2**

(χ^2 = 28.033, df = 2, N = 4107, p < .001)

Cramer's V = 0.8

Figure 17 shows the proportion of shockable and non-shockable rhythms in the groups and Table 13 shows the statistical analysis between groups with missing patients removed to form a complete case analysis. There is a significant difference in cardiac arrest rhythm between groups with patients presenting with a shockable rhythm in G1b being 10 percentage points lower than G2 and approximately 15 percentage points lower than G1a.

3.4. Location of cardiac arrest (NB. on ambulance removed from analysis n=251)

On ambulance was removed from the analysis because these all would have been in G1a (EMS witnessed) and not have added any value to the findings.

Appendix A5a displays a bar chart of the location of the OHCA broken down into G1 subgroups and G2. Home was the predominant location of OHCA across all groups with the biggest difference between groups being the numbers of patients suffering their OHCA in a public place; 23.7% in G2 compared with 10.9% in G1a.

Table 14: Statistical analysis cardiac arrest location between groups

Location	**Home**		**Nursing/Residential Home**		**Public Place**		**Healthcare Facility**		**Other**	
Group		%		%		%		%		%
G1a	Observed	80.4	Observed	3.5	Observed	10.9	Observed	3.4	Observed	1.8
	Expected	71.5	Expected	4.4	Expected	20.7	Expected	1.3	Expected	2.1
	Difference	**8.9**	**Difference**	**-0.9**	**Difference**	**-9.8**	**Difference**	**2.1**	**Difference**	**-0.3**
G1b	Observed	74.4	Observed	5.1	Observed	18	Observed	0.8	Observed	1.7
	Expected	71.5	Expected	4.4	Expected	20.7	Expected	1.3	Expected	2.1
	Difference	**2.9**	**Difference**	**0.7**	**Difference**	**-2.7**	**Difference**	**-0.5**	**Difference**	**-0.4**
G2	Observed	68.7	Observed	4.5	Observed	23.7	Observed	0.8	Observed	2.3
	Expected	71.5	Expected	4.4	Expected	20.7	Expected	1.3	Expected	2.1
	Difference	**-2.8**	**Difference**	**0.1**	**Difference**	**3.0**	**Difference**	**-0.5**	**Difference**	**0.2**

(χ^2 = 96.607, df = 10, N = 3997, p < .001) .

Cramer's V = 0.110

The difference between groups predominantly lies with group G1a. In G1a, 8.9% more patients than statistically expected have a cardiac arrest in the home and 2.1% more than statistically expected arrest in a healthcare facility.

3.5. Aetiology of OHCA

Appendices A5c and A5d illustrate the aetiology of the OHCA. In all groups the majority of patients suffered an OHCA from a medical cause.

3.6. Cardiac arrest witnessed status

The witness status of OHCA in all groups is tabled in Table 11. All G1a were EMS witnessed and this was how the group was defined. In G1b 92.4% were bystander witnessed in comparison to 84.5% of G2.

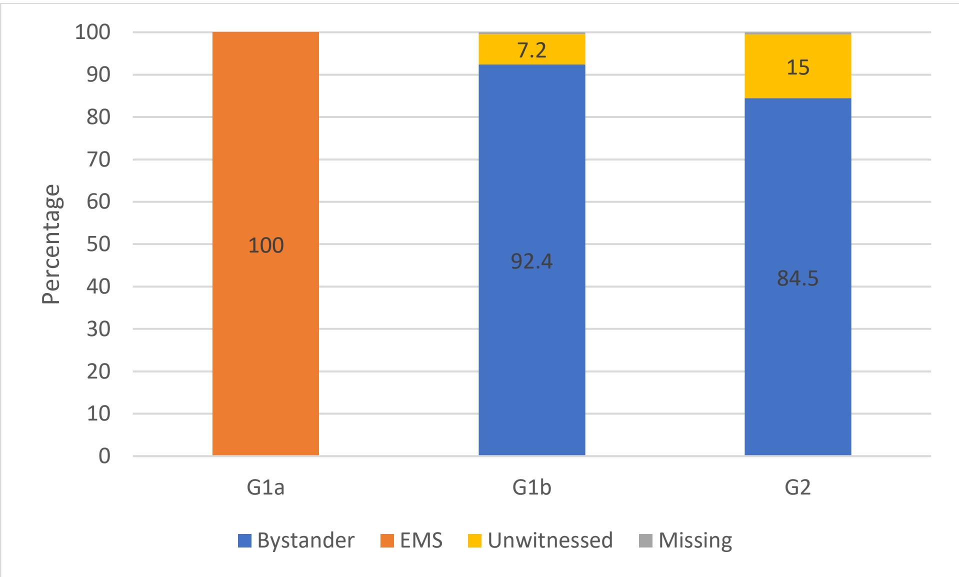

Figure 18. OHCA witnessed status by group

Witness status 'unknown' n=17 was removed from the analysis to perform a complete case analysis. The differences in witness status between groups is partly due to the way the groups have been defined. G1a are all EMS witnessed OHCA. There is, however, a difference between witness status between G1b (bystander witnessed 92.4%) and G2 (bystander witnessed 84.5%).

3.7. Bystander CPR

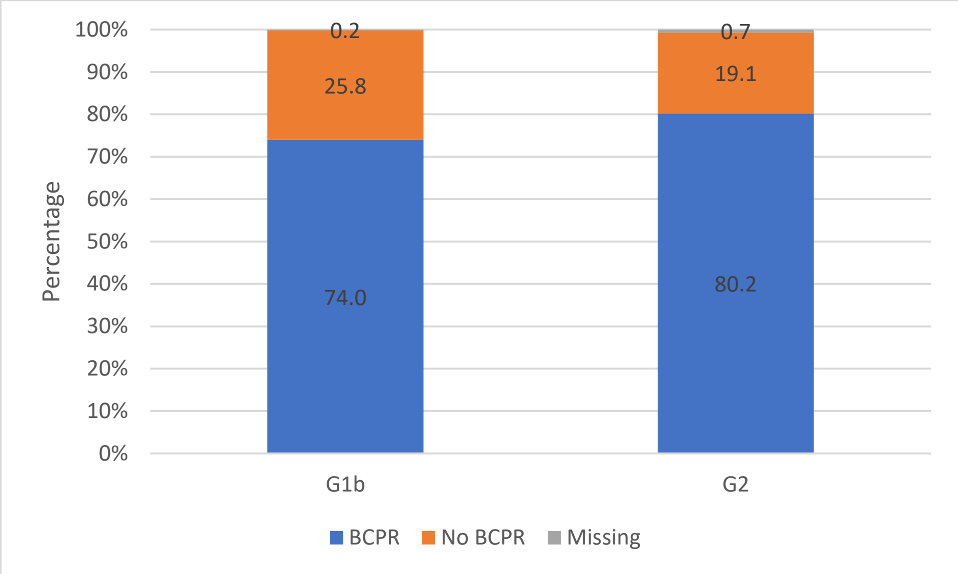

Figure 19 Distribution of bystander CPR status between G1b and G2

G2 have a higher proportion of patients receiving bystander CPR than G1b, 80.2% versus 74.0% respectively.

3.8. Utstein status

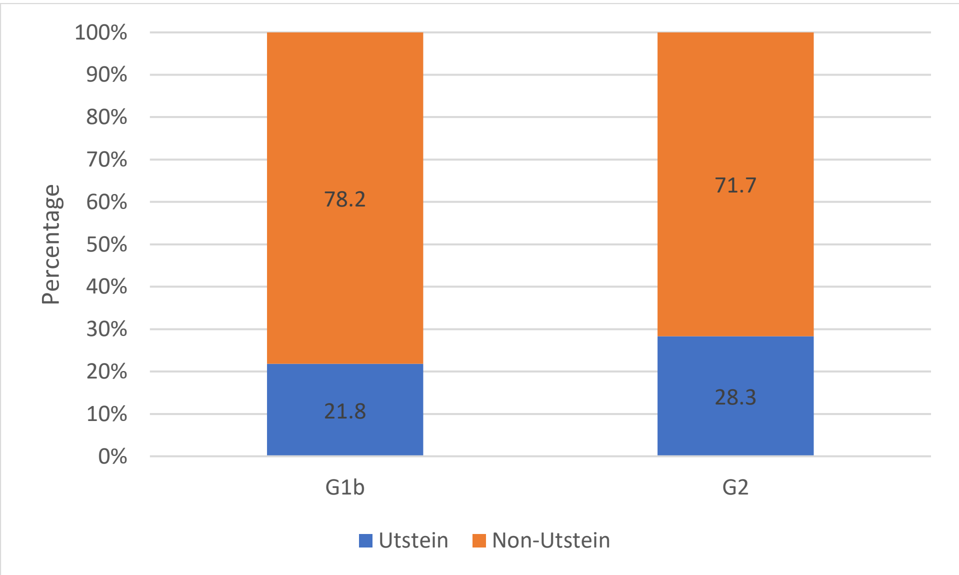

Figure 20 Utstein status G1b and G2

The Utstein comparator group are bystander witnessed OHCA who are in a rhythm amenable to defibrillation. G1a are EMS witnessed and so do not feature in the Utstein comparator analysis of this dataset and the numbers of patients in G1 and G2 are displayed in Table 11. Defining a comparator group in this way aims to provide consistency in the way OHCA outcomes are reported[181]. G1b have less (21.8%) Utstein patients than G2(28.3%).

3.9. Out-of-Hospital cardiac arrest outcomes

3.9.1. Hospital Conveyance

Patient conveyance to hospital varied between groups with the highest percentage of patients conveyed to hospital in G1a and the least patients conveyed to hospital in G1b.

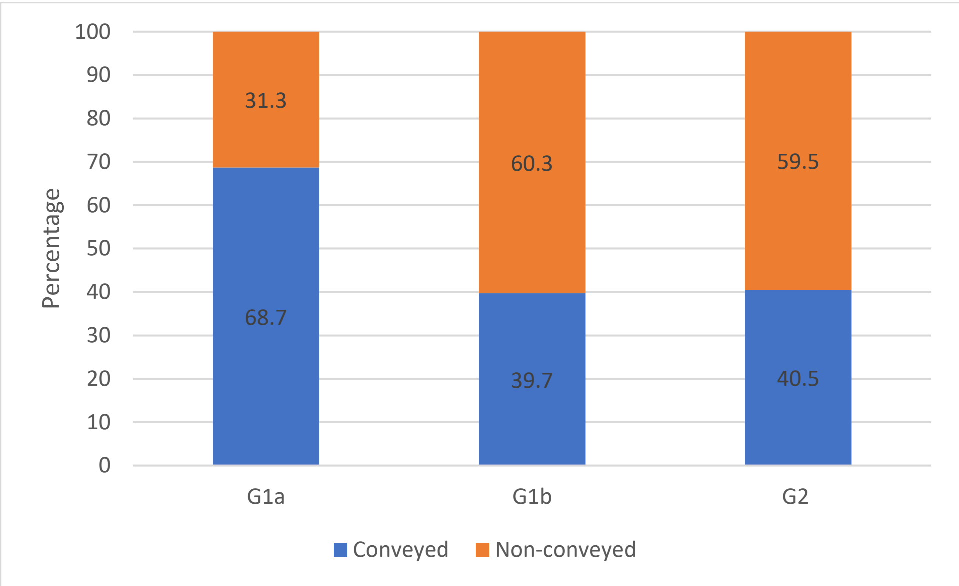

Figure 21: Hospital conveyance

Table 15: Statistical analysis of hospital conveyance

Conveyed	**Conveyed**		**Non-conveyed**	
Group		%		%
G1a	Observed	68.7	Observed	31.3
	Expected	46.9	Expected	53.1
	Difference	**21.8**	**Difference**	**-21.8**
G1b	Observed	39.7	Observed	60.3
	Expected	46.9	Expected	53.1
	Difference	**-7.2**	**Difference**	**7.2**
G2	Observed	40.5	Observed	59.5
	Expected	46.9	Expected	53.1
	Difference	**-6.4**	**Difference**	**6.4**

(χ^2 = 242.796, df = 2, N = 4245, $p < .000$)

Cramer's V = 0.239

The numbers of patients conveyed to hospital in each group is shown in Table 11. There is a significant difference in rate of conveyance between groups with 21.8% more patients conveyed in G1a than statistically expected.

3.10. Sustained return of spontaneous circulation

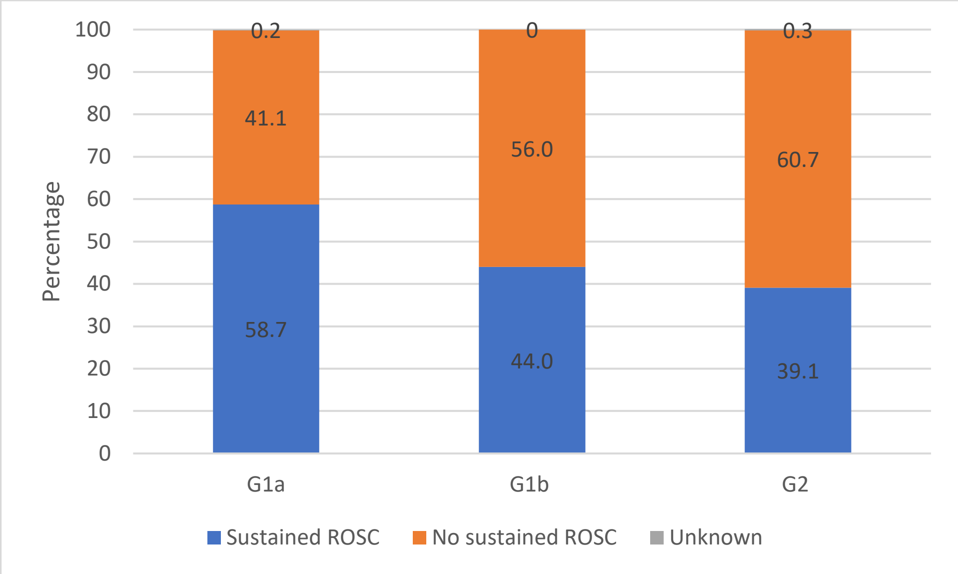

Figure 22: Sustained return of spontaneous circulation G1a,G1b and G2

Table 16: Statistical analysis of sustained ROSC

Sustained ROSC	**Sustained ROSC**		**Non-sustained ROSC**		**Unknown**	
Group		%		%		%
G1a	Observed	58.7	Observed	41.4	Observed	0.2
	Expected	44.1	Expected	55.6	Expected	0.2
	Difference	**14.6**	**Difference**	**-14.5**	**Difference**	**0**
G1b	Observed	44	Observed	56	Observed	0
	Expected	44.1	Expected	55.6	Expected	0.2
	Difference	**-0.1**	**Difference**	**0.4**	**Difference**	**-0.2**
G2	Observed	39.1	Observed	60.7	Observed	0.3
	Expected	44.1	Expected	55.6	Expected	0.2
	Difference	**-5**	**Difference**	**5.1**	**Difference**	**0.1**

Patients where the status of sustained ROSC is unknown n=7(0.2%) were removed from the analysis to allow for complete case analysis.

(χ^2 = 84.495, df = 1, N = 4236, p < .000)

Cramer's V = 0.122.

Numbers of patients in each group who had had a sustained ROSC are displayed in Appendices A4r and A4s. There is a significant difference in sustained ROSC between groups with G1a having 14.6% more patients achieving a sustained ROSC than expected. This significant result only relates to G1a.

3.11. Survival to hospital discharge

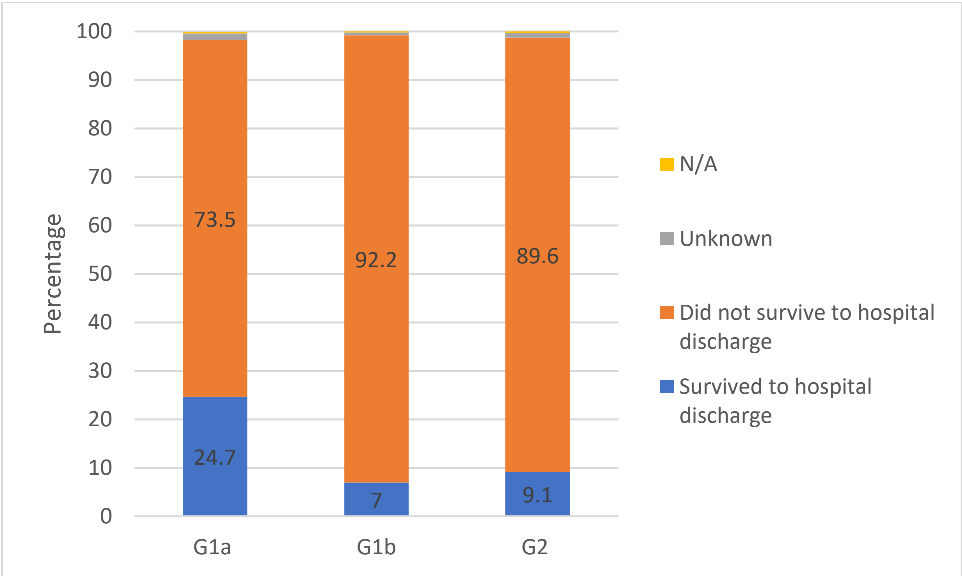

Figure 23. Survival to hospital discharge G1a,G1b and G2

Table 17: Statistical analysis of survival to hospital discharge

Survival to hospital discharge	**Survival to discharge**		**Non survival to discharge**		**Unknown**		**Not applicable**	
Group		%		%		%		%
G1a	Observed	24.7	Observed	73.5	Observed	1.4	Observed	0.3
	Expected	12.5	Expected	86.2	Expected	1.1	Expected	0.3
	Difference	**12.2**	**Difference**	**-12.7**	**Difference**	**0.3**	**Difference**	**0**
G1b	Observed	7.0	Observed	92.2	Observed	0.6	Observed	0.2
	Expected	12.5	Expected	86.2	Expected	1.1	Expected	0.3
	Difference	**-5.5**	**Difference**	**6**	**Difference**	**-0.5**	**Difference**	**-0.1**
G2	Observed	9.1	Observed	89.6	Observed	1.0	Observed	0.3
	Expected	12.5	Expected	86.2	Expected	1.1	Expected	0.3
	Difference	**-3.4**	**Difference**	**3.4**	**Difference**	**-0.1**	**Difference**	**0**

Unknown 41(1.0%) and not applicable 12(0.3%) were removed from the analysis. It was unclear what 'not applicable' referred to. A complete case analysis was performed.
(χ^2 = 179.631, df = 2, N = 4187, p < .001)
Cramer's V = 0.207

The numbers surviving to hospital discharge in each group are shown in Appendices A4t and A4u. There is a significant difference in survival to discharge between groups with 12.2% more patients than statistically expected surviving to hospital discharge in G1a. Further analysis of the differences between groups indicates that there is a not a statistically significant difference in survival to hospital discharge between G1b and G2. The statistically significant difference is between G1a and the G1b/G2 groups.

G1b and G2
(χ^2 = 8.647, df = 4, N = 3263, p = .071)
Cramer's V = 0.051

G1a and G2
(χ^2 = 171.065, df = 4, N = 3755, p = <.001)
Cramer's V = 0.213

G1a and G1b
(χ^2 = 74.770, df = 3, N = 1434, p = <.001)
Cramer's V = 0.228

3.12. Survival to 30 days

Patient numbers surviving to 30 days in all groups are tabled in Table 11. The group with the highest number of patients (22.5%) surviving to 30 days is G1a.

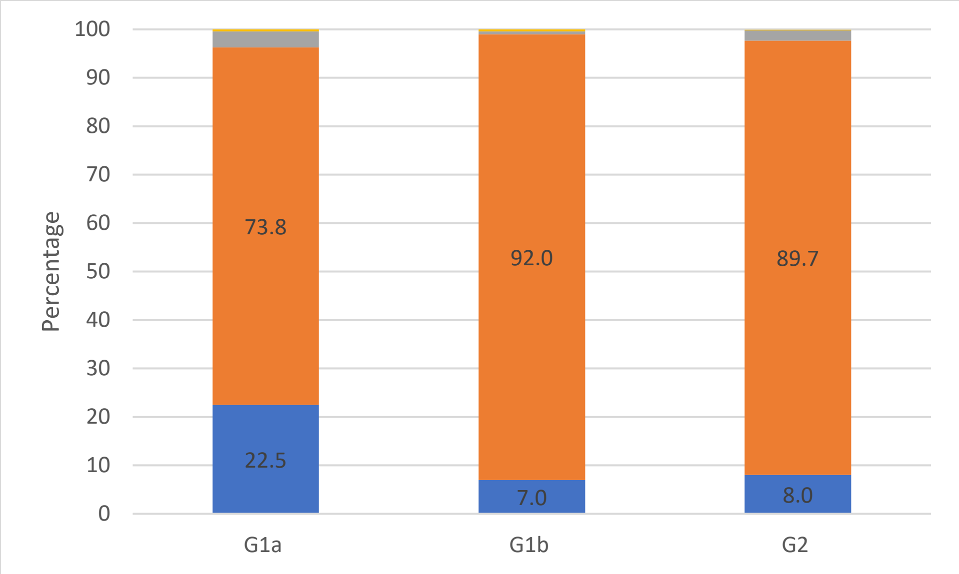

Figure 24: Survival to 30 days G1a,G1b and G2

Table 18: Statistical analysis of survival to 30 days G1a, G1b and G2

Survival to 30 days	**Survival to 30 days**		**Non Survival to 30 days**		**Unknown**	
Group		%		%		%
G1a	Observed	22.5	Observed	73.8	Observed	3.7
	Expected	11.2	Expected	86.3	Expected	2.4
	Difference	**11.3**	**Difference**	**-12.5**	**Difference**	**1.3**
G1b	Observed	7	Observed	92	Observed	1.0
	Expected	11.2	Expected	86.3	Expected	2.4
	Difference	**-4.2**	**Difference**	**5.7**	**Difference**	**0.6**
G2	Observed	8	Observed	89.7	Observed	2.2
	Expected	11.2	Expected	86.3	Expected	2.4
	Difference	**-3.2**	**Difference**	**3.4**	**Difference**	**-0.2**

To do a complete case analysis unknown n=92(2.2%) and missing n=10(0.2%) were removed from the analysis.

(χ^2 = 168.114, *df* = 2, *N* = 4141, *p* < .001)

Cramer's V = 0.136

There are 11.3% more patients than expected in G1a who survive to 30 days.

This analysis was repeated with G1b and G2 to see if the difference only resided with G1a.

(χ^2 = 0.716, *df* = 1, *N* = 3199, *p* = .397)

Cramer's V = 0.015

There is no statistically significant difference between these two groups.

3.13. Utstein comparator

Table 19: Utstein Comparator Survival to 30 days in G1b and G2

Utstein Survival to 30 days	**Survival to 30 days**	**Non Survival to 30 days**	**Total**
Group			
G1b	23(23.7%)	74(76.3%)	97(100)
G2	170(23.0%)	566(76.9%)	736 (100)

To do a complete case analysis unknown missing n=4(0.5%) were removed from the analysis.

(χ^2 = 0.018 *df* = 1, *N* = 833, *p* = .893)

Cramer's V = 0.005

There is no significant difference in survival to 30 days in the Utstein comparator group between G1b and G2.

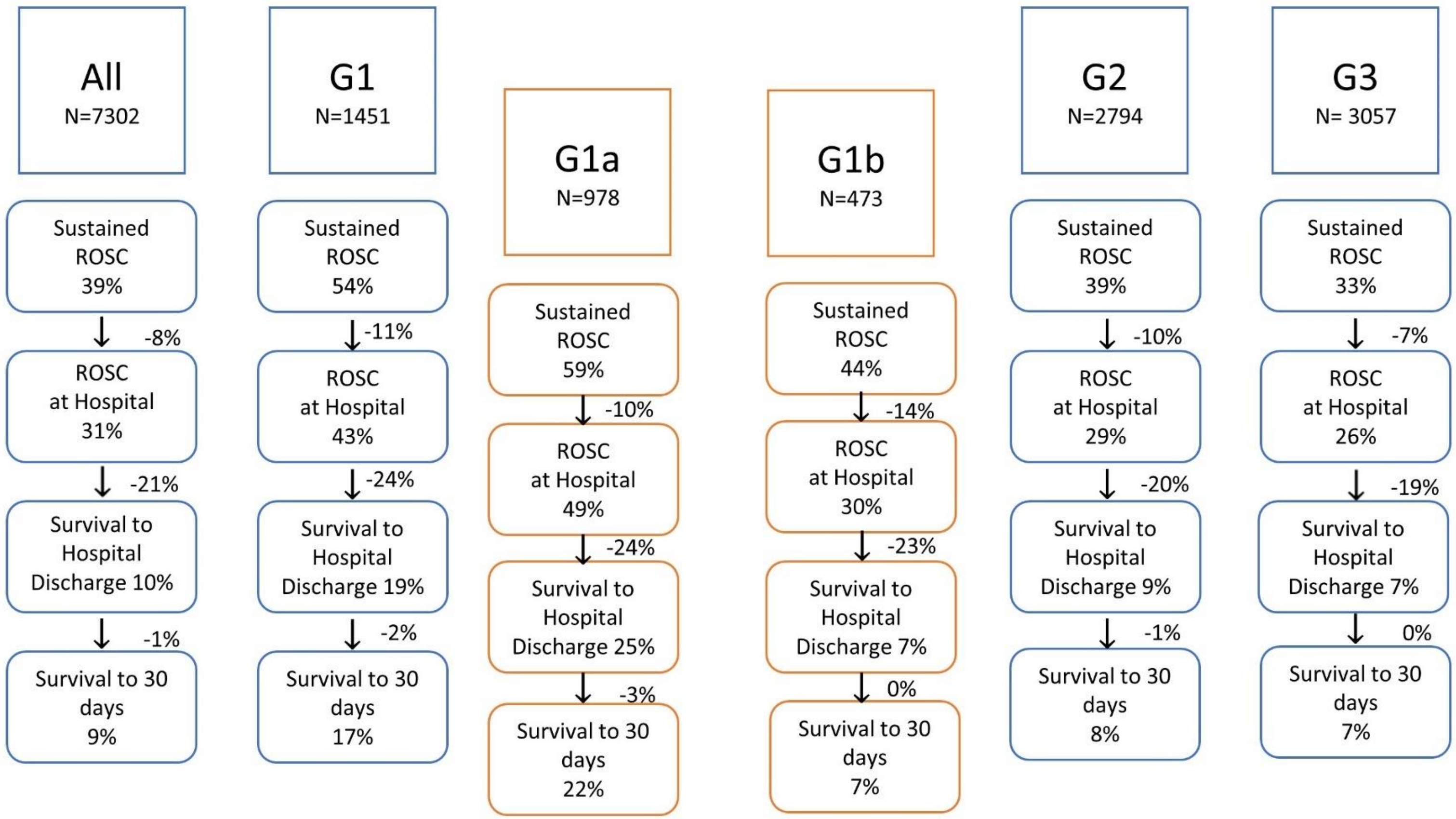

Figure 25: Patient flow all groups

3.17 EMS call outcomes

3.17.1 Response times

The response times in G1 and G2 are indicated in Appendix A4x. G2 has a mean response time of 9 minutes compared to a mean response time of 22 minutes in G1. The response time of the G1 subgroups and G2 is displayed in Table 22. G1a has the longest mean response time of 00:23:50 minutes.

Table 11 shows the initial response category and the differences between G1 and G2 with 28.1% of patients receiving a category one response in G1 compared to 76.2% in G2. The percentage of patients allocated a category one response are 19.8%, 45.2% and 76.2% in G1a, G1b and G2 respectively.

3.17.2 Initial response category within groups

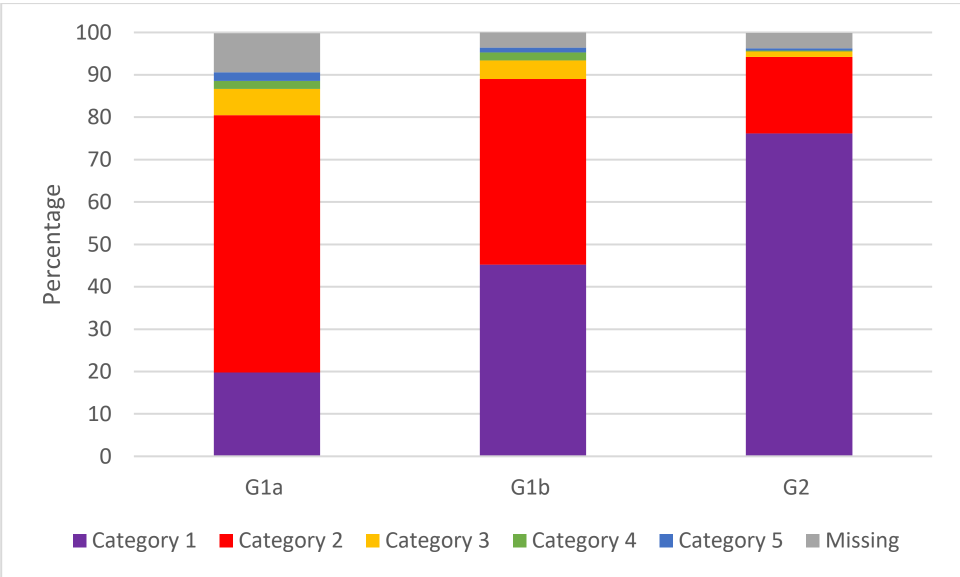

Figure 26: Initial response categories G1a,G1b and G2

Table 20: Statistical analysis of the initial response category

Category at T5	**Category 1**		**Category 2**		**Category 3**		**Category 4**		**Category 5**		**Missing**	
Group		%		%		%		%		%		%
G1a	Observed	19.8	Observed	60.7	Observed	6.2	Observed	1.9	Observed	2	Observed	9.2
	Expected	59.8	Expected	30.7	Expected	2.8	Expected	0.8	Expected	1	Expected	4.9
	Difference	**-40**	**Difference**	**30**	**Difference**	**3.4**	**Difference**	**1.1**	**Difference**	**1**	**Difference**	**4.3**
G1b	Observed	45.2	Observed	43.8	Observed	4.4	Observed	1.9	Observed	1.1	Observed	3.6
	Expected	59.8	Expected	30.7	Expected	2.8	Expected	0.8	Expected	1	Expected	4.9
	Difference	**-14.6**	**Difference**	**13.1**	**Difference**	**1.6**	**Difference**	**1.1**	**Difference**	**0.1**	**Difference**	**-1.3**
G2	Observed	76.2	Observed	18	Observed	1.3	Observed	0.2	Observed	0.6	Observed	3.6
	Expected	59.8	Expected	30.7	Expected	2.8	Expected	0.8	Expected	1	Expected	4.9
	Difference	**16.4**	**Difference**	**-12.7**	**Difference**	**-1.5**	**Difference**	**-0.6**	**Difference**	**-0.4**	**Difference**	**-1.3**

Missing data n=207 (4.9%) was removed from the analysis to provide a complete case analysis.

(χ^2 = 1003.246, df = 8, N = 4038, p < .001)

Cramer's V = 0.352

There is a significant difference in categorisation at T5 between groups.

3.17.3 Final response category

Table 11 indicates that more patients are categorised as Category 1 as the call progresses. At final categorisation at G1, 34.1% of patients are categorised as requiring a Category 1 response compared to 91.6% of patients in G2.

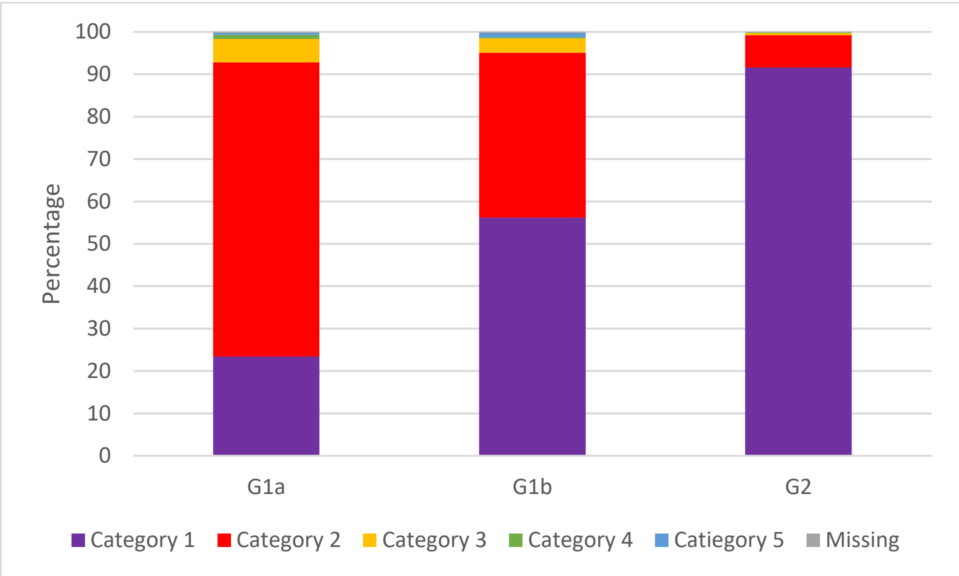

Figure 27: Distribution of the final response category within groups

Table 21: Difference between observed and expected final categorisation

Final Cat	**Category 1**		**Category 2**		**Category 3**		**Category 4**		**Category 5**		**Missing**	
Group		%		%		%		%		%		%
G1a	Observed	23.4	Observed	69.4	Observed	5.5	Observed	1	Observed	0.5	Observed	0.1
	Expected	71.9	Expected	25.3	Expected	2.0	Expected	0.3	Expected	0.3	Expected	0.1
	Difference	**-48.5**	**Difference**	**44.1**	**Difference**	**-2.0**	**Difference**	**0.7**	**Difference**	**0.2**	**Difference**	**0**
G1b	Observed	56.2	Observed	38.9	Observed	3.4	Observed	0.2	Observed	1.1	Observed	0.1
	Expected	71.9	Expected	25.3	Expected	2.0	Expected	0.3	Expected	0.3	Expected	0.1
	Difference	**-15.7**	**Difference**	**13.6**	**Difference**	**1.4**	**Difference**	**-0.1**	**Difference**	**0.8**	**Difference**	**0**
G2	Observed	91.6	Observed	7.6	Observed	0.6	Observed	0.1	Observed	0.1	Observed	0
	Expected	71.9	Expected	25.3	Expected	2.0	Expected	0.3	Expected	0.3	Expected	0.1
	Difference	**19.7**	**Difference**	**-17.7**	**Difference**	**-1.4**	**Difference**	**-0.2**	**Difference**	**-0.2**	**Difference**	**-0.1**

Missing data was removed 2(0.1%) to provide a complete case analysis.

(χ^2 = 1741.365, df = 8, N = 4242, p < .000)

Cramer's V = 0.453

There is a significant difference in final categorisation between groups.

3.17.4 Most common MPDS cards at categorisation

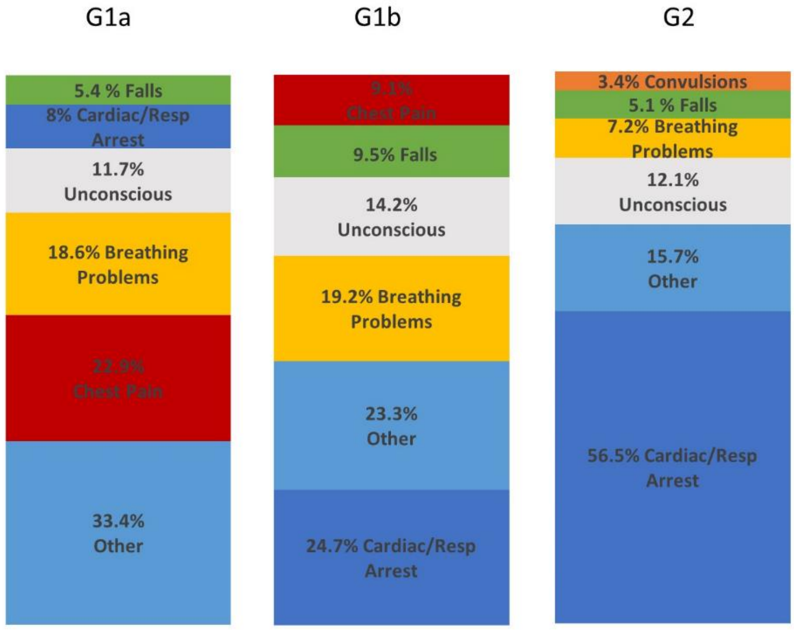

Figure 28: Most common initial MPDS cards G1a,G1b and G2

Figure 28 shows that the predominant AMPDS card in G1a is chest pain compared to cardiac/respiratory arrest in both G1b and G2. Appendices A6a to A6c also demonstrate the high number of breathing problems during categorisation and how this is more apparent in G1b and G2 in comparison with G1a.

4. Sensitivity Analysis

Table 22 indicates the numbers of patients in each group in the sensitivity analyses.

Table 22: Numbers of patients in groups sensitivity analysis

	Group 1b n(%)	Group 2n(%)
0 Minutes	692 (21.2)	2575(78.8)
3 Minutes	473(14.5)	2794(85.5)
10 Minutes	236(7.2)	3031(92.8)

Table 23: Results sensitivity analyses

	Presenting Rhythm (N = 3181)	ROSC (N = 3260)	Survival to discharge (N = 3226)	Survival to 30 days (N = 3199)
0 Minutes	(χ^2 = 13.13, *df* = 2, *p* < .001) Cramer's V=0.064	(χ^2 = 6.46, *df* = 1, *p* = .11) Cramer's V= 0.045	(χ^2 = 0.08, *df* = 1, *p* = .355) Cramer's V = 0.16	(χ^2 = 0.03, *df* = 1, *p* = .870) Cramer's V=0.003
3 Minutes	(χ^2 = 13.87, *df* = 1, *p* <.001) Cramer's V = 0.066	(χ^2 = 3.87, *df* = 1, *p* = .049) Cramer's V=0.34	(χ^2 = 2.34, *df* = 1, *p* = .126) Cramer's V=0.027	(χ^2 = 0.72, *df* = 1, *p* = .397) Cramer's V = 0.015
10 Minutes	(χ^2 = 8.38, *df* = 1, *p* =.004) Cramer's V = 0.051	(χ^2 = 1.19, *df* = 1, *p* = .276) Cramer's V = 0.19	(χ^2 = 1.92, *df* = 1, *p* = .165) Cramer's V = 0.24	(χ^2 = 0.93, *df* = 1, *p* = .333) Cramer's V = 0.17

The sensitivity analyses indicates that the finding of there being a statistically significant difference in presenting rhythm between groups is robust. G2 are more likely to have a shockable rhythm and G1b less likely to have a shockable rhythm than statistically expected. When the sensitivity analyses were conducted on patient outcomes to include sustained ROSC, survival to hospital discharge and survival to thirty days there was not a statistically significant difference between G1b and G2. With the 3-minute cut off applied to sustained ROSC the result is significantly different statistically, but this result is isolated and insufficient to suggest a meaningful finding when all other results are statistically non-significant across time points and outcomes.

5. Discussion

5.1. Summary of key findings

Data analysis compared the characteristics and outcomes of patients who were alive at the time of the EMS call to patients who had already suffered an OHCA at the time of the EMS call, with interesting findings. There are key differences between Group 1 (not in cardiac arrest at the time of the EMS call) and Group 2 (already in cardiac arrest at the time of the EMS call). There are also key differences between the Group 1 subgroups G1a (EMS witnessed) and G1b (Not EMS witnessed) and Group 2.

When looking at the key differences between Group 1 and Group 2, and the Group 1 subgroups (G1a and G1b) and Group 2, there are significant differences between the groups. Firstly, there are more women in Group 1 than Group 2, most noticeably in the G1b group (not in cardiac arrest at the time of the EMS call and not witnessed by EMS staff); 39.1% female versus 30.8% female in G1b and G2 respectively. G1b are more likely to be bystander witnessed than G2, but less likely to receive bystander CPR. G1b are statistically significantly less likely to present with a shockable rhythm, despite being alive at the time of the EMS call, and this finding is robust across the sensitivity analyses. The EMS witnessed sub-group (G1a) are more likely to achieve a ROSC (58.7% versus 39.1% in group 2), and 22.5% of G1a patients survive to 30 days compared with 7% and 8% of G1b and G2 patients respectively. Although G1b patients are alive at the time of the EMS call, they have less Utstein patients than G2 (21.8% and 28.3% respectively). There are large differences in EMS response times. Patients in Group 2 have a mean response time of 9 minutes, compared to 24 and 19 minutes in G1a and G1b respectively. The response times link very closely to the way the calls are categorised, with G2 EMS calls significantly more likely to receive a category one response (76.2%) compared to 19.5% and 45.2% in G1a and G1b respectively. When investigating the AMPDS codes, G1 patients are a more disparate group than G2 and there are also differences between G1a and G1b. The largest single code in G1a is chest pain at 22.9%, followed by breathing problems 18.6%. In G1b the predominant code is cardiac/respiratory arrest (24.7%) and then 19.2% coded as breathing problems. Group 2 have the predominant code as cardiac arrest (56.5%) and 12.1% coded as unconscious.

Further investigation of the AMPDS code descriptions reveals the following differences: the predominant code description in G1a is difficulty speaking between breaths (12.9%) and then clammy with chest pains (9%). G1b has a predominant code description of cardiac/respiratory arrest not breathing at all (17.1%), followed by difficulty speaking between breaths (9.1%). G2 has a predominant code description of cardiac/respiratory arrest not breathing (39.2%), followed by cardiac/respiratory arrest agonal (14.1%). Predominantly the AMPDS card descriptions indicate a breathing issue to include not breathing at all and ineffective breathing amongst others and in each group the AMPDS code descriptions contain more descriptions relating to breathing problems at the final coding in comparison to the initial coding.

In the following sections I will discuss these findings in more detail.

5.2. Comparison of OHCA characteristics and outcomes with published data

In the study population patients were included in the analysis if they were aged 18 years, or over. The mean age of the study population was 68.07 years. The Out-of-Hospital Cardiac Arrest Outcomes (OHCAO) Epidemiology Report, published in 2019[182], had a mean age of patients of 66.6 years and this registry includes OHCA patients of all ages (including children) across England, thereby explaining the higher mean age in my study. In the study data, 26.1% had a shockable rhythm, 70% of OHCA occurred at home and 87.5% were presumed to have a medical cause and this data is comparable to national data[182] and Malaysian and Australian data[183]. Bystanders witnessed 54.3% of OHCA, with 66.4% of OHCA receiving bystander CPR. In this dataset 9% of patients survived to 30 days after their OHCA. A systematic review and meta-analysis of 141 studies[184] indicates the global pooled 1 month survival rate to be 10.7%, however this summary statistic is derived from a wide degree of variation across countries and systems. The best performing systems and their survival rates are widely reported to be Holland 28%[185], Seattle 22%[64] and Norway 25%[186]. Survival to 30 days for the Utstein comparator group in this dataset was 22.1% and this can be compared to the analysis of the EuReCa ONE Study that included 27 European nations. A 2016 analysis of EuReCa One found that 29.7% of patients in the Utstein group survived to either 30 days, or to hospital discharge[187].

5.3. Exploration of findings

5.3.1. Sex differences

Within the study population the uneven sex split is similar to findings of epidemiology studies internationally[188–190]. The data set analysed included patients who had suffered an OHCA and had received resuscitation from EMS staff. Sex differences in the treatment and outcomes of OHCA have previously been explored. An American study by Blewer et al.[191] found that men were more likely than women to receive bystander CPR where the OHCA occurred in a public place (39% of women versus 45% of men) and this has been linked to fears of being accused of sexual assault if chest compressions are performed[192]. However, this sex difference in bystander CPR was not apparent where the OHCA occurred in the home. In the UK this difference in bystander CPR rates would have an impact on the inclusion of women in the data set. For example, The Joint Royal Colleges Ambulance Liaison Committee Clinical Guidelines[193] state resuscitation efforts would be futile where:

- It has been 15 minutes since the onset of collapse
- There has been no bystander CPR prior to the arrival of the ambulance
- There is an absence of any exclusion factors
- There is an asystole or agonal rhythm for more than 30 seconds

Where a patient who has suffered an OHCA does not receive bystander CPR there is a potential impact on whether that patient is resuscitated by EMS staff subsequently, and consequently whether they would be eligible for inclusion in this data set.

Another factor that might influence women's presence in the data is the observation that women are approximately half as likely as men to be found in a shockable rhythm and so are less likely to be resuscitated[194]. Oving at al.[195] investigated a large cohort of OHCA patients in the Netherlands and established that within the cohort, OHCA occurred almost equally between the sexs. The sex difference in OHCA occurrence was 47.3% women and 52.7% men, however women were less likely to be resuscitated than men; 14.8% of women were resuscitated when compared to 34.6% of men receiving resuscitation. This difference in resuscitation rates between sexs is supported by Lewis at al.[196]. Oving et al.'s[195] data reflected the findings of Blewer et al.[191] with men more likely to receive bystander CPR (72.7% men compared to 67.9% women), even if the OHCA was witnessed.

Building on this discussion, Watkins and colleagues[197] found that OHCA in women is less likely to be correctly recognised by call-handlers than OHCA in men. Arguably the patients in G1 are not yet in OHCA at the time of the EMS call, but Watkins and colleagues[197] included patients where an OHCA diagnosis was made at hospital or through reference to the EMS reports and included all patients that proceeded to have an OHCA whether alive at the time of the EMS call or not. However, Watkins et al.[197] only included patients who were transferred to hospital, excluding from the analysis a group who were declared deceased at scene.

Research suggests that women who suffer OHCA are older than men[198]. They are also less likely to have an OHCA in a public place than men[198]. Existing literature suggests that patients who suffer their OHCA in a residential area as opposed to a public place are more likely to have characteristics associated with a poor outcome[199]. Older patients with multiple comorbidities may be less likely to be resuscitated and in the UK, paramedics are encouraged to make 'best interest' decisions and withhold resuscitation where the patient is in the final stages of an advanced, incurable, or terminal condition, which would include dementia and general frailty[193]. There is, however, potential for a systematic bias in the way EMS respond to and treat female OHCA patients that is suggested by previous research, and which is worthy of further investigation.

5.3.2.Differences in presenting rhythm

Regarding the characteristics of the OHCA, G1b have the lowest proportion of patients presenting with a shockable rhythm and this is likely to be because of the comparatively long response time and the cardiac rhythm transforming from ventricular fibrillation or pulseless ventricular tachycardia into pulseless electrical activity (PEA), or asystole before EMS arrival. In G1a there were 5.1% more patients than statistically expected presenting with a shockable rhythm; reflecting Lee et al's[200] findings of high rates of EMS witnessed OHCAs presenting with a shockable rhythm. Interestingly, Hostler and colleagues[201] found that 43% of EMS witnessed OHCA patients presented in a PEA rhythm as opposed to a shockable rhythm(25%). In this data 36.9% of G1a patients presented in a shockable rhythm, which is between Lee et al's[202] and Hostler et al's[201] findings.

5.3.3. Witness status

Interestingly 92.8% of G1b patients are bystander witnessed compared to 84.9% of G2 patients. I anticipate that this difference will reflect the likelihood that G1b were alive during the EMS call, which is normally made by another person, and therefore the OHCA is more likely to be witnessed. Patients in G2 may have been found in cardiac arrest and therefore the event was less likely to be witnessed.

5.3.4.Bystander CPR

G2 are recorded to have the highest chance of receiving bystander CPR and this is likely to be because of EMDs recognising the OHCA on the EMS call and delivering tCPR advice. These patients are also more likely to suffer their OHCA in a public place, which may act to increase the probability of bystander CPR. There have been numerous initiatives in the UK to improve bystander CPR and access to public defibrillators[58] . The subset G1b, with the highest proportion of women, were more likely to be bystander witnessed than G2 (92.8% versus 84.9%), however they were less likely to receive bystander CPR (27.2% versus 80.2%). This corroborates the findings of Blewer and colleagues who described female sex as less likely to receive bystander CPR[191]. This will only be part of the explanation though; G1b are more likely to present with breathing problems and it might be that a bystander fails to recognise a patient deteriorating into agonal breathing and this is discussed further in section 5.3.10 below.

Interestingly, 23.8% of G1a have bystander CPR recorded even though they are EMS witnessed and professionals were on scene to deliver resuscitation. This finding may be due to recording errors by EMS staff. It could also be that bystanders assist with the initial phase of the resuscitation and EMS staff record this as bystander CPR.

5.3.5.OHCA outcomes

Subgroup G1a is EMS witnessed and the immediate treatment by EMS staff following OHCA is linked to improved survival[201]. Unsurprisingly, the EMS witnessed sub-group (G1a) are more likely to achieve a ROSC and survive to 30 days compared with G1b and G2 patients. The comparatively high survival rate in G1a links to the high incidence of cardiac symptoms in this group and the associated increased chance of survival found in Lee et al's study[202] of EMS witnessed OHCA. 51.5% of the cardiac symptom group in Lee et al's study[202] presented in a shockable rhythm and had the best rate of survival to discharge (42.7%) with a good neurological outcome.

Although G1b patients are alive at the time of the EMS call, they consist of less Utstein patients than G2, presumably because of the longer response time leading to transformation into a cardiac rhythm that is not shockable. G1b patients are, however, more likely to achieve a ROSC than G2 patients, but are more likely to lose the ROSC at hospital than G2. G1b also have the worst survival rates of any group with a survival to 30 days of 7% compared to 8% in G2. The sensitivity analyses indicated that there was no statistically significant difference in OHCA outcomes between G1b and G2.

The timing of the OHCA is a critical factor in survival. Poor survival in G1b will be associated with the time delay between suffering the OHCA and the arrival of EMS. For each minute of OHCA, without any treatment, the chance of survival diminishes by 5.5% per minute[203]. The impact of a delay in treating OHCA and associated poor outcomes have been well documented. A delay in EMS response delays lifesaving treatments such as early defibrillation and early CPR and where a patient initially presented in a shockable rhythm, this rhythm may progress to a non-shockable rhythm before EMS arrival[204]. It could be surmised that G1b patients have less chance of survival because they are less likely to present with chest pain than G1a. In addition, G1b have comparatively long response times, low rates of bystander CPR, a higher proportion of females and increased age, which are all associated with poorer outcomes. Arguably the subgroup G1b could show significant improvement in survival if the recognition of imminent OHCA and response to these patients was optimised.

5.3.6. Response categories and response times

There are large differences in EMS response times between the groups and subgroups.
G2 are patients that have suffered their OHCA before the time of the EMS call and 76.2% are triaged initially as a category one response. Even though Group 2 have the highest proportion of patients receiving a category one response there are still 23.8% of patients in OHCA at the time of the EMS call who are not recognised as such. Corresponding to the categorisation, G2 have the fastest response time at 09:05 minutes compared to 23.5 minutes and 19.17 minutes in G1a and G1b respectively. The outcomes for G2 are however poor with only 8% of patients surviving to 30 days and less patients than statistically expected conveyed to hospital. An explanation for this may be that these patients are already in OHCA at the time of the EMS call, and may have been in OHCA for some time before the EMS call was made.

When investigating the AMPDS codes, G1 patients are a more disparate group than G2 and there are also differences between G1a and G1b. The most common presenting symptom (MPDS card) in patients whose cardiac arrest was witnessed by EMS staff (G1a) was chest pain at 22.9%, followed by breathing problems 18.6%. In G1b the predominant code was cardiac/respiratory arrest (24.7%) and then 19.2% coded as breathing problems. Group 2 have the predominant code as cardiac arrest (56.5%) and 12.1% coded as unconscious. Further investigation of the AMPDS code descriptions reveals the following differences: the predominant code description in G1a was difficulty speaking between breaths (12.9%) and then clammy with chest pains (9%). G1b has a predominant code description of cardiac/respiratory arrest not breathing at all (17.1%), followed by difficulty speaking between breaths (9.1%). G2 has a predominant code description of cardiac/respiratory arrest not breathing (39.2%), followed by cardiac/respiratory arrest agonal (14.1%).

5.3.7.Prodromal symptoms in OHCA

There is some existing research into prodromal symptoms in OHCA. Lee et al.[202] found that 40% of EMS witnessed OHCA patients reported prodromal symptoms prior to their OHCA. A study by Nehme and colleagues[79] specifically investigating EMS witnessed OHCA presenting with prodromal symptoms found that delays from symptom onset and activation of EMS were associated with poorer survival. Nishiyama et al.[205] investigated prodromal symptoms in OHCA of both cardiac and non-cardiac origin. The most frequent prodromal symptoms in OHCA believed to be of cardiac origin were dyspnoea (27%), chest pain (20.7%) and syncope (12.7%). The most frequent prodromal symptom found in OHCA of non-cardiac origin were dyspnoea (40.7%), with chest pain presenting rarely at 3.4%. The data analysed here included all adult OHCA regardless of OHCA cause. All the symptoms described by Nishiyama and colleagues[205] are described in the most frequently occurring MPDS cards and MPDS descriptors appearing in Appendices A6a to A6c. Greater knowledge of prodromal symptoms both within EMS systems and through public health campaigns, may help to improve the recognition of critical illness by patients, their families, and carers and also EMS call-takers. The response to high-risk patients could be improved as a result, enhancing survival, or preventing the OHCA from occurring through prompt treatment.

5.3.8.Chest pain

The EMS response to G1a patients is very different to the G1b and G2 groups. As previously acknowledged in the categorisation of G1a the most frequently occurring single MPDS card is chest pain (22.9%). Chest pain is coded as a category 2 response in AMPDs, with a target average response time of 18 minutes[206]. The higher proportion of chest pain as a presenting symptom in this subgroup will have contributed to the 48.5% less than statistically expected receiving a category one response and the 44.1% more than statistically expected receiving a category 2 response. G1a had the longest response times with a mean of 23:50 minutes compared to 9:05 minutes in G2.

5.3.9.Breathing problems

G1b patients have very different features to G1a patients. In total 24.7% of G1b patients code as ‘cardiac or respiratory arrest/death’ and this card does not feature in the ten most common MPDS cards for G1a. Only 9.1% of MPDS cards are for chest pain compared to the 22.9% in G1a and 2% in G2. G1b also have the highest proportion of patients coding as ‘breathing problems’ at 19.2%. It is likely that the patients in G1b present as initially more critically unwell, at the time of the EMS call, than patients in G1a and this is reflected in the call categorisation and the response time. G1b patients predominantly have breathing problems which mean they are more likely to be correctly categorised as requiring a category one response.

As previously stated, the timeliness of actions in relation to OHCA is critical to a patient’s chances of survival. G1a patients are more likely to be patients presenting with chest pain and subsequently receive a category 2 response with a longer response time, but because their OHCA is witnessed by EMS they receive immediate treatment and are more likely to survive. G1b patients present as more critically unwell with breathing problems. G1b patients deteriorate quickly into OHCA and are in OHCA by the time EMS arrive, greatly reducing their chance of survival.

5.3.10. Agonal breathing

In G1b and G2 eight out of ten and nine out of ten respectively of the most frequently occurring MPDS card descriptors related to breathing. Recognising OHCA on the EMS call as detailed in Chapter Two is challenging and one of the main reasons documented is agonal breathing. Agonal breathing is reported to be present in up to 40% of OHCA and leads to confusion and withholding of bystander CPR [207]. Agonal breathing is a gasping pattern of respiration before terminal apnoea[208] and is described by EMS callers as breathing and variations of breathing[209]. Agonal breathing is associated with a witnessed OHCA and where EMS arrive within a short time of collapse[210], it is also associated with a shockable rhythm[210,211]. Brinkrolf and colleagues[212] and Fukushima and colleagues[209] found that if the OHCA was witnessed by a bystander and the patient was agonal breathing the possibility of bystander CPR was significantly lower than if the patient was not agonal breathing. Agonal breathing is associated with a higher probability of ROSC[213] and Wolfskeil[211] found that a high gasping rate is associated with ROSC rather than a slower rate of gasping. Patients in G1b had a relatively high incidence of breathing problems. It is feasible that a proportion of G1b patients deteriorated into OHCA and displayed agonal breathing. Any bystanders witnessing the event may have mistaken agonal breathing for breathing and not delivered CPR, this would contribute to the low survival rate in G1b.

5.3.11. Sensitivity Analyses

The sensitivity analysis helped confirm that the presenting rhythm was significantly different between groups, with G1b having less patients in a shockable rhythm than statistically expected. The sensitivity analysis also confirmed that the outcome data of sustained ROSC, survival to hospital discharge and survival to thirty days were not sensitive to varying assumptions regarding the precise time of cardiac arrest. As these three outcomes are closely linked it is unsurprising that findings in relation to sustained ROSC are then reflected in both survival to discharge and survival to thirty days.

6. Limitations

This was an analysis of retrospective data. There are well-documented disadvantages of using retrospective data that apply to this study including missing data and confounding factors[214]. In terms of missing data, the largest group of 3057 patients (Group 3) were excluded from the main analysis because of the missing ‘time of the OHCA data’ required to understand if the patients were alive at the time of the emergency call, or not. The majority (61%) of patients in Group 3 were recorded as unwitnessed OHCA, indicating that the exact time of the OHCA was unknown and explaining why a proportion of this data was unrecorded. It is likely that some of the group 3 patients would have been alive at the time of the emergency call, but missing data did not allow their identification.

The scene of an OHCA is emotionally charged and chaotic and this would compound errors in recording accurate data such as the time of the OHCA. Because of this potential uncertainty in the accuracy of 'time of OHCA' reporting, and the risk of inadvertently wrongly allocating patients to G1b and G2, a decision was made to adopt a 'time of OHCA' that included an additional three minutes to reduce the impact of any recording error. As a result, there was potential for some overlap between G1b and G2 and a sensitivity analysis was completed to test the robustness of the findings.

This study is limited in its analysis of inequalities. Differences in sex between groups was analysed and commented on, but additional inequalities were not considered in this study. Data on ethnicity is not well collected in the ambulance service cardiac arrest registry dataset and would not lend itself to a meaningful analysis. Indices of Deprivation[215] could have been derived from the dataset by using postcode data, but this data collection was not planned. The Resuscitation Council UK's Systems saving lives Guidelines[216] advises that researchers should report data on barriers and motivators to CPR promotion in respect of ethnic, socio-economic, cultural and educational backgrounds.

The data could not be analysed to identify if there had been more than one call for the incident describing a change in the patient's presentation. This data would have been a useful addition to the dataset. Another limitation is the fact that patients were only included in the data analysed if they had a cardiac arrest and were resuscitated by EMS staff. To fully understand the ambulance response to OHCA patients there needs to be an analysis of all patients to include those that were not resuscitated by EMS staff. From the data analysed it cannot be quantified how many patients were alive at the time of the EMS call and were not resuscitated by EMS staff. There may be a group of patients that were alive at the time of the call, but the time taken to respond, and a lack of bystander CPR, would have meant resuscitation would no longer be viable.

7. Conclusion

If we could recognise patients who are going to suffer an OHCA more effectively during the EMS call, then a more optimum response to these patients could be provided. There is the potential to prevent the OHCA from occurring in the first place, EMDs can stay on the call to provide tCPR if the OHCA does occur, a first responder can be activated to the scene to provide immediate assistance, or EMS can attend quickly enough so that more OHCAs are EMS witnessed and treatment is provided immediately with a consequent improvement in patient survival. However, categorising all patients as category one would place unmanageable demand on EMS systems putting other patients at risk. There are a limited number of EMS resources and appropriate triage of patients works to effectively allocate these resources. If patients are incorrectly allocated a category one response then EMS resources are directed away from other patients who are not categorised as a category one, but who also require an emergency response and have time critical conditions. The ongoing challenge is to recognise patients at imminent risk of OHCA more effectively without overwhelming EMS systems in the process.

Where a patient is alive at the time of the EMS call, but their OHCA is unwitnessed by EMS (G1b), patients do particularly badly in terms of survival. These patients present very differently to G1a, 'EMS witnessed OHCAs' and predominantly complain of problems associated with breathing. This group of patients provide a learning opportunity to allow EMS systems to better identify patients presenting with breathing problems who are critically unwell and presenting with agonal breathing, or who are at imminent risk of OHCA and respond more effectively to them. Poor survival rates in this group are a consequence of the aetiology of the OHCA, potential unrecognised agonal breathing, the timing of the OHCA and low rates of bystander CPR.

In group G1a there are comparatively long response times. The aetiology of the OHCA in this group and the fact the OHCA was witnessed by EMS staff corresponds to the relatively high rate of survival. If we could recognise and respond to these patients more effectively there is an opportunity to provide early treatment and to prevent the OHCA from occurring.

This data analysis has highlighted the sex imbalance in the EMS response to OHCA with the potential for an unconscious bias in the way EMS triage and respond to OHCA, and in the behaviour of bystanders at a cardiac arrest. There is also the possibility that a group of patients are missing from the data because they do not fit the resuscitation criteria of EMS staff, and resuscitation is not attempted as a result. EMS respond most quickly to patients who have already suffered an OHCA and consequently have a lower chance of survival. EMS systems have optimised the response to this group of patients who are already in OHCA at the time of the EMS call and there is a need to understand how to similarly optimise the response to patients who are alive at the time of the EMS call, but at high risk of cardiac arrest.

8. Chapter Summary

This research has highlighted the disparity in the EMS response and outcomes of patients who suffer an OHCA and the potential to respond more effectively to improve outcomes from OHCA. There are opportunities to design research to further investigate these findings and to design training and EMS systems to recognise imminent OHCA and optimise outcomes. Improvements in the first link of the chain of survival in OHCA that either prevent the OHCA from occurring, or allow quicker initial treatment by EMS staff when a cardiac arrest happens, will ultimately save lives. I take these findings forward into the next chapter where I will use conversation analysis to investigate calls where a patient is alive at the time of the EMS call, but then deteriorates into OHCA, to understand differences in the call interaction and the way EMS calls are categorised.

Chapter Four: Conversation Analysis of Emergency Calls

1. Chapter Overview

Following the Systematic Mixed Studies Review (SMSR) investigating the features of Emergency Medical Service (EMS) calls that facilitate or inhibit Emergency Medical Dispatcher (EMD) recognition that a patient is in, or at risk of, cardiac arrest and reported in Chapter Two I proceeded to report an analysis of out-of-hospital cardiac arrest (OHCA) registry data in Chapter Three. The findings reported in Chapter Three indicated that where a patient is alive at the time of the EMS call and then proceeds to suffer an OHCA before arrival at hospital they are significantly less likely to receive a category one response (7-minute response time target), the fastest UK EMS target response time. Not receiving a category one response puts the patient at a disadvantage, not least because the patient receives a less optimal response in terms of ambulance response time, but the Emergency Medical Dispatcher (EMD) may terminate the EMS call negating the opportunity to perform telephone Cardiopulmonary Resuscitation (tCPR) should the patient collapse and their heart stop beating before EMS arrival on scene. In addition, where the severity of a patient's condition is not realised on the EMS call an emergency first responder is less likely to be activated to the scene to provide emergency first aid. With evidence suggesting emergency first responders make an important contribution to increasing survival rates in OHCA[204] this is an important consideration.

For all the reasons stated above it is imperative to identify those patients who are at imminent risk of OHCA on the EMS call so that an optimal ambulance response can be provided. Clear and efficient communication between the caller and the EMD is critical to enable timely access to medical help[217]. EMD decision-making during the call is supported by remote triage software described in Chapter One. The challenge here is not to over triage patients as unnecessarily requiring a category one response and overwhelm EMS systems by a lack of specificity. This would prevent any improvement from being made and have a detrimental effect on the ambulance response to critically unwell patients, and to all patients generally. Individuals calling concerning patients in a time-critical situation also face a challenge - that of reporting the patient's condition adequately in order to receive the correct assistance.

This chapter focusses on the interaction between callers and EMDs in a sample of EMS calls. I have chosen to use applied conversation analysis (CA), to analyse the emergency call data. CA is considered an "observational science" focussed on recordings and detailed transcripts of naturalistic talk data. Although a qualitative research method, it is unique in that the focus of analysis is not participants' experiences, but rather what participants to an encounter are doing or achieving in, and through, their talk.

There is a growing body of work where CA has been used to investigate healthcare encounters. Here, CA research has been successful in investigating the rules and norms that are adopted during routine healthcare tasks[218]. For example, CA studies of GP-patient interaction have focused on the delivery of diagnoses and treatment planning and treatment recommendations[219]. CA studies can identify recurrent patterns of communication behaviour, and then statistics can be used to explore potential associations between target interactional variables and the immediate outcomes of an encounter[220]. These sorts of findings have been used to generate evidence that can be used to support interventions aimed at improving outcomes and enhancing practice. CA studies have informed training to change practitioner behaviour in fields such as general practice, mental health and dementia[218].

Applied CA research has also included studies of calls to emergency services[221]. Whalen and Zimmerman[222] detail the social organisation of emergency calls and the consequences of sequential context and interactional treatment. For example, CA has been used previously to explore how a caller's claims of entitlement can affect emergency call-takers dispatch decisions[223]; how rights and responsibilities displayed by callers and call-takers can affect the action trajectory of an emergency call[224], and the role of emotional displays in the management of interaction in calls to 911[225]. In Raymond and Zimmerman's[224] work they explore the "rights" and "responsibilities" of the caller and the EMD. The caller has the "right" to seek help and the EMD has the "right" to ask questions. Callers then have the "responsibility" to answer those questions and the EMD has the "responsibility" to dispatch in a timely manner, where appropriate to do so.

CA studies of EMS (ambulance service) calls have previously provided important insights into the opportunities and challenges in the EMD and caller interaction[222,226,227]. Booker and colleagues[227] used CA to explore EMS calls for primary care situations and investigated talk patterns occurring in EMS calls for patients in low acuity situations resulting in an emergency ambulance being dispatched. CA researchers have previously identified the importance of calm, clear and efficient communication when an EMS call is made for a patient in OHCA[217]. Any miscommunication during the EMS call will interfere with the activation of the optimum ambulance response to that patient. A previous conversation analysis and linguistic analysis study of emergency calls completed in Australia aimed to improve the identification of patients already in OHCA[217]. This found that changing the tense of a key question from, "what happened" to "what's happened" in the dispatch protocol changed the response of the caller so that they gave an informative short report rather than using a longer narrative format. A short report format of dialogue is preferable for EMDs because it allows them to prioritise the call in a more timely manner[217]. In a separate study, Riou et al.[226] identified that when callers give the reason for the call before they are asked for it (pre-emption), then when they are asked for the reason for the call, as per the script, the caller treats this as a request for more information and information regarding the reason for the call is lost. The result is that the caller does not repeat what has already been said and this leads to information being lost to the EMD with associated delays in providing appropriate assistance.

The caller and EMD interaction is clearly critical and provides an opportunity to identify communication behaviours that could be used to improve the identification of those patients who are at imminent risk of OHCA and optimise patient outcomes. My research specifically investigates a corpus of EMS calls where the patient is alive at the time of the EMS call and subsequently deteriorates into OHCA. The research compares and examines differences between those patients that received the highest priority EMS response and those that did not, to understand the implications of possible differences in calls for subsequent developments (i.e., triage outcomes). To my knowledge this phenomenon has not been previously explored.

2. Methods

2.1. Choice of conversation analysis (CA)

CA was chosen as the methodology because it has been successfully used to study healthcare encounters and how certain communication behaviours might be associated with patient outcomes[220]. The systematic mixed studies review reported in Chapter Two indicated that there is variability in the way that EMDs adhere to the dispatch protocol and in their skill at interviewing a caller.

CA is focused on three principles of talk:

- Social action (questioning or answering)

This principle is concerned with the action people are performing through their talk. Participants achieve action in a coordinated way with their talk; in both what they say and what they do not say. Examples are asking, complaining, noticing etc.[228]

- Action sequences (adjacency pairs i.e. requesting and granting)

Talk is usually structured in two or more sequential turns with a minimal format of a two-move sequence called an adjacency pair, an example would be an invitation and acceptance[229].

- Turn design (formulation)[218]

This principle is concerned with how turns are formatted to implement an action[230].

CA is an appropriate methodological choice to investigate the EMD and caller interaction because I am interested in the outcomes of the interaction associated with the EMS call triage of critically unwell patients and how the social action; action sequences and turn design, influence the triage outcomes.

An alternative method that could have been used to analyse this data was discourse analysis (DA). The method of CA was chosen over DA because CA examines the organisation and ordering of talk in interaction and examines language as social interaction, whereas DA is concerned with the variation in language use and the context of language production and the functions it performs[96]. DA is employed to understand the meaning of what people say and how they say it[97]. My research was concerned with the structure of the EMS call and the order of the verbal interaction related to it. As CA is concerned with how order is created and sustained on a microinteractional level and the 'how' of participant interaction it was the method suitable to meet the aims and objectives of my research[98].

2.2. Sampling strategy

Calls were sampled from cardiac arrest registry data from the UK South Western Ambulance Service NHS Foundation Trust (SWASFT). During Chapter Three (data analysis) patients who were recorded as being alive at the time of the EMS call and who then subsequently suffered an OHCA were identified from the data set and labelled as Group One. Group One was used to select cases for the CA research.

Sample size in qualitative research is not determined a priori. Schegloff[13] sets out the case that where CA is concerned, quantification is no replacement for analysis, stating that a single case can be sufficient for CA research. Fifty EMS recordings where patients were at imminent risk of OHCA (Group One) were identified for inclusion as described in Figure 29. These patients were drawn from two cohorts, those who were triaged as requiring the most immediate ambulance response (Category 1), and those who were triaged as requiring a less immediate ambulance response (Category 2, 3, 4, or 5) summarised below:

Cohort 1: Patients who were alive at the time of the emergency call, but went on to suffer an out-of-hospital cardiac arrest in the prehospital phase of care and who ***did*** initially code as category 1;

Cohort 2: Patients who were alive at the time of the emergency call, but went on to suffer an out-of-hospital cardiac arrest in the prehospital phase of care and who ***did not*** initially code as a category 1.

In each cohort 25 calls were selected in the following way, 15 calls were selected through random sampling of the cohort and 10 calls were selected using purposive sampling, focusing on cases of interest[232] identified from the findings from Chapter Two (systematic mixed studies review) and Chapter Three (data analysis) of the thesis. These included cases where the category had changed during the EMS call triage and cases where the categorisation had been upgraded to a higher priority response or downgraded to a lower priority response during the EMS call triage process. I also purposively selected EMS-witnessed OHCA, OHCA occurring in a healthcare facility, patients aged less than 30 years old, unwitnessed OHCA, EMS-witnessed ventricular fibrillation OHCA, OHCA occurring greater than one hour after the EMS call and calls where the final categorisation was category four.

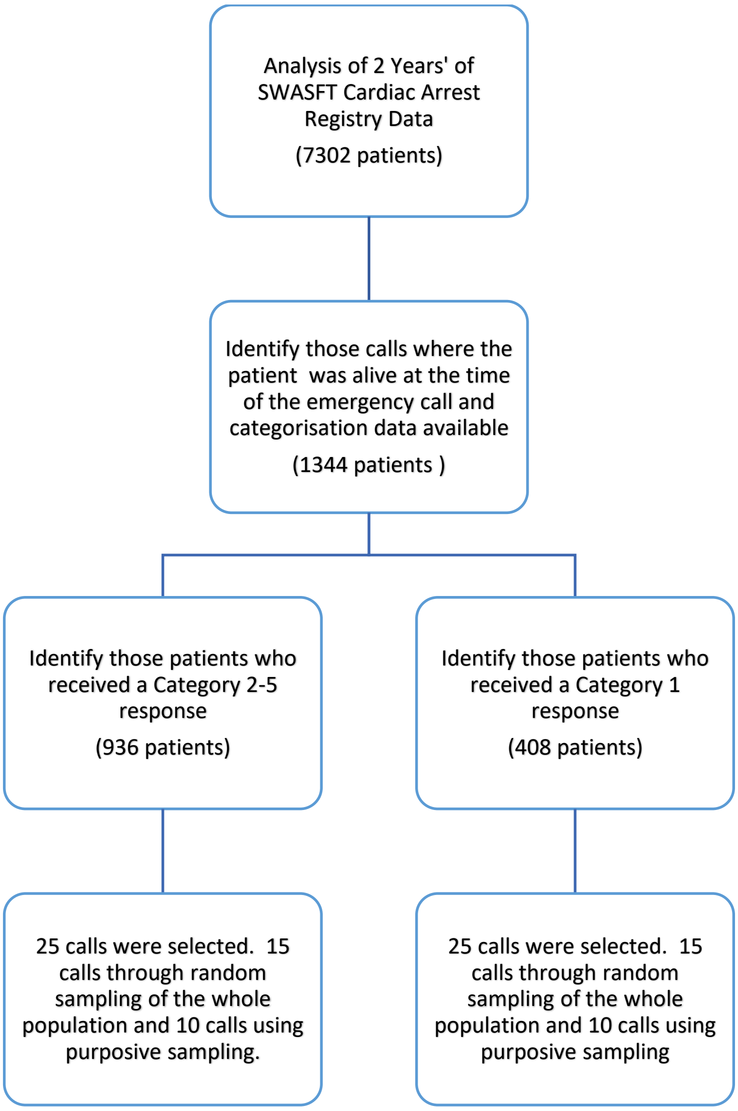

Figure 29. Sampling EMS call data for conversation analysis

EMS calls are routinely recorded and stored by the service. Once the cases were selected, spoken names, telephone numbers and locations were redacted using Audacity[233] editing software (Muse Group, Pittsburgh) by a data officer in SWASFT. The pseudonymised call data recordings were then transferred using a password protected and encrypted hard drive and sent to a University of the West of England approved transcriber using a secure file upload system. The call recordings were initially transcribed verbatim and then reviewed to identify their general overall structural organisation. The stage of the EMS call identified as being of interest and selected for detailed analysis was the beginning of the EMS call, the Pre-Triage Questions (PTQ) up until the point that the address details were taken as illustrated in Figure 30. The PTQ was introduced to the EMS call in this system during the Ambulance Response Programme established in 2015[206] and was considered worthy of exploration for several reasons. The PTQ is a relatively new addition to the EMS call structure in the UK, developed to enable the rapid identification of those patients in OHCA, or who are at immediate risk of OHCA i.e. those not breathing, or who are unconscious with noisy breathing, indicative of agonal breathing[234]. In addition, whilst reviewing the calls to familiarise myself with the data, I observed these questions to be a common source of interactional 'trouble' for both the caller and the EMD.

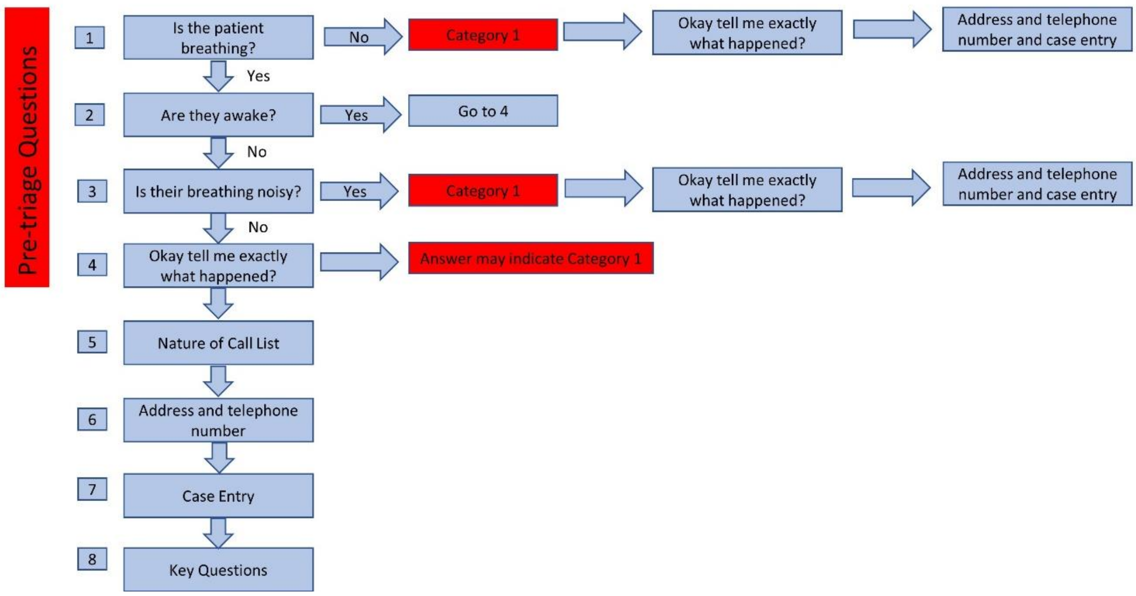

Figure 30: Pre-Triage Questions

The PTQ sections of call recordings were transcribed in detail according to standard Jeffersonian conventions[235]. Transcription in CA is a constituent part of the methodological process[236] because the details of an interaction are a fundamental part of how participants respond and build actions[237]. The transcription not only records what has been said, but also how it was said[237]. EMS call recordings and detailed transcripts of these sections were analysed systematically to identify recurrent patterns of interest. CA methods were used to elucidate the organisation of the action sequences, design of turns-at-talk and the word choices participants made that work together to implement the PTQs as a component activity of the calls,[238] and that may help identify a patient at imminent risk of OHCA.

In Chapter Two, the Systematic Mixed Studies Review identified that the emotional state of the caller can cause problems for the EMD. I therefore used the Emotional Content and Cooperation Score (ECCS)[161] to assess the audio recordings of the calls. The ECCS was developed by the National Academy of Emergency Medical Dispatch[239] and has five levels: 5, uncontrollable, hysterical; 4, uncooperative, not listening, yelling; 3, moderately upset but cooperative; 2; anxious but cooperative; and 1, normal conversational speech. Each call was assessed and the ECCS was recorded.

3. Results

Fifty EMS call recordings were successfully identified in the system, downloaded and transcribed for analysis. On review of the call recordings twelve patients were excluded, as indicated in Table 24, leaving 38 calls available for analysis - 16 calls in cohort one and 22 calls in cohort two. These calls were not able to be excluded prior to this initial review as I was unable to access the calls at the point of selection and I was only able to recognise the calls were ineligible once the anonymised calls were transferred for review. Table 25 describes the 38 included calls.

As described in Chapter Three, the time of the OHCA is very difficult to establish from the data and unless someone is monitoring the patient with a cardiac monitor it is impossible to be completely sure of when a patient's heart definitively stops. This uncertainty has meant that some patients have been excluded from this data set because they may have been in OHCA, or displaying signs of agonal breathing, at the time of the EMS call. Agonal breathing is a pattern of breathing that can occur just before or at the time of death, ceasing over a number of minutes[43]. Agonal breathing is common in the early stages of cardiac arrest and is often reported as gasping[44]. My research is concerned with the better identification of patients on the EMS call who are alive, but at imminent risk of OHCA. The inclusion of patients that could be interpreted as agonal breathing is unhelpful because they could already be in OHCA which would mean they do not fit my inclusion criteria.

Three patients were therefore excluded because on review of the call data it was likely that the patient was already in OHCA at the time of the EMS call. A further five patients were excluded as on review it was likely that the calls related to patients that were agonal breathing. These eight calls were all in cohort one and were categorised correctly as requiring a category one response. In addition, two calls were excluded as they were third-party calls (someone who is neither with the patient nor knows the patient), one call was excluded as it was an unintended contact with the 999 system and one call was excluded as the patient, making the call was unable to hear (see Table 24).

Table 24: Calls excluded from analysis with reasons

Call	**Cohort**	**Reason for exclusion**
1	1	Third party call from police
2	1	Probable agonal breathing
3	1	Probable agonal breathing
5	1	OHCA at time of call
9	1	OHCA at time of call
10	1	Probable agonal breathing
13	1	Probable agonal breathing
24	1	OHCA at time of call
25	1	Probable agonal breathing
37	2	Third party call from police
39	2	Unintended contact with the 999 system
41	2	Patient unable to hear

Table 25: Details of included calls

Call	Patient age	Patient sex	Caller Status	Final category of response	Change in category of response	Clinical categorisation and any change	Call length min:sec	ECCS*	Witnessed status	Response Time (minutes)	Survived to hospital discharge
4	44	Male	Family/friend	Category 1	Cat2-Cat1	Not alert with Chest Pains to Cardiac/Respiratory Arrest – breathing Uncertain (Agonal)	11:51	3– 4/5	Bystander	9	No
6	65	Male	Family/friend	Category 1	Cat2-Cat1	Unconscious or Fainting – Effective Breathing to Respiratory Arrest – Ineffective Breathing	11:11	2-3	Bystander	9	No
7	60	Female	Family/friend	Category 1	Cat2-Cat1	Difficulty speaking between breaths to known lung disorder with ineffective breathing	11:22	1	EMS	9	No
8	71	Male	Family/friend	Category 1	Nil	Ineffective breathing to Cardiac/Respiratory Arrest – Breathing Uncertain (Agonal)	20:36	1	Bystander	17	No
11	65	Male	Family/friend	Category 1	Nil	Ineffective breathing	3:52	3	EMS	10	No
12	92	Male	Family/friend	Category 1	Nil	Ineffective breathing to	11:40	3	EMS	10	No

						Cardiac/Respiratory Arrest – Breathing Uncertain (Agonal)					
14	80	Female	Family/friend	Category 1	Cat2-Cat1	Not alert after falling to Cardiac / Respiratory Arrest - Not Breathing at all	5:18	2	Bystander	33	No
15	91	Male	Bystander	Category 1	Nil	Cardiac / Respiratory Arrest - Breathing Uncertain (Agonal) to Drowning / Diving /SCUBA Accident - Underwater domestic rescue	8:19	1	Bystander	4	No
16	77	Male	Bystander	Category 1	Cat 2-Cat 1	Unconscious or Fainting - Not Alert to Respiratory Arrest - Ineffective Breathing	27:30	3	Bystander	26	No
17	69	Male	Family/friend	Category 1	Cat 2-Cat 1	Unconscious or Fainting - Not Alert to Unconscious Agonal / Ineffective Breathing	10:55	2--3	Bystander	7	No
18	49	Female	Family/friend	Category 1	Cat 3 – Cat 1	Sick Person Abnormal breathing to	30:36	2	Bystander	9	No

						Not Alert and Haemorrhaging Medical Bleed					
19	71	Female	Family/friend	Category 1	Cat 4-Cat 1	Stroke with Abnormal Breathing No evidence (Less than X hrs) – passed for clinical review	7:08	2	EMS	48	No
20	67	Female	Family/friend	Category 1	Cat 5-Cat 1	Fallen over 6hrs with Injuries to proximal area without priority symptoms To Unconscious post fall	5:11	2	Bystander	15	No
21	57	Male	Family/friend	Category 1	Nil	Unconscious post fall	9:16	3	EMS	6	No
22	50	Male	Healthcare Professional	Category 1	Nil	Cardiac / Respiratory Arrest - Not Breathing at all	9:20	2	EMS	6	No
23	18	Female	Bystander	Category 1	Nil	Continuous or Multiple Fitting to Fitting and Not Breathing	8:12	2	EMS	4	No
26	70	Male	Family/friend	Category 2	Nil	Chest Pains Heart attack or Angina History	5:07	2	EMS	2	No
27	77	Male	Family/friend	Category 2	Nil	Not Alert after Falling to Not Alert after Falling - Still on the Ground	3:54	2	EMS	8	Yes

28	80	Male	Patient (first party caller)	Category 2	Nil	Difficulty speaking between breaths	2:23	2	Bystander	38	No
29	60	Male	Family/friend	Category 2	Nil	Unconscious or Fainting - Effective Breathing	9:46	4	EMS	6	No
30	63	Male	Family/friend	Category 2	Nil	Difficulty speaking between breaths	3:22	1	Bystander	18	No
31	32	Male	Family/friend	Category 2	Nil	Overdose/Poisoning (ingestion) Not Alert to Intentional Overdosed and Not Alert	2:28	2	Bystander	69	No
32	59	Female	Family/friend	Category 2	Nil	Not Alert with Breathing Problems to Stroke Not Alert No evidence (Less than X hrs)	8:50	2	Bystander	42	No
33	45	Male	Family/friend	Category 3	Nil	Chest Pain over 35 breathing Normally	3:32	2	EMS	43	Yes
34	55	Male	Family/friend	Category 2	Nil	Difficulty speaking between breaths	8:18	2	EMS	4	Yes
35	79	Female	Family/friend	Category 2	Nil	Not Alert after Falling	7:20	2	Bystander	10	No
36	84	Male	Family/friend	Category 2	Cat4-Cat2	Fallen - Not Dangerous Proximal Area Injuries to Difficulty speaking between breaths	6:18	1	EMS	9	No
38a	31	Male	Family/friend	Category 2	Cat5-Cat2	Abnormal Breathing	1:24	2	EMS	Unknown	No

38b	31	Male	Family/friend	Category 2	Cat5-Cat2	Abnormal Breathing	8:04	2	EMS	Unknown	No
40	78	Female	Patient (first party caller)	Category 2	Nil	Difficulty speaking between breaths	16:19	2	EMS	15	No
42	76	Male	Family/friend	Category 2	Nil	Difficulty speaking between breaths	3:16	2	EMS	13	Yes
43	54	Male	Family/friend	Category 2	Nil	Clammy with Chest Pains	5:29	2	EMS	12	Yes
44	91	Female	Family/friend	Category 4	Nil	Fallen - Not Dangerous Proximal Area Injuries	3:20	1	EMS	69	No
45	83	Female	Healthcare Facility	Category 2	Nil	HCP & AED On scene (immediately life threatening) A&E transport	4.50	1	Healthcare Professional	28	No
46	21	Female	Bystander	Category 2	Cat3-Cat2	Unconscious or Fainting - Alert with Abnormal Breathing to Fitting during Pregnancy	5.31	2	Bystander	33	No
47	26	Male	Family/friend	Category 2	Nil	Overdose/Poisoning (ingestion) Not Alert to Intentional Overdosed and Not Alert	5.29	2	EMS	3	No
48	76	Female	Healthcare Professional	Category 2	Cat4-Cat2	Female over 45 with Abdominal Pain Above Naval to Unconscious or Fainting - Changing Colour	4:17	2	Unwitnessed	15	No

49	80	Female	Bystander	Category 2	Cat1-Cat2	Unconscious post fall	7:16	1	Bystander	17	No
50	57	Male	Bystander	Category 2	Cat2-Cat1	Cardiac / Respiratory Arrest - Not Breathing at all to Unconscious or Fainting - Not Alert	6:49	2-3	Bystander	8	No

*Emotional Content and Cooperation Score

In the analysis below, illustrative extracts are presented, identified by cohort and call number, with lines numbered for ease of referral. The speaker identifier 'E' refers to EMD and 'C' refers to the Caller. A key to Jeffersonian transcription conventions is included in Appendix 6 of my thesis. For insight into distribution, the percentage of calls in each cohort where a finding is evident is displayed.

3.1. Institutional Talk and the EMS call

Institutional talk (e.g., medical, classroom, news interview or courtroom interactions), is different to ordinary conversation in that turn-taking is usually pre-allocated and turns are constructed or designed to serve an institutional agenda. Heritage[240] describes ordinary conversation as the 'master institution' with institutional talk as a 'restricted local variant' in which specific and particular tasks are addressed in a particular way. Heritage and Greatbatch[241] recognised that not only does institutional talk vary from ordinary conversation, but it varies widely across institutional tasks and settings. An EMS call is monotopical and designed to elicit information regarding the seriousness of the situation so that the call can be triaged and the correct category response allocated to the emergency[242]. As mentioned previously, one major feature of the EMS call data set analysed is that EMD interaction is scripted and guided by Advanced Medical Priority Dispatch Clinical Decision Support Software (CDSS).

Whalen and Zimmerman[222] note that calls to emergency services can be characterised by the following overall activity phases, 1. Opening/identification, 2. Request, 2a Interrogative Series, 3. Response, 4. Closing. This is certainly the case in the EMS call data where turns at talk are ordered via Question-Answer sequences across a number of activity phases or tasks to be achieved, incrementally moving towards the end goal of completion. Although this overall structural organisation is well known by EMDs it is usually unfamiliar to callers. Whalen and Zimmerman[222] used a single case analysis of an EMS call to demonstrate how a caller and EMD can have very different perceptions of what is happening and what is supposed to happen during an emergency call. This misalignment led to a failure to deliver the help required with important consequences.

Although both participants come to the EMS call with distinct goal orientations (e.g. EMDs treat the callers as routine cases and conversely the caller sees their case as unique and personal[243]), they work together across the different activity phases in ways that co-construct it as an EMS call. For example, Koole and Verberg[244] highlighted that participants in emergency calls are orientated to what is expected of their participation in the call, and in this Dutch study callers in their first turn report a 'what' and a 'where' regardless of the call-taker's opening sequence.

The following analysis focuses on the opening and PTQ phases of the EMS calls to illustrate the extent to which the component tasks/activities are accomplished, or progressively developed. I investigate the roles the caller and EMD play in the process and how smoothly the participants shift between tasks as well as the elements of the interaction that may facilitate or impede an optimal EMS response to patients at high risk of OHCA.

3.2. EMS call opening

My first observation is that in the call-openings in this corpus, the caller is not given an opportunity to return a greeting, or to self-identify before the first PTQ (breathing) is asked. The call often opens with “Ambulance Service, is the patient breathing?”, or a close version of this. At best at the start of the interaction the EMD says “Hello” before the breathing question is asked. Whalen and Zimmerman[245] investigated the differences in openings in calls for help and compared them with openings in ordinary telephone conversation. Ordinary telephone calls have a summons/answer sequence followed by an identification/recognition sequence and then a greetings sequence. Emergency calls display a modified opening, reduced in comparison with ordinary conversation. Whalen and Zimmerman[245] note the focus on identification-oriented over recognition-oriented response to the telephone summons and the absence of greetings sequences[245]. Traditionally calls for help locate the first topic slot to the caller and it is here where the ‘reason for the call’ is delivered[244]. In this corpus of calls this expected sequence of events does not occur because the breathing PTQ is attached to the call opening which may disrupt the caller’s expectations. Many of the calls included here for analysis displayed misalignment or asymmetry between the caller and EMD in terms of the interaction. Misalignment in CA occurs where responses do not align with the proposed activity or sequence and work against the proposed action; responses do not match with the formal design preference of the turn[246]. Misalignment presents a challenge in a time sensitive call because it creates inefficiency and risks information loss.

In 50% of total calls there is misalignment in the call opening between the caller and EMD.

((38% of Cohort 1)(59% of Cohort 2))

Extract 1 displays an example of misalignment between the caller and the EMD and the efforts of the EMD to realign the call.

Extract 1: ***Cohort 1, Caller 8***

01 E: Ambulance Service ().

02 C: Yeah hi there .hhh um (.) I just wondered °>if it was<°

03 possible to get an a:mbulance to [eleven-]

04 E: [Okay- (0.3)] just bear with me (.) i- sorry >I

05 just need to ask you a few questions. is the patient br[eathing< no:rmally?

06 C: [Yes,

07 Uhm:: (.) e's got pulmonary (0.3) what's it called?,=hhhh (.) um

08 (1.1)

09 C2: Uhm (0.2) rheumatoid arthritis and pulmonary lungs,

10 C: Oh he's got pulmona[ry fiBROSis s[o he's-

11 E: [Yeah but right- [Right ↓no:w is he

12 bre[athing normally for him?

13 C: [>bi-<

14 (0.4)

15 C: °°y-°° fo:r him yeah_ he sort of collapsed on the floor_ we've

16 managed [to get him on the bed, but th-

17 E: [Okay (0.3) >all right< (0.2) is he awa:y**k**?

18 (0.4)

19 C: Uh (.) is he awake? is he awake xxxx?,

20 C2: Eh- (.) yeah (.) he's #uh (.) #uhm-=

21 E: =Right okay has he got any <serious bleeding.>

22 (0.5)

23 C: No(hhh)

24 (0.7)

E: Thank you .hh (.) what's the M:AYn reason for >the
emergency< call ↓please.
(0.2)
C: Uhm (.) well e'd cuhlapsed on the floor and I've managed
to get him on a bed apparently now he's not responding_
hang on(hhh)_
(0.5)
E: Right okay. What's the [inaudible] please_
((Inaudible background conversation))
(1.1)
E: What's the address of the emergency.

Instead of identifying themselves in response, the caller begins at line 2 with an acknowledgement 'yeah' and then makes a request for help with the 'what' and the 'where' as per usual caller expectation[244]. The EMD interrupts the caller at line 4, 11 and line 17. Interruption in CA is when one person self-selects to speak when another's turn is clearly in progress (as opposed to about to start or almost hearably complete) and often involves overlapping talk[247]. These interruptions are the EMD orienting to the institutional requirement that certain tasks need to be accomplished prior to eliciting the reason for the call; it is the EMD enforcing the institutional agenda. There are delays in progression of the call caused by the misalignment in the interaction as both parties persist in pursuing their own agenda.

A basic rule in conversational turn-taking is that participants take turns to speak and talk "one at a time". Studies of talk-in-interaction indicate that this is overwhelmingly achieved[248]. Overlapping talk is a claim to the turn space. In Extract 1, line 4 when the EMD interrupts by initiating and continuing their turn at talk mid-turn and in overlap, the overlap is sequentially consequential making the caller abandon their request for help instead of continuing and "fighting for the floor"[248]. However the caller does persist with their agenda of wanting to tell the "what" and the "where" in lines 7,10 and 15 This misalignment between caller and EMD causes delay and risks information loss.

3.3. EMD Action

In a number of cases the EMD recognises uncertainty in the answer to the first PTQ and takes action ((13% of Cohort 1)(9% of Cohort 2)).

Extract 2: *Cohort 2, Caller 27*

01 E: A:mbulance ↑Service?, is the patient breath↑ing?

02 (0.7)

03 C: #Ah- #ah- #e- #e- #e- yeah e's breathing,

04 (0.4)

05 E: °#Ah-° (.) he's bre:athing?

06 C: Yes he p(h)assed ou[t,

07 E: [Thank you- o[kay is he awa:yk?

08 C: [So I-

09 (0.4)

10 C: °#Ah-° (0.3) yes just about [(.) yes.

11 E: [Thank you_ is there any

12 serious bleeding?

13 (0.5)

14 C: °#Ah-° °#ah-° °#e-° n::o, (0.4) [°no°

15 E: [Thank ↑you_ what's

16 the address of the emergencee,

In Extract 2, the EMD does not immediately accept the caller's answer as evidenced at line 5 by them querying the response. The interactional trouble in the sequence is marked by an inter turn delay at line 2 and the pre-answer behaviour of non-lexical vocalisations uttered before giving an answer in line 2. This recognition of interactional trouble by the EMD is important as it can indicate abnormality in breathing and the possibility that the patient is deteriorating, and this can be acted on later in the call. In this case, however, this assessment of breathing is the only breathing assessment in the interaction and breathing is never reassessed. There is no further monitoring of the patient after the scripted triage ends and the call is disconnected.

3.4. Narrative Expansions

The caller may respond to a PTQ with a minimal answering response of ‘yeah’ plus a narrative expansion. This is seen in (31% of Cohort 1))(32% of Cohort 2)) and occurs equally between cohorts.

The caller may initially deliver a minimal response to the PTQ and then take an opportunity to answer ‘more than the question’ by delivering a narrative concerning their reason for the call. This phenomenon is described by Stivers and Heritage[249] in their studies on doctor-patient interaction. Questions designed as yes/no questions (e.g., is the patient breathing) limit the opportunity for extended answers by constraining the response options. This is also described by Schegloff[250] who describes how question-answer adjacency pairs work to constrain next actions. When callers work with the EMD and provide minimal responses they are aligning with the EMD, but sometimes the caller will take advantage of their allocated slot by expanding on their answer, providing more than the question asked for[249].

Within the data set there are three examples where the caller gives a minimal response plus expansion to the breathing PTQ (Calls(8,14)(32)). These callers interactionally misalign with the EMD by pushing through a narrative of the reason for their call. An example is illustrated in Extract 3 below.

Extract 3: *Cohort 1 Caller 14*

01	E:	[Ambulance Service, is the patient breathing
02		normally?
03		(0.6)
04	C:	ah- hou- .hh yes well (0.2) she’s just (.) gone to the- .hhh
05		actually she’s been in bed s:ic**k** all week .hhh an’ she’s just
06		tried to get to the <to:il>let and she’s fallen off the toilet; .h[hh=
07	E:	[Is=
08	C:	=and sh-]
09	E:	=she aw]ay**k**?
10	C:	Just like .hhh she- she is awa:yk but=tu:h .hhh °nu-° (0.3)

11 you know, (0.3) °n-° [not-] not-

12 E: [Is there a-]

13 (0.3)

14 C: Is there any serious ↓bleeding;

15 (0.6)

16 C: There's no serious bleeding from what I can see (.) sh[e's jus'=

17 E: [°°Okay.°°

18 C: =lying here 'an I .hhh (0.2) I'm afrayd I'm not in a fit state to be

19 able tu:w (.) pick her up either. .hh[h

20 E: [Okay\ what's the address

21 of the emergency?

In Extract 3, after a 0.6. second delay in responding to the EMD's breathing PTQ, and some perturbation, in line 4 the caller replies with "yes" before a well-prefaced elaboration. Well-prefacing can indicate non-straightforwardness in responding[251]. However, the EMD appears to accept this "yes" as a straightforward confirmation that the patient is breathing normally, evidenced by their proceeding to ask the next question at line 14. At line 10, the caller answers the awake PTQ, going on to qualify their response and the EMD cuts off the qualification. This call was coded as Category 2, 'fall and not alert' with a second call upgrading the patient to a category 1 response subsequently. However, if the patient was not breathing and not awake the call would have been graded as requiring a Category 1 response.

The effect of the narrative expansion impacts the critical PTQ sequence. It delays progressivity and if left unrecognised by the EMD leads to lost information that may not be revisited later in the EMS call trajectory. This has been described previously by Riou[226] where caller pre-emption regarding the reason for the call leads to lost information that is critical to the triage. The EMD can easily interpret the initial "yes" as straightforward confirmation that the patient is breathing, or breathing normally and important signals that impact on the EMD's understanding of the patient's situation may be missed. In the case of Callers 14 and 32 no attempt is made to assess the patient's breathing after the PTQs.

In Extract 4 below, Caller 32 displays a substantial narrative expansion to the breathing PTQ. This is an extensive departure from the phase structure of the EMS call. When the expansion is extended as in Extract 4 it allows the caller to prioritise their own agenda / project as opposed to following the agenda of the EMD.

Extract 4: *Cohort 2,Caller 32*

01 E: H:ello. Ambulance Emergency is the patient bre:thing normally?

02 (0.5)

03 C: Yeah she’s- she’s >lying=on=the=floor<- >she’s lying on the< (.)

04 floo::r <and she’s>=suh .hhhH (0.3) sort of half-naked- my wife

05 is half-naked hh .hhh (0.3) an::d >she can har<- (0.3) she::’s

06 (0.5) sort of looking as if >she’s had< an u:h- uh- (0.5) an

07 attack of some sort,

08 E: So wh- when you say attack what do you mean,

09 (0.4)

In Extract 4, at line 2 there is a 0.5 second inter turn gap before the caller answers “Yeah” and then launches into a narrative pursuing their own agenda. Now placed in the role of story recipient, the EMD temporarily abandons any further PTQ activity. The EMD asks if the patient is awake and breathing much later, 1 minute 47 seconds into the call; there is a problem with understanding and the EMD does not recognise the abnormalities indicated with the patient’s breathing. Even when the patient indicates they cannot breathe, this is not picked up by the EMD and the severity of the patient’s condition goes unrecognised.

The caller’s pursuit of their own agenda and persistence to deliver a narrative may continue for a few interactional turns, or it may continue for a longer period before the caller and EMD roles come back into alignment. In the case above, the interaction comes into alignment after the caller has given the address details. The misalignment between the caller and the EMD leads to critical information loss and the potential for the deteriorating patient to go unrecognised. Further into the call the EMD’s persistence and focus on progressing the protocol mean that critical information regarding the patient’s breathing is lost.

3.5. Incorrect information

Where the caller is not anticipating the first PTQ to happen so early in the call and is unable to give a straightforward response to the breathing question, they may answer inaccurately to prevent the interaction from stalling and to progress their agenda or goal (Callers (15),(50))

Extract 5: *Cohort 2,Caller 50*

01 E: Ambulance is the patient breathing?,

02 (0.8)

03 C: .hhh uhh no he’s got (.) blood coming out of his mouth and he’s

04 cllapsed;

05 E: Okay and not breathing (.) is that?,

06 (0.4)

07 C: Uhm (.) is he breathing, (1.4) yeah he’s just cllapsed and there’s

08 Blood’s coming out of his nos[e?,=

09 E: [Yeah but is- is the patient breething\

10 (0.3)

11 C: IS HE BREATHIN\ (.) I don't know he’s in the pub I’m out here (0.4)

calling you,

12 (0.6)

In Extract 5, the caller pursues their own agenda of giving information and getting an ambulance to attend as quickly as possible. There are significant inter-turn delays at lines 2 and 6 indicating interactional trouble and an intra-turn delay in line 7 when pushed to answer if the patient is breathing. CA studies have identified preference as an organising feature of social interaction, and a bias for preferred actions[252]. Where affiliative actions, for example agreements and acceptance, are the preferred response they are produced immediately; in contrast, dispreferred responses, for example disagreements and rejections, are usually delayed and mitigated[253]. Studies have shown the timing of preferred and disprefered responses differs. Where there is a gap of 700ms or more, there is an association with dispreferred actions. Where there is a gap of 300ms or more there is an increase in the likelihood of a qualified answer and the likelihood of a disprefered format[254]. Participants to interaction continually monitor each other’s behaviour and are sensitive to timing and gaps as a potential indicator that there is 'trouble' ahead[254]. The EMD clearly picks up on this uncertainty and pursues the response for a second time at which point the caller admits that they do not know the answer.

3.5.1.Delayed response PTQ

The caller may delay responding because there is an issue with the patient's breathing, or an issue with assessing the patient's breathing. For example, there may be a delay if the caller needs to move closer to the patient to assess their breathing. For EMDs, the cause of any delay in responding will be difficult to ascertain over the telephone. In 26 cases there is a delayed response to the beathing PTQ which may signify that there is an issue with the patient's breathing; or there is uncertainty in the response (Callers (81% of Cohort 1)(59% of Cohort 2)).

Extract 6: *Cohort 2, Caller 49*

01 E: Ambulance Service, is the patient breathing,

02 (1.4)

03 C: .hhhHH yes (.) I believe she is_

04 (0.3)

05 E: Is the patient conshush,

06 (0.7)

07 C: No_

08 (0.8)

09 E: Does their breathing sound ↓noisy,

10 (1.5)

11 C: No;

12 (0.7)

13 E: O::#k(h)ay .hh what- tell me exactly what's happened?,

The question, 'is the patient breathing' is designed for a 'yes' response (a 'yes-preferred' question). In Extract 6, there is an inter turn delay of greater than one second following the question at line 2 and then following the second breathing question at line 10, indicating trouble in responding. A silence of less than 300 milli seconds (ms), as previously indicated, has been associated with the delivery of a preferred answer and silences of greater than 300 ms indicate an upcoming dispreferred answer[255]. When a turn is completed and a participant has been selected to produce a next action, the silence is understood as the absence of that action[256]. A noticeable silence can indicate trouble in responding. In addition, there is a stretched hearable inhalation preceding the response at line 03 where the caller is gearing up to respond that delays the response further. The eventual response is affirmative, ‘yes’, but then “I believe she is” indicates a degree of uncertainty. In this interaction the trouble appears to be due to caller uncertainty about breathing status. The uncertainty around breathing continues throughout the call. The breathing is not queried again until 1min 41 secs into the call. At 4min 05 secs a breathing assessment tool is used and the EMD establishes the patient is not breathing effectively. At 5 min 28secs, the breathing is assessed with the breathing assessment tool again and assessed as normal. The call is downgraded from a category 1 to a category 2 call. The call is coded as ‘unconscious post fall’ and the patient suffers an OHCA shortly after the EMS triage ends.

3.6. Variation in the breathing PTQ

In some 66% of cases the EMD asks:

“Is the patient breathing?” and an example is illustrated in Extract 7.

((44% in Cohort 1) (82% in Cohort 2))

Extract 7: ***Cohort One, Caller 38***

01 E: Ambulance ↑Service is the patient breethin?,

02 (0.3)

03 C: Yes. but his lips are going blue?, hh .h[hh

04 E: [Okay. Is the patient

05 conscious?

06 C: Yes.

07 (0.8)

08 E: °All right° Tell me exactly what’s happund?

09 C: He: (0.2) uhm (.) was- (0.2) woke up this morning, felt uhm

10 we(hhh)- he was- (.) had er:- °°i-°° >sort of< he’s been

11 vomiting but uhm his breathing within the last twenty

12 minutes has (0.2) gone rea- it’s (0.2) really (.) really

13 quite strug- he’s struggling?, .hh[h

In another 34% of cases:

“Is the patient breathing normally?” ((56% in Cohort 1))(18% in Cohort 2))

There are examples of this question working well as in Extract 8 below.

Extract 8: *Cohort 1, Caller 7*

01 E: .pt .hhhH Ambulance Service is the patient breathing

02 normally,

03 C: .hhh er (.) ↓no.

04 (0.4)

05 E: Okay (.) are they awake,

06 (1.4)

07 C: Sorry?

08 E: Are they awayk,

09 (0.5)

10 C: Yes.

11 E: Okay (.) .hhh (.) any serious bleeding?

12 C: Er (.) ↓no.

13 E: Okay (0.2) and what’s the main reason for the emergency

14 ↓call please.

15 C: Um: (.) my mum is u:m: (0.5) currently undergoing chemo

16 fo:r (.) uh (.) cancer_ she’s ‘ad chemo today; .hhh

17 E: Yeah?,

18 C: Um:: (0.6) so she’s just (.) gon: upstairs >’n used the

19 toilet< and she’s just come down ‘n she’s kind of having

21 .hhh like a panic (.) attack where she can't control her

22 breathin' an'- a[n' she's struggling to breath(hh)e

23 E: [Okay.

24 What's the address please.

[0:00:34.5]

The caller clearly understands the question and answers it accurately.

This is not always the case as Extract 9 indicates below.

Extract 9: ***Cohort 1, Caller 6***

01 E: Ambulance Service, is the patient breathing normallee;

02 (0.7)

03 C: Um (0.2) yes (0.2) just_

04 E: Okay (.) are they awake?

05 C: .hhh is he- (0.2) is he awake? (0.6) No::\ [(.) no:_

06 E: [Okay\ (0.4) is there

07 and serious bleeding?

08 (0.4)

09 E: .hhh no:?, hhhH

10 O: And what's the address of the emergen-

Illustrated in Extract 9, Caller 6 may have heard the first question as "Is the patient breathing", however the interturn delay at line 2 and the qualification at line 3 might be enough for an EMD to suspect that the patient's breathing is not normal, however this is not recognised in this case. A "No" to the initial and second PQT would have instigated an immediate category one response. This call is initially coded as a category two call that was later upgraded to a category one call. Breathing is explored further at line 94 and the caller clearly expresses abnormality with breathing at this later stage and the breathing is described at this point in the interaction as "very laboured".

In the case of Caller 8 (previously described in Extract 1), when asked if the patient is breathing normally, the caller says "yes" in overlap with the EMD and before they have heard the word “normally”, the caller then continues to describe the patient’s medical history related to their breathing. The EMD repeats the breathing PTQ at line 11. The question “Is the patient breathing normally” is designed as a yes/no question but incorporates a ‘candidate answer’, building in certain presumptions regarding the caller’s knowledge of what breathing ‘normally’ looks and sounds like[257]. By using a ‘candidate answer’ the EMD endorses that it is a likely possibility that the patient is breathing normally and the offer of a ‘candidate answer’ guides the respondent to know how to answer. Candidate answers can be useful when the speaker would like the recipient to respond efficiently, provide certain information, or respond in a particular way[257]. The response given in Extract 10 conforms to the question design, “y- for him yeah”.

Extract 10: ***Cohort 1, Caller 8***

01	E:	Ambulance Service ().
02	C:	Yeah hi there .hhh um (.) I just wondered °>if it was<°
03		possible to get an a:mbulance to [eleven-]
04	E:	[Okay- (0.3)] just bear with me (.) i- sorry >I
05		just need to ask you a few questions. is the patient br[eathing< no:rmally?
06	C:	[Yes,
07		Uhm:: (.) e’s got pulmonary (0.3) what’s it called?,=hhhh (.) um
08	(1.1)	
09	C2:	Uhm (0.2) rheumatoid arthritis and pulmonary lungs,
10	C:	Oh he’s got pulmona[ry fiBROSis s[o he’s-
11	E:	[Yeah but right- [Right ↓no:w is he
12		bre[athing normally for him?
13	C:	[>bi-<
14	(0.4)	
15	C:	°°y-°° fo:r him yeah_ he sort of collapsed on the floor_ we’ve
16		managed [to get him on the bed, but th-
17	E:	[Okay (0.3) >all right< (0.2) is he awa:y**k**?

This difference in the data allows for a comparison of the effect of asking the breathing PTQ in different ways. Asking “Is the patient breathing normally” can sometimes be problematic, but just asking “Is the patient breathing” can lead to abnormal breathing being overlooked in the PTQ. As Figure 31 illustrates, when the EMD asks the patient “Is the patient breathing normally?” a higher proportion of patients are categorised as category 1 than if the EMD asks “Is the patient breathing?”. This finding could be because a ‘candidate answer’ can be viewed as a ‘correction invitation’. A respondent can correct the assumption that the breathing is ‘normal’ and elaborate in their answer, potentially leading to more accurate categorisation[257].

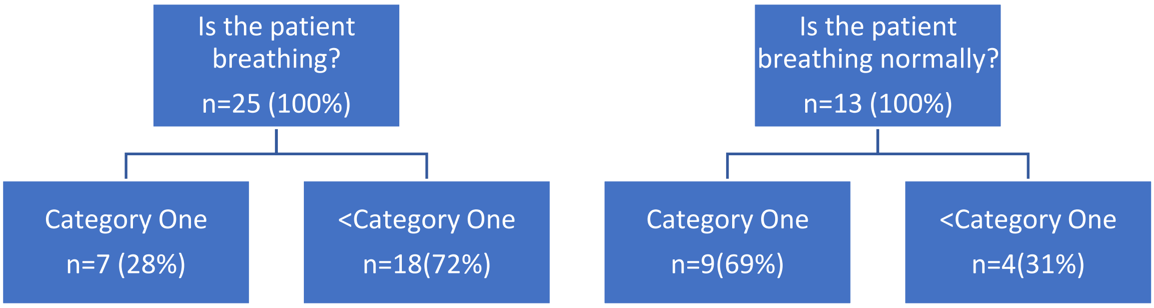

Figure 31: Differences in asking the breathing PTQ and related call categorisation

3.7. Clinical conditions

In Chapter Three (data analysis) the findings indicated that there were differences in the clinical presentation of patients between groups. The clinical condition of ‘Falls’ features across all groups, but has the highest proportional representation in G1b (alive at the time of the EMS call and not witnessed by EMS). ‘Chest Pain’ also features in G1 (not in OHCA at the time of the EMS call), but not in G2 (in OHCA at the time of the EMS call), and predominantly in G1a (EMS witnessed OHCA) . ‘Chest Pain’ is normally allocated as requiring a category 2 response and ‘Falls’ may be allocated a category 3 or 4 response and could be waiting a long time. It is important to try to understand features of the interaction in these two clinical groups that, if better understood, could lead to the recognition that these patients are deteriorating and at imminent risk of OHCA and require a category one response.

3.7.1. Fall with a "long lie".

There are two calls that involve patients that have fallen and been on the floor for a long time ("long lie") (Callers 20 and 44). In both these calls the quality of the patient's breathing is not investigated further after the breathing question in PTQ. Extract 11 illustrates this.

Extract 11: *Cohort 2, Caller 44*

01	E:	Ambulance ↑Service is the patient breethin:g?
02	(0.4)	
03	C:	.pt .hhh yes she is, hh[hh
04	E:	[Is the patient conscious?
05	(0.5)	
06	C:	Y:es she i[s_
07	E:	[O↑kay tell me exactly what's <↓happened,>
08	C:	.hhh uhm (.) °it's° my ninety-one-year-old mother?,
09		.hhh I've come up this mo:rning to see how she is
10		°#er:-° (.) I don't know whether she's fallen out of
11		BEd or .hhh she's on the floor basically and I can't get
12		her off the floor, .h[hh uhm:]
13	E:	[Right what's the add]ress?
14	(0.6)	

The quality of the patient's breathing is not assessed further following the breathing PTQ, but there is trouble in the interaction when the breathing PTQ is asked as well as non-lexical vocalisations. There is a significant inter turn delay at line 2. There is a strong possibility that the patient has had a "long lie" as she is evidently confused, shown later in the interaction and the history expressed later in the call indicates the patient was last seen 13 hours previously. The call is categorised as a category 4 and coded as a fall. The patient suffers an EMS witnessed OHCA around 1.5 hours after the EMS call.

Caller 20 has also had a “long lie”, and is originally coded as a category 5 before the call is eventually upgraded to a category one. During key questioning the caller indicates abnormality of breathing, but the quality of the patient’s breathing is not assessed by the EMD.

3.7.2. Chest pain with abnormal breathing

There are eight chest pain patients included in the data (13% in Cohort 1 and 27% in Cohort 2)**.**

The majority of these patients (75%) indicate abnormal breathing in the PTQ.

Extract 12: *Cohort one, Caller 4*

01 E: Ambulance Service is the patient breathing?,

02 (0.8)

03 C: .hhhH Pardon?

04 E: Is the patient breathing?

05 C: Um heavy breathin’ but he’s not breathin’ veree well=is::

06 really odd;

07 E: Okay are they awayk?,

08 (0.6)

09 C: .hhhH (.) they are, bu:t (.) they’re not breathing >very well<

10 I just had to move ‘im: from the living room tuh the- (0.3) tuh

11 the bedroom which is literally (0.3) kuple a steps away

12 >tuh< go toilet_ hhh and he’s literally c(h)ulLApsed because

13 he needed to go to the toil- .hhhHH an’ he >k(hh)udn’t<

14 really mo- he can’t move off the toilet; he can’t

15 hardly talk. [I’m- I’[m DOWnSTAirs (.) .hhh an’ he is right up

Chest pain is predominantly coded as requiring a category 2 response, but Callers 4 and 21 are triaged as requiring a Category One response and the reasons for this will be examined more in-depth below using Caller 4 as an example.

Caller 4 above is an interaction of interest. The full transcript is included in Appendix 7b to give further context to this interaction. The caller scores initially on the Emotional Content and

Cooperation Score (ECCS) [161] as ECCS 3, 'moderately upset' before progressing to ECCS 4/5 'uncooperative, not listening/uncontrollable, hysterical'. As this interaction was impacted by the emotional state of the caller I took this into account. Whalen and Zimmerman[225] describe hysteria as an 'intense form of affect' and that an hysterical caller must be hysterical about something and it is the EMD's role to decipher and respond to this situation. Whalen and Zimmerman[225] also note that in these instances the progress of the EMS call is affected. Feldman[258] recognises the non-compliance of emotional callers and the dispatcher's role in attempting to control the call in order to control the caller.

In the case of Caller 4 there is clear evidence of the progress of the call being affected as the EMD attempts to manage the caller. The caller offers a substantial narrative expansion to the awake PTQ, previously described in section 3.4. The caller pre-empts with information indicating abnormal breathing and is clearly distressed about the state of the patient's breathing. The caller also pre-empts that the patient has collapsed. Later in the call the caller becomes completely uncontrollable/hysterical and there are 11 turns of the EMD, in an attempt to regain control, repeatedly saying 'Listen to me so we can help him' before another caller comes onto the line and states that the patient is now unconscious, but still breathing. This repetition of "Listen to me so we can help him" is referred to by the International Academy of Emergency Dispatch as "repetitive persistance"[259]. Repetitive persistence is designed to gain the cooperation of callers who are emotional[221]. Feldman[258] notes the 'directive' plus the 'reason' in "Listen to me, so we can help him" to maintain control. It is considered essential for an EMD to regain 'control' of the interaction and it is suggested that the caller is actually desperate for the EMD to regain control[225], but this does not occur in this instance with Caller 4. The EMD does not regain control of the call with Caller 4, but the caller does eventually pass the phone to another caller and control is regained at this point. The call is initially triaged as category two and is upgraded to category one 'cardiac/respiratory arrest – breathing uncertain' even though the second caller completes a breathing check and establishes normal breathing. The patient is in OHCA when the ambulance crew arrives. The EMD could have kept this call triaged as a category 2 call, but I would hypothesise that the hysteria in the call prompted the EMD to upgrade the call (rightly in this case) to a category one.

In the case of Caller 21, presented in Extract 13 below,the caller is also ECCS 3, moderately upset at the beginning of the call, but this does not progress up the ECCS scale. The caller is crying, there are many audible outbreaths. At line 5 there is an inter turn delay of 1.9 seconds indicating the dispreferred response in line 4. "Is the patient conscious?" is a yes/no question and the caller gives a non-conforming response which appears to cause issues for the EMD, marked by the delay. In line 15 the EMD acknowledges how upset the caller is by saying, "just try and stay nice and calm for me".

This direction at line 15 is not scripted, but the EMD gives the caller a 'directive', without the 'reason' as seen in Extract 12, "Listen to me so we can help him". Research suggests that where EMDs show an awareness of the emotional state of the caller and respond to the emotional clues they are more likely to be able to effectively manage the interaction and obtain the information sought[260]. The display of emotion in the interaction with Caller 4 and Caller 21 appears to impact the EMD's triage of the call making an outcome of category one more likely.

Extract 13 *Cohort 1, Caller 21*

01 E: Ambulance Service is the patient breething?

02 C: .hhh uh yes:: (HHHH[HHHH).

03 E: [And is the patient conscious?,

04 C: HHhhh .hhh uh: semi?, HHHHH

05 (1.9)

06 E: Okay_ tell me exzactly what happened?

07 C: .hhh uhm (.) he's- he's been suffering from %chest

08 pains #lay:tely(HHH) .HHHH and we've got an

09 app(hh)ointment with a cardiologist tomorr[ow,(hhhh)=

10 O: [Yeah?,

11 C: =.HHHHH and °#um° (.) he's obviously got up in the

12 middle of the night, HHH .HHHH uhm (.) and he's had

13 a fa:ll, and there's- there's blood over the floor, he's

14 gashed himself and he's %having trouble breathing, .hhhh

15 E: O::kay\ (0.8) just try and stay nice and calm for me.

16 C: #Yeah I am.

17 E: What's the full address of the emergen[cy?

18 C: [It's [*Redacted*].

3.8. Patient is calling for themselves

There are two callers in the data set where the caller is the patient (first party callers) and, in each case, they are having breathing difficulties (Calls 28,40). Both callers are in great distress and exclaim that they cannot breathe. Neither call receives the highest priority category and both suffer an OHCA before the ambulance arrives on scene.

Extract 14: *Cohort two, Caller 28*

01 E: Ambulance Service is the patient breathing normally?

02 (1.6)

03 C: It’s a pulmonary embolism.

04 E: Oka:y (.) is the patient breathing normally_

05 (0.4)

06 C: Yes hhhhH.

07 E: Thank you (.) [and are they al-]

08 C: [N::↓o:::\ I ca-] .hhh

09 (0.6)

10 E: Are th[ey awake?

11 C: [I can’t breathe?,

12 (0.3)

13 E: Is it for yourself?,

14 C: I can’t breathe(hhH)

15 E: Okay is there any serious bleeding?,

16 C: N:o:,(hhH)

17 (1.1)

18 E: Okay what’s the address of the emergency?,

Extract 15: ***Cohort two, Caller 40***

01 O: A[mbulance Service, is th[e patient breathing?

02 C: [hhhHHHHH [.hhH HHHH .hhhhHHH iss

03 m(hhh)e m(hhh)ee .hhh MM(hhh)e[eeu(hhh)

04 O: [Oka:y_ tell me exa[ctly=

05 C: [.hhhH

06 O: =what’s happened?

There is an obvious problem when the patient is calling about themselves as the questioning asks “Is the patient…” and this does not lend itself to a first party caller creating alignment issues at the first question. This is evident at lines 2 and 3 in both transcripts. This creates the requirement of effort and delay in aligning the caller and EMD.

In Extract 14 there is a 1.6 second interturn delay before the caller responds to the question and then the caller gives a non-conforming response to the Yes/No question because they want to express their reason for calling. The caller pre-empts the reason for the call in line 3. The caller appears to mishear the breathing PTQ as “Is the patient breathing?” and answers “Yes” at line 6, although evidently the caller is not breathing normally. The question at line 10 asks “are they awake” again not aligning with a first party caller. The caller and EMD do not align until line 15, when the question is asked about serious bleeding.

Extract 15 is interesting because the caller quickly makes the EMD aware that the patient is the caller at line 2, buy saying “it’s me”. The EMD then skips the PTQ and asks “what’s happened”, presumably because the patient is talking to the EMD and obviously awake and breathing. Missing the initial breathing question prevents any clues regarding the patient’s breathing being relayed to the EMD and any subtle clues regarding the condition of the patient’s breathing are lost.

This is an interesting observation which is worthy of further consideration. Where a patient is alone and collapses after making an EMS call there is no one to advocate for them and initiate a further EMS call or begin CPR, where they are unable to do so themselves. In these cases the chain of survival is broken as soon as the EMS call ends. These cases could be further explored to understand the clinical and communication factors that indicate the need for a category one response. In the meantime, first party callers who are alone and complaining of breathing difficulties could be more extensively interviewed to understand the severity of their condition before the EMS call is completed.

3.9. Health care professionals

Health care professionals (HCPs) often make emergency calls for patients and can be expected to be more familiar with the phase structure and overall goals of EMS calls. In this section I investigate an EMS call made by an HCP to understand how the anticipated familiarity of the structure of the EMS call impacts on the interaction efficiency.

Extract 16: *Cohort 2, Caller 48*

01 E: Ambulance Service is the patient breathing?

02 (0.3)

03 C: Yes she's breathing?

04 (0.3)

05 E: Is the patient conscious?

06 C: Uh: (.) yeah it's conscious (.) for the [minute, it's still conscious.

07 E: [°°uh-°°

08 Okay, tell me exactly what's happened?

There are two HCP calls (Callers 22 and 48). The interaction flows with minimal delay, indicating familiarity with the sequence. The institutional interaction has been described as constraining for the 'lay person'[261], but in the instances of an HCP they are not 'lay' and are familiar with the specialisation of the interaction and equipped to participate in an efficient way.

Extract 16 illustrates that the delays witnessed in many of the 'lay' calls do not appear in this extract. The caller gives type conforming answers in response to yes/no questions. The interturn delays at line 2 and 4 are on the boundary of being a dispreffered response as they are 300ms, but the caller gives a preferred response. There is an efficient flow of information, and the interaction progresses well.

4. Discussion

The EMS interaction is an institutional encounter as opposed to ordinary conversation with its own unique fingerprint. My analysis of a sample of call recordings where a patient has collapsed and suffered an OHCA after the EMS call has been instigated has revealed new knowledge. Key findings include interactional issues with the call opening to include:

- Narrative expansions

- Caller delivery of incorrect information in response to PTQs
- Delays in response to PTQs
- EMD action to align the interaction
- Variation in the breathing PTQ format

Interactional variables of interest and variation in call outcomes to include:

- Chest pains
- Falls with a 'long lie'
- Emotional variation
- First party callers
- Healthcare professionals.

Examining the differences between the two cohorts has identified aspects of the EMD management and the caller's behaviour that have important implications for practice. There are noticeable interactional elements common to both cohorts that can be used to enhance public education, EMD training and improve the EMD identification of patients who are at imminent risk of OHCA. There are also observations that can be linked to a specific cohort.

Calling an ambulance is not a common practice and most people will only contact EMS twice in their lifetime[262]. Members of the public are unlikely to be familiar with the activity structure of the EMS call. In addition, by the very nature of the call, they are predominantly contacting EMS because of a stressful situation. The current EMS call opening does not allow the caller to express their reason for their call in their first turn, which is what a caller unfamiliar with the EMS triage system might expect. In fact, the addition of the PTQ to the sequence, dependent on answers, means the caller cannot express the reason for the call until either their 2nd, 3rd or 4th turn and this assumes no expansions to the sequence caused by trouble in the interaction. This mismatch between caller expectations and the EMS call structure often causes misalignment at the beginning of the EMS call, hindering the progression of the call towards both institutional and caller goals. It also frustrates the flow of both the caller and EMD and risks the loss of valid information. Misalignment in the call may lead to the EMD taking action to bring the caller into alignment with the tasks that need to be accomplished through various means including interruption.

This phenomenon has been described previously, but in relation to a different stage of the EMS call by Riou and colleagues[226] who found that caller pre-emption of the reason for the call early in the EMS call sequence meant that critical information was not repeated and recorded at the "appropriate" time. Instead, at the request for the reason for the call the caller frequently gave additional information, rather than the original information. Disaffiliation may occur where a caller becomes frustrated because they don't understand the logic behind the institutional sequence and the collaboration between caller and EMD becomes ineffective[263].

Interactional misalignment in relation to call openings has been previously documented in a CA study of the UK NHS 111 healthcare telephone triage service[264]. Although the call opening in this setting is slightly different, the design of the opening means that the caller is not permitted to express their reason for the call until the second activity phase of the call which creates misalignment. The authors concluded that ill-fittedness concerning the structure of NHS 111 calls adds to risk of system failure. In a different clinical setting, a nurse-led help line for cancer advice, the study of call openings and interactional misalignment led to the development of a simple strategy of a fluid call opening to meet the goal of a smooth exchange of information and provision of support[265].

Progressivity in calls relating to call openings has been explored previously in research on telephone helplines[266]. There are obvious differences between helplines and an EMS call, but research findings indicated that progressivity was enhanced where a four-part turn was used to include: recognition of the caller; self-identification; formulation of the caller's problem; a request for further telling[266]. Clearly time is of the essence in an EMS call, but the mismatch in caller expectation and the design of the EMS call sequence causes delays to the progressivity of the EMS call. Either a public education campaign to educate callers and/or a well-designed modification to the initial opening of the EMS call could work to save time and confusion during the EMS call and assist with the timely recognition of those patients who are at imminent risk of OHCA.

A caller will sometimes answer more than the question to force through their own agenda. This is referred to as narrative expansion[249] and in some cases substantial narrative expansion is observed in this corpus of calls. A narrative rather than a short report of what has happened, as previously described by Riou and colleages,[217] causes delays to progression during the EMS call.

Narrative expansions are equally spread between both cohorts. A narrative expansion is linked to misalignment at the call opening where the caller's expectations of the trajectory of the call are not met. The impact of the caller narrative, rather than a short report, has been described previously in the literature in relation to recognition and dispatch for OHCA[217], but this previous research focused on the answer to the question "okay, tell me exactly what happened", rather than the PTQ sequence. Riou and collegues'[217] main finding was that the switch in tense from "what happened?", in the scripted prompt, to "what's happened?" significantly increased the likelihood of the caller providing a short report, rather than a narrative answer to this question. A short report is much more desirable during EMS telephone triage as short reports take less time to unfold and require less turns. In this corpus of call data there does not seem to be any pattern in how the EMD asks the PTQs and the caller's propensity to answer with a narrative. In my data the issue appears to be with the caller's expectations of their role during the call opening. The PTQ are designed to have quick fire responses and the caller's provision of a narrative response introduces delays and potential confusion. Previous research has recommended that members of the public are educated on the structure of the EMS call and the process of EMS call handling and dispatch so that the interaction is more aligned and efficient between the caller and the EMD[267,268] . The continuing requirement for this is evident in my research findings.

When a caller is responding to the PTQs they may give inaccurate information to prevent delays in the progression of the call and this causes obvious issues for the EMD trying to triage the call. In relation to the breathing PTQ, in 68% of cases there was a delayed response to the initial breathing PTQ. In part this might be due to misalignment between caller and EMD, but also it might signify issues with the patient's breathing as in all the cases with a delayed response to the breathing PTQ there is an issue with the patient's breathing that becomes apparent during triage. Clegg and colleagues[269] have previously quantified that the time taken to establish whether a patient is breathing during the EMS call took the most number of interactional turns and the longest times in comparison to other aspects of the EMS call.

In the data set the breathing PTQ is worded in one of two ways:

- Version 1- Is the patient breathing normally?
- Version 2 - Is the patient breathing?

This initial PTQ is problematic because it is the first question asked before the caller has a chance to offer their reason for the call. Asking the initial PTQ as version one appears to give the patient a higher chance of receiving a category one response, although the numbers are small. The way the caller answers this question could assist the EMD in identifying patients with abnormal breathing which then allows the call to be categorised as requiring a category one response further into the call triage. It is conceivable that the EMD retains the information expressed and applies it later in the sequence. Another factor to consider is that the Ambulance Response Programme also introduced "Nature of Call" at the same time at the PTQ. Nature of Call (NoC) is a predefined set of problems listed early in the call management process and illustrated in Figure 29. If a patient is described as having one of these problems a category one response is immediately dispatched.

Asking the first PTQ as version 1 could alert the EMD to a problem in the NoC list instigating a category one response.

In the majority of this data set there are issues indicated during PTQs with the patient's breathing. Depending on the chosen 'main reason' for the call by the EMD there may be no option, or limited option, to question the caller further about the patient's breathing following PTQ and this has important implications for monitoring patients throughout the EMS call. Where clinical conditions (chest pain, falls) were investigated during this research a lack of ongoing monitoring of the patient's breathing was a concern. A check for deterioration in the patient's condition before EMS call closure would be useful, alongside an option for the EMD to monitor the patient's breathing if they are concerned during the call.

Chest pain is a clinical group of interest because it is one of the most frequent calls received by EMS[270]. In this corpus of calls 75% of the chest pain cases analysed had abnormal breathing indicated in the interaction. Chest pain is predominantly coded as requiring a category two response and this group are worthy of further exploration to understand how to identify patients at imminent risk of OHCA during the EMS call.

Previous research has indicated that relatives of patients instigate a high proportion of the EMS calls relating to OHCA, and relatives are more likely to be emotionally distressed in comparison to other bystanders during the EMS call[269]. Caller 4 indicates the impact of a higher ECCS score. The higher ECCS score appears to influence the EMD triaging the patient to a category one response. It has been previously noted that EMDs have limited resources to handle the 'emotional caller'. EMDs have been equipped with the technique of 'repetitive persistence' and a continuous repeat of a solicitation to get the caller's attention[258]. Recognising that a caller is emotional can help limit escalation[260] and in this corpus of calls an EMD is shown to come out of the script to acknowledge a caller's emotions in Extract 13.

In two calls where the patient was calling for themselves (first party caller) there were issues with the progression of the call because the design of the PTQs do not lend themselves to someone calling for themselves; the caller is immediately disadvantaged. Conversely where the caller is a healthcare professional there are not the same issues with call progression and misalignment that are seen in calls originating from members of the public. This suggests that further public education may prove beneficial in improving the alignment and efficiency of EMS calls.

Stivers and colleagues[271] report that anthropologists have claimed that language is culturally specific and that there exist vast differences in the timing of turn-taking. In contrast others argue that there is a universal system for turn-taking. To investigate these differences of thought Stivers and colleagues completed a cross-linguistic comparison, testing opposing hypotheses that turn-taking is language and culture dependant and alternatively that there is a universal system with unimodal distribution of turn transitions. Stivers concludes that there are strong universals across cultures in interactional systems. Stivers argues that there is a stable interactional foundation of language across cultures with strong parallels in turn-taking behaviour. This finding has important implications for the generalisability of this research. In EMS using the same institutional interactional design, the same patterns of interactional behaviours might be expected, and this is worthy of further investigation.

My analysis of the EMS interaction using CA has allowed important insights into the EMS interaction and the difficulties that arise. The overarching issue that causes inefficiency on the EMS call is the misalignment between caller and EMD expectations. There are several opportunities to improve the EMS interaction. The structure of the EMS call interaction could be adjusted so that the caller and EMD align much more quickly preventing delays. Educating members of the public regarding the structure of the EMS call and how to efficiently make an EMS call would be useful. In addition, EMDs could receive more advanced communication skills training that helps them to recognise subtle clues in the interaction that the patient might be critically unwell.

5. Limitations

This study was completed in one ambulance service in the United Kingdom and this service used Advanced Medical Priority Dispatch Software. The EMDs are not clinically trained, and the findings may not be generalisable to other EMS settings using alternative systems to triage EMS calls. This study used a relatively small data set of 38 calls, but patterns of communication were found that evidence what can go wrong in EMS calls for patients at imminent risk of OHCA. Nine patients were excluded from cohort one which meant there was a mismatch in numbers between cohort one and cohort two.

As set out in the methods section of this chapter, I took the approach that having a sample size determined apriori is not compatible with qualitative research. In this study I have taken a 'rule of thumb' approach, based on discussion with the supervisory team and passed experiences and selected 50 cases for analysis. However this approach lacks a clear rationale[272]. When cases were excluded, I knew that the corpus remaining was sufficient to demonstrate many interactional features of interest and that I did not need to expand my sample further. If I were to revisit the sample size in this study, I would take an alternative approach and analyse the data sequentially and make a context-dependant decision as the analysis builds.

The data included for analysis was 2018-2019 data and procedures change quickly in line with performance and service developments. In this data set the EMDs ask the breathing PTQ in one of two ways. Over time the PTQ has been revised and during the Ambulance response Programme (ARP) the format of the PTQ was mandated. Since this data collection time period the questions are asked as in Figure 29 and the option to ask "Is the patient breathing normally" has been removed[234].

This study used CA to analyse recording of EMS calls. There was access to triage and clinical outcomes, but no access to caller's experiences of the EMS call to inform the analysis. In addition, there was no video data to compliment the audio data that would have provided more context to the analysis of EMS calls. An understanding of how the EMD was interacting with the decision support software and also how the caller was interacting with the patient would have been useful.

6. Conclusions

The way the EMS call opens does not lend itself to an interaction that progresses smoothly, undermining the optimal information exchange that is in the interests of all parties. The design of the EMS call, and in particular the opening PTQ, can cause interactional trouble that impacts on call progression and risks critical information loss. However, the PTQ are also positively associated with identifying patients in OHCA and the early prediction of patients requiring a category one response[234]. Adjustments to the call opening to quickly align the caller and EMD are worthy of further exploration. The breathing PTQ is asked in two formats and the addition of "normally" to the breathing PTQ appears to increase the likelihood of the EMD recognising breathing deterioration and allocating a higher category response.

CA analysis of the EMS call interaction in patients who suffer an OHCA after the EMS call is made has proven to be very useful in highlighting subtle features of the interaction that help and hinder the recognition of a patient who is critically unwell. It is feasible that some of the findings can be used to support communication education for EMDs aimed at improving the recognition of patients that are at imminent risk of OHCA so that they can receive the fastest possible (category one) response. Public education on the format of EMS calls would help to align the caller and EMD and optimise the EMS call process.

7. Chapter Summary

The use of CA to analyse EMS calls has provided a valuable insight into some of the challenges in the EMS interaction and how these can relate to outcomes. The research has highlighted opportunities to improve the EMS interaction, either through changes to the activity phases such as the order or design of questions, via education of members of the public, enhanced communications education for EMDs, or a combination of all three. These research findings compliment Chapters Two and Three. In the next Chapter, I report on the final stage of my research which was to share my research with Emergency Operations Centre employees and to gather their views on how the research findings can inform changes in practice and further research.

Chapter Five: Interviews With Emergency Operations Centre Employees.

"Pretty big cog in the link, really. Really big link in the chain"

1. Chapter overview

In Chapter Two, the systematic mixed studies review (SMSR) indicated that there is an absence of research investigating those patients who are alive when the EMS call is made and subsequently deteriorate into out-of-hospital cardiac arrest (OHCA). To begin to address this gap in the research, data analysis investigating ambulance cardiac arrest registry data linked with computer aided dispatch (CAD) data is reported in Chapter Three. The main findings of Chapter Three indicate that there is disparity between the recognition and response to those patients who are alive at the time of the EMS call and then suffer an OHCA and those patients already in OHCA at the time of the EMS call. EMS respond much more quickly and effectively to those patients already in OHCA at the time of the EMS call and this has an impact on patient outcomes. Moving forward it is important to understand how we can improve the EMS recognition and response to those patients who are alive at the time of the EMS call and at imminent risk of OHCA. In Chapter Four, conversation analysis of EMS calls where patients are alive at the time of the EMS call indicated the problems caused by interactional misalignment between the caller and EMD and the effect of different variations of questioning on the EMS call trajectory.

This chapter reports the findings from interviews with EMS staff who are employed in the Emergency Operations Centre (EOC) and is focused on the views of participants regarding the outcomes of the preceding work conducted during this fellowship. EOC staff are employed in roles such as EMD and these staff answer the emergency calls and use scripted dispatch software to triage EMS calls and categorise them to an appropriate ambulance response. Other staff employed in EOC are EMS call auditors who complete compliance audits of the EMDs using the dispatch software, clinical advisors who provide clinical support to EMDs and complete more in-depth EMS call triage where appropriate, Clinical Leads and EOC Management.

2. Methods

The philosophical approach underpinning the research described in this chapter is social constructivism. This paradigm asserts that reality is a construct of the human mind[272] and that the nature of reality is shaped by the social interaction between the participants and the reseacher[273]. A fundamental assumption is that social reality is constructed and subjective and suitable for qualitative enquiry[274]. In the context of this research I accepted that each participant would have constructed their own reality based on their individual experiences of attempting to recognise patients who are at imminent risk of OHCA on the EMS call and this research aimed to explore the nuance of these experiences. Participants' experiences were therefore explored through understanding that the "meaning" of their accounts was formed by the interaction between the participants and myself, the researcher.

Two ambulance Trusts participated in the research. Ambulance service one covers 10,000 square miles geographically, has two EOCs, plans for 39 EMDs at the busiest times and handles around 4000 EMS calls per day. Ambulance service two covers 6500 square miles geographically, has two EOCs and handles around 2500 EMS calls per day. Initially the aim was to recruit 20 participants to the study using purposive sampling. The EOC is where EMS calls are received and triaged and the staff that work there may be Emergency Medical Dispatchers, Team Leaders, Clinical supervisors, and Auditors, amongst other roles. To meet the study inclusion criteria participants were required to be employed in the EOC by one of the two participating ambulance Trusts and have experience in managing emergency calls. Following completion of the interviews, participants were invited to take part in a focus group.

Participants were recruited by advertising the study through social media, Trust research teams, key EOC team members and through internal Trust advertising using approved adverts. A link to the participant information sheet (PIS) was also distributed alongside the adverts. Potential participants contacted the researcher to express an interest in participating in the study and they were sent the PIS. Once a participant had confirmed that they might like to participate an interview was arranged for a convenient time. Potential participants were resent a PIS with a consent form up to two weeks before the scheduled interviews. In addition, participants were sent a link to a short film https://vimeo.com/572936095/7a79552833 and asked to watch the short film describing the preceding studies. Participants were encouraged to ask any questions they might have prior to the interview. Due to the ongoing COVID-19 pandemic all interviews were conducted virtually via MS Teams. The interviews were recorded in MS Teams and the file was shared via an MS Teams group with a University of the West of England approved transcriber. Interviews were transcribed verbatim and anonymised and shared with the researcher.

Reflexive thematic analysis (RTA)[275] was used to analyse the data. A combined deductive and inductive approach was taken to the RTA[276]. I had approached this objective with preconceived ideas regarding themes based on the work completed in my previous three chapters. My interpretations of the data were theoretically informed and I had a predefined set of four overarching themes which are displayed in Appendix 8 [276]. An interview guide was formulated based on these themes (Appendix A9a), and during the analysis the data was coded into these themes. I also inductively analysed the data and generated new themes and sub themes as I sifted through the transcripts. The deductive and inductive analyses were combined into the final overarching themes and sub themes. All study documents, PIS and consent forms are reproduced in Appendices A9a to A9e. I recognised that my role in the process was central to the knowledge produced[277] and that my interpretations of the data were likely to be different to another researcher's interpretations[276]. Themes were identified where there was a central organising concept. A central organising concept is a concept that captures patterns in the data and establishes the core point of this pattern. Identifying the central organising concept brings coherence to the theme[278]. I determined that I had a central organising concept when I identified core concepts in the data through observation of patterns and meaning. Once these core concepts were identified, themes were organised around them. During the research process I kept a reflexive diary to document any of my personal beliefs and judgements that may have incidentally affected the research[279] and this is included in Appendix 8.

In RTA no two researchers would be expected to reproduce codes or interpret themes in the same way and therefore attempting to provide accounts of reliable coding or consensus is not in keeping with the approach. However, given that this PhD is being conducted with the support of a supervision team, 20% of transcripts were examined by a second reviewer (SV) for the purposes of sense checking and to aid interpretation of the findings.

The phases of reflexive thematic analysis as detailed by Byrne, 2021[276] are detailed below:

I. Familiarisation with the data
   This phase consisted of reading and rereading the interview transcripts.
II. Generating initial codes
   Data was uploaded into NVivo[280]. Any data that was linked to the research question was coded and then recoded multiple times until I was happy with the coding.
III. Generating themes
   At this stage aggregated meaning and meaningfulness across the data set was used to generate candidate themes.
IV. Reviewing potential themes
   A review of relationships in the data and codes informing each theme was conducted. Themes were reviewed in relation to the data set ensuring that the items were appropriate to inform a theme and to inform the interpretation of the data set. In practice at this stage

the coding and themes were revised into a finalised thematic framework.

V. Defining and naming themes

I presented a detailed analysis of the thematic framework expressing each theme and subtheme in relation to the data set and research question ensuring consistency with the data set and research question.

VI. Producing the report

Completion and final inspection of the report.

3. Results

In total twelve semi-structured interviews were completed with ambulance Trust employees from the EOC in two United Kingdom (UK) ambulance Trusts, four of these interviewees also took part in a focus group following their interview.

The demographics of the interview participants are described in Table 26.

Table 26: Participant demographics

Interviews **N=12**			
Participants	**Age**	**Years EMS Experience**	**Job role(s)**
P01 (Trust 1)	31	3	Emergency Medical Dispatcher auditor
P02 (Trust 1)	47	13	Emergency Care Assistant, Emergency Medical Dispatcher
P03 (Trust 1)	24	3.5	Emergency Medical Dispatcher Special Operations Dispatcher
P04 (Trust 1)	59	17	Emergency Care Assistant Ambulance Technician Paramedic Clinical Mentor Clinical Advisor (EoC)
P05 (Trust 1)	46	14	Paramedic 111 clinician Senior Manager (EoC)
P06 (Trust 1)	21	1.5	Emergency Medical Dispatcher
P07 (Trust 1)	20	0.5	Community First Responder

			Emergency Medical Dispatcher
P08 (Trust 1)	20	2	Emergency Medical Dispatcher Emergency Medical Dispatcher & Floor Walker
P09 (Trust 2)	23	5	Emergency Medical Dispatcher
P10 (Trust 2)	20	3	111 Health Advisor Emergency Medical Dispatcher
P11 (Trust 2)	23	1.5	Emergency Medical Dispatcher Ambulance Technician
P12 (Trust 2)	42	19	Emergency Medical Dispatcher Team leader
Focus Group	P04,P08,P11,P12		

The mean age of participants was 31 years old, and the mean years of experience was 7 years.

Using RTA I identified three main themes to include: The dispatch protocol and EMD audit; Identifying and responding to deteriorating patients; Education, knowledge and skills. Each of these main themes consisted of sub-themes and these are illustrated in Figure Thirty One below and will be further described.

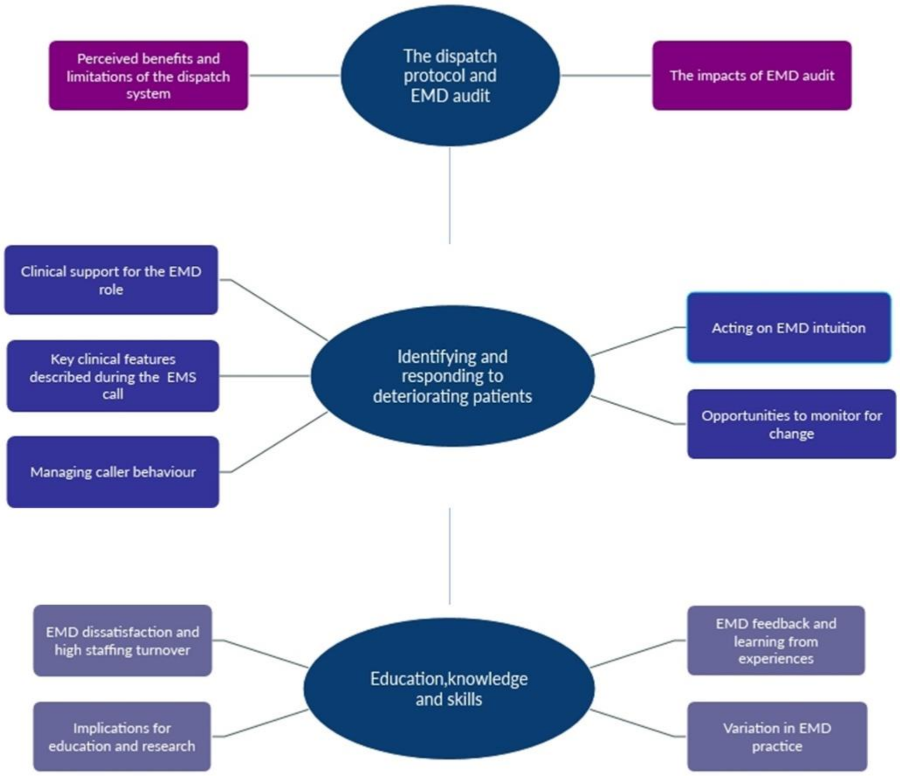

Figure 31. Thematic Map

Theme One: The dispatch protocol and audit

Theme one consisted of two sub themes: Perceived benefits and limitations of the dispatch system; The impacts of EMD audit.

Perceived benefits and limitations of the dispatch system

There were mixed feelings amongst participants about the benefits and limitations of the dispatch protocol. There was recognition that the system is good at identifying patients who are in OHCA or at imminent risk of OHCA.

P11 "I think (it) does a really, really good job. Sticking to it can be quite tricky because people don't understand the instructions or the questions sometimes…".

However some participants expressed the opposite view.

P02 "I don't think there's anybody in the control room that likes MPDS because it's so restrictive in your ability to be able to interrogate".

They described the restriction of the dispatch protocol on the EMDs capacity to triage the call.

P08 "…It is very much, we put our faith in the PROQA system and that is very much it. You are not allowed outside the remit of PROQA. You ask the questions exactly as they are written".

P07 "And I've had other calls as well where like just situationally like if I'd been able to have a bit more freedom from the protocol, it would have made it a cat 1 so much quicker. And it would have been so much more predictable to know that patient was in arrest".

P03 "And I think it's... it's kind of the same for when you're probing for those bits of information with your unwell patient, you're... you're going to get in trouble for doing it despite the fact that that's... that's kind of the only reason you're... you're doing the job is for that one patient at that one point, but yet, you're not allowed to do what you think you need to".

Participant two highlighted that AMPDS does not recognise peri-arrest and described what they do to counteract that.

P02 "With regard to the cardiac arrest call, one of the issues with MPDS is it doesn't recognise peri-arrest. They're either in cardiac arrest, or they're not. One of the back… one of the benefits of having my… my background and my clinical training is the fact that I can pick up on those red flags that say to me this person's going to arrest very, very quickly. And with that in mind, what I tend to do is I try and… to get the caller to get the patient onto the floor in a position where, if they do arrest, we can start CPR as quickly as we possibly can. I think I've picked up on it about three or four times, and by the time we've got them onto the floor they've been into arrest. So, we've got hands on chest pretty much as soon as they've arrested".

Some EMDs do deviate from the scripted dispatch protocol where they need to calm the caller, or Where they feel it is required to triage appropriately even though they will fail their compliance audit.

P04 "…Yeah, the only thing that that I... I notice is that there are human factors, and if you hear someone panicking because their relative is dying, you... you do tend to step away from things like protocols because you're a human and you want to help them cope with that. But yeah, I mean there's... sometimes, the... the protocol is too robotic, and it doesn't account for what's actually happening. And by stepping away, sometimes, the call taker will probably fail that audit, but they will probably... and sometimes... and evidentially, I've had cases where they've saved a life a lot better because they've been... they've stepped away from it".

Alternatively other participants recognised that they were not clinically trained so really had to put their faith in the dispatch protocol.

P01 "…it depends on the call, really. An experienced EMD knows that you've got to trust the protocol, trust the protocol as best you can, and you should stick to it. But it can be to the point of, "I don't think this is right," like, it can... it can sometimes be to the point of, "I think this person needs a cat two ambulance when it's a cat three." If you're experienced, you kind of realise that, and then... but you can't change that as an EMD, because you don't have obviously the clinic... the clinical skills, and you've got to trust the protocol…".

The participants described that there is clinical support available when the EMD feels that the triage outcome doesn't fit with the patient's situation.

P08 "However there are definitely situations where as EMDs we feel they don't necessarily fit the situation correctly. We don't have a lot of scope to move around erm which is why the hub has our clinicians, our paramedics, doctors and nurses to ask for further advice. they don't fit the situation correctly As EMDs . I have actually had it with a patient before where they had called back and they had deteriorated and unfortunately they were at a very low category response, they were on category 3. At which point I did raise it to my supervisor, you know that I wasn't very happy with this erm and from there we then kind of played the protocols a little bit so we then got him to a category 2 by assessing his breathing rather than assessing his chest pain and that bumped him to a category 2. And actually just as I was about to hang up the call, he did go into cardiac arrest".

Services had attempted to alleviate some of the issues by implementing trigger words for ineffective breathing to help the EMDs to triage the calls.

P03…there are more trigger words for abnormal or ineffective breathing which I think is prob... probably makes it easier now. I mean, before it could... it depends how strict you were with it, I think before, so you could get stuck at your pre-triage question for kind of maybe 10-15 seconds because they maybe haven't said the right word but it's a little bit close or... or that kind of... kind of thing…"

The impacts of EMD audit

Participants discussed how EMDs are highly audited and scored on their performance in adhering to the dispatch protocol and their customer service. Audit could be perceived to be a positive thing as it might confirm that the EMD had followed procedure correctly.

P07 "Did I miss something there that could have told me that patient was going to go into cardiac arrest? And they were like, no, according to MPDS rules, you did everything right, you might have had the instinct, but you didn't… MPDS did not allow for that…"

However, audit scores impact on whether EMDs can do overtime and apply for promotions.

P02 "And… because the audit score is on it and the fact that your audit performance has a big impact on whether or not you can progress within the hub, either to floor walking or team leading and things, or… or even mentoring. Or even actually doing overtime…".

Consequently, participants expressed that less experienced EMDs are highly focused on adhering to the dispatch protocol, whereas more experienced EMDs will deviate from the protocol where they think it is in the best interests of the patient.

P04 "Yeah, I think the inexperienced ones are scared to do that because they know that they will fail the audit for whatever reason. But I know the experienced ones go, hmm, meh, okay, you know. I know I'm doing a deviation. I know I'll fail this audit, but I can stand up for myself and explain why. And often, I will say to them if you fail your audit for that, come and talk to me. I will represent you for that one because and I... I often put notes in saying, you know, I'll put a note in saying good... good call to deviatefrom protocol in this case. This has absolutely helped in every way, you know. So I will actually put a note in that says that to support them".

P02 "So much onus is put on your… your audit scores that new guys are ter… are so focussed on getting high compliant audits, that they don't pick up on the nuances of being a call handler. So, they're literally just asking the questions as written, and nothing else".

Participant four expressed that the audit should take into account whether a deviation from the scripted protocol resulted in a more appropriate outcome for the patient.

P04 "So I think they... what they need to do is start deciding if their deviation from protocol has had the right effect. And if it has don't... don't fail their audit. Fail their audit from audit perspective, but don't penalize them for stepping off the line, making a decision and a good call. Don't penalize them for that. That's what we're there for to make good calls.

Theme Two: Identifying and responding to deteriorating patients

The theme 'identifying and responding to deteriorating patients' comprised five sub-themes: Clinical support for the EMD role; Key clinical features described during the EMS call; Acting on EMD intuition; Opportunities to monitor for change; Managing caller behaviour.

Clinical support for the EMD role

Participants expressed that they were constrained by the dispatch protocol in identifying and appropriately categorising patients who they thought were at imminent risk of OHCA. Where an EMD felt a patient was not going to receive the appropriate categorisation, there were procedures in place to enable them to raise their concerns with a clinician who could then directly upgrade the call, based on obvious clinical severity, accept the call from the EMD as a 'hot transfer', or re-contact the caller by telephone to complete further triage to support an upgrade. In instances where there is confusion or uncertainty, live video via the "GoodSam App"[75] (GOODSAM Limited, London) can support the triage. These procedures to escalate a call to a clinician were different in the two Trusts. One Trust had a system where the EMD raised their concern to an EMD team leader, who then, if they felt it was justified, escalated the concern to a clinician. In the same Trust there were clinician 'floor walkers' who were available to assist EMDs directly, where there were any concerns. Where a 'floor walker' is unavailable the EMD can use a 'hunt line' which calls all the on-duty clinicians, this line is tried three times before a blue Clinical Support Desk warning is applied by the EMD and a clinician will check the warning. In the second Trust there is just the first line of support in place; EMDs refer any concerns to an EMD Team Leader who then contacts the Clinical Assessment Team who will decide whether to accept the referral. Participants consistently identified difficulties in accessing timely support from clinicians to assist with concerns. Timely access to clinical support was reported as a major issue as EMDs reported that there were not enough clinicians to meet the demand in the EOC.

P02 "… any concerns we have we're supposed to flag to either a floor walker or a team leader first, and then ask permission if we can flag it to the team leader. Not a team leader. A clinician. And it used to be that we'd try and phone clinicians direct, but now they go into what's called a clinical [hunt], and if one's available they'll answer… they'll answer the phone. But quite often they're not available and it's either because some are out on breaks, or their call volume is just too high. So, you're then told put a warning on, but that doesn't help if the patient is potentially in cardiac arrest. You've got a crew that's on a category two call that's nearby but aren't going to get diverted because this isn't as high a priority because it's still a cat two as well".

Participants expressed concerns about delays and what these delays mean for patients and the frustration caused to EMDs.

P10 "…and then it goes back to what we said earlier about having to raise somebody, them not knowing what you mean and then having to get a clinician, and then you've got this, sort of… at least a 15 minute period there when potentially you might get a duplicate call, "Oh, yeah, patient's not breathing now." Okay, great, you know, that… that's, sort of, the battle that you have so…".

P02 "And I went absolutely mental because, although the call handler tried to flag it up, nobody looked at… not one single person looked at that call between her trying to flag it and us arriving on scene and finding him dead…".

Participants also acknowledged that the system of accessing clinical support needed modifying and that a better developed system of clinical support would allow earlier recognition of patients who are at imminent risk of OHCA.

Focus Group P12 "Yeah, I think it's definitely something that we ought to look into because it is too hard for us to try and get hold... I mean they're not even on the same floor as us, the clinicians, because we're all spread out at the moment...".

Participants described a disconnect between the EMDs and the clinical support available to them.

*Focus Group P12 "The difficulty is, though, I mean I don't know what it's like at ****, but certainly at ****, where we're based, the clinicians really don't like communicating with the EMDs. We have no direct line of communication...".*

Key clinical features described during the EMS call

Participants discussed the key clinical features described on the EMS call concerning patients that were at imminent risk of OHCA. Participants discussed the importance of recognising deteriorating breathing, unconsciousness and any facial colour change.

Participants expressed the importance of recognising abnormal breathing as a red flag for potential OHCA.

P07 "…the biggest thing that comes to mind is the ineffective breathing problem, because that's the Biggest… that's the call that I've always had go to a cardiac arrest. And that I think for me is the most common thing that changes, is ineffective breathing goes to unconscious and that's CPR".

Recognition of agonal breathing was described by one participant as being straightforward.

P09 "…when someone's agonal breathing they really do tell you, like you... or you know, like they're tell you oh, he's had this God-awful noises, it's something that they will bring up, not something that you have to ask of them".

However other participants described assessing a patient's breathing as very challenging.

P08 "…so assessing breathing for us is probably one of the biggest challenges there are, as EMDs. It's one of the hardest things".

Assessment of consciousness was described as being difficult because a patient's consciousness could fluctuate and the EMD has to make a judgement call on the information that they are given.

P02 "Because like… so, I generally go on the theory that if someone is in and out of consciousness it all depends what they are most of the time. If they're predominantly conscious and keep passing out, they're awake. And then I change it to unconscious when they go unconscious. If they're predominantly unconscious and wake up occasionally before passing out again, I just leave it unconscious…".

In addition a participant stated how unconsciousness by itself might not be indicative of a seriously unwell patient.

Interviewer "So assessing consciousness in the deteriorating patient. Do you think... do you think that's problematic or it's okay?

P04 "…Yes, because unconscious isn't always dangerous unless it's blocking an airway. So people faint".

The most definitive feature expressed was that of a facial colour change, predominantly the patient going blue. This feature was described as binary, either there was a colour change or there was not, whereas consciousness and breathing can be variable and more difficult to assess.

P02 "in actual… actual fact they're going to go into cardiac arrest quite shortly. So, in addition to, a), whether or not they're breathing, b), how the call… caller describes their breathing, and c), quite often a patient that's going into cardiac arrest, the caller will give a description of a colour change. "He's not conscious, he's barely breathing, and he's going blue."

Acting on EMD intuition

In every EMD interview, the participant described having an intuition about certain callers who they felt were calling regarding patients at imminent risk of OHCA. The EMDs discussed not really being able to identify what it was about the call that triggered the intuitive feeling. Some EMDs suggested it was something about the caller's voice that relayed how scared they were.

P04 "Well, it's when the dispatchers, the EMDs, they think... now this is not... this is not right for whatever reason. Either it's... this is rubbish masquerading as serious or this is serious masquerading as rubbish. And they... they have just a gut feeling and they're really good at that".

P06 "it's something that doesn't just feel right, if that makes sense. We all seem to have gut feelings of when things don't quite sit right. We know the protocol step well, but a caller will say something and it's just like, that's not quite right. So then you have to seek clinician advice for it".

Participant eight described this intuition using an example of hearing fear in the caller's voice .

P08 "…I said earlier, when you can hear the little catch in the back of someone's throat when they're explaining something to you that makes you feel like the person is very scared".

Participant nine described how an intuition that something isn't right then creates a challenge for the EMD as they try and relay their concerns to allow clinical involvement in the triage.

P09 "I find a lot of the time it's like this gut instinct that you get, which is a bit difficult to try and like get everyone to get on the same page. But I get it with my new people as well, I'm like you will get this gut feeling that something just isn't right".

Opportunities to monitor for change

Participants discussed the design of the dispatch protocol and how it assesses the patient in the moment the question is being asked. The software is not designed for monitoring patients who might be deteriorating during the call and predominantly questions are not revisited during the course of the EMS call.

P5 "I think it's the ones... it's more subtle changes. So if you're looking at someone's conscious level gradually deteriorating, all the respiratory effort going down, it's things like that that the system isn't very well set up for".

Participants had experience of managing calls where the patient had deteriorated during the call, but the EMD had not been able to ascertain that this had occurred using the protocol. Some participants described adapting their call management to better identify deterioration in patients they were concerned about.

P06 "I tend to use [inaudible] unconscious protocol when you're dealing with an unconscious patient. And one of the instructions is, "Look at them very carefully and tell me exactly what you see and hear *them doing." So I tend to use that even if I'm not in that part of the protocol, just to see what they're going to say. Because sometimes they'll say something and you're a bit like, "I need more information there." But you can't ask for it. So I tend to use that, because it is scripted somewhere else."*

Participant ten described opting to use a breathing tool that can be utilised when a patient is unconscious.

P10 "…that's really important that the breathing tool, you know, for us says… it's the one that says, you know, about assessing their breathing. That's really useful for you, especially in those patients that are unconscious and, you know, you're not quite sure, the caller's not quite clear".

Once EMDs had completed the scripted questions in the dispatch protocol and given advice to the caller there is an option to stay on the call to monitor the patient. EMDs discussed utilising this option to monitor the patient.

P11 "Then once you've coded the call, as long as there's no instructions to be delivered but you have to stay on the line, it's then more freelance. So you can then, if you had a burning question that you needed to get in but weren't allowed at the time, you can then get it in then in that sort of discussion at the end. So I find it fairly easy to stick to it really. There's only a few times I can think of where I've had to fail an audit for the patient's benefit, like, just answering a question myself or…I don't know, it's tricky".

Participant seven described how they use this opportunity to monitor patients who have issues with their breathing.

P07…I think that's why monitoring is very important. Like I… especially with a patient that's got breathing problems, I'll always make sure that's the first thing I do. Once I've gone through my instructions and before I consider putting the phone down, I'll just check in again and be like, just to check in again, how is their breathing? And if at that point they go, oh well, it's got so much worse, then okay, that's where I'm going to consider staying on the line or making a cat warning if that's necessary or whatever it…".

Participant twelve expressed their duty of care to the patient and the importance of monitoring where indicated regardless of demand.

P12 "…and it is important to sort of maybe just… just try to… I mean, I try to concentrate on each call as they come through, and, regardless of whether there's calls waiting, you know, if I need to stay on the phone for a little bit longer then… then I do, because at the end of the day, the staffing levels *aren't really my responsibility. My responsibility is that po… that person that's come through to me on a 999 call…" .*

The same participant expressed that pressures on Trusts to meet response time targets can be a barrier to EMDs upgrading calls in circumstances where re-categorisation will result in time targets being missed.

FG P12 "I mean, another thing as well I would say is EMDs need to be brave enough to upgrade something to a cat. one, if they think it needs a cat. one without worry that they're going to be [complianced] or that the dispatcher's going to come down on them or whatever because I know it's not very nice when you've been on the phone with somebody for 20 minutes and they've taken a turn for the worst and you have to cat. one it and then they've already lost the... the... you know they've not been able to arrive within time but at the end of the day we've got to take care of the patient we've got, so…".

In terms of making improvements for the future, participants suggested that changing the process of call-taking so that EMDs must complete an element of monitoring during the call rather than leaving it to EMD discretion might improve recognition of those patients at imminent risk of OHCA.

FG P11 " I think what you said, XXXX, about it being up to the EMD, it's not a requirement for them to check in, that's a really good point, maybe it should be a requirement to check in more often or really that skill of knowing to check in more often should be taught so that to make sure it's appropriate, that'sa really good point".

Managing caller behaviour

Callers do not always behave in a way that allows the EMD to triage the call effectively. Participants described how callers do not expect the call to be answered and to be asked a question about breathing immediately and how callers will persist with saying what they want to say, or mishear the first questions.

Focus Group: P12 "The person on the end of the phone's not necessarily... you know, they've got through to you and they want to tell you what they want to tell you, they're not always listening to the question and they sometimes panic answer. I've had quite a few that will say no, the patient's not breathing when it becomes quite clear when they tell you what the problem is that the patient is breathing or they could actually be the patient themselves".

Participants described managing emotional callers and how they don't always feel adequately prepared to manage callers who are distraught.

P01 "They're protocol-driven, the questions. It's all there for you. The system is there of how to do it all, but how to calm that caller and how to deal with that caller is all down to you, you know?"

Theme Three: Education, knowledge and skills

Theme three comprised four sub themes: EMD dissatisfaction and high staffing turnover; Implications for education and research; EMD feedback and learning from experiences; Variation in EMD practice.

EMD dissatisfaction and high staffing turnover

There is a high turnover of EMD staff in the EOC and the role attracts a relatively low pay banding with a salary range of £20,330 - £21,777[281]. EMDs often leave the role and obtain promotion within the service or outside of EMS.

P03 "I think it's too easy to be employed as an EMD, and there's too many other... there's too many attractive options that EMDs can go and do even within the service let alone outside".

P06 "Yeah, there's a huge turnover of staff in the control rooms".

Participants felt that the role didn't reflect expectations and the result was an inexperienced workforce.

P11 *"Exactly the same with us, yeah. They either do what I've done and gone up the road or they leave because of stress or shifts or lack of fulfilment or the job's not been what they expected, they go elsewhere. Yeah, we have a massive turnover of staff. I went in. I think the last time I was away from control was three months and everyone was… it was like who are these people? So it's scary. It means that lots of people are within the first few months or years, which means they might not have the gut feeling instinct they need and, yeah, that's not great for patients really sometimes".*

EMDs also expressed a lack of empowerment in their role. EMDs are aware of the barriers to the recognition of patients at imminent risk of OHCA, but they do not feel that services listen to their views and suggestions for improvement.

P06 " Yeah, because I think some of it is the ones that are good at it get experienced with it, they sort of get a bit sick of it because nothing seems to change no matter what you do. So then they end up leaving to go and do other stuff".

Participant eleven expressed that EMDs feel unable to influence any change and this is frustrating.

P11 "Another thing I'd say to that is like it is a critical part and yet high... more senior staff and *management don't seem to listen to any advice that... or ideas that we might have. I don't know what **** is like but ****, we say oh, this needs wrong or this is something that's recurring and they're like okay, whatever, but this is right, but they don't do the job and we do, so it's, yeah, we don't... there's no platform for EMDs' thoughts and..."*

Implications for education and research

Participants identified that EMD training had a focus on the systems that they were going to use in their role. EMDs welcomed what first aid training they had received on their EMD course, but they would like more education on clinical signs and symptoms.

P07 "I was kind of impressed at how much they went into detail about breathing problems and what agonal breathing really means and stuff. But we still only had like a couple of days of first aid train… like our first aid training was one day, and they did quite a lot of detail about like breathing and what it means to be ineffective breathing, what it means to be agonal breathing, and went into quite a lot of detail about what an asthma attack sounds like, what a this sounds like, what different types of wheezes can be like, and things that we really need to be looking out for in calls. And they did do the breathing bit in quite a lot of detail. But we still only four weeks of training, and most of that is learning the system of how to use the computers and how to use all the different systems and protocols and everything. And actually…".

Participants thought that improvements could be made to the education of EMDs. EMDs recognised that they did not need extensive clinical training, but they were of the opinion that some more education concerning the clinical signs and symptoms of patients who are deteriorating and at imminent risk of OHCA would help them to identify this patient group on the EMS call.

P06 "Yeah. So just some basic clinical awareness. We don't need to be clinically qualified, but just know some signs and symptoms that could indicate that patient is really, really unwell and that they could arrest".

P05 "…if we can get something, if we can move to a position where we're more intimately understand the sort of correlation between kind of red flags or red flag phrases or, you know, what are those early warning signs that we..."

In addition participants thought that the EMD training could be improved by listening to recordings of real life calls. Participants discussed how callers often describe more than one condition and the EMD must make a choice concerning which protocol to choose, which then determines the questions asked.

P02 "What I think they need to do is, by the time they get to week four, I think they need to be using actual calls to triage through the system because no call is ever simple. Nobody ever phones up about one thing. It's generally three or four things by the time they come to phoning 999. The patient's been unwell for several weeks and their abdo… dominal pain is worse, and they've now got chest pain. They've got breathing problems and are feeling… all sorts of bits and bobs going on that never fit nicely into one protocol. So, I think what they need to do is use actual call recordings in the final weeks to get them before they go out and start to take a management stage".

Participants also recognised the benefits of additional communications training to help them to manage emotional callers, or those callers resistant to the dispatch protocol.

P06 "There's no training on that at all really. They'd play you hysterical callers, but they [never] tell you how to deal with it."

P02 "one of the downsides with the scenarios… and it's the same when you're doing patient assessment scenarios as a clinician. You're… you're lacking a key element of patient assessment, and that's that emotional response of the family, or the emotional response of the patient, or the visual cues that you get with patients when you're… you're assessing them face to face".

Participants also expressed that the public required education focussed on the structure of an EMS call so that callers would anticipate the nature of the questions asked and understood that the EMD provided that first link in the chain of survival.

P07 "thing you can do about that is educate the public before they make these calls".

P10 "I think, you know, I would say public awareness of what will happen on a 999 call is really important, you know, for people to be aware of, "Okay, you're going to get through to somebody that, you know, is quite skilled and that he's going to be able to triage you and look after you and, you know, the help's already started from that point." I think public awareness of that is massively important and that… you know, because the EMD role…".

FG P12 "I think educating people is the way forwards, really. We really ought to educate more than what we do: you know, educating people why they should be ringing 999, educating people what happens when they ring 999".

EMD feedback and learning from experiences

A dominant finding was the EMDs' desire for the opportunity to receive feedback on some incidents. Where EMDs had received feedback it was a positive experience that enabled education.

P05 "…actually, in a really positive way like for once, we actually got some closure around it. We were able to have those discussions, but yeah, for the same, you know, in... within the same breath training linked to sort of actual previous jobs, and, you know, in the ability for them to reflect in a... in a more live environment on something that's just happened. I think it'd be hugely beneficial…".

However, EMDs rarely receive any kind of feedback on patient outcomes.

P03 "…as a EMD, I maybe receive feedback in total three times one via [a plaudit] six months later, and a couple via dispatchers that I knew and just happened to have a corridor conversation with. Not... there's very, very little actual feedback at all".

Participants recognised the value of patient outcome feedback.

P06 "Yeah, I don't really think there's enough support and feedback in the trust, in the control rooms anyway. So you deal with a call, you put the phone down, and that's all you ever know…".

Currently if an EMD would like to find out a patient's outcome they have to actively try and find out what happened and there is no easy way of doing this. There was some annoyance regarding the emphasis on audit compliance feedback, but not on patient outcome feedback and performance in recognising those deteriorating patients. Participants felt that the opportunity to obtain patient outcome feedback would facilitate learning and support EMD well-being.

P07 "So yeah, like getting the feedback on especially ones that suddenly go to arrest, I think is really important, at least so that I've got the chance to go, actually, can I listen back to that? Actually, is there something I did wrong?".

However, the same participant recognised that they did not always want to know the patient outcome because a negative outcome could potentially be difficult for the EMD to manage, especially where children are concerned.

P07 " I think that's a bit of a hard one because there's some calls where I don't want to know, and there's some calls, especially like children, I don't ever like to know the outcome just because it's so much easier to assume that the paramedics went and worked their magic and sorted everything and it's totally fine".

Participant eleven expressed that there is an opportunity for service improvement by using patient outcome feedback. Where patient outcomes do not reflect an appropriate category of call this information could be used to formulate a picture of how well the dispatch protocol is working and to make changes based on evidence.

P11 Absolutely, yeah. Yeah, it could highlight faults in AMPDS or, like I said, our allocation of categories to each code. That could highlight a problem as well".

Variation in EMD practice

Participants recognised that there was variability in EMD performance. Some EMDs were skilled at detecting nuances in the interaction that identified a patient who was very unwell.

P8 *"I think that going back towards the training process and in regards to communication skills. I've mentioned kind of briefly and I think it depends on the person I think a lot of being an EMD comes from communication skills and social skills and being able to recognise, like I said earlier, when you can hear the little catch in the back of someone's throat when they're explaining something to you that makes you feel like the person is very scared. And I think that's something people either have, or they don't have. I feel like although you can develop communication skills, emotionally being in tune with someone, is something unfortunately some people don't have and you can't really, you know I think it does come into play quite a lot. I think that's why it's such a hard job."*

The experience of the EMD is reflected in how they use the dispatch software to triage the patient. EMDs will select different protocols depending on experience and this will impact on triage outcomes.

P01 "…then that's when the EMD has to make their first proper decision about which protocol do they then select. So this is when the knowledge or the experience or the skill of the EMD makes a big difference, and can make a big difference to those patients that... if they're not spotting that there's a problem".

Participants also expressed variability in motivation and work ethic.

P09 "I mean there's obviously like the really, really good ones and then there's the people that do the bare minimum and that's where I worry. I mean I shouldn't have that worry but sometimes I'll take a phone call and think oh, thank goodness I took that because somebody else could have just not put as much effort in…"

P09 "I don't know how to say it but some people will just do what the system tells them or what their team leader tells them and not like push it further, whereas I would push it..."

The same participant highlighted a tendency for some EMDs to focus on the system rather than on what the caller is saying which might lead to missed opportunities in recognising deteriorating patients.

P09 "I have to say, I would just say they need to put the emphasis on like actually taking in the whole picture of the call and focusing on the patients because I find a lot of people are just wanting to tick a box and move on and if you actually just take the time to listen and like focus on what's going on around them you might pick it up more."

4. Discussion

4.1. The Dispatch Protocol and Audit

There are two main triage systems used in the UK, Advanced Medical Priority Dispatch System (AMPDS) and NHS Pathways[73]. In general AMPDS is considered to be a more linear system leading to a quicker categorisation process than NHS Pathways[73]. AMPDS is the triage software used in the two participating EMS Trusts in this study and is acknowledged to have a sensitivity of 76.7% for detecting patients in OHCA[282].

Theme one, 'The Dispatch Protocol and Audit' identified that although the dispatch protocol was very good at identifying most patients who required a category one response, the rigidity of the protocol meant that identification of some critically unwell patients was challenging. The use of AMPDS by EMDs is heavily audited and EMS auditing of EMDs performance in adhering to the dispatch protocol constrains EMDs and compels them to focus on protocol adherence over acting on any intuition concerning patient presentation.

The International Academy of Emergency Dispatch (IAED) has a quality assurance programme[283] and performance feedback has been found to improve protocol compliance[284]. A condition of the IAED license agreement is that EMDs are audited regularly. EMDs have their performance measured through a protocol compliance audit. Emergency Dispatch Quality Assurance personnel audit calls against set standards and any under-performance is addressed through education[285]. EMD calls are randomly selected and audited by a member of the audit team and then a performance report is sent to the EMD[283]. Automated protocol-based call-taking is considered accurate and consistent[286] and the IAED endorses compliance audit to maintain quality standards[287].

4.2. Identifying and Responding to Deteriorating Patients

Theme two, 'Identifying and Responding to Deteriorating Patients' indicated that clinical support for the EMD role could be more effective if more clinicians were available in EOC, or with different models of working to allow more effective use of clinician time. EMDs are not clinically trained and there is an absence of research focusing on optimal models for clinical support to EMD roles. This area could be usefully explored in the future. It was apparent that there were differences between the two services participating in this research in the way clinical support for EMD roles was structured. Participants did not appear to consider either model to be optimum for raising concerns focused on patients who are at imminent risk of OHCA and in one service a disconnect was reported between clinicians and EMDs. Recently published research by Moller and colleagues[288] recognised the requirement for teamwork between stakeholders in Emergency Medical Dispatch. Although the context of Moller and colleagues'[288] research was slightly different, the sentiment expressed here is largely the same. An understanding and respect for different roles within the dispatch and responding teams would promote effectiveness.

EMDs were aware of the key clinical features that can indicate a patient is about to deteriorate into OHCA and emphasised colour change as one of these clinical features. The key clinical features of breathing, unconsciousness and declaration of colour change identified in this study reflect the findings of my systematic mixed studies review, reported in Chapter Two[289].

EMDs expressed how they often have an intuition concerning certain patients and how explaining this to other staff to act on their concerns was challenging. The subject of EMD intuition was prominent as it was mentioned in every interview with an EMD and was a dominant feature, but this area is not well explored in the literature in relation to EMDs. My study findings indicate that often EMDs cannot describe what contributes to their intuition, but one participant in my study mentioned the 'little catch in the back of someone's throat'. This finding links to a study investigating nurse telephone triage of patients reporting cardiac symptoms. The study found that nurses assess paralanguage, tone of voice, gasping, breathing speed and shortness of breath when using telephone triage. In the cardiac nurse study, when the nurse's interpretation of the patient's condition does not fit with the outcome of the Clinical Decision Support Software (CDSS) the nurse would either 'tinker' with the responses to make sure the patient received the response that the nurse felt was indicated, overrule the CDSS recommendation, comply with CDSS, or refer to a GP[290]. In relation to this, previous research has demonstrated that EMDs' decision-making is dependent on both vocal expressions and the intensity of expression and found that EMDs are particularly tuned in to expressions of 'fear' with the strongest influence on decision-making being when a case is severe [291].

A study with findings in favour of scripted dispatch and completed in London Ambulance Service found that when AMPDS was introduced it was confirmed that AMPDS was much more accurate than an EMD in identifying OHCA patients and that the EMDs' belief that they could triage better than the system was misguided, however this study investigated those patients already in OHCA, rather than those at imminent risk of OHCA[292]. A study that has previously explored EMDs' decisions to override the dispatch system found that EMDs do not always appropriately override the dispatch protocol and that the dispatch protocol is more accurate and consistent than the subjective intuitions of dispatch staff[286]. Forslund et al.[293] detailed the use of personal qualities such as intuition in the area of emergency dispatch, but the study did not explore the accuracy of EMD intuition. Similarly nurses employed as EMDs noted the reliance on their intuition to override the system when they felt necessary[294]. The absence of patient outcome feedback in this setting limits the ability of EMDs to know whether their intuitive feelings are justified. There needs to be a better understanding of whether EMD perceptions of intuition are accurate and more research is required in this area.

Some callers' behaviour is challenging to manage. It has been noted previously that callers are not aware of the structure of an EMS call, and this could be alleviated through public awareness campaigns[288] . Callers are not expecting the format of the EMS call and callers often just want to inform the EMD of the reason for their call, rather than answer scripted "pre-triage questions" designed to detect cardiac arrest. Callers may also be upset or angry, and EMDs need to manage these situations. EMDs have reported that callers present in a variety of emotional states that impact on the trajectory of the call[288]. Holmstrom and colleagues [295] investigated experiences of 'difficult calls' to EMS and identified seven themes: calls with communication barriers; calls from agitated or rude callers; calls about psychiatric illness; calls from third parties; calls about rare or unclear situations; calls with unknown address; calls regarding immediate life-threatening conditions. In the theme 'Calls regarding immediate life-threatening conditions' there was disparity in the responses with some EMDs relying on the protocol to navigate the call and other EMDs reporting these calls being difficult to manage and causing them emotional distress.

4.3. Education, knowledge and skills

Theme three, 'Education, knowledge and skills' indicated that the high staffing turnover of EMDs contributes to the loss of knowledge and skills as EMDs progress into different roles or leave to work elsewhere. EMDs expressed feeling frustrated and disempowered in their role. In relation to EMD retention and dissatisfaction, a systematic review in 2017 identified Emergency Medical Dispatching as a stressful job with a significant proportion of EMDs reporting negative effects on their psychological health. Amongst others, the stressors reported included: working in under resourced and pressurised environments; exposure to traumatic calls; a lack of control over high workload; a lack of support from "management"[296]. In support of Golding et al., [296] an American study published in 2021[297] identified the negative impacts of chronic secondary exposure to traumatic events requiring well developed stress management skills and the importance of recruiting EMDs who already possess these skills. Recommendations from the researchers included enhanced psychological and stress testing to enable successful recruitment and retention of EMDs, promotion of effective management of chronic stress, expectation management regarding career development and a realistic explanation of the EMD role and associated demands[297].

Participants expressed the need for some additional clinical training in the recognition of patients that are at imminent risk of OHCA to improve their recognition of these patients during call triage. They also felt that the inclusion of enhanced communications training using real life EMS calls would be beneficial to assist EMDs in managing situations where the caller expresses multiple clinical issues, or where the caller is not progressing through the call as expected because they are upset or confused amongst other reasons.

As highlighted in Chapter Two, the systematic mixed studies review, simulation training for EMDs has been found to improve OHCA recognition[298]. Teaching EMDs to recognise agonal breathing has had positive results and increased telephone cardiopulmonary resuscitation[299] and there is potential to investigate simulation training and recognition of clinical signs of deterioration in the patient who is at imminent risk of OHCA. Riou and colleagues[300] proposed that call-taker training in the interactional differences in the call could help to identify patients in OHCA and studies have noted the desire for EMDs to receive more clinical and communications training[293]. Research by Gerwing and colleagues[301] recognised the absence of overlap between studies that emphasise the effect of subtle differences in communication behaviour with studies that focus on training in verbatim scripts and simulation. Gerwing and colleagues'[301] study aimed to enhance EMD communication skills to align the EMD better with the caller in terms of roles, knowledge, responsibility and emotional involvement and also assess the impact on decision-making time. The researchers found that communication training could improve the EMD and caller interaction without abandoning index-driven questioning and this training reduced decision-making time. This pilot study demonstrates the potential for integrating communications training into existing EMD practice.

Currently EMDs do not routinely receive clinical outcome feedback and participants welcome the opportunity to receive feedback on some patients they have triaged. This would be viewed as an opportunity to learn, but also to support EMD emotional well-being. A lack of EMD feedback has been reported previously [302]. In this Danish study the participants noted that the lack of feedback negatively impacted EMD well-being. The only time EMDs received feedback was where something had gone wrong and they were held to account. Hardeland and colleagues[298] included structured EMD feedback and debriefing on recognition of OHCA in their training intervention and this was found to improve OHCA recognition. A scientific statement from the American Heart Association identified the importance of recognition and feedback to EMDs in response to OHCA[303], but again the focus appears to be on patients already in OHCA, and not the deteriorating patient at imminent risk of OHCA. However, there is no reason to think that feedback would not be useful in the deteriorating patient group.

Variation in EMD practice is supported in the existing literature. In support of the findings from the interviews analysed, Moller and colleagues[288], although focused on paramedics and nurses working as EMDs, also found that experience as EMDs effected performance. Hardeland et al. [304] identified that EMDs use different strategies during EMS call triage and these strategies impact on performance.

4.4. Data Saturation

The data sample for this study consisted of 12 individual interviews and one focus group consisting of four people. There has been debate around the usefulness of the concept of 'data saturation' in qualitative research[305]. Data saturation is considered to have been achieved where no new themes are constructed from the data[305] and the addition of more participants contributes nothing further to the analysis[306]. Braun and Clarke[305] argue that the judgement around when to stop data collection is subjective. Malterud and collegaues[306] promote the concept of 'information power' over 'data saturation' in qualitative research. Information power is linked to the aims of the study, whether they are narrow or broad as well as sample specificity, use of established theory, quality of dialogue and analysis strategy. In this study I predicted that my sample did not have to be large because my study aims were narrow, my sample was specific and the quality of the dialogue was strong. I did not feel that there were established theoretical perspectives to support the study which would indicate that a larger sample might be needed.

4.5. Participant recruitment

My initial aim was to recruit 20 participants into the study. There were challenges with recruitment as I recruited participants from the Emergency Operations Centre in the midst of a global pandemic when ambulance service were under severe pressure[307]. Following the 12 individual interviews I did re-advertise through established communication channels in the participating EMS organisations and used snowball sampling[308] by asking existing participants to recommend the study to any of their colleagues to recruit some more participants, but there were no volunteers at that time. In addition, some initial volunteers did not go ahead with an interview after expressing an interest to participate because of poor health and emotional well-being and this was an interesting element of the study. At this stage I reviewed my transcripts and completed the focus group interviews and determined that there was enough new knowledge generated in the data to address the aim of the study. My interview transcripts were rich with data, providing new insights, and indications for future research were apparent. This is supported by Malterud and colleagues[306] who advocate an approach where the researcher estimates what they think the sample size should be and then constantly re-evaluates this estimate through the data collection process to understand the information power of the sample.

Reflecting on the sample of EOC employees recruited, whilst I had a good range of roles and experience, I postulate that the participants represent EOC staff who are more engaged and proactive than EOC employees who did not volunteer to participate. However, despite this I do think that the findings can be extrapolated to employees who did not participate. This is because the participants reflected on the practice of their colleagues and the system as a whole as well as their own individual experiences and practice.

4.6. Reflexive thematic analysis

This study used Reflexive Thematic Analysis (RTA). RTA was chosen as a suitable methodology because it had the flexibility I required to analyse the data set. Researchers take many different approaches to thematic analysis (TA) and these approaches are underpinned by differing methodological assumptions. Braun and Clarke[277] have framed their approach to TA as Reflexive Thematic Analysis, since it reflects their distinct approach of putting the researcher's role in knowledge production central in the process.   RTA allowed me to be both deductive and inductive and this was important because of the focus of the research and the fact I was coming to the research with preconceived ideas.   RTA is widely used in qualitative research[309], however there is limited information on the trustworthiness and rigour of TA[310]. The benefits of using TA include the ease of learning the method and the flexibility of the approach[311], whilst disadvantages of TA include a lack of literature on the method causing doubts about rigour[311]. In addition, there is potential that the flexibility of the method risks inconsistency in theme development [310]. Because TA has been less well-defined than alternative qualitative methods the terminology associated with the method has sometimes been inaccurate, or inconsistent[311].

In this study NVivo software[280] was used to code the interview data and the researcher maintained a log of decisions made when recoding the data. Decisions were also discussed during supervision meetings. At each point of data analysis the file was saved which gave an audit trail of changes to coding. Although I understood my interpretations of the data to be unique based on my own position and experiences, because this study is conducted under supervision a second researcher (SV) analysed 20% of the interview transcripts and independently coded them. This coding was comparable and not contradictory as recommended by Koch et al. [312].

An alternative method of analysis which was considered but not used in this research was grounded theory. I approached this final objective having completed three related objectives. This final objective was concerned with discussing the findings of the research to this point with EOC staff. I was coming to this objective with preconceptions and existing findings to explore. As grounded theory is concerned with generating theory and not investigating preconceived theories, I did not judge it to be a suitable methodology to use in this instance[313] . In grounded theory data analysis runs concurrently with data collection and the data is undetermined before the beginning of the study. Grounded theory relies on theoretical sampling with further data collection reliant on previous analysis[314]. Glaser and Strauss, the recognised founders of grounded theory, developed the constant comparative method for organising and analysing qualitative data[315]. In the current study the sample was defined and the focus was on interpreting the data and generating theory, rather than constructing theory alongside data collection.

Discourse analysis was also considered, but disregarded as it is focused on examining language and it's function in the social context[97] which was not the focus of this work. Interpretative Phenomenological Analysis (IPA) was considered as a methodology, but not utilised because I had clear themes that I wanted to explore with the participants and IPA is not conducive to that[316]. IPA is very much participant orientated and the researcher must set aside any preconceptions, prejudgements and biases[317].

4.7. Reflexivity

During the research process I kept a reflexive diary to document my evolving perceptions, a log of procedures, any methodological change and my personal introspections[318] and this is available in Appendix 8. I approached data collection with preconceived ideas that had been formulated during the previous objectives of the research. Although I have not worked in EOC I do regularly work clinically as a paramedic and I recognised that my experiences as a paramedic would influence the analysis of the data.

The reflexive diary was useful in helping me to reflect on my role in shaping the data analysis. There were elements of the process that I felt could be improved and I wanted to understand how these aspects could be developed. Elements of interest included the beginning of the call interaction and a prior observation that when this is confused the interaction quickly misaligns. I was also keen to understand how information gets lost and why deterioration is not recognised during the call. I came to the research with the interpretation that the EMD role is under-valued and that recognition of the importance of this role in the chain of survival in OHCA and better support for this role would allow improvements for patients. My position was that of social constructionist and the findings of my research are derived from social interaction in which I played a central role; the findings are a subjective reality. Understanding my own impact on the research process and findings, putting reflexivity at the heart of the research, enables a more credible and rigorous study.

5. Limitations

This study was based in the United Kingdom (UK) and involved two ambulance Trusts both of which used Advanced Medical Priority Dispatch (AMPDS) in their computer aided dispatch. Although the findings of this study may not be entirely generalisable to other EMS and dispatch models I believe that the findings are useful to consider in alternative systems. If the UK is considered in isolation, the other main dispatch software utilised within the UK is NHS Pathways. Like AMPDS, NHS Pathways is also used by non-clinical health advisors who use scripted triage software[319]. Non-clinical health advisors are supported by clinicians and an EMS call is triaged through a clinical hierarchy where life threatening conditions are initially assessed to trigger an immediate response and then the call progresses through less urgent conditions[320]. There are distinct similarities between the two systems and the findings of this research will be generalisable, at least in part, to both.

The aim of this research was to investigate the views of the participants on the results of the preceding chapters and I approached this research with preconceived ideas concerning the challenges EMDs face in recognising and responding to patients that are at imminent risk of OHCA. These preconceived ideas were explored during the interviews. Although I attempted to support the participants to express their additional thoughts and experiences there is a risk that opportunities for participants to spontaneously offer new insights could have been limited.

The initial intention to meet the study aims was to complete face to face interviews and focus groups, but the COVID-19 pandemic meant that University of the West of England guidelines changed and face to face interview activities were no longer supported and instead online methods of data collection were mandated[321]. There has been limited use of Virtual Interviews (VI) in research prior to the COVID-19 pandemic[322]. A study exploring nurses taking part in qualitative research using VI reported some technical difficulties, but generally the interview experience was reported to be positive because of ease, cost effectiveness, data was easy to manage and there were security options[323]. Negative impacts of using online interviews include impeding people from participation because of a lack of internet resources[324], however I do not think that this was a factor in my research as when the participants expressed an interest they were unaware that the research was entirely virtual. No participants chose not to take part because of a lack of equipment to participate in a virtual interview. An additional fact to consider is the impact of anyone else present on the participant's responses and confidentiality where sensitive topic areas are being discussed. Face to face interviews have been found to contain marginally more statements than VI, but it is suggested the benefits in terms of cost and convenience outweigh this observation[325]. The methodological literature on using VI remains limited[326] and the COVID-19 pandemic meant that conducting interviews in this way was not initially planned and considered; rather the methods for data collection were adjusted to meet the legal and safety restrictions in place at the time.

On the theme of COVID-19, the global pandemic placed ambulance services under extreme pressure. During this time many changes were made to operational practice. In the Emergency Operations Centre excessive demand meant that EMDs were disconnecting from calls rather than staying on the line because emergency calls were stacked and waiting to be answered. These pressures and the impact on

EMDs will have had some influence on the way the EMDs responded in the interviews. The effect of COVID-19 on this study could not have been predicted, but the impact is acknowledged and reflected on during this research.

6. Conclusions

Reflective thematic analysis of 12 semi-structured interviews and one focus group of EMS staff employed in the Emergency Operations Centre of two ambulance trusts identified three main themes: The Dispatch Protocol and Audit; Identifying and Responding to Deteriorating Patients ; Education, Knowledge and Skills. Areas identified with potential to lead to improvement in recognition and response for patients who are at imminent risk of OHCA were education of EMDs in clinical recognition of the patient at imminent risk of OHCA, communications training, use of real life calls for training and the addition of a system of patient outcomes feedback to improve practice. In addition, education of the public in the structure of EMS calls, when to contact EMS and measures to improve public understanding that the EMD is a critical element in the first link in the chain of survival are all likely to prove beneficial. EMDs indicated that more comprehensive opportunities to monitor the patient's condition as the EMD call progresses would be helpful in identifying those deteriorating and high-risk patients alongside an improved model of clinical support for EMDs that assists EMDs in optimising the response to patients at imminent risk of OHCA. EMDs require improvements in their working conditions and their opportunities to effect change.

This study has provided an important insight into the challenges that EMDs face in recognising and prioritising patients at imminent risk of OHCA. Analysis of data has indicated that there are key opportunities for development aimed at improving the recognition and response to this high-risk patient group.

7. Chapter Summary

In this chapter I have reported the findings of individual interviews and a focus group interview with EOC staff who are experienced in EMS call triage. The aim of the research was to investigate EOC staffs' views on the preceding objectives of this fellowship and to understand their thoughts regarding how the research findings to date can be progressed to improve the EMS recognition and response to patients who are at imminent risk of OHCA.

Data was analysed using reflexive thematic analysis and three overarching themes were identified from the data. These themes are the dispatch protocol and EMD audit; Identifying and responding to deteriorating patients; Education, knowledge and skills. Findings indicate that members of the public do not always understand how the EMS call functions and that the EMDs are an important element of the chain of survival and are not delaying help. The main findings also identified that the rigidity of the protocol acted as a barrier to identifying patients at imminent risk of OHCA and there was inadequate timely access to clinical support to assist EMDs with their concerns. EMDs identified that assessments of breathing, consciousness and colour change are important. EMDs described having an intuition regarding which patients might be at high risk of OHCA, however they found acting on these intuitions difficult because of the barriers in accessing clinical support. The dispatch system is not conducive to monitoring the patient as the EMS call progresses. EMD training and education is predominantly system focused. There is a high turnover of EMDs in the EOC and EMDs do not receive patient outcomes feedback which is considered highly desirable.

Moving forward, EMDs require more timely access to clinical support to raise any concerns regarding patient triage. Training and education of EMDs can be improved by including more comprehensive training in recognising clinical signs and symptoms of patients at high risk of OHCA, the inclusion of real-life calls and communications training.   A system of patient outcomes feedback should be explored to enhance EMD education and job satisfaction. Members of the public would benefit from education on the structure of the EMS call and the role of the EMD in the chain of survival. The findings of interviews with EOC staff have identified opportunities to improve the recognition and response to patients at high risk of OHCA and further research will be planned to lead on from this fellowship to develop an intervention aimed at improving the EMS recognition and response to patients at high risk of OHCA.

This Chapter completes my data collection and interpretation of each element of the Thesis as an individual piece of research. In the next Chapter I will draw together the entire body of work, synthesising my key findings, highlighting strengths and weaknesses and identifying areas for future research. I also reflect on my personal development as a researcher.

Chapter Six: Discussion

1. Chapter overview

This discussion chapter draws together the findings of the four IMARI objectives and frames the findings in the existing literature. The four main chapters complement each other with Chapter Two, the Systematic Mixed Studies Review, demonstrating that patients at imminent risk of OHCA are an under-researched group. Chapter Three, the retrospective observational data review, indicates that the patients at imminent risk of out-of-hospital cardiac arrest (OHCA) are not well recognised and responded to by EMS. Chapter Four, the conversation analysis (CA) of EMS calls, identifies some issues in the caller and EMD interaction and how the design of the EMDs' script does not allow for a completely efficient and accurate extraction of the reason for the call from the caller. Finally, interviews and a focus group with Emergency Operations Centre (EOC) staff gives their views on the findings of IMARI and how improvements can be made to the recognition and response to patients at imminent risk of OHCA. The limitations of the research are discussed, and recommendations are made on developing these findings to improve the recognition and response to patients at imminent risk of OHCA.

2. Overview of the aims and objectives

This body of work aimed to answer the research question, how can the recognition and response to patients who are at imminent risk of OHCA be improved? The PhD Fellowship investigated how improvements can be made to enable the earlier identification of patients contacting Emergency Medical Services (EMS) who are at imminent risk of cardiac arrest, to provide the most timely and effective response possible, thereby reducing mortality and improving clinical outcomes in this high-risk patient group.

The research was set out in four objectives:

Objective A: To complete a systematic review of primary research investigating the features of an EMS call interaction that facilitate call-taker recognition of patients who are in OHCA, or at imminent risk of OHCA.

Objective B: To understand the current EMS call triage, EMS response and survival of patients at imminent risk of OHCA. Two cohorts of OHCA patients were identified; those that were triaged as requiring the highest priority ambulance response (category 1) and those that were triaged as requiring a lower priority ambulance response (Category 2, 3 or 4).

Objective C: Conversation analysis (CA) of the Emergency Medical Dispatcher (EMD) and caller interaction on the emergency call to identify call features that may facilitate recognition of patients who are critically unwell and at imminent risk of OHCA.

Objective D: To conduct interviews and a focus group with EMDs, dispatchers and clinical supervisors in the Emergency Operations Centre to gather and understand their views on how the findings of this fellowship can be used to improve the recognition and response to patients who are at imminent risk of OHCA.

3. Research findings

3.1. The absence of research on patients who suffer OHCA after the EMS call is answered

The European Resuscitation Council Guidelines, 2015 and 2021[10] recognised the importance of identifying patients who are at high risk of OHCA, but not yet in OHCA, and the importance of the call for help in the potential prevention of OHCA. The guidelines specifically reference prodromal symptoms and specify the importance of recognising chest pain of a cardiac origin and myocardial ischaemia before a patient collapses to allow EMS to arrive quickly and improve survival. A focus on those at imminent risk of OHCA as well as those already in OHCA reflects the revised Chain of Survival from 2005 which emphasised the importance of recognising critical illness and/or angina and cardiac arrest prevention both in and out of hospital. Experts in the field hoped that this change would prompt earlier recognition of those people at high risk of imminent cardiac arrest, with a subsequent early call for help and the opportunity to prevent the cardiac arrest occurring, if treatment was given early enough[12].

Interestingly, despite this focus on patients who are at imminent risk of OHCA and their early recognition on the EMS call for help, there is little research to guide improvements in the EMS system. The International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations[327] completed a recent systematic review on dispatch diagnosis of OHCA, but obviously this does not include those patients not in OHCA at the time of the EMS call.

On completion of my Systematic Mixed Studies Review (SMSR)[289] I found an absence of research investigating the interaction between the EMD and callers regarding patients who are not in OHCA when the EMS call is made, but who deteriorate into OHCA subsequently and this absence of research confirmed the requirement for focused investigation and provided the impetus to continue with the planned research fellowship.

3.2. EMS witnessed OHCA

Moving forward, Objective B (data analysis) sought to distinguish the characteristics and outcomes of patients who suffer an OHCA after the EMS call is made. EMS witnessed OHCA is a readily identifiable group of patients who are alive when the EMS call is made, but this group makes up only a proportion of the patients who are alive at the time of the EMS call. An equally important group is that which has an OHCA that is witnessed by a bystander, or not witnessed at all. There is, however, some existing literature on EMS witnessed OHCA, whereas to the author's knowledge there is no evidence regarding patients who are alive at the time of the EMS call, but do not have an EMS witnessed OHCA.

Reviewing the evidence relating to EMS witnessed OHCA, Hostler and colleagues[201] investigated Resuscitation Outcome Consortium (ROC) regional centres in North America and found that 25% of EMS witnessed OHCA presented with a ventricular tachycardia/ventricular fibrillation rhythm (shockable rhythm) and 43% pulseless electrical activity (non-shockable rhythm). This is a lower proportion of shockable rhythms than in my analysis of the data during Objective B (data analysis). Also, 59% regained a return of spontaneous circulation (ROSC), very similar to my findings (58.7%) and 18% survived to hospital discharge, lower than in my research (24.7%). Axelsson and colleagues[328] found 51% of EMS witnessed OHCA patients to present with ventricular fibrillation (shockable rhythm) and listed independent predictors of survival as ventricular fibrillation, cardiac aetiology, OHCA outside the home and decreasing age.

In my data analysis, it is not surprising that EMS witnessed patients do comparably well in terms of survival. The aetiology of the OHCA in this group and the fact the OHCA was witnessed by EMS staff corresponds to the relatively high rate of survival. If we could recognise and respond to these patients more effectively there is an opportunity to provide early treatment and to prevent the OHCA from occurring. Nehme and colleagues[79] investigated EMS witnessed OHCA of a presumed cardiac origin. Predominant prodromal symptoms were reported to be chest pain, dyspnoea and altered level of consciousness. Patients had a survival rate of 37%, higher than in my findings (24.7%), but Nehme and colleagues were looking at OHCA of presumed cardiac origin only, which tends to have a higher survival rate in this context. Early treatment before OHCA was associated with higher survival outcomes. The underlying aetiology of the OHCA was linked to survival with patients with chest pain or other angina-type symptoms more likely to arrest into a shockable rhythm, while patients with dyspnoea and hypotension were more likely to arrest into an asystolic or pulseless electrical activity cardiac rhythm. Thus, the type of prodromal symptoms correlate with both the initial cardiac arrest rhythm and the likelihood of survival.

Nehme and colleagues'[79] findings link directly to the differences in patient outcomes between the groups in my Objective B (data analysis). I had two main groups, Group 1 (not in OHCA at the time of the EMS call) and Group 2 (in OHCA at the time of the EMS call). Group 1 had two subgroups, G1a (EMS witnessed OHCA) and G1b (not EMS witnessed OHCA). G1b had a very poor survival outcome of 7% and a higher proportion of MPDS coding for breathing difficulties which could feasibly be a contributor to poor outcomes in consideration of Nehme's[79] findings that patients with dyspnoea are more likely to arrest into a non-shockable rhythm. Conversely, G1a had the highest proportion of chest pain at 22.9% which will similarly contribute to higher rates of survival in this subgroup. Another factor to consider is that my SMSR identified that assessing breathing and recognising abnormal breathing was a particular issue on the EMS call, and could also be a factor in the poor survival outcomes of G1b.

Marijon and colleagues[329] investigated warning symptoms associated with OHCA and found that 51% of patients had warning symptoms before their OHCA, but only 19% of these patients contacted EMS to report their symptoms. Patients contacting EMS were more likely to report chest pain and have symptoms of heart disease. Survival in patients who contacted EMS to report their symptoms before collapse was 32.1% compared to a survival of 6% in those who did not contact EMS to report their symptoms. These findings indicate that it is not only important for us to recognise the patients contacting the EMS system with symptoms indicative of imminent OHCA, but also for the public to be educated regarding symptoms of concern and when it is appropriate to contact EMS.

3.3. The focus on the response to patients already in OHCA

The previous section indicated that there is some research focussed on the characteristics and outcomes of EMS witnessed OHCA, but I have been unable to find any literature relating to the recognition of, and response to, patients who are alive at the time of the EMS call and go on to have a cardiac arrest before EMS arrival. This suggests that my findings are novel and add value to the existing literature. My findings indicate that patients who are alive at the time of the EMS call are much less likely to be categorised as requiring a category one response than patients already in OHCA at the time of the EMS call. This leads to significantly longer response times for patients who are alive at the time of the EMS call, impacting negatively on their survival. EMS respond most quickly to patients who have already suffered an OHCA and consequently have a lower chance of survival. EMS systems have optimised the response to this group of patients who are already in OHCA at the time of the EMS call, and we don't fully understand how to similarly optimise the response to patients who are alive at the time of the EMS call, but at high risk of cardiac arrest.

I proceeded to investigate the EMS call interaction of patients who suffered an OHCA, but were alive at the time of the EMS call. Using conversation analysis (CA) to investigate the initial stages of the EMS call interaction it was clear that the recognition of those patients already in OHCA is quite rightly a priority, but efforts to recognise patients already in OHCA may disadvantage those patients deteriorating and at imminent risk of OHCA. An example could be the addition of the Pre-Triage Questions (PTQ) at the beginning of the EMS call. Making the first question an important question about breathing, with no opportunity for the caller to speak before this point leads to misalignment in the interaction and lost information. This is a significant finding in view of the importance given to those patients deteriorating and at high risk of OHCA in the Chain of Survival[12] and the current European Resuscitation Council Resuscitation Guidelines,[327] and suggests that these recommendations haven't yet been translated into practice in the UK.

In an effort to better recognise patients already in OHCA the Ambulance Response Programme mandated the PTQ focused on breathing and consciousness. PTQ was introduced at the same time as Nature of Call (NoC) which is a predefined list of problems that facilitate the early identification of patients with a potentially life threatening emergency[73]. Opening the call with the PTQ does not allow the caller to express their reason for the call in their first turn, which is what a caller unfamiliar with the EMS triage system would expect. This mismatch between patient expectations and the reality of the EMS call sequence causes misalignment on the call and hinders the progression of the call. It also frustrates both caller and EMD and risks the loss of valid information. This is problematic because EMDs reported in the focus group and interviews that they think the PTQ and NoC are good at identifying patients who are critically unwell and in OHCA, but they also recognise that the PTQ causes issues with interaction and effective triage. EMDs recognise that a caller's naivety regarding the structure of the EMS call causes interactional problems and delays to EMS call triage. Investigating calls from HCPs who are familiar with the PTQ in Objective C (conversation analysis) indicates that they do not cause a problem in the interaction and that where a caller is familiar with the EMS call sequence the call can be triaged much more effectively and as designed.

3.4. The dispatch protocol

There were mixed findings in relation to the dispatch protocol. A systematic review conducted by the International Liaison Committee on Resuscitation focused on patients already in OHCA and identified that there was a lot of variability in the accuracy of algorithms and criteria for recognising patients in OHCA. The review recommended implementation of standardised algorithms, but noted the evidence to support this is of low quality. Dispatch centres have been advised to optimise sensitivity, and high quality research was recommended to examine the knowledge gaps in this area[327]. The National Framework to Improve Care of People with OHCA in England supports the evaluation and improvement of telephone scripts that EMDs use to identify patients in OHCA[59]. My SMSR indicated that adherence to the dispatch protocol and the asking of key questions is variable with associated impacts on triage effectiveness and outcomes.

During Objective D (interviews) adherence to the dispatch protocol was explored in detail. There were mixed responses regarding adherence to the dispatch protocol with some respondents indicating their reliance on adherence as they recognised they did not have the clinical experience required to step outside of the scripted protocols. Other respondents indicated that certain situations meant they needed to deviate from the protocol, for example where callers are very upset and not cooperating as required and the SMSR also indicated that distressed callers create issues for EMDS in managing the EMS call. EMDs also indicated in the interviews that they did not strictly adhere to the dispatch protocol where they had intuitive feelings that the patient was more unwell than the caller was indicating.

3.5. The caller and EMD interaction

One of the findings from the SMSR was that the way the caller and EMD interact is a critical factor impacting on the recognition of OHCA and deteriorating patients. The way the caller interacts with the EMD effects the approach of the EMD to managing the EMS call and the subsequent trajectory and outcome. The EMD and caller interaction has been explored previously,[217,226,300] and findings from these studies indicate that interaction design can lead to loss of information, the use of tense impacts on the length of a response[217] and the use of qualification to a breathing question can indicate that a patient is breathing abnormally[300]. Objective A (SMSR) and Objective D (interviews) both identified variability in EMD approach to the EMS call interaction. My Objective C (CA) indicates that EMDs do not always ask questions in the same way and this impacts on EMS call triage outcomes; in my data this is most noticeable where the EMS asks the breathing PTQ in one of two different ways:

a. Is the patient breathing?
b. Is the patient breathing normally?

Asking “Is the patient breathing normally?” appears more likely to lead to the call being triaged as a category one response. I hypothesise that this finding might relate to the caller giving additional information when the question is asked in this way that can then be remembered by the EMD and acted on in the NoC element of the triage, triggering a category one response.

Conversation analysis (CA) in Objective C found that narrative responses are more likely in OHCA patients where a patient is alive at the time of the EMS call and categorised as category two than if they were alive at the time of the EMS call and categorised as category one. Narrative responses have been recognised previously as causing delays during EMS calls[217]. The CA also indicated that the emotional level of the caller directly effects the trajectory of the call. The more upset a caller is, the more likely the patient will be triaged as a category one response. This links to the findings of the SMSR that a highly emotional caller can indicate to the EMD that a patient is in OHCA, but also that a calmer caller may give the EMD false reassurance. The literature indicates that these calls can be difficult to manage[295] and the findings from this fellowship indicate that additional EMD training in managing emotional callers would be beneficial.

3.6. Workplace culture

The interviews and focus groups with EMDs and other EOC staff revealed a workplace culture that did not appear conducive to improving the recognition of patients at imminent risk of OHCA. There is a high turnover of EMD staff and as a result valuable experience is lost. EMDs are highly monitored through compliance audit, but during the interviews it was reported that these audits do not acknowledge protocol deviations that may have contributed to a patient being correctly triaged. Interviewees did not feel that their experiences were valued in attempts to improve the triage of critically unwell patients, and they felt that access to timely clinical support could be improved. EMDs also reported a lack of patient outcome feedback that would improve learning. EMDs mentioned regularly having intuitive feelings regarding certain patients they felt were at imminent risk of OHCA. Patient outcome feedback would allow EMDs to follow up on these patients to discover if their intuitions were correct.

3.7. Assessing a patient's breathing

A topic common to every objective was the assessment of a patient's breathing during EMS triage. The SMSR identified that where breathing is adequately addressed on the EMS call an OHCA is more likely to be recognised[136,142,146,151,156]. However, this is not easy with misinterpretation and a lack of clarity regarding breathing status[134,138,146,149,153,157,162] being the main reasons why OHCA may not be recognised on the EMS call. EMDs are reliant on the caller's interpretation and communication of the patient's breathing status and equally the caller is also relying on the EMD's interpretation and actions based on the information given. It is an emotionally charged and high-risk interaction.

The importance of adequately assessing a patient's breathing was reinforced in Objective B where analysis of the outcome of AMPDS triage indicated that breathing problems were frequently coded across all groups as the main reason for the call. Objective C (CA) identified the interactional issues caused by the EMS call opening and the misalignment between the caller and EMD caused by the caller being unaware of the institutional structure of the EMS interaction. Structuring the EMS call so that a first question asked is about breathing status in an interactionally troubled call may actually prove unhelpful in establishing a patient's breathing status. There are varied patterns to the call data, but the main issue is confusion at the initial breathing PTQ, and this then may play out in different ways. There are confusion and time delays establishing the facts about a patient's breathing and this links closely to Clegg and colleagues'[269] findings regarding the main hold ups on the EMS call focused on establishing a patient's breathing status.

These findings were explored further in Objective D (interviews). Interviewees liked the Nature of Call (NoC) system changes introduced during ARP[73]. They described the challenges of assessing breathing on the EMS call and highlighted the difficulties in monitoring a patient's breathing through the EMS call. The dispatch protocol and compliance audits make it difficult for EMDs to step away from the dispatch protocol and monitor a patient's breathing as the EMS call progresses. EMD experience and motivation in their role also comes into play. There are decisions to be made when it comes to choosing the main medical complaint to follow for the remaining call triage. The choice of protocol determines the questions to be asked and directly impacts on the triage of the patient[73].

3.8. Patient monitoring during the EMS call

The dispatch protocol in this research was AMPDS which assesses the patient at a point in time and does not lend itself to monitoring deterioration in the patient's condition as the call proceeds. Participants in Objective D described this as a hinderance to recognising those patients that are deteriorating and at imminent risk of OHCA. EMDs did discuss informal strategies that they adopt for monitoring patients when they were concerned; more formal methods with oversight and patient monitoring would be welcomed and have the potential to achieve significant benefits by identifying the deteriorating patient, who is at imminent risk of OHCA, more accurately.

3.9. Gender differences

There are gender-based differences in survival from OHCA, with men more likely to survive to hospital discharge than women. The gender difference in survival is most pronounced in patients considered to have a favourable prognosis[330]. There are also associated gender differences in the assessment and treatment of myocardial infarction.[331] The "gender gap" in myocardial infarction recognition has been reported previously,[332]and I anticipate there is likely to be a relationship between the myocardial infarction "gender gap" and the potential "gender gap" in OHCA survival demonstrated in my work, and also reported elsewhere[333]. Anderson and Pepine[334] suggest that some gender differences in the outcomes of patients suffering myocardial infarction may be related to the female status and female-specific conditions being linked to ischaemic heart disease later in life.

Meischke and collegaues[332] found that women have a longer delay in seeking care when experiencing an Acute Myocardial Infarction (AMI) as well as older people and people who are diabetic. Women are more likely to be older and more likely to be diabetic. Women and men also present differently when suffering an AMI, with women less likely to become clammy, but more likely to suffer with shortness of breath and nausea. There was no difference in the incidence of chest pain between genders, but the quality of chest pain was not investigated. Clamminess, associated with males, was statistically significantly associated with a shorter time delay prehospital[332]. These findings are relevant to the IMARI study because as Chapter Three indicates, subtle differences in patient symptoms impact on the way a call is triaged and categorised. Granot and colleagues[335] investigated gender differences in the perception of chest pain and found that men and women present differently with chest pain. Women are more likely to describe pain in their back, stomach, neck and chin. Men predominantly associated their chest pain with heart disease whereas 73% of women did not. Also, women complained more of dyspnoea, dizziness, palpitations and irritability in comparison to men. These gender differences link to the discussion in section 3.2 of symptoms of chest pain being more likely to progress into a shockable rhythm and survival, whereas breathing difficulties are more likely to progress to a non-shockable rhythm with reduced survival.

The findings in Chapter Three relating to gender indicate that there was the highest proportion of females in G1b, the group that was alive when the EMS call was answered, but who did not have their OHCA witnessed by EMS. This group also has the lowest number of patients surviving to 30 days (7%). There were also 36.9% female patients in G1a compared to 30.8% female patients in G2, and the predominance of chest pain in G1a would make this group interesting to analyse further to investigate how women present on the EMS call in comparison to men, and associated differences in response. Unfortunately, my data analysis did not look specifically at gender differences in EMS call categorisation, but this would be an interesting addition to any future analysis. Watkins and colleagues[197] reported that females in OHCA are less likely to be recognised as such on the EMS call. As reported in chapter two, there may be a systematic bias in the way EMS respond to patients who are alive when the EMS call is answered and then suffer an OHCA, and this warrants further investigation.

3.10. Bystander CPR

There are disparities shown in Objective B (data analysis), regarding the proportions of patients who receive bystander CPR. Patients who are alive at the time of the EMS call are more likely to have a bystander witnessed OHCA, but less likely to receive bystander CPR than patients who are already in OHCA at the time of the EMS call. These figures are understandable because EMDs play a crucial role in the first link of the chain of survival. When an EMD recognises OHCA on the EMS call they immediately instruct the caller to initiate CPR, known as telephone CPR (tCPR). In OHCA immediate CPR can double or triple survival rates[10]. If an EMD does not recognise that a patient is in OHCA on the EMS call then there are missed opportunities for early tCPR and defibrillation using a public access defibrillator. The data indicates that patients who are alive at the time of the EMS call are less likely to be recognised as critically unwell and the call can be disconnected by the EMD once complete, negating the opportunity for the EMD to provide tCPR if the patient has a cardiac arrest subsequently. The data indicates that in Group 1b, 92.8% of OHCAs are bystander witnessed, but only 74.2% receive bystander CPR. This means that there are 18.6% of group 1b who could receive bystander CPR, but do not.

Barriers to the initiation of bystander CPR have been explored in the literature and a scoping review by ILCOR[336] identified factors associated with improving and hindering the willingness of bystanders to perform CPR. Factors were grouped into "personal factors", "CPR knowledge-based factors" and "factors relating to procedural issues". However, the authors noted that difficulties in the early recognition of OHCA were a major issue to overcome. These difficulties in OHCA recognition and early treatment are much more pronounced in G1b and will contribute to the poor outcome in this group of patients.

3.11. EMD education

There is limited evidence to guide the education of EMDs in general. Hardeland and colleagues[162] found that targeted simulation, education and feedback improved the recognition of OHCA, while Bohm and collegues[146] found that educating EMDs to understand and recognise bystander descriptions of agonal breathing improved tCPR. In Objective D (interviews) the participants expressed that they felt their training could be improved. EMDs specifically identified that some additional clinical training in the recognition of the deteriorating patient would be useful. In addition, EMDs indicated that the use of "real life" examples of EMS calls from deteriorating patients during role play would help improve the recognition of patients at imminent risk of OHCA.

3.12. Public education

In section 2.2 I described that Marijon and colleagues[329] found that approximately half of OHCA patients had warning symptoms, but only 19% of these patients made contact with EMS prior to collapse and OHCA. This finding indicates that there is a requirement for public education focused on warning signs before OHCA. Nehme and colleagues[337] found that a comprehensive mass media campaign which aimed to improve community awareness of heart attack symptoms substantially reduced the incidence of OHCA and associated deaths. Wellens[338] points out that the impact of the public awareness campaign was felt only during and shortly after the campaign, and also that it had less of an impact on women. Public education is important; the public require education in the signs and symptoms that indicate a patient is at high risk of OHCA, to include the signs and symptoms relating to all genders.

The public also require education on what happens when they contact the EMS system. King County, USA[339] with the highest survival rates internationally from OHCA, have a "Communities of Care Programme" which includes "What to do when calling 911". The team have developed materials with clear messaging on preparing to relay information and what to do when EMS arrive. Well-designed public awareness has the potential to prepare the general public regarding the structure of an EMS call and how to work with the EMD to support the correct triage of the patient. Better interactional alignment between the caller and EMD at the beginning of the EMS call is critical to improving the triage of these high-risk patients.

4. Developments

4.1. Artificial intelligence

Artificial intelligence (AI) is a relatively new tool to assist with identifying patients in OHCA and has been recognised as a knowledge gap in research[327]. It is currently unknown whether AI could improve recognition of OHCA compared with EMD recognition[327] and this knowledge gap, identified in the 2021 International Consensus[327], clearly translates to the recognition of those patients at imminent risk of OHCA on the EMS call.

A retrospective study conducted in Sweden[340] found that machine learning can recognise more patients in OHCA in the first minute of the call than EMDs. A recent randomised controlled trial conducted in Denmark[341] to examine machine learning to identify OHCA has shown promise in the recognition of OHCA, recognising some OHCAs quicker than EMDs and with a sensitivity and specificity of 85% and 97% respectively. Regardless, human factors in the prospective RCT meant that OHCA recognition did not significantly improve because EMDs did not always comply with the alerts. This is a developing area of technology and research that shows promise for improving the response to patients who suffer OHCA, and who are at imminent risk of OHCA.

4.2. Wearable technology and ancillary tools

There is potential for wearable technology to be used to alert EMS when a patient collapses. Smartphones already have the capacity to detect falls and to detect the absence of a heart rate[51]. Mobile phones and smart speakers have also been shown to be effective in identifying cardiac arrest without contact[342]. Remote video link has demonstrated potential in identifying OHCA, and GoodSAM (GOODSAM Limited, London) "Instant-On-Scene"[343] can allow clinicians to identify deteriorating patients more easily. In addition the GoodSAM app (GOODSAM Limited, London) can alert trained bystanders to a person suffering an OHCA and to the location of the nearest public access Automated External Defibrillator[75].

5. The impact of the study's findings

The initial idea for the thesis arose because survival from OHCA globally remains poor at 8.8%[184]. OHCA is a catastrophic event requiring immediate intervention if a patient is to have any chance of survival. In the United Kingdom (UK) each year there are around 80,000 OHCAs; approximately 31,000 of these receive resuscitation from ambulance staff[26]. OHCA remains a leading cause of cardiovascular mortality within the UK[344] and survival to hospital discharge in the UK is only 7-8%[66]. When patient outcomes following OHCA are compared internationally it is evident that the UK is under-performing in terms of patient survival. The best performing ambulance services internationally have OHCA survival rates as high as 56% in the Utstein Group[64]. This research is ultimately aimed at improving outcomes from OHCA, and preventing OHCA by improving the first link in the chain of survival in OHCA. However, improvements in the recognition and response to patients who are at imminent risk of OHCA may act to reduce survival in OHCA overall. If all preventable OHCAs are prevented then the remaining group of OHCAs will be largely unsalvageable, and so a successful prevention programme could appear to decrease the overall survival rate from OHCA. A population measure of mortality (e.g. total deaths occurring outside hospital) would be required to demonstrate this.

My research investigated EMS systems that use AMPDS dispatch software. AMPDS is predominantly successful at recognising victims of OHCA and has a sensitivity of 76.7% and a specificity of 99.2%[282]. The current treatment recommendations following an ILCOR systematic review are that dispatch centres should have a standardised algorithm to determine if a patient is in OHCA at the time of the EMS call and this is a strong recommendation, though with low certainty evidence[327]. The findings of this Fellowship should be viewed as an opportunity to improve the existing system.

Patients who are alive when the EMS call is made and then proceed to suffer an OHCA have a better chance of survival than patients who are already in OHCA because there is an opportunity for EMS to provide early treatment and prevent the OHCA from occurring in the first place, or EMS may witness the OHCA, or arrive soon after the OHCA to provide early treatment that offers the patient an improved chance of survival. These opportunities to improve survival rely on an early EMS alert and subsequent early recognition by EMS that a patient is at imminent risk of OHCA and the initiation of an appropriate response. An investigation of the EMS recognition and response to patients who are alive at the time of the EMS call and then proceed to suffer an OHCA has not previously been completed and was the impetus for this fellowship.

The high OHCA survival rates in King County, Seattle, USA is not down to one overriding factor, but to “the aggregation of marginal gains”[345]. However, as Deakin[346] has pointed out, the links in the chain of survival are not equal and there is the most to gain from the first link in the chain of survival as this is where there are the most patients. This novel investigation of patients who were alive at the time of the EMS call has generated important insights and findings that can be taken forward into further research with the aim of improving outcomes from OHCA. The findings indicate that EMS do not respond as effectively as they could to patients who are alive at the time of the EMS call and then suffer an OHCA. The reasons for this are multifaceted and contribute to poor survival rates from OHCA.

To improve outcomes from OHCA there needs to be equal attention placed on those patients who are not already in OHCA when the EMS call is made as there is on those patients who are already in OHCA. The relatively high survival rates of patients who suffer an EMS witnessed OHCA clearly demonstrates the impact of early treatment on survival. There is an argument to focus attention on those patients for whom existing evidence suggests a higher chance of survival, i.e., chest pain patients. However, I do not believe that this area is well enough understood at present, and the evidence of gender differences in presentation and EMS response requires further research. Placing an emphasis on chest pain patients is likely to further increase the gender gap in the recognition of, and survival from, OHCA.

The full picture of EMS recognition and response to OHCA cannot be understood until the data also includes those patients that were not resuscitated by EMS. EMS in the UK make best interest decisions for patients who are terminally ill, or where resuscitation would be unlikely to be of benefit to the patient[193]. Some patients may not be resuscitated where the response time has been over 15 minutes since the onset of OHCA, where there has been no bystander CPR, there are no reversible factors and the patient is asystolic[193]. In some of these incidents, if the EMS response had been within 15 minutes these patients would have been resuscitated and eligible for inclusion in this study.

6. Implications for practice

The IMARI study adds value and insight in meeting its original objectives to identify how improvements can be made in the recognition and response to patients who are at imminent risk of OHCA. The findings from Objective B clearly indicate that EMS do not respond as effectively as they could to patients that are at imminent risk of OHCA, but who are not yet in OHCA when the EMS call is made.

The group of patients that are alive at the time of the EMS call prior to OHCA are under-researched and under-represented in the literature, however my results also indicate that the issues preventing early recognition of patients at imminent risk of OHCA are multifaceted. Key implications for practice, arising from this thesis, are as follows:

a) Members of the public need to be enabled to recognise the symptoms of a patient at high risk of OHCA and encouraged to contact EMS immediately and report the symptoms.
b) Members of the public also require education on the process of EMS call-taking so that when they need to contact the system in an emotive and highly stressful situation, they can communicate in the best way to obtain the required help for the patient.
c) The EMS call-taking system requires modification so that the caller and EMD can rapidly interactionally align to allow a smoother and more effective interactional transaction and subsequent triage of the patient.
d) The EMS call-taking system also requires modification so that EMDs are better able to monitor for deterioration in a patient's condition through the call.
e) Models of clinical support for EMDs during EMS call triage are not currently functioning in the most optimal way to support the recognition of this high-risk patient group.
f) EMDs would benefit from clinical outcomes feedback in a model that will support their education.
g) EMDs would also benefit from additional education in recognising the deteriorating patient, the use of real-life EMS calls in their education and additional communications training.
h) Dispatch software compliance audits should recognise when an EMD steps away from the protocol for good reasons that benefit the patient's triage.
i) The EOC workplace culture requires improvement so EMDs perceive themselves as valued members of the team and the essential element in the chain of OHCA survival that they are reported to be.

Moving forward, an important consideration is that ambulance services are under extreme pressure[347], more so now than ever. Therefore, any system changes need to be sensitive and specific to avoid overwhelming already overstretched resources. A category one EMS response must be reserved for people with life threatening illness or injury.

7. Limitations

There are a number of limitations of IMARI to be considered when interpreting these results:

a) I did not have practical support costed in for my SMSR, which was an oversight. SMSR selected databases were screened, and appraised in full by one reviewer and a second reviewer (SV), screened and appraised 20% of the studies. The Mixed Methods Appraisal Tool (MMAT)[348] was used to appraise the included studies and the MMAT manual[348] recommends that two people independently complete the appraisal process because it is about judgement making. Two people should also independently screen the literature as single screening has been found to substantially overlook studies[349].

b) I numerically graded the included papers and this is discouraged in the latest version of the MMAT[348], however I felt I could justify this by giving detailed comments in the results tables concerning the limitations of each included item.

c) One strength of the SMSR, that could also be considered a limitation, is that the qualitative and quantitative findings did not lend themselves to meta-analysis and meta-synthesis respectively, however I feel the breadth of research included in this review adds important context to the topic area and a review of this breadth and nature has not been published previously.

d) When conducting Objective B (data analysis), it was clear that "time of OHCA" was not accurately recorded by EMS. This data point was required to determine whether the patient was alive, or already in OHCA, at the time of the EMS call; a crucial factor in my analysis. This was a predictable challenge when considering that OHCA is a highly emotive and stressful event. OHCA may be unwitnessed, and where witnessed, bystanders may not recognise a patient is in OHCA and EMS staff may be so focused on immediate patient treatment that they do not accurately record the time of the OHCA. As a result of these factors there is an element of estimation when recording the time of OHCA in the data.

e) Group three, the largest group of patients in the data, were omitted from the data analysis in Objective B because the time of OHCA was not recorded.

f) Inaccuracies in recording the time of the OHCA impacted on the groupings of the patients into Group 1 (alive at the time of the EMS call) and Group 2 (already in OHCA at the time of the EMS call). To overcome this an agreement was made in supervision to allow some "blurring" between Group 1 and Group 2 and to conduct sensitivity analyses using different time point cut offs. Patients were allocated to Group 1 where their OHCA was recorded as being three minutes, or longer, after the time of the EMS call and this grouping formed the basis of the main analysis. Sensitivity analysis was conducted at zero minutes and ten minutes. On review of the categorisation and response time analysis in Objective B I feel confident that the three-minute cut off worked well in placing most of the patients in the correct groups as the results of these sensitivity analyses were as expected.

g) A further limitation of Objective B (data analysis) is the use of data from 2018/2019. Ambulance services are constantly evolving and there will have been many changes to the process of triaging EMS calls since this time. The most obvious impact will be from the COVID-19 pandemic and the implementation of numerous AMPDS protocol updates[350]. The extreme pressure that EMS have witnessed has meant that EMS have had to implement measures such as "urgent disconnect" which is where the EMD must disconnect the EMS call immediately after instructions are given, in order to answer another call waiting in the queue.

h) The data did not allow me to ascertain whether there had been more than one EMS call for the same incident, and this would have been a useful addition to the data.

i) The data in Objective B (data analysis) was from one ambulance trust that used the AMPDS triage system. Although ambulance trusts in the UK use one of two triage systems, AMPDS or NHS Pathways[73], there will be SWASFT-specific elements to the triage process and the results of this analysis cannot be generalised to alternative systems.

j) The data only included patients that had been resuscitated by EMS staff and the inclusion of patients who had suffered an OHCA and not received EMS resuscitation would be a useful addition to the existing dataset, allowing a fuller picture of the recognition and response to patients who are alive at the time of the EMS call, but who then go on to suffer an OHCA.

k) Objective C (CA) investigated calls where the patient was alive at the time of the EMS but then went on to suffer an OHCA. There were two cohorts; patients that received a category one response and patients that did not receive a category one response. With hindsight, it would have been useful to include a third group, those that were already in OHCA at the time of the EMS call as it would have been interesting to compare and analyse these EMS interactions alongside those patients who were not in OHCA during the EMS call.

l) The EMS call dataset did not include EMS calls where there was a language barrier, or any obvious barriers to communication. One call where the caller could not hear was excluded. The findings of IMARI can therefore not be generalised to patients where there are communication barriers, and further research is required to optimise the recognition and response to patients at imminent risk of OHCA where such barriers to communication exist.

m) The EMS call data was linked to the EMS calls analysed in Objective B (data analysis), and so this data is also from 2018/2019 with multiple changes to the EMS call-taking process since this time. Eight patients had to be excluded from cohort one because when the calls were reviewed it was evident that the patient was either already in OHCA at the time of the EMS call, or probably agonal breathing which meant that they did not fit the inclusion criteria. This also reflects inaccuracy in the recording of cardiac arrest time by EMS staff as discussed under Objective B above.

n) There was an absence of consideration of additional potential inequalities in the dataset to include ethnicity and social deprivation.

o) Video would have been a useful addition to the data set as it would have shown how the EMD was interacting with the Computer Decision Support Software (CDSS). Video data of the caller is currently not feasible, but with advances in ancillary technologies and GoodSAM (GOODSAM Limited, London) Instant On Scene Video Technology[75,343], this may be feasible in the future and will add valuable information to conversation analysis in EMS.

p) Whilst ambulance trusts in the UK use CDSS, there will be differences between trusts around some elements of the EMS call-taking process. An example in SWASFT would be that the Trust approves “trigger” words or phrases that link into the “Nature of Call” screening during the initial stages of call triage. Differences between UK trusts and between EMS internationally will mean these findings will not be generalisable to all systems.

q) Objective D (interviews) was completed whilst the COVID-19 pandemic was ongoing and restrictions were still in place[324]. The University of the West of England did not allow face-to-face research to take place and all interviews had to be conducted virtually. Whilst virtual interviews brought many benefits of convenience, there were also challenges. A researcher lacks presence in a virtual interview[351] and that lack of presence may limit the quality of the data collected because subtleties such as eye contact and body language that are more easily interpreted in a face-to-face interaction are not as apparent.

r) I was pleasantly surprised by the response to adverts for interview and focus group participants. EMS were under severe pressure and EMDs were working in a highly pressured and stressful environment, more so than in pre-pandemic times. You[351] acknowledged that the loneliness brought about by the pandemic influenced people to want to connect virtually and may have encouraged them to share more easily in a virtual format. This observation could also be seen as a limitation as participants may have seen the interview as an opportunity to “offload” because of frustrations they felt at work and participants’ responses will have been influenced by the changes in practice brought about by COVID-19. One participant did drop out from interview as they recognised that they were not psychologically well enough to take part and their mental health had been negatively affected by the pandemic. There may have been other participants who might have taken part before the pandemic, but the impacts on psychological health may have prevented them from participating at the time of recruitment.

s) Virtual focus groups allow geographically diverse participants to be involved in the same research,[352] and I found this particularly useful and valuable when involving participants from geographically distant ambulance trusts in one focus group. The interaction between the participants from the two different trusts was particularly revealing. However, Objective D (interviews) only included participants from two ambulance trusts and both trusts used AMPDS software. Findings from Objective D (interviews) may not be generalisable to EMS with alternative triage models and software support.

8. Strengths of IMARI

The strength of IMARI is that it is a novel study that has provided new insights into the response to OHCA patients who are alive at the time of the EMS call, and who have a relatively high chance of survival, if responded to appropriately. This is a group of patients that are underserved in the existing literature. IMARI consisted of four objectives with distinct methodologies; each objective informed those that followed and contributed new knowledge to the phenomenon of interest. The results of IMARI provide impetus for a diverse range of further research aimed at directly improving the response to this high-risk group of patients with potential to inform international guidelines and significantly improve patient outcomes from OHCA.

9. The researcher journey

My journey through the IMARI Fellowship has been interesting with many challenges caused by COVID-19. Predominantly challenges were more personal in terms of disruption to family routines and the challenges of working from home and a lack of interaction with colleagues, rather than impacting on the research. Direct impacts on my progress with IMARI were more concerned with networking and dissemination. I had planned international research trips to Denmark and Australia to network with researchers investigating triage and dispatch for OHCA in EMS, and these opportunities were lost. Similarly, any opportunities to engage at 'live' conference events were not possible during the Fellowship. However, I hope that restrictions will ease and I can hold some funds over from the Fellowship to disseminate my findings at 'live' conferences in the near future. Some educational courses were postponed, and as a result I was not able to participate in them.

Objective A (SMSR) was challenging because of the SMSR methodology. The conduct of SMSR is relatively uncommon and I found designing the study complex. When conducting the study I found it particularly difficult synthesising the literature from such diverse methodologies. Once complete I was pleased with the finished product because it incorporated diverse studies and gave important context to the difficulties in triaging EMS calls concerning OHCA. When submitting the SMSR for publication one of the reviewers was particularly concerned with the focus on "recognition" studies over "prediction" studies, however no "prediction" studies met the inclusion criteria of the SMSR. This reviewer's comments did make me evaluate what "new" evidence my SMSR brought to this area as there were no studies that definitively included my patient group of interest; those alive at the time of the EMS call and not yet in OHCA. On reflection, even though there are existing systematic reviews focused on the recognition of patients already in OHCA at the time of the EMS call, no study is published that is an SMSR in this area and the focus of my review on the EMS call interaction and the diversity of the studies included adds new insights to the existing literature.

Objective B (data analysis) brought interesting challenges focused on determining which patients were "alive" at the time of the EMS call and which patients were already in OHCA. This challenge made me think about what constitutes being "alive", and what I meant by the terminology used in my research.

"Death occurs when there is permanent loss of capacity for consciousness and loss of all brainstem functions. This may result from permanent cessation of circulation and/or after catastrophic brain injury. In the context of death determination, 'permanent' refers to loss of function that cannot resume spontaneously and will not be restored through intervention"[353].

On reflection "alive" is not the right term to use and perhaps "not yet in OHCA" and "in OHCA" are better terms. Objective B also highlighted the challenge of being able to determine when someone was definitively in OHCA, without electrocardiogram or ultrasound confirmation, and how some cases were reliant on judgements from a bystander witness or EMS staff. Reflecting on this point I determined that the important focus of my work was on those patients who were clearly "alive" at the time of the EMS call and then went on to suffer an OHCA, rather than those who were already collapsed and very close to OHCA, or in OHCA, at the time of the EMS call. In practice it was very difficult to distinguish between these latter two categories of patient.

During Objective C (CA) I focused in on my "not yet in OHCA" group and did not perform CA on my Group 2 patients; already in OHCA at the time of the EMS call. In hindsight having a third group of Group 2 patients would have been beneficial to understand if there is a difference in the interaction in this situation. It would have been useful to understand if the patient already being in OHCA makes the interaction more efficient in comparison to those calls where the patient is potentially deteriorating into OHCA.

In Objective D (interviews) I found it challenging to keep the participants on track as they were so focused on patients already in OHCA. Participants digressed multiple times to discuss the challenges of recognising patients already in OHCA when the EMS call is made. I believe that this was an inevitable consequence of the focus of institutions and guidelines on this group of patients over the group of patients who are critically unwell and at imminent risk of OHCA. This observation allowed me to reflect on the bias of systems in favour of those patients already in OHCA over patients who are critically unwell and at imminent risk of OHCA. I find this interesting because the latter group have a much higher chance of survival than the former group.

Overall, on completion of this body of work, I am proud of the insights I have gained into this area and the challenges I have overcome on the journey. I believe IMARI makes an important and valuable contribution to OHCA research.

Recommendations for further research

Further research investigating the triage, response and characteristics of patients who are alive at the time of the EMS call and then suffer OHCA

To my knowledge this is the only study to specifically look at the EMS response, characteristics and outcomes of patients who are alive at the time of the EMS call and who deteriorate into OHCA before hospital arrival. Further research on this subject is warranted.

EMD Education

Further research is indicated to understand the most appropriate ways of educating EMDs in effective communication strategies to better manage the EMS call interaction and optimise patient outcomes.

Further research is required to understand what additional first aid and clinical education would benefit EMDs in recognising patients at imminent risk of OHCA.

Understanding patients absent from the data

There is a group of patients missing from the data who were not resuscitated by EMS. Further consideration, and inclusion, of the EMS response to patients who are not resuscitated and therefore absent from this data set would be valuable.

Gender imbalance in the data

There is an imbalance in the OHCA data as a whole in terms of gender. This has already been investigated to some extent in the existing literature and has been found to extend to post resuscitation care[354]. However, there is also an imbalance in gender in those patients who are alive at the time of EMS call and who go on to suffer OHCA in comparison to patients already in OHCA at the time of the EMS call. There were more females in Group 1, with the greatest proportion of females in group 1b; the group with the lowest chance of survival. Further investigation to understand how we can optimise the response to women and increase survival is warranted. Specifically, it would be useful to investigate any gender imbalance in call categorisation that might be associated with differences in patient outcomes.

Modification to the EMS call opening

More research should be conducted to investigate whether a modification of the EMS call opening that aligns the caller and EMD would positively improve the triage of patients who subsequently deteriorate into OHCA.

Also, research is required to investigate whether modifying the initial PTQ from, "Is the patient breathing" to "Is the patient breathing normally" consistently enables the recognition of more critically unwell patients who are at imminent risk of OHCA, and the underlying reasons for this.

Public education on prodromal symptoms and CPR

Further research should be conducted that investigates the most appropriate way to educate members of the public concerning prodromal symptoms of OHCA and the need to contact EMS before a person collapses. In addition, there needs to be more public education on when it is appropriate to perform CPR.

Public education on the structure and function of the EMS call

Research is required that investigates the optimum way to educate members of the public concerning the structure of the EMS call so that the public can answer the questions in the most appropriate way to achieve the correct response.

Further research is required investigating the best way of educating members of the public on the function of the EMS call to specifically include understanding the EMS call as the first link in the chain of survival, and the fact that the EMS call isn't delaying help, but is the beginning of help.

10. Conclusion

The IMARI study addressed four objectives to improve the recognition of, and response to, patients at imminent risk of out of hospital cardiac arrest. It combined: a systematic mixed studies review investigating the features of an EMS call interaction that facilitate call-taker recognition of patients who are in OHCA, or at imminent risk of OHCA; a retrospective observational study to understand the recognition of, and response to, patients who are not in OHCA at the time of the EMS call and who deteriorate into OHCA subsequently; a conversation analysis of the EMS call for patients who are not in OHCA at the time of the EMS call, but who suffer an OHCA before hospital arrival; interviews and a focus group with Emergency Operation Centre staff to gather their views on the findings of IMARI and how best to take the research forward to improve the recognition and response to patients at imminent risk of OHCA.

Objective A (SMSR) identified a lack of published research investigating patients who are not in OHCA at the time of the EMS call, but who proceed to have an OHCA after the EMS call is answered. The studies analysed demonstrated variation in practice and results across EMS systems. A dominant finding was the importance of (and difficulty in) recognising abnormal/agonal breathing during the EMS call. The review also identified that the way in which the EMD manages the EMS call is a critical factor in their ability to recognise OHCA and the deteriorating patient. Adherence to the dispatch protocol and the asking of key questions is variable with associated impacts on triage. In addition, the way the caller interacts with the EMD influences the approach of the EMD to managing the EMS call and the subsequent trajectory and outcome. The caller's level of emotional distress impacts on the EMD and their assessment of the EMS call. The majority of callers are calm and cooperative, but high levels of emotional distress may indicate an OHCA and calm callers may create uncertainty or false reassurance. A highly distressed caller can make it challenging for the EMD to manage the EMS call in the most effective way because they may not cooperate with the EMD asking the scripted questions, and the EMD cannot triage the call unless the caller answers the prescribed questions.

Objective B (data analysis) identified key differences between Group 1 (not in OHCA at the time of the EMS call) and Group 2 (in OHCA at the time of the EMS call), and also between the Group 1 subgroups (G1a (EMS witnessed) and G1b (not EMS witnessed) and Group 2. There are more women in Group 1 than Group 2, most noticeably in the G1b group (not in cardiac arrest at the time of the EMS call and not witnessed by EMS staff). G1b are more likely to be bystander witnessed than G2, but less likely to receive bystander CPR. G1b are statistically significantly less likely to present with a shockable rhythm, despite being alive at the time of the EMS call. G1a are more likely to achieve a ROSC and 22.5% of G1a patients survive to 30 days compared with 7% and 8% of G1b and

G2 patients respectively. There are large differences in EMS response times. Patients in Group 2 have a mean response time of 9 minutes, compared to 24 and 19 minutes in G1a and G1b respectively. The response times link very closely to the way the calls are categorised, with G2 EMS calls significantly more likely to receive a category one response compared to G1a and G1b.

Objective C (CA) indicates that callers accessing the EMS system have preconceived expectations concerning the structure of the EMS interaction. EMS calls are an institutional interaction that does not follow the "rules" of everyday conversation. The current EMS call opening does not allow the caller to express the reason for the call in their first turn, which is what a caller unfamiliar with the EMS triage system would expect, and the addition of the pre-triage questions (PTQ) further complicates this. The mismatch between caller expectations and the EMS call structure often causes misalignment at the beginning of the EMS call, hindering the progression of the call towards both institutional and caller goals. Interactional misalignment frustrates the flow of both the caller and EMD and risks the loss of valid information. Subtle changes to the way the breathing Pre-Triage Question is structured appear to impact triage outcome. The analysis indicated that a caller's emotional state influences the actions of the EMD and the way they triage the EMS call.

Finally, Objective D (interviews) identified three main themes:

a) Theme 1. The Dispatch Protocol and Audit

This theme recognised that although the dispatch protocol was considered very good at identifying most patients who required a category one response, the rigidity of the protocol meant that identification of some critically unwell patients was challenging. The use of AMPDS by EMDs is heavily audited and EMS auditing of EMD performance in adhering to the dispatch protocol constrains EMDs and compels them to focus on protocol adherence over acting on any intuition concerning patient presentation.

b) Theme 2. Identifying and Responding to Deteriorating Patients

This theme indicates that clinical support for the EMD role could be more effective if more clinicians were available in EOC, or with different models of working to allow more effective use of clinician time. EMDs expressed how they often have an intuition concerning certain patients and how explaining this to more senior staff to act on their concerns was challenging. Another finding was that a caller's behaviour can be challenging due to emotion, or because they are unaware of the format of the EMS call.

c) Theme 3. Education, Knowledge and Skills

In this theme EMDs identified that additional clinical skills/first aid training would be useful to support them in identifying deteriorating patients at imminent risk of OHCA. In connection with this, clinical outcomes feedback regarding patients that EMDs had triaged was identified as a potentially useful tool in educating EMDs to recognise deteriorating patients as well as supporting them with the stress of their role. In addition, EMDs would value communications training to support them with managing any challenging interactions.

There are several limitations to be considered. The IMARI study focused on United Kingdom Emergency Medical Service systems that use the Advanced Medical Priority Dispatch System decision support software and the findings may not be generalisable outside of the United Kingdom, or to other Computer Decision Support Software systems, such as NHS Pathways. However, IMARI has resulted in important findings that are worthy of further investigation with the potential to improve the recognition and response to this high-risk patient group, thereby improving patient outcomes and long-term survival following out of hospital cardiac arrest.

11. Study implications

The study findings identified a lack of published research focusing on improving the recognition and response to patients at imminent risk of OHCA. IMARI has identified areas where changes in practice and education have the potential to lead to improvements in the recognition and response to patients who are at imminent risk of OHCA. These areas include education of EMDs in the recognition of a patient at imminent risk of OHCA, EMD communications training, use of real life calls for simulation training and the addition of a system of patient outcomes feedback to improve practice. In addition, education of the public in prodromal symptoms of OHCA, the structure of EMS calls, when to contact EMS and measures to improve public understanding that the EMD is a critical element in the first link in the chain of survival are all likely to prove beneficial. Adjusting the Computer Decision Support Software so that the interaction between the caller and the EMD can be better aligned early in the EMS call will work to increase accuracy and efficiency in the call-taking process. EMDs indicated that more comprehensive opportunities to monitor the patient's condition as the EMD call progresses would be helpful in identifying those deteriorating and high-risk patients alongside an improved model of clinical support for EMDs that assists EMDs in optimising the response to patients at imminent risk of OHCA. EMDs also require improvements in their work culture and their opportunities to effect change so that they perceive themselves as valued members of the resuscitation team.

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Appendices

Appendix 1: Medline search strategy

Medline Search Strategy May 2021		
1	"HEART ARREST"/ OR "OUT-OF-HOSPITAL CARDIAC ARREST"/	34,081
2	(out-of-hospital cardiac arrest).ti,ab	6,982
3	(out of hospital cardiac arrest).ti,ab	7,467
4	(heart arrest).ti,ab	10,721
5	(out-of-hospital heart arrest).ti,ab	779
6	(out of hospital heart arrest).ti,ab	905
7	(cardiac arrest).ti,ab	39,902
8	(OHCA).ti,ab	2,913
9	(OOHCA).ti,ab	76
10	*(1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9)*	57,295
11	("EMS call").ti,ab	72
12	("Emergency Medical Service call").ti,ab	12
13	("999 call").ti,ab	29
14	("112 call").ti,ab	7
15	("911 call").ti,ab	72
16	("emergency call").ti,ab	469
17	("emergency medical system call").ti,ab	2
18	("emergency medical call").ti,ab	11
19	(dispatch*).ti,ab	3504
20	*(11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19)*	3991
21	*(10 AND 20)*	810

Appendix 2: Systematic Mixed Studies Review Certainty Tables

A2a: High certainty quantitative papers

Quantitative Papers (Grouped by certainty) and listed in descending order of date of publication

Quantitative Descriptive Study						
Berdowski (2009) Importance of the first link: Description and recognition of OHCA in an emergency call[144]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT 2018
Prospective Observational Study. To investigate the recognition of OHCA on the emergency call.	Jan 2004 – Sep 2004	Amsterdam, Netherlands. Consecutive high priority emergency calls to the Greater Amsterdam Dispatch Unit, where a layperson was the caller.	OHCA recognition sensitivity 71%. Specificity 99.3%. The 82 patients with a cardiac arrest not recognised by the dispatcher showed lower survival rates compared with the 203 patients with recognised cardiac arrests, as shown in an unadjusted Kaplan-Meier model (log-rank P 0.04). When a cardiac arrest was suspected, the mean time interval between call and dispatching was 1.88 minutes (SD,1.10 minutes) versus 2.82 minutes (SD, 1.60 minutes) when cardiac arrest was not suspected (P0.001). Mean time interval from call to arrival also differed significantly: 8.55 minutes (SD,	Unclear	Unclear which dispatch system was used for triaging calls and whether the results are generalisable to other systems.	High

			4.93 minutes) for calls with cardiac arrest suspicion versus 9.95 minutes (SD, 3.73 minutes) for calls without cardiac arrest suspicion (P0.01). When not recognising the cardiac arrest, the dispatcher did not ask about the patient's breathing in 42 calls (51%); the caller gave a positive answer when asked about presence of breathing in 16 calls (20%); and the patient was reported to breathe abnormally in 20 calls (24%). For the calls in which cardiac arrests were recognised, these numbers were 51(25%), 10 (5%), and 41(20%), respectively. Asking for breathing differed significantly in these groups (P=0.001). Description of the facial colour as blue or purple occurred in 16.5% of OHCAs and contributed substantially to the probability of a cardiac arrest (p=0.001). Abnormal breathing was described in 40% of the calls in which the dispatcher asked if the patient was breathing. In those			

			patients, prevalence of cardiac arrest was 32%.			
Randomised Controlled Trial						
Meischke (2017) Simulation training to improve 9-1-1 dispatcher identification of cardiac arrest: A randomised controlled trial[159]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT 2018
A parallel prospective randomised controlled trial. To determine if simulation training improved OHCA identification and time to T-CPR for EMDs using a CBD guideline-based dispatch system.	Sep 2013 – Apr 2016	US. 128 EMDs from 13 9-1-1 call centres in the states of Washington, Oregon, Alaska and Arizona.	In seven of the 256 assessment calls, the participant did not recognise the need for T-CPR; Recognition of the need for T-CPR was greater in the intervention compared to the control group (100% versus 94%, p = 0.01). The mean time to transition to T-CPR was 21 s less in the intervention group than the control group (60 vs. 81 s, p < 0.001). Similarly, time to instruction was 23 s less in the intervention group than the control group (73 vs 91 s, p < 0.001). These times were similar for each of the two scripts used in the assessment. When assessing performance on real life OHCA calls, after adjusting for call centre,	Criteria-Based Dispatch	The study findings may not be generalisable to non-CBD dispatch systems. May not be generalisable to other EMD centres. Confounders not considered. The length of effect of intervention not	High

			comparing the performance of EMDs who had completed the study protocol of 4 simulation trainings with EMDs who had less than 4 trainings showed statistically significant differences for label ($p = 0.022$) and consciousness ($p = 0.041$), indicating that receiving 4 trainings was associated with better performance on these skills.		taken into consideration.	
Quantitative non-randomised study						
Chien (2019) Impact of the caller's emotional state and co-operation on out-of-hospital cardiac arrest recognition and dispatcher-assisted cardiopulmonary resuscitation[134]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT 2018

Retrospective Cross-Sectional Study. To examine the association between callers' Emotional Content and Cooperation Score (ECCS) and dispatchers' OHCA recognition and DA-CPR instruction performance.	Nov 2015-Oct 2016	Northern Taiwan Emergency call audio recordings of documented adult, non-traumatic OHCA. 2015/2016	Dispatchers recognised OHCA in 251 (68.4%) cases. Unambiguous responses about the patient's consciousness and breathing status were received in 343 (93.5%) and 281 (76.6%) cases, respectively. Only 8.4% of the callers rated as ECCS 4–5. The rate of OHCA recognition was the greatest in the ECCS 4–5 group. These results suggest that a high ECCS level can be a preliminary clue for the dispatcher for recognising OHCA. An unambiguous response for patient consciousness was similar across the ECCS levels (92.7%–95.7%), whereas the unambiguous response rate for patient breathing status was highest in the ECCS 3 (84.8%), followed by ECCS 2 (84.0%), ECCS 4–5 (77.4%) and ECCS 1 (68.5%) caller groups. Dispatchers failed to recognise OHCA in 30 cases where an unambiguous response to the patient's breathing status was obtained.	Unclear	May not be generalisable outside of Mandarin speaking population. Small sample size. Possible bias in assessing ECCS.	High

			The rate of OHCA recognition by dispatchers increased with ECCS level: ECCS 1 (61.8%), ECCS 2 (72.0%), ECCS 3 (76.1%), ECCS 4–5 (77.4%). Dispatcher error contributed mostly to the reason for non-recognition of OHCA in the low ECCS groups (ECCS 1: 73%, ECCS 2: 77%). In multivariable analysis, dispatchers were significantly more likely to receive unambiguous responses about the patient's breathing status from callers classified as ECCS 2 (adjusted OR (AOR)=2.6, 95%CI 1.4 to 4.7) and ECCS 3 (AOR=2.6, 95%CI 1.1 to 6.4). Dispatcher OHCA recognition was significantly associated with the ECCS 3 group (AOR=2.3,95%CI 1.1 to 5.0). The cooperative caller group had a significantly higher successful delivery rate of DA-CPR instruction than the uncooperative caller group (85.9%vs 54.2%, p<0.01).			

			The median times to OHCA recognition, CPR instruction and chest compression were 38.0, 80.5 and 170.0s, respectively, in the cooperative caller group and 29.0, 91.5 and 122.0s, respectively, in the uncooperative caller group.			

A2b: Moderate certainty quantitative papers

Quantitative Papers (Grouped by certainty) and listed in descending order of date of publication

Quantitative Descriptive Study						
Castren (2001) Do health care professionals report sudden cardiac arrest better than laymen?[147]						
Study Design Aim	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT 2018
Prospective study. To compare the emergency calls made by health care providers and by laymen reporting a non-traumatic cardiac arrest, and to evaluate the handling of these calls by dispatchers.	Jan 1996 – Dec 1996	Helsinki, Finland. Helsinki EMDs.	**Group 1 Doctors and Nurses** 70% cardiac arrests recognised. Survival to hospital discharge 21%. The dispatcher asked less questions and more likely to abandon protocol and only asked 10% of these callers to do CPR. **Group 2 Other Health Care professionals** 74% cardiac arrests recognised. Survival to hospital discharge 32%. **Group 3 Laymen** 73% of cardiac arrests recognised. Survival to hospital discharge 28%.	Criteria-Based Dispatch	276 in group 3 compared to just 33 in group 1.	Moderate

			21% asked by dispatchers to do CPR. Callers were usually calm and cooperative. TCPR instructions were given to 27% of the laymen and to 40% of relatives calling, but to only 2% of the professional callers.			
Quantitative Descriptive Study						
Garza (2003) The accuracy of predicting cardiac arrest by emergency medical services dispatchers: the calling party effect[148]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT 2018
Retrospective Review of EMS Dispatch Data. To analyse the accuracy of EMS dispatchers in predicting cardiac arrest and to assess	Jan 2000 – Jun 2000	US. Midwest urban EMS system using AMPDS.	The sensitivity for a code of OHCA given was 68.3% (95% CI 3.3% to 73.0%) with a PPV of 65.0% (95% CI 60.0%to 69.7%). Fourth-party callers had the highest sensitivity at 74.29% (95% CI 62.2% to 83.7%), whereas second-party callers had the highest PPV at 71.67% (95% CI 65.3% to 77.3%).	Advanced Medical Priority Dispatch System	Retrospective data collection. Unable to check accuracy of paramedic field diagnosis of OHCA.	Moderate

the effect of the caller party on dispatcher accuracy in an advanced life support.			Chi-square analysis comparing the sensitivity between the calling parties was not significant (x^2 = 3.728, 2 df, p=0.17). The appropriateness of the final coding was scored at 94.78% (95% CI 92.63% to 97.79%), meaning the quality improvement reviewer agreed that the correct dispatch code was given approximately 95% of the time. The overall dispatch protocol compliance score was 85.22 % (95% CI 83.33% to 87.10%), meaning the dispatcher followed the protocol according to the EMD standards, about 85% of the time. There was no significant statistical difference in scores between the calling parties for final coding (p =0.88) or in protocol compliance (p =0.37).			
Quantitative Descriptive Study						

Nurmi (2006) Effect of protocol compliance to cardiac arrest identification by emergency medical dispatchers[152]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT 2018
Prospective Study. The objective of the study was to assess the effect of protocol compliance to the accuracy of cardiac arrest (CA) identification by the dispatchers.	1996.	Helsinki, Finland.	The numbers of correctly identified true witnessed (Group 1) and unwitnessed (Group 2) CAs were 122 and 441, respectively. One hundred and sixteen patients were not identified as CA by the dispatchers (17%) but were found to be lifeless when the ambulance crew arrived at the patient (false negative, Group 3), including CAs missed by the dispatcher as well as patients arrested while waiting for the EMS unit to arrive. Ninety-seven calls were incorrectly categorised as CA by the dispatcher and the patient was not in CA when the ambulance crew arrived (false positive, Group 4). The patients falsely categorized as CA were commonly patients with transient ischaemic	Criteria-Based Dispatch	Possible errors and bias introduced when extracting audio data. Data included patients arresting between the start of the emergency call and EMS arrival on scene. Data collected in 1996. Criteria based dispatch system. Results may not be generalisable to other dispatch systems.	Moderate

			attack, stroke, intoxication, syncope or seizures. Information about consciousness and breathing, required by the protocol, was gathered in 52.4% of all emergency calls, more often in witnessed than in unwitnessed cases (72.3% versus 45.0%, $P < 0.001$). The cardiac arrest identification rate was not significantly higher when the protocol was adhered to in witnessed cases (80.4% versus 74.4%, $P = 0.5111$). In unwitnessed cases, the identification rate was lower when the protocol was adhered to (79.7% versus 87.8%, $P = 0.0117$) cases. In the group of unidentified cardiac arrests (Group 3) the protocol was adhered to in 60.3%, more often in witnessed (66.7%)			

			than in unwitnessed (57.8%) cases. In witnessed cases where the protocol was adhered to, the delay to dispatching a first unit was shorter (median, 71 s versus 91 s, P < 0.0001), but there was no significant difference in dispatching delay of MICU (median, 157 s versus 132 s, P = 0.4039). The Bayesian analysis revealed that from all 42 points gathered from every call only three question/answer combinations were associated independently with CA, namely: (1) consciousness; (2) breathing normally; (3) having seizures. The identification rate of CA was 69% when breathing was not described and rose to 80% when described as abnormal and to 89% when described as absent.			

Quantitative Descriptive Study						
Ma (2007) Evaluation of emergency medical dispatch in out-of-hospital cardiac arrest in Taipei[149]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT 2018
Retrospective Observational Study. Review of dispatch audio recordings to examine the emotional content and cooperation score (ECCS) among Mandarin Chinese speaking callers for cardiac arrests, and evaluate the performance of the EMS dispatching system.	Jan 2004-Apr 2004	Tapei. Taipei Fire Department Dispatching Centre. Uses a simplified version of the priority dispatch tool.	The sensitivity and positive predictive value (PPV) for predicting OHCA by dispatchers was 96.9% and 97.9%, respectively. The average ECCS was low at 1.42 in this Mandarin speaking population. The level of consciousness was not asked about it in 75 cases (55% = 75/137). The breathing status was not raised in 56 cases (32% = 56/175). Of the 119 cases, actual breathing status was determined in 91 cases and in 28 cases it was unclear. Only 38% of OHCA patient received on scene CPR, including bystander initiated (n = 13, 6%)	Simplified Priority Dispatch Protocol	Small sample. Unclear if ‘targeting’ of cases may have introduced selection bias. Unclear how data was linked from ‘field diagnosis’ to obtain call data. May have been bias through missing data. 50/30 calls excluded due to missing data. Interview checklist is an unvalidated tool. Questionable whether the results are generalisable outside	Moderate

			and T-CPR provided by dispatchers (n = 17, 9%) or duty nurse in the dispatching centre (n = 45, 23%). Among those calls without CPR (n = 124, 62%), T-CPR was not offered by the dispatchers in 113 cases (57%) and 11 callers (5%) were not willing to perform T-CPR. Of the cases analysed, 79 interviews (39.7%) were optimal (5 points) and 85 (42.7%) close to optimal (4 points) regarding the dispatcher's interview skills. In 32 (17.6%) cases, the interview skill was suboptimal (3 points). Three cases (1.5%) were deemed to be unacceptable (2 points).		of the Mandarin speaking population.	
Quantitative non-randomised study						
Clawson (2008) Effect of a Medical Priority Dispatch System key question addition in the seizure/convulsion/fitting protocol to improve recognition of ineffective (agonal) breathing[135]						

Study Design Aim	Date of Data Collection	Setting/ Participants	Main Findings	Dispatch Software	Limitations	Quality Grade MMAT 2018
Retrospective Comparative Study - Before and after study comparing a changed MPDS protocol with updated breathing question. To investigate the impact of a new assessment question in the MPDS seizure protocol on the ability of the EMDs to identify the presence of agonal or ineffective breathing.	2004-2006	London OHCA patients and those 'Blued In' (paramedic declaration of high acuity)	Within v11.2 the odds of OHCA outcome in the 12-A-1 code was significantly reduced by 50% (OR (95%CI):0.5(0.29,0.85), p=0.009. OHCA outcome in v11.2 was almost twice more likely in combined delta codes than in all other protocol 12 descriptor codes (OR (95%):2.10(1.30,1.40), p=0.002). The isolated key question (irregular breathing) was successful and resulted in the additional capture of 22 OHCA patients in the new 12-D-3 irregular breathing determinant code. The decrease in OHCAs in target 12-A-1 appears to be linked to increase in OHCAs found in 12-D-3.	Advanced Medical Priority Dispatch System	One year difference in data collection periods. Possible confounders not considered.	Moderate
Quantitative non-randomised study						

Roppolo (2009) Dispatcher assessments for agonal breathing improve detection of cardiac arrest[142]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT 2018
Prospective before and after study. The specific aim of this study was to determine whether the new protocol increased the detection of agonal respirations by EMDs and thus the presence of cardiac arrest.	Unclear	US. The emergency medical dispatch system in Dallas.	22 patients with agonal breathing detected in the 4 months after protocol implementation compared with 0 patients in the 8 months prior. After introduction of the agonal breathing protocol, the percentage of patients who did not have EMD criteria for cardiac arrest, but actually were in cardiac arrest decreased from 28.0% (168/599) to 18.8% (68/362; p = 0.0012), a yield of an additional 100 patients over the 4-month follow-up period. Survival to ED admission was similar between the two groups; p = 0.9979. Presenting rhythm was ventricular fibrillation (VF) or pulseless	Emergency Medical Dispatch Programme developed by The Association of Public Safety Communications Officials.	Hawthorne effect. Non randomised design. Did not investigate those patients breathing ‘normally’ so unclear if these patients triaged correctly.	Moderate

			electrical activity (PEA) in 85% of those identified as having agonal breaths versus 46% without them (asystole; p = 0.002). Bystanders started CPR significantly more frequently after the new protocol was instituted (60.9% before vs. 71.5% afterward, p = 0.006). Dispatchers found that asking the bystander to say “now” every time they witnessed the patient breath was most helpful in detecting when these respirations did indeed occur. Dispatchers also felt that putting the phone next to the patient was not helpful. Dispatchers reported the use of the 10 s interval was very sensitive in that all cases identified as having agonal respirations had frequencies much less than six per minute.			

Quantitative non-randomised study						
Lewis (2013) Dispatcher-Assisted Cardiopulmonary Resuscitation: Time to Identify Cardiac Arrest and Deliver Chest Compression Instructions[139]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch software**	**Limitations**	**Quality Grade** MMAT 2018
Retrospective Cohort Study. Aimed to identify and characterise the factors that led to nonrecognition of cardiac arrest by EMDs.	2011	United States 590 OHCA EMS Calls	EMDs recognised OHCA in 80% of cases. Where the EMD could assess consciousness and breathing the OHCA was not recognised in 8% of cases. EMDs are less likely to recognise OHCA where the arrest is witnessed. The caller is more likely to give uncertain or contradictory information regarding consciousness in 54.3% of cases where the OHCA was not recognised compared to 22% of	Unclear	19% of eligible calls were unavailable for analysis due to tech issues. Assumptions were made regarding what the EMD was thinking based on the EMS call recording	Moderate

			cases where the arrest was recognised. The patient was more likely to be reported as breathing, or contradictory information given in 74.3% of unrecognised cases as opposed to 35.7% of recognised cases			
Quantitative non-randomised study						
Hardeland (2014) Comparison of Medical Priority Dispatch (MPD) and Criteria Based Dispatch (CBD) relating to cardiac arrest calls[138]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch software**	**Limitations**	**Quality Grade** MMAT 2018
Observational Study. The aim of this study was to compare two commonly used medical dispatch tools in handling cardiac arrest calls; Medical Priority Dispatch (MPD) used	MPD Site: 1st May 2010 – 30th April 2011 CBD Site: 1st Jan 2007 – 31st Dec 2007	Oslo & Akershus, Norway. Richmond, US.	Protocol adherence was similar for the MPD and CBD systems with 100 (100%) vs. 136 (97%) calls successfully clarifying consciousness (p = 0.14) and 100 (100%) vs. 137 (98%) clarifying respiratory arrest(p = 0.27), respectively. Absence of normal breathing was initially clarified by the dispatcher in 28 (28%) in the	Medical Priority Dispatch and Criteria-Based Dispatch	Different years of data collection (2007 CBD site and 2010/11 MPD site) may have confounded. Small sample size.	Moderate

in Richmond, USA and Criteria Based Dispatch (CBD) used in Oslo and Akershus, Norway.			MPD system and 51 (36%) of the calls in the CBD system (p = 0.17), and cardiac arrest recognised in 82 (82%) and 108 (77%) (p = 0.42) calls respectively. In both systems the most frequent reason for not recognising cardiac arrest was misinterpretation of agonal breathing. Pre-arrival CPR instructions were offered in 81% vs. 74% (p = 0.22) of eligible cases and declined in 7% vs. 5% (p = 0.58) in the MPD vs. CBD systems, respectively. The most frequent reason for not offering CPR instructions was failure to recognise cardiac arrest due to agonal breathing. Pre-arrival CPR instructions were offered faster and more frequently in the CBD system, but in both systems chest compressions were delayed 3–4 min. Earlier recognition of cardiac			

			arrest and improved CPR instructions may facilitate earlier lay rescuer CPR.			
Quantitative descriptive study						
Travers (2014) Out-of-hospital cardiac arrest phone detection: Those who most need chest compressions are the most difficult to recognise[156]						
Study Design **Aim**	**Date**	**Setting** **Participants**	**Main Findings**		**Limitations**	**Quality Grade** MMAT 2018
Prospective Observational Study. Aimed to measure prospectively the rate of OHCA recognition.	May 2012	France. Paris Firefighter (FF) Dispatch Centre.	Dispatcher recognised 50/82 (61%) OHCA. The comparison between detected and undetected OHCAs highlighted differences in assessment of ventilation status and victim outcome. The presence of agonal breathing and the absence or incomplete ventilation status assessment decreased the likelihood of recognizing OHCA. There was a link between the request to put a hand on the abdomen and correct CA recognition (p = 0.001).	Unclear	Small sample. Risk of subjective selection.	Moderate

			The median time and the interquartile range from the call to CA recognition was 2 min 23 s (1 min 51 s to 3 min 7 s). Among the 50 detected CAs, 27 received dispatcher-assisted CPR. The median interval from the call beginning to the CPR initiation was 3 min 37 s (2 min 57 s to 5 min).			
Quantitative non-randomised study						
Møller (2016) Recognition of out-of-hospital cardiac arrest by medical dispatchers in emergency medical dispatch centres in two countries[151]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT
Observational Registry Study. To analyse and compare the accuracy of OHCA recognition by	Jul 2013 – Dec 2013	Sweden and Denmark	Using data from OHCA registers and EMDC data: The sensitivities for recognition of cardiac arrest was 40.9% (95% CI: 37.1–44.7%) in the Capital Region of Denmark and 78.4% (95% CI: 73.2–83.0%)	Criteria-Based Dispatch	Differences between countries in data registration practices. Differences in the proportion of missing	Moderate

medical dispatchers in two countries.			in Skåne Region in Sweden (p < 0.001). When also adding in data from emergency call recordings: The sensitivities for OHCA recognition were 80.7% (95% CI: 77.7–84.3%)in Denmark and 86.0% (95% CI: 81.3–89.8%) (p = 0.06) in Sweden. Consciousness and breathing were addressed in general and more frequently in the recognised OHCA groups in both regions. In Denmark 48% of audio recordings had missing dispatch codes. “Unclear problem” (17%) was the most frequent dispatch code for audited non-recognised OHCA and possible death (12%) for audited recognised OHCA in Denmark. In Sweden breathing difficulties was the most frequent dispatch		data and ability to link data. Criteria Based Emergency Medical Dispatch Systems. Results may not be generalisable to alternative dispatch systems.	

			code in both groups of audited cases (23% recognised and 21% unrecognised). The highest priority response was provided in all but one of the audited cases where OHCA was recognised and in 90% and 97% of the audited non-recognised calls in the Capital Region and the Skåne Region, respectively.			
Quantitative descriptive study						
Biancardi (2017) Cardiac arrest recognition and telephone CPR by emergency medical dispatchers[145]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT 2018
Simulation Study To explore the recognition of OHCA by EMDS and the frequency of telephone assisted CPR offered to bystanders.	Unclear	Malta 52 ED Nurses	In a simulation where the patient is not breathing 92% recognised OHCA, TCPR started in 75% of cases. 88% dispatched code red response. In the agonal simulation 42% recognised OHCA, TCPR started in	Unclear	Simulation study so may not reflect 'real life' scenario. Hawthorne Effect.	Moderate

			41%. 77% dispatched a code red response.			
Quantitative descriptive study						
Mirhaghi (2017) Recognizing Sudden Cardiac Arrest May Require More Than Two Questions during Telephone Triage: Developing a Complementary Checklist[150]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT 2018
Content analysis OHCA emergency calls. To develop decision-support tools to identify patients experiencing sudden OHCA. Simulated case scoring.	April 2015 – Jun 2015	Iran. Emergency Medical Dispatch Centre in Mashhad University of Medical Sciences.	Content analysis of calls identified 3 main themes: callers' tone and presence of background voices, calling for ambulance and providing an address, and description of the patient's primary complaint and respiration status. The mean (SD) percentages of correct responses were 66.9%±27.96% prior to the use of checklist and 80.05%±10.84% afterwards). Dispatchers had correctly identified 68% and 66% of SCA	Unclear	Unclear how many dispatchers were invited to participate to evaluate selection bias. Dispatchers used the checklist to triage calls they had already triaged, may have positively impacted scoring. Simulation study, results may be different in practice.	Moderate

			and non-SCA cases; the use of the checklist increased this accuracy to 84% and 76%, respectively.			
Quantitative non-randomised study						
Hardeland (2017) Targeted simulation and education to improve cardiac arrest recognition and telephone assisted CPR in an emergency medical communication centre[160]						
Study Design **Aim**	**Date of data collection**	**Setting/ Participants** **Time of data collection**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT 2018
Prospective Interventional Study To evaluate the effectiveness of performance-based education, training and feedback on cardiac arrest call handling in Oslo University Hospital EMCC	2014	Norway All OHCA calls Pre-intervention Jan 2013 – Jan 31st 2014 Post-intervention May 14th 2014 – Dec 31st 2014	Significant improvement in recognition of OHCA following the intervention (89 vs. 95%, $p = 0.024$). Delayed recognition significantly reduced following the intervention (21 vs. 6%, $p < 0.001$).	Criteria-Based Dispatch	Risk of confounding. Non-randomised design. Differing time periods before/after intervention.	Moderate

Quantitative descriptive study						
Riou (2018) 'She's sort of breathing': What linguistic factors determine call-taker recognition of agonal breathing in emergency calls for cardiac arrest?[153]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT 2018
Retrospective Linguistic Analysis. Investigating recognised and unrecognised emergency calls for confirmed OHCA. To explore whether the language used by callers to describe breathing impacts on call-taker recognition of agonal breathing and hence cardiac arrest.	Jan 2014 – Dec 2015	St Johns Ambulance Western, Perth, Australia. 176 emergency calls of paramedic confirmed OHCA. MPDS Dispatch Software.	Amongst recognised and unrecognised calls, the breathing status question received an answer in 89% of calls. 64% initially reported as breathing. OHCA recognised in 28% of calls with a yes answer, 95% with a no answer and 79% with a non-answer response. 32% of answers to the breathing question were qualified. Qualification found in 44% of yes answers. Qualified yes answers were suggestive of agonal breathing, but they were treated similarly to plain yes answers. Call-takers entered in ProQA that the patient was breathing after	Medical Priority Dispatch Software V12.1.3, implemented with ProQA software.	Small sample of 176 calls. As the calls were stratified for OHCA recognition, our results are not representative of the whole population of OHCA cases. MPDS dispatch system and may not be generalisable beyond this system.	Moderate

			94% (47/50) of qualified yes-answers and 94% (59/63) of plain yes answers. OHCA was subsequently recognised in 22% (14/63) of calls with a plain yes-answer and in 36% (18/50) of calls with a qualified yes-answer. The odds of OHCA recognition were not significantly higher following a qualified yes-answer rather than a plain yes-answer (Odds Ratio 1.96; 95% Confidence Interval 0.86-4.57; p = 0.11). Overall, the median time to the breathing sequence was 56 s (IQR 44–72) from call start, and the median duration of the breathing sequence was 5 s (IQR 3–10). The median duration of the breathing sequence was significantly shorter (p < 0.001) in calls where OHCA was not recognised (median 4 s, IQR 3–7) than in calls where OHCA			

			was recognised (median 7 s, IQR 4–12).			
Quantitative non-randomised study						
Derkenne (2020) Improving Emergency Call Detection of Out-of-Hospital Cardiac Arrests in the Greater Paris Area: Efficiency of a Global System with a New Method of Detection[136]						
Study Design **Aim**	**Date**	**Setting/** **Participants** **Time of data collection**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT 2018
Repeated cross-sectional design to assess performance improvement in a Dispatcher Assisted CPR programme (DA-CPR) over the period of 2012 to 2018.	2012-2018	Paris, France. OHCA patients cared for by a Basic Life Support Team during the study period.	Dispatchers correctly identified 54% of recognizable OHCAs in 2012, 76% in 2015, 83% in 2017, and 93% in 2018. In 2012, dispatchers assessed breathing for 71% of patients, and this proportion increased to 97% in 2018. t-CPR performance increased from 51% to 84% during the 6 years of observations. The rate of dispatchers searching for a defibrillator increased from 0 to 20% and the rate of ongoing CC	Unclear	Potential for confounders. Different number of patients between each study period. Questionable whether results are generalisable outside of the study context.	Moderate

			at BLS arrival increased from 36% to 83% (p = 0.01). In contrast, the rate of CPR-bystander before call did not improve significantly (4% to 17%, p = 0.22), nor did the survival rate. After adjusting for confounders, OHCA detection was associated with breathing assessments, particularly when assessed with HoB (aOR: 13.1 95%CI: 4.8-39.5), during the 2018 period (aOR: 3.4, 95% CI: 1.1-10.8), and when the OHCA occurred in a public place (aOR: 0.14, 95%CI: 0.05-0.4), (compared to an OHCA at home). Neither age nor the seniority of dispatchers was associated with the success of OHCA detection or t-CPR. The sensitivity of HoB for CA detection was measured among patients at 96.2%.			

			Public places were adversely associated with the detection of OHCAs.			
Quantitative non-randomised study						
Mao (2020) Is your unconscious patient in cardiac arrest? A new protocol for telephonic diagnosis by emergency medical call-takers: A national study[140]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade**
Prospective before and after study Sought to determine the sensitivity, specificity, likelihood ratios, time to diagnosis and time to 1st compression when the modified protocol was introduced for unconscious patients.	July 2018	Singapore. 513 EMS calls for unconscious patients	Only a 50.4% adherence to the ‘after’ protocol which included assessing breathing using hand on belly technique. Analysed on intention to treat basis and ‘after’ group had a diagnostic accuracy of 84.4% opposed to 67.5% in the ’before’ group. No significant change in time to chest compressions. Standard breathing question is problematic.	Unknown	Low adherence to the ‘after protocol’. Risk of bias – test-retest bias, observer bias, history bias.	Moderate

Quantitative non-randomised study						
Schwarzkoph (2020) Seizure-like presentation in OHCA creates barriers to dispatch recognition of cardiac arrest[143]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade**
Retrospective cohort study. To determine the impact of seizure-like activity among OHCA patients during EMS calls.	2014-2018/2020	United States 3502 OHCA EMS calls	In the seizure activity group there were significant delays in the EMD asking consciousness and breathing questions and establishing abnormalities. The seizure activity group had a longer median time to the EMD establishing OHCA. The seizure activity group were often described as abnormal breathing and turning blue, purple or red.	Unclear	4-year study period and confounders not considered. Comparatively small number where seizure activity described compared with non-seizure activity (149v3353)	Moderate
Quantitative descriptive study						
Stangenes (2020) Delays in recognition of the need for telephone-assisted CPR due to caller descriptions of chief complaint[154]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade**

EMS call analysis. To test if caller descriptions of chief complaint delays EMDs recognition of the need for telephone-assisted CPR (T-CPR).	Unclear/2020	United States 434 OHCA EMS calls	The way the caller describes the chief complaint effects OHCA recognition and delays tCPR delivery with the greatest delay for incorrect medical condition complaints. EMDs often pursue questioning relating to the specific diagnostic condition at the expense of key consciousness and breathing questions.	Criteria-Based Dispatch	Unclear how real cardiac arrest calls were selected. Data was part of a randomised controlled simulation study and may not be generalisable to other systems. The results may not be generalisable to EMS systems not using Criteria-Based Dispatch	Moderate
Quantitative descriptive study						
Tamminen (2020) Spontaneous trigger words associated with confirmed out-of-hospital cardiac arrest: a descriptive pilot study of emergency calls[155]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade**
Descriptive pilot study - retrospective registry study	Jan 2017 – May 2017	Finland. 80 emergency	64% of the sample were confirmed as true cardiac arrests, and 36% were regarded as non-	Unclear	Underpowered to show association.	Moderate

analysing linguistic content. to examine the association between true OHCA confirmed by ambulance personnel and laypeople's spontaneous trigger words regarding physiological deterioration of a patient in the context of emergency-dispatcher-suspected or EMS encountered OHCA.		calls of dispatcher suspected or EMS encountered OHCA.	cardiac arrest events. Most cardiac arrests were suspected after an ambulance was dispatched, and two confirmed cardiac arrests were not recognised by the dispatcher. A total of 291 spontaneous trigger words were analysed; 32% and 14% of them concerned breathing and altered level of consciousness, respectively. Spontaneous trigger words that were more frequently used to describe true cardiac arrest were 'is not breathing' (n = 9 [18%], 'the patient is blue' (n = 9 [18%], 'collapsed or fallen down' (n = 12 [24%], and 'is wheezing' (n = 17 [33%], 'Is snoring' was associated with a false suspicion of cardiac arrest (n = 1 [2%] vs n = 6 [21%].		Uncertain if generalisable outside of Finland.	
Quantitative non-randomised study						
Gram (2021) Assessment of a quality improvement programme to improve telephone dispatchers' accuracy in identifying out-of-hospital cardiac arrest[137]						

Study Design Aim	Date of Data Collection	Setting/ Participants	Main Findings	Dispatch Software	Limitations	Quality Grade
Quality assessment study. To analyse and compare the accuracy of the Emergency Medical Dispatch Centre in identifying OHCA before and after an educational intervention	2017-2020	Denmark 673 OHCA EMS calls	Significant difference in the sensitivity of identifying OHCA between pre-intervention and post-intervention periods. Sensitivity pre-intervention 82.3% (95% CI: 76.4-87.2%) Sensitivity post-intervention 92.7% (95% CI: 88.2-95.8%) (p=0.0014) Time to answer the key questions did not improve.	Unclear	Confounding factors not considered	Moderate
Quantitative non-randomised study						
Riou (2021) 'I think he's dead': A cohort study of the impact of caller declarations of death during the emergency call on bystander CPR[141]						
Study Design **Aim**	**Date of Data Collection**	**Setting/** **Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade**

Retrospective cohort study. To examine the relationship between caller's declarations of death and their response to dispatcher's initiation of CPR and to OHCA recognition	2014-2015	Australia Non-traumatic adult OHCA	There was a significant difference between declarations of death and whether the OHCA was witnessed, or unwitnessed. Callers were more likely to make a declaration of death in an unwitnessed event. Initial recognition of OHCA was significantly more frequent where the caller made a declaration of death. A caller was significantly more likely to decline to do CPR where they had made a declaration of death before dispatch. In 15% of cases where callers made a declaration of death achieved prehospital ROSC and 9% had ROSC on arrival at hospital.	Advanced Medical Priority Dispatch System	The study examined initial OHCA recognition, but only included those that were recognised by the EMD. The study excluded those patients that continued to be unrecognised and that were also not resuscitated by EMS.	Moderate

A2c: Low certainty quantitative papers

Quantitative Papers (Grouped by certainty) and listed in descending order of date of publication

Quantitative Descriptive Studies						
Bang (2003) Interaction between emergency medical dispatcher and caller in suspected out-of-hospital cardiac arrest calls with focus on agonal breathing. A review of 100 tape recordings of true cardiac arrest cases[46]						
Study Design **Aim**	**Date of data Collection**	**Setting/** **Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT 2018
Prospective study evaluating 100 tape recordings of EMS calls. To assess EMD ability to identify and prioritise OHCA and offer CPR. To assess frequency and caller's descriptions of agonal breathing.	Sep 2000-Oct 2001	Sweden EMS calls for OHCA recorded at 1 dispatch centre.	Level of Consciousness only questioned in 75% of cases. Respiration only questioned in 2/3 of cases. Is s/he breathing normally? Only raised in 41% of cases. In 2/3 of cases the quality of the interview was highly commended, 11% insufficient, 26% unapproved – important questions omitted. There was an opportunity to identify 79% of cases, but only 62% identified.	Unclear	No detail on how the 100 calls were selected. Only included OHCA patients admitted to hospital. Deceased on scene omitted from study.	Low

			69% callers were calm, 96% cooperative. 16% of patients were reported awake at start of call. 2/3 patients it was clear that unconscious and not breathing/normally. In 10% cases no ALS dispatched despite signs of a life-threatening condition.			
Bohm (2009) Tuition of emergency medical dispatchers in the recognition of agonal respiration increases the use of telephone assisted CPR[146]						
Study Design **Aim**	**Date of Data Collection**	**Setting/** **Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT 2018
Before and after study. Investigating whether tuition in recognising agonal breathing improves EMD identification of OHCA and the offer of TCPR.	2004-2006	Stockholm, Sweden.	There was a high willingness to receive CPR instructions among the bystanders, 97% in 2004 and 100% in 2006. T-CPR was offered in 47% (n=36) of cases before tuition and 68%(n=52) after (p=0.01). In agonal respiration 23% had been offered T-CPR in 2004 whereas 56% were offered T-CPR in 2006(p=0.006).	Medical Index Protocol	The months of the year are different in the 2 separate sampling periods. Limited mention of potential confounders.	Low

			After tuition, there were at least five instances when the EMD did not offer T-CPR. The main reason for the EMD not to recognize CA and failing to offer T-CPR in these cases was their inability to recognize abnormal/agonal respiration.			

A2d: High certainty qualitative papers

Qualitative Papers (Grouped by quality)

Qualitative Studies **HIGH QUALITY**						
Bang (2002) Dispatcher-assisted telephone CPR: a qualitative study exploring how dispatchers perceive their experiences[130]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade**
Qualitative semi-Structured Interview Study. To assess the emergency medical dispatchers' ability to identify and prioritise OHCA and offer T-CPR and to give an account of the frequency of agonal respiration and the caller's descriptions of breathing.	Unclear	Sweden 10 Emergency Medical Dispatch Staff	12 categories and 31 subcategories. Categories for perception in identifying OHCA were; trust the witness's account, be open-minded and to be organised. Categories for perception in offering t-CPR were: to feel prepared to connect with the witness on a mental level by being organised, flexible and supportive, to obtain a basis for assessments and to be observant for diverse obstacles in a situation. Categories for perception in providing t-CPR were: to feel engaged, to be supportive of the witness, to feel secure by recognising response-feedback from the witness, to observe external	Unclear	Small sample Possibility of selection bias.	High

			conditions with regard to the locality and technical complications, to be composed and adjust to the needs of the situation, to feel competent or to feel despair.			
Riou (2018) Hijacking the dispatch protocol: When callers pre-empt their reason-for-the-call in emergency calls about cardiac arrest[132]						
Study Design	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade**
Conversation analysis of a subset of 66 OHCA emergency calls where the caller pre-empted a reason for the call. To explore trajectories of emergency calls where the caller pre-empted a reason for the call.	2014/2015	Western Australia. A subset of 66/200 OHCA emergency calls where the caller pre-empted a reason for the call.	Reason-for-the-call pre-emption is a common practice in emergency calls processed with a dispatch protocol in which the address and telephone number are the first two orders of business. Caller pre-emptions typically occur very early in the call, often as early as the caller's first turn. They often receive minimum tokens of receipt by call-takers but are not explicitly attended to as they arise. The main challenge that pre-emptions pose for call-takers is when they open the "official" reason-for the-call sequence later in the calls. If call-takers deliver the scripted turn "okay tell me exactly what	Advanced Medical Priority Dispatch System	No discussion of reflexivity. No clear detail of the conversation analysis methodology.	High

			happened" as usual, callers tend to treat it as a request for more information. They rarely repeat the reason-for-the-call they already pre-empted, and they can occasion delays by providing additional, superfluous information. Out of the 66/200 callers who had pre-empted a reason-for-the-call earlier on, 10 callers (15%) prefaced their response to the official prompt ("okay tell me exactly what happened") with "I don't know" or "dunno". By contrast, in the 134/200 calls without pre-emption, only 6 callers (4%) responded to "okay tell me exactly what happened" with an I-don't-know preface. The difference was found to be statistically significant ($\chi 2$, $p=0.02$).			

A2e: Moderate certainty qualitative papers

Qualitative Papers (Grouped by quality)

Qualitative Studies MODERATE QUALITY						
Jensen (2012) Factors associated with the successful recognition of agonal breathing and cardiac arrest by 9-1-1 communications officers: A qualitative iterative survey[131]						
Study Design **Aim**	**Date of Data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade**
Qualitative Telephone Interview Study using the Theory of Planned Behaviour. To identify and describe barriers and facilitators perceived to influence the recognition of abnormal breathing and delivery of T-CPR.	2009	Canada. 24 Ambulance Communication Officers (ACOs).	Retaining the top 75% of themes for each construct resulted in six behavioural, seven subjective normative, and 13 control beliefs. Control beliefs appeared to have the most important influence on the intention of ACOs to recognise abnormal breathing and administer CPR instructions. Subjective norms played a minor role.	Advanced Medical Priority Dispatch System	No discussion of reflexivity. Unable to identify origin of quotes from supplemental data.	Moderate

Alfsen (2015) Barriers to recognition of out-of-hospital cardiac arrest during emergency medical calls: a qualitative inductive thematic analysis[129]						
Study Design **Aim**	**Date of data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade**
Inductive Thematic Analysis OHCA emergency calls. To identify factors affecting medical dispatchers' recognition of OHCA during emergency calls in a qualitative analysis of calls.	2012	Denmark 13 emergency calls of unrecognised OHCA and 8 emergency calls of recognised OHCA.	3 themes: Caller's physical distance, caller's emotional distance, caller is a healthcare professional. Caller's physical distance (caller near patient, caller not near patient, caller assesses the patient). Emotional distance (keeping calm, losing control). Caller is a healthcare professional (responsibility is handed over to the caller, caller assumes responsibility).	Criteria-Based Dispatch – nationwide priority tool	No discussion of reflexivity. Minimal detail regarding how themes were agreed.	Moderate

A2f: High certainty mixed methods paper

Mixed Method Study (Grouped by quality)

Mixed Methods Study HIGH QUALITY					
Hardeland (2016) Factors impacting upon timely and adequate allocation of prehospital medical assistance and resources to cardiac arrest patients[157]					
Study Design **Aim**	**Date of data Collection**	**Setting/ Participants**	**Main Findings**	**Limitations**	**Quality Grade** MMAT 2018
Observational data, non-participant observation and in-depth Interviews. To explore, understand and address issues that impact upon timely and adequate allocation of prehospital medical assistance and resources to out-of-hospital cardiac arrest patients.	2013/2014	Norway Data from 3 x Norwegian EMC Centres and 19 interviews with dispatchers.	There were significant site differences in their adherence to algorithm (clarification of consciousness and normal breathing) (90, 96 and 72%, respectively, $p < 0.001$), recognition of cardiac arrest (89, 94 and 78%, respectively, $p < 0.001$) and provision of CPR instructions (83, 83 and 61%, respectively, $p < 0.001$). The most frequent reason for delayed or failed recognition of cardiac arrest was misinterpretation of agonal breathing. Qualitative themes were: Protocol use and platform of knowledge Situational Assessment Interrogation strategy/Assessment of breathing	Based on Criteria Based Dispatch and may not be generalisable to other dispatch systems.	High

A2g: Moderate Certainty Mixed Methods Paper

Mixed Methods Paper (Grouped by quality)

Mixed Methods Study MODERATE QUALITY						
Watkins (2021) Predictors of recognition of out of hospital cardiac arrest by emergency medical services call handlers in England: a mixed methods diagnostic accuracy study[158]						
Study Design **Aim**	**Date of data Collection**	**Setting/ Participants**	**Main Findings**	**Dispatch Software**	**Limitations**	**Quality Grade** MMAT 2018
Mixed methods retrospective study using qualitative call analysis and data analysis. To identify key indicator symptoms and patient factors associated with correct OHCA dispatch allocation.	2013-2014	United Kingdom	Key indicator symptoms for OHCA were 'not breathing'. Reports of effective breathing, abnormal pulse, or heart rate, fluctuating level of consciousness and being female decreased the likelihood of OHCA being identified. Estimated sensitivity of 72.8% (CI 65.8 to 79.1%) and a specificity of 99.4% (CI 99.3 to 99.6%) for call handlers' recognition of OHCA. Complete adherence to the dispatch protocol would have	Advanced Medical Priority Dispatch System	Risk of selection bias as patients who were not conveyed to hospital were excluded. Small sample sizes. Findings may not be generalisable to EMS services not using AMPDS.	Moderate

			increased sensitivity by 7%, but reduced specificity to 95.7%.			

Appendix 3: Ambulance service data imported into SPSS and data descriptions

Field Number	Field Name	Field Description
1	Identification Number	Unique identification Number
2	Date of arrest	Date of OHCA
3	Time of arrest	Time of OHCA
4	Time of arrest - time of EMS call	Time difference between the time of OHCA and the time of the EMS call
5	Incident Number	Ambulance Service Identification Number
6	Sex	Gender
7	Age	Patient's Age
8	Age units	Age Units (i.e. Years, Months)
9	Pt ethnicity	Patient's ethnicity
10	Cause of arrest	Cause of OHCA (i.e. medical, trauma)
11	Location of arrest	Location of OHCA (i.e. home, public place)
12	Occurrence witnessed by?	OHCA witnessed (i.e. not witnessed, bystander)
13	Dispatcher identified Cardiac Arrest (i.e. Red1)?	Call categorisation
14	Treatment before EMS arrival (First responders are included as EMS service): Bystander CPR	Bystander CPR
15	Bystander defibrillation	Bystander defibrillation
16	ROSC on arrival of EMS?	Patient had ROSC when the crew arrived
17	Time of EMS call	Time of EMS call
18	First monitored rhythm	First monitored cardiac rhythm by EMS
19	Any ROSC (> 30 seconds)	Sustained ROSC
20	Survived event ROSC on arrival at hospital	ROSC on arrival at hospital
21	Time of ROSC	Time of sustained ROSC
22	Date of discharge	Date of hospital discharge

23	Survival to hospital discharge	Survival to hospital discharge
25	Date of death	Date of patient's death
26	Survival to 30 Days	Survival to 30 days
27	Time at hospital	Time of arrival at hospital
28	Call number	Ambulance Service Identification Number
29	Final Despatch Code	Final MPDS code
30	Response Category	Final response category
31	Final MPDS Description	Final MPDS card description
32	Final MPDS Card	Final MPDS card
33	Response Target 1 Clock Stop Time	EMS response time
34	Text Of First SOE Text After T5	Initial MPDS code and matched category
35	DespatchCodeOfFirstSOETextAfterT5	Initial MPDS code
36	Category Of First SOE Text After T5	Initial response category
37	First SOE MPDS Description	Initial MPDS car description
38	First SOE MPDS Card	Initial MPDS card
39	Text Of Last SOE Text After T5 And Before Clock Stop	Final MPDS code and matched category
40	Despatch Code Of Last SOE Text After T5	Final MPDS code
41	Category Of Last SOE Text After T5	Final response category

Appendix 4: STROBE Statement—checklist of items that should be included in reports of observational studies (Chapter Three)[355]

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	60	A retrospective observational study
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found		This is a thesis chapter and there is no abstract at this stage, but this information is within the chapter.
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported		Within the chapter overview and the thesis introduction.
Objectives	3	State specific objectives, including any prespecified hypotheses	38,60	To understand the current ambulance emergency call triage, ambulance response and survival of patients at imminent risk of OHCA. To report on both the EMS response to patients who had already suffered an OHCA at the time of the EMS call and the EMS response to patients who suffered an OHCA after the EMS call had been initiated.
Methods				
Study design	4	Present key elements of study design early in the paper	60-66	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	61	Two years of SWASFT OHCA cardiac arrest

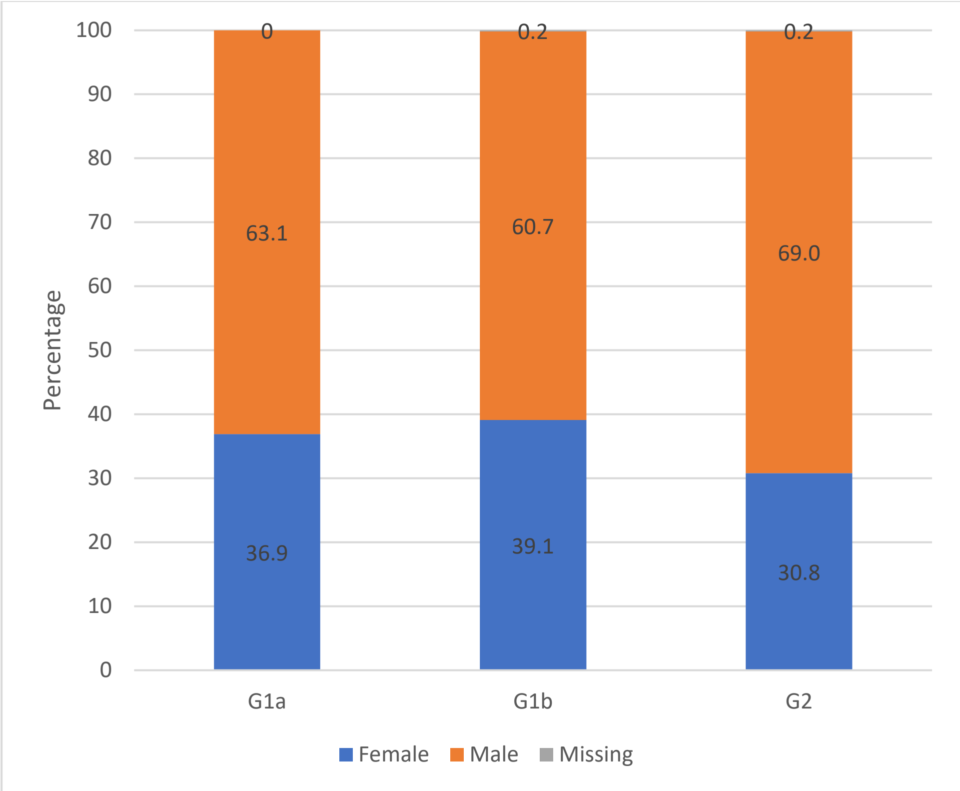
				registry data (1st January 2018 to 31st December 2019) were linked to CAD data.
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	66	Patients recorded in the SWASFT OHCA registry, in the data collection period, aged 18 years and over were included for analysis with no exclusions.
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case		
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	67/76	Defined in Tables 10 and 11.
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	61-66	Methods section.
Bias	9	Describe any efforts to address potential sources of bias		I completed a sensitivity analysis to address the inaccuracy of recording the time of OHCA in the registry data.
Study size	10	Explain how the study size was arrived at		The team agreed that 2 years of OHCA data would be enough to show trends in the analysis.

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	65-66	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	65	The data analysis involved interrogating the dataset using descriptive statistics including percentages and chi square analysis for associations.
		(*b*) Describe any methods used to examine subgroups and interactions		
		(*c*) Explain how missing data were addressed		Missing data was removed for tests of association so that there was a full case analysis.
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy		
		(*e*) Describe any sensitivity analyses	65, 104-104	
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	66	
		(b) Give reasons for non-participation at each stage		n/a
		(c) Consider use of a flow diagram	72-73	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders		Unavailable beyond age and gender. Discussed in discussion section.
		(b) Indicate number of participants with missing data for each variable of interest		All results
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)		30 days, if survive.

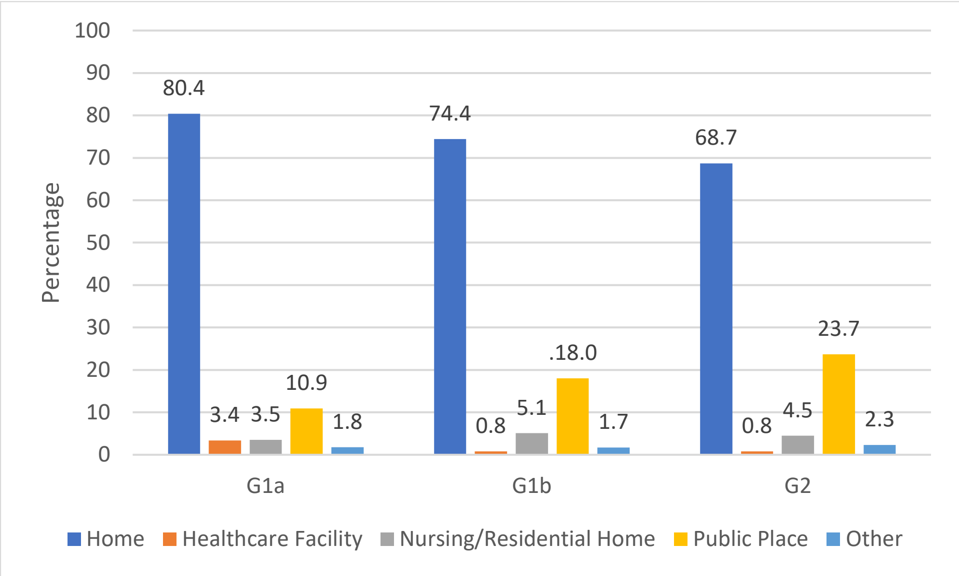
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time		n/a
		Case-control study—Report numbers in each exposure category, or summary measures of exposure		n/a
		Cross-sectional study—Report numbers of outcome events or summary measures		n/a
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included		n/a
		(*b*) Report category boundaries when continuous variables were categorized		n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	65, 104-104	
Discussion				
Key results	18	Summarise key results with reference to study objectives	105-113	Discussion
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	112-113	Discussion
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	105-114	Discussion/Conclusion
Generalisability	21	Discuss the generalisability (external validity) of the study results	203	Limitations
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	2	Acknowledgements

Appendix 5: Additional retrospective data analysis data

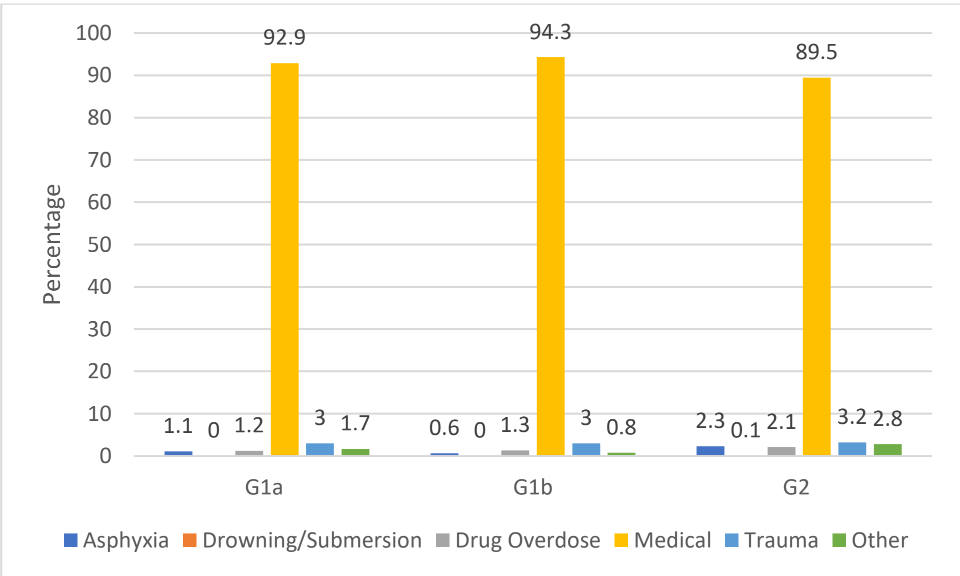
A5a: Gender proportions in G1a, G1b and G2



A5b: Location of OHCA in G1a,G1b and G2



A5c: Aetiology of cardiac arrest within groups



A5d: Statistical analysis of the aetiology of OHCA G1a, G1b and G2

Aetiology	Asphyxia		Drowning		Drug o/d*		Medical		Trauma		Other	
Group		%		%		%		%		%		%
G1a	Observed	1.1	Observed	0	Observed	1.2	Observed	92.9	Observed	3	Observed	1.7
	Expected	1.8	Expected	0	Expected	1.8	Expected	90.8	Expected	3.2	Expected	2.3
	Difference	**-0.7**	**Difference**	0	**Difference**	**-0.6**	**Difference**	**2.1**	**Difference**	**-0.2**	**Difference**	**-0.6**
G1b	Observed	0.6	Observed	0	Observed	1.3	Observed	94.3	Observed	3	Observed	0.8
	Expected	1.8	Expected	0	Expected	1.8	Expected	9038	Expected	3.2	Expected	2.3
	Difference	**-1.2**	**Difference**	0	**Difference**	**-0.5**	**Difference**	**3.5**	**Difference**	**-0.2**	**Difference**	**-1.5**
G2	Observed	2.3	Observed	0.1	Observed	2.1	Observed	89.5	Observed	3.2	Observed	2.8
	Expected	1.8	Expected	0	Expected	1.8	Expected	9038	Expected	3.2	Expected	2.3
	Difference	**0.5**	**Difference**	**0.1**	**Difference**	**0.3**	**Difference**	**-1.3**	**Difference**	**0**	**Difference**	**-0.5**

*Drug Overdose (Drug o/d) (χ^2 = 25.261, df = 10, p <.005) Cramer's V = 0.055

Appendix 6: Description of the 10 most frequently occurring MPDS cards

A6a: Description of the 10 most frequently occurring MPDS cards at initial categorisation and Final categorisation in G1a

(Descriptions with breathing problems highlighted in yellow)

Top 10 card descriptions at initial categorisation	%	**Top 10 card descriptions at final categorisation**	%
Difficulty speaking between breaths	12.9	Cardiac / Respiratory Arrest - Not Breathing at all	10.8
Clammy with Chest Pains	9.0	Respiratory Arrest - Ineffective Breathing	9.2
Ineffective Breathing	5.9	Cardiac / Respiratory Arrest - Breathing Uncertain (Agonal)	6.0
Unconscious or Fainting - Not Alert	5.3	Difficulty speaking between breaths	3.7
Not Alert with Breathing Problems	4.3	Unconscious or Fainting - Not Alert	3.6
Unconscious or Fainting - Effective Breathing	4.3	Not Alert with Breathing Problems	3.3
Cardiac / Respiratory Arrest - Not Breathing at all	4.1	Unconscious Agonal / Ineffective Breathing	3.1
Not alert with Chest Pains	3.6	Not alert with Chest Pains	3.0
Cardiac / Respiratory Arrest - Breathing Uncertain (Agonal)	3.4	Not Alert after Falling - Still on the Ground	2.8
Not Alert after Falling	2.6	Ineffective Breathing	2.0

A6b: Description of the 10 most frequently occurring MPDS cards at initial categorisation and
final categorisation in G1b

(Descriptions with breathing problems highlighted in yellow)

Top 10 card descriptions at initial categorisation	%	**Top 10 card descriptions at final categorisation**	%
Cardiac / Respiratory Arrest - Not Breathing at all	17.1	Cardiac / Respiratory Arrest - Not Breathing at all	19.2
Difficulty speaking between breaths	9.1	Cardiac / Respiratory Arrest - Breathing Uncertain (Agonal)	10.4
Cardiac / Respiratory Arrest - Breathing Uncertain (Agonal)	6.1	Respiratory Arrest - Ineffective Breathing	5.9
Not Alert with Breathing Problems	5.9	Unconscious Agonal / Ineffective Breathing	5.5
Unconscious or Fainting - Not Alert	5.5	Unconscious or Fainting - Ineffective Breathing	4.2
Ineffective Breathing	5.1	Arrest post fall	3.4
Not Alert after Falling	3.6	Fitting and Not Breathing	3.4
Not alert with Chest Pains	3.2	Ineffective Breathing	2.7
Unconscious Agonal / Ineffective Breathing	3	Obvious/expected Death questionable	2.3
Unconscious or Fainting - Effective Breathing	3	Complete obstruction / Ineffective Breathing - Food	1.9

A6c: Description of the 10 most frequently occurring MPDS cards at initial categorisation and
final categorisation in G1b

(Descriptions with breathing problems highlighted in yellow)

Top 10 card descriptions at initial categorisation	%	Top 10 card descriptions at final categorisation	%
Cardiac / Respiratory Arrest - Not Breathing at all	39.2	Cardiac / Respiratory Arrest - Not Breathing at all	40.2
Cardiac / Respiratory Arrest - Breathing Uncertain (Agonal)	14.1	Cardiac / Respiratory Arrest - Breathing Uncertain (Agonal)	14.4
Unconscious Agonal / Ineffective Breathing	3.9	Respiratory Arrest - Ineffective Breathing	13.2
Ineffective Breathing	3.5	Unconscious Agonal / Ineffective Breathing	3.4
Unconscious or Fainting - Effective Breathing	3.5	Unconscious or Fainting - Ineffective Breathing	2.2
Respiratory Arrest - Ineffective Breathing	2.4	Arrest post fall	1.7
Unconscious or Fainting - Not Alert	2.3	Fitting and Not Breathing	1.4
Not Alert with Breathing Problems	2.1	Ineffective Breathing	1.3
Unconscious or Fainting - Ineffective Breathing	2.1	Obvious/expected Death questionable	1.2
Difficulty speaking between breaths	1.8	Complete obstruction / Ineffective Breathing - Food	0.9

Appendix 7

Appendix 7a: Key to Jeffersonian Transcription

Transcription Conventions	
E: [Word] C: [Word]	Square brackets aligned across adjacent lines signifies the occurrence of overlapping talk
E: Word= C: =Word	Equals signs signifies latching and indicates where there is no beat of silence between turns, or between parts of one turn.
0.7	Timed gap
(.)	Just noticeable pause
. Period	Falling intonation
? Question Mark	Strongly rising intonation
, Comma	Slightly rising intonation
_ Underscore	At a turn ending represents level intonation
Underlining	Indicates stress, or emphasis
LOUD	Loud talking or shouting is indicated in capitals
°Degree Signs°	Degree signs indicate soft or quiet talk
↑pitch	Sharp upward change in pitch
Hell:o	Underlining followed by colon indicates an up down contour through the word
>compressed<	Compressed, or rushed talk
<slower>	Slower speech
:	Prolongation of a word
Stop-	Hyphen after a word indicates a stop
£	Smiley voice
#	Creaky voice
~	Tremulous voice
(possible hearing)	Transcriber uncertainty
((cough))	Transcriber transcription of events
H hh hhh	Hearable breathing
Huh/hah/hhah/hah	Laughing

Adapted from Hepburn and Bolden (2017)[237]

Appendix 7b: Extract 12

Persons Present

EMD:	(E)
Caller:	(C)
Caller 2:	(C2)
Caller 3:	(C3)
Patient:	(P)

01 E: Ambulance Service is the patient breathing?,

02 (0.8)

03 C: .hhhH Pardon?

04 E: Is the patient breathing?

05 C: Um heavy breathin’ but he’s not breathin’ veree well=is::

06 really odd;

07 E: Okay are they away**k**?,

08 (0.6)

09 C: .hhhH (.) they are, bu:t (.) they’re not breathing >very well<

10 I just had to move ‘im: from the living room tuh the- (0.3) tuh

11 the bedroom which is literally (0.3) **ku**ple a **st**eps away

12 >tuh< go toilet_ hhh and he’s literally c(h)ulLApsed because

13 he needed to go to the toil- .hhhHH an’ he >k(hh)udn’t<

14 really mo- he can’t move off the toilet; he can’t

15 hardly talk. [I’m- I’[m DOWnSTAirs (.) .hhh an’ he is right up

16 E: [Is- [Is there-

17 C: =in the attic (.) because (0.3) .hhh umm where I live it’s like

18 (.) it’s hard to explain >I haven’t got a< fo:ne in- .hhh there’s

19 an office ‘n I have to go right upstairs and he’s on the

20 °toil-° it’s weird .hhh b[ut he’s been bad for three days, but=

21: E: [I-

22 C: =it’s getting worse_

23 E: Okay is there any serious ↓bleeding,

24 (0.6)

25 C: .hhh (0.3) umm I don’t think so [#n- (0.4) no_]

26 E: [No? What’s the add]ress

27 of the emergency.

28 (0.3)

29 C: Par↑don?

30 E: What’s the <ad↑dress of the e↓mergency>.

[0:00:49.5]

31 C: [*Redacted*].

32 E: Tell me exactly…

33 C: [Inaudible].

34 E: Tell me exactly what’s happened.

35 C: Well, he’s not breathing properly… he can’t breathe… he can’t move. If he stands

36 up, he falls to the floor. He can’t breathe properly. He’s like [*panting*]… he’s gasping for a

37 breath, and he… he’s literally screaming… he’s like that… because it hurts so much. He can’t

move, he can’t do nothing.

E: What hurts?

C: His breathing, his chest… it hurts when he moves, and he can’t move…

E: Okay.

C: Or nothing.

E: Okay. What’s the phone number you’re calling from?

C: [*Redacted*]. Yeah…

E: Okay. Are you with him…?

C: It’s a landline.

E: Okay. How old is he?

C: He’s… [fucking hell]… he’s…

[*Speaking in background*]

C: [Yes, all right, yeah]. I don’t know his date of birth. It’s, er…

E: Approximately?

C: 12th… no, it’s not the 12th; that’s wrong. [*Redacted*].

E: Okay. Just repeat the address so I know I have it correct.

C: [*Redacted*].

E: Okay. And is he completely alert?

C: Yeah, he knows… he knows… oh, shit, I’ve locked myself out. I hope I can get in. [Inaudible].

E: Does he have difficulty speaking between breaths?

C: Well, [inaudible] down… downstairs. Oh! [No, you’ve got to come downstairs and let me in. I’ve locked myself out. Oh, shit! [Inaudible] all I know he’s really ill. [Inaudible]. Right, can you talk to these Ambulance people? [Inaudible] talk to them, I’ll try. Here are… quick].

E: Who is there?

C: [Sit down. Here… here are].

E: Hello. Who is…?

C: I’m going to let you talk to him. Here are.

E: No, wait…

P: [*Groaning*].

O: I don’t need to speak to the patient. Hello.

C: [Talk to her! [Inaudible], they’re on the phone now!]

P: Hello.

E: Hello. I… I’m sorry. Are you…?

P: Hello.

E: Are you the patient?

P: Yes. [Inaudible].

C: Sorry, I don’t know what’s wrong. He’s sitting… he’s sitting and banging his head into the wall!

E: Okay.

C: [Inaudible].

E: Listen… listen to me [inaudible].

C: [Inaudible].

E: Listen to me, so that we can help him. Okay?

C: [Inaudible].

E: Listen to me, so that we can help him. How…?

C: He’s not moving [inaudible].

E: Listen to me, so that we can help him. Tell me exactly what’s happening now.

76	C:	He’s [inaudible] a really heavy object.
77	E:	What do you mean by collapsing?
78	C:	[Inaudible] his head back and everything, he can’t… I can’t get him to [inaudible].
79	E:	Right…
80	C:	[Inaudible].
81	E:	Okay. Help him…
82	C:	[Inaudible].
83	E:	Listen to me.
84	C:	He’s [inaudible].
85	E:	Listen to me…
86	C:	[Inaudible]…
87	E:	So that we can help him.
88	C:	[Inaudible] and he [inaudible] to take that.
89	E:	Okay...
90	C:	He’s [inaudible]…
91	E:	Listen to me, so that we can help him.
92	C:	[Inaudible].
93	E:	Listen to me, so that we can help him.
94	C:	I don’t want him to die…
95	E:	Listen…
96	C:	[Inaudible]… [*weeping*].
97	E:	Listen to me, so that we can help him.
98	C:	[Inaudible].
99	E:	Listen to me, so that we can help him.
100	C:	[*Screaming and shouting in background*].

101 E: Hello. Just listen to me, so that we can help him

102 C: [*Weeping*].

103 C2: Sorry?

104 E: Is this somebody else?

105 C2: I'm a friend.

106 [*Shouting in background*].

107 E: Sorry. Are… are you with the patient

108 [*Screaming in background*].

109 C2: Sorry?

110 E: Are you with the patient.

111 C2: [Stop! Stop!]

112 E: Is he completely alert?

113 [*Shouting in background*].

114 E: Is he conscious?

115 C2: No, he's not conscious.

116 E: He's not conscious?

117 C2: No.

118 [*Shouting in background*].

119 E: Okay. Help is being arranged…

120 C2: He's breathing

121 E: Help is being arranged as quickly as possible. Okay

122 [*Screaming in background*].

123 C2: Sorry

124 E: Help is being arranged as quickly as possible. Okay

125 C2: Sorry?

126 E: Help is being arranged

127 C2: Oh, right… cool.

128 E: Okay?

129 C2: Do you know where to… to come to

130 E: I’m organising the help for you now. Just stay on the line.

131 C2: Okay.

132 E: Okay? Is there a defibrillator available

132 [*Shouting in background*].

133 C2: [Inaudible]. [Stop! Stop a minute. I’m trying to…!] Sorry?

134 E: Is there a defibrillator available?

135 C2: No.

136 E: No? Okay. Okay. Listen carefully. Are you…?

137 C2: Yeah.

138 E: Right by him now?

139 C2: Yes.

140 E: Okay. Listen carefully. Lie him flat on his back on the floor, and remove any pillows.

141 C2: Yeah. Hold on, [inaudible]. [Do you want to just hold that?]

142 C3: Hello.

143 E: Hello, there.

144 C3: Hiya. He’s just…

145 E: Listen carefully. Lay him…

146 C3: Yeah.

147 E: Flat on his back on the floor, and remove any pillows.

148 C3: Yeah, xxxxx just moving him now. One second.

149 E: Great. Okay. We’re coming as quickly as we can.   Okay?

C3: Yes. Yeah, he's on the floor now

E: Great. Now, place your hand on his forehead, your other hand under his neck, and tilt the head back.

C3: Yeah, he is. He's in the re…

E: Yeah.

C3: He's in the recovery position now.

E: Okay. He needs to be flat on his back now, please

C3: He's… he is breathing

E: Okay, but lie him flat on his back and tilt his head back

C3: Yeah… yeah…

E: Yeah?

C3: That's fine, yeah.

E: Now put your ear next to his mouth. Can you feel or hear any breathing?

C3: Can you feel him breathing?

[*Shouting in background*].

C3: [Inaudible] you're not helping the situation at the minute. We're on the phone to them, so just calm down one second]. Sorry, bear with me one second.

E: Okay.

C3: [Is he breathing?] Yes, he's breathing.

E: Yeah? Okay.

C3: Yeah.

E: I want you to say now

C3: Yeah.

E: Every single time he takes a breath in, starting immediately

C3: [You need to tell me every single time he's taking a breath in, and you've got to say now]. [Inaudible]

E: Every breath if you could tell me.

C3: [He's choking… you need to lift his chin up. He's choking… lift his… that's it]

E: Has he taken a breath

C3: He's… he's not… he is breathing…

E: Yeah. Okay, so I need to try and make an assessment of his breathing over the phone, so you need to be my eyes, and tell me every time he's taking a breath in.

C3: [Shush! Go to the office. Be quiet, because I can't hear them on the phone]. [*Speaking in background*].

C3: [Can you shush! Go to the office. Go to the office. Go to the office, please. Thank you. Shush!] Right, and he is taking a breath

E: And the next one? Has he taken a breath in that time? Hello

C3: No, sorry, I'm just listening. [Is he actually breathing?] He is breathing, but I can't actually fully see.

E: Okay. Well, you need to get right down to his level, put your ear next to his mouth, and look down his chest, so that we can tell exactly when he is breathing, because we need to know that he is definitely breathing.

C2: Yeah… no, he is breathing…

E: Okay.

C2: He is breathing.

E: So, every time he takes a breath in, tell me, so that I can work out exactly how effective his breathing is

C2: I mean, he seems to be breathing quite frequently.

E: Okay. So, every time, just say the word "now", so that I know he's taken a breath

C2: Yeah… now

E: And the next one?

C2: Now

E: And the next one

C2: Now.

E: And the next one?

C2: Now.

E: Thank you. Okay. He's breathing at a normal rate. All right

= C2: Yeah.

E: Stay right with him, make sure his head is tilted back, and check breathing often.

C2: Yeah.

E: If he vomits, turn him on his side and clean out his mouth and nose. I'll stay on the line until help arrives.

C2: Yeah… cool.

O: Tell me when the Ambulance crew is right with him, or if anything changes. Okay

C2: Yeah.

E: What's the patient's name

C2: [*Redacted*]

E: Okay. Don't worry, that's okay. We… we're coming as quickly as we can to him, okay

C2: Yeah, sure

E: Just keep watching him; let me know if anything changes at all. Is the front door unlocked ready for the Ambulance crew?

C3: I can go and open it.

E: You can do it? Okay, great, thank you.

C3: [Are they here]?

224 C2: [Don’t know].

225 E: How’s he doing? Has anything changed?

226 C2: No. Yeah, it’s all right, the paramedics are here

227 E: Yeah? I’ll leave you with them then. Okay

228 C2: All right… all right, thank you

229 E: You’re welcome. Take care. Bye-bye.

230 C2: Okay. Bye-bye.

END OF INTERVIEW

Appendix 8: Predefined Themes and Reflexive Diary

Theme One	Theme Two	Theme Three	Theme Four
Difficulties adhering to the dispatch protocol	Managing hysterical callers	The assessment of clinical signs	Experiences of EMD education

<u>Reflexive Diary</u>

<u>7th July 2021</u>

I am concerned that some of the questions might be leading the participants and that the interview guide might be too long and not focused enough. I will aim to ensure questions are open and not leading and leave out some of the questions that do not seem so relevant.

Interested in the PQT sequence and whether asking the breathing question here then leads to the caller not answering this question accurately later in the triage. Realisation that questions asked in the PQT do not then link into AMPDS. I will explore this further with participants.

<u>9th July 2021</u>

The participants tend to focus on those patients already in OHCA, rather than those at imminent risk of OHCA. Decision to make a conscious effort to keep reminding the participants of the patient group of interest.

I have noted how interviewing the participants during a time of increased demand linked to COVID that I am not interviewing during 'normal' working conditions and there have been many changes brought in because of COVID, for example urgent disconnect. Some of the points the participants are making link to pre COVID and the situation has got a lot worse in terms of response since COVID. The participants are under a lot of stress at work and feel that they are failing patients, and this might reflect in some of their responses.

<u>15th July 2021</u>

All the participants are mentioning acting on intuition, that they can't quite explain where it comes from. I am interested to know how accurate these intuitions are and what their basis is. EMDs are concerned about delays in getting their concerns acted on. I am wondering if a big part of improving response will be based on improving the access to prompt clinical support for the EMDs.

There is some confusion regarding whether the PQT are designed to highlight imminent risk of OHCA patients as well as OHCA patients.

19th July 2021

I note that monitoring of patients during the call is variable. It seems some EMDs are navigating the system so they can achieve this and stay under the radar of audit. Other EMDs do not focus on monitoring at all. There is uneasiness about recent directives to not stay on the line after triage due to demand.

17th August 2021

It seems that compliance audit hinders recognition of some patients. Is it that many of the patients not receiving category one when at high risk of OHCA are calls where there is a troublesome interaction with a lot of confusion. If the EMDs felt supported to slightly deviate from the protocol, could they recognise some of these patients?

Also noted EMD frustration over the inclusion of 'struggling ' in breathing trigger words as it leads to over triage.

11th September 2021

Interesting to note the differences in the models of clinical support between the two Trusts and the different cultures in the two Trusts.

20th September 2021

Colour keeps coming up in clinical signs mentioned on the call.

I notice how EMDs use the system in different ways and that there is variation between EMDs in the way they manage a call and the dispatch software.

I am unsure about saturation, but I am sure that I have new knowledge in this area. I have decided to recruit some more participants, if possible, just to see if there is anything else to add.

27th September 2021

It appears EMDs are not well supported in their roles. EMDs are very keen for clinical feedback, but at the same time that would have to be supportive and limited to when the EMDs would like feedback. If there was a better connection between EMDs and outcomes of patients, could it act as a motivator for EMDs?

I feel that many of the interviewees are discussing very similar aspects of their role. There is a lot of similarity between Trusts, but also some subtle differences reflective of culture.

5th October 2021

I have evolved the interview style so that I collect more meaningful data. The questions I ask have become vaguer than previously so that the participant can direct the conversation and I can just prompt it in specific directions. The problem of the EMD wanting to naturally discuss those already in OHCA over those at imminent risk of OHCA continues and is interesting. It is possible that there is so much focus on those already in OHCA that the group who are alive and then have an OHCA can be overlooked.

15th October 2021

I feel that the staff taking part in this research are motivated and perhaps not reflective of all EMDs, although they do reflect on other staff's practice. I think that participants are more conscientious than some EMDs, but participants appear to have a good insight into the practice of others.

At this point I think that I have rich data with a lot of insight around the preconceived themes. The analysis of the interviews has allowed construction of ideas and interpretations I hadn't previously conceived. I have been amazed how well recruitment went and I think this reflects the motivations of those participating to improve their working practices for patient and their own benefit.

7th November 2021

I have spent a lot of time reading and rereading transcripts. I have coded all the data and recoded multiple times. There are some overlapping codes between themes. The themes have been tweaked to reflect the inductive analysis. I am pleased with how the analysis has evolved.

15th November 2021

I think the findings have been constructed to accurately reflect the socially constructed interpretations of the interaction between participants and myself. I will continue to check the findings with participants.

Appendix 9: Research Documents
A9a: Interview Guide

IMproving the Ambulance recognition and Response for patients who are at imminent risk of cardiac arrest. The IMARI Study

Introduction:

My name is Kim Kirby and I am completing a PhD at UWE. Thank you for volunteering to take part in this research. The focus of my PhD is improving outcomes from out-of-hospital cardiac arrest and I am particularly interested in patients who suffer a cardiac arrest after the 999 call is made. Although I do have experience working as a paramedic it is important that you view me as a researcher with no experience in this area. Studying patients who are alive during a 999 call, but who go on to suffer a cardiac arrest before they reach hospital, can help to identify the features of a 999 call that suggest a patient is at high risk of having a cardiac arrest. The conversation that occurs between the person who calls 999 and the ambulance call handler is particularly important. I am keen to hear your views on how improvements can be made.

I would like to discuss some of my findings so far with you and to understand your experiences and views on how we can improve the ambulance response to patients who suffer an out-of-hospital cardiac arrest after the 999 call is made. I shared a video with you prior to this interview detailing my research to date.

Do you have any questions about that video, or about this research before we begin the interview properly?

Interview topic guide

Adhering to the dispatch protocol

Literature suggests that often call-takers do not directly follow the dispatch protocol. One study also says that EMDs are more likely to identify OHCA where the dispatcher does stray from the dispatch protocol. What are your views on the dispatch protocol in relation to patients who are deteriorating and at risk of imminent OHCA?

How easy do you find it to adhere to the dispatch protocol in your role?

Hysterical callers

Literature suggest that most callers are calm enough to answer the EMD's questions. What are your experiences of managing hysterical callers? Literature also suggests that hysteria can indicate OHCA and that a calm caller may create a false reassurance. What is your view on this?

What about the deteriorating patient, how does hysteria relate to these patients?

Assessing breathing status

The pre-triage questions are focussed on identifying those patients in cardiac arrest already and identifying agonal breathing. Assessing the breathing status of patients during the 999 call is well known for being a challenging area. Do you have any thoughts on any differences in assessing breathing in patients who are at high risk of out-of-hospital cardiac arrest as opposed to patients who are already in cardiac arrest?

How do you find assessing breathing status in the deteriorating patient as opposed to the patient already in cardiac arrest and agonal breathing?

Do you think that asking about breathing in pre-triage influences the responses to the breathing questions further into the triage?

Do you use any strategies or techniques to identify abnormal breathing in the deteriorating patient?

Do you have any views on specific trigger words that might indicate the deteriorating patient who may ego on to suffer an out-of-hospital cardiac arrest?

Evidence suggests difficulty in breathing is a common prodromal symptom in EMS witnessed OHCA, do you have any views and experiences of this?

Consciousness

What about assessing consciousness status in the deteriorating patient? Is this problematic?

Colour

Have you any opinion on the way callers might describe a patient's colour and what this might mean?

Training

What about call-taker training. Can you describe the training you received to be a call-taker? What are your experiences of this training?

Was there any communications training?

Would you like to see any changes to the way call-takers are trained?

Finally, do you have anything more to add on how we can improve the response to patients who are alive when the emergency call is made and deteriorate into cardiac arrest before they reach the hospital?

Today we have discussed some research findings and you have told me about your experiences of managing emergency calls regarding cardiac arrest patients and patients who are at imminent risk of cardiac arrest. Do you have anything else you would like to add to your interview?

Thank you very much for taking part in this interview.

A9b: Study Participant Information Sheet (interviews)

IMproving the Ambulance recognition and Response for patients who are at imminent risk of cardiac arrest. The IMARI Study

Participant Information Leaflet

What is the purpose of the study?
Out-of-hospital cardiac arrest occurs when a person's heart stops beating suddenly outside hospital. It is a catastrophic event requiring immediate treatment if the person is to have any chance of survival. OHCA remains a leading cause of death in the United Kingdom. In December 2018 only 8% of OHCA patients treated by the ambulance service survived to leave hospital.

Studying patients who are alive during a 999 call, but who go on to suffer a cardiac arrest before they reach hospital, can help to identify the features of a 999 call that suggest a patient is at high risk of having a cardiac arrest. The conversation that occurs between the person who calls 999 and the ambulance call handler is particularly important.

This research is being completed as part of a PhD which has been funded by the National Institute of Health Research. The purpose of this research study is to improve the recognition of patients contacting the 999 ambulance service who are critically ill, and at high risk of suffering a cardiac arrest before they reach hospital. Recognising these people when they dial 999 means the fastest possible ambulance response can be sent to them, to prevent them from having a cardiac arrest, or treat them immediately if a cardiac arrest does occur.

You are being invited to participate in this research by taking part in an interview. The interview discussions will gather the views of individuals who work in the Emergency Operations Centre on our research and generate ideas as to how best to build on these research findings and improve call-taker recognition of patients who are at imminent risk of OHCA during a 999 call.

Why have I been chosen?
You have been invited to take part because you are employed in an NHS ambulance Trust Emergency Operations Centre (EOC). Your opinion and experiences are important to us because you have a practical understanding of working in the EOC. You can inform this research and help us understand the specific challenges faced by EOC staff, and also opportunities to improve practice and patient outcomes.

Who is in charge of this research?
The research is being conducted by Ms Kim Kirby a paramedic and PhD student at the University of the West of England, Bristol. Approval for the study has been granted by the research governance team at South Western Ambulance Service NHS

Foundation Trust (SWASFT), East Midlands Ambulance Service, University of the West of England (UWE) Research Ethics Committee and the Health Research Authority. The interviews will be carried out by Ms Kim Kirby.

Do I have to take part?
No, taking part is entirely voluntary. It is up to you whether you wish to contribute. Please read this information sheet and then decide. If you agree you will be asked to sign a consent form prior to the interview. You are free to change your mind and withdraw your data from the study without giving a reason. If you decide not to take part, you do not have to give a reason and it will not have any effect on your work.

What will I be asked to do if I do take part?
You are being asked to take part in an interview. You will be interviewed by a researcher who will discuss this research and how the recognition, during the emergency call, of patients who are at imminent risk of out-of-hospital cardiac arrest can be improved. The discussion is expected to last approximately 60 minutes.

Before the interview begins the participants you will be asked to sign a consent form and will be asked to give consent to the discussion being audio recorded. The audio recording will be transcribed by a University of the West of England approved transcriber and a data sharing agreement will be in place. Everything that is said in the discussion will be treated in confidence and all data will be anonymised.

How will we use information about you?
We will need to use information from you for this research project. This information will include your name and contact details held by the site or sponsor for the research. People will use this information to do the research or to check your records to make sure that the research is being done properly. People who do not need to know who you are will not be able to see your name or contact details. Your data will have a code number instead.

We will keep all information about you safe and secure. Once we have finished the study, we will keep some of the data so we can check the results. We will write our reports in a way that no-one can work out that you took part in the study.

What are your choices about how your information is used?
You can stop being part of the study at any time, without giving a reason, but we will keep information about you that we already have. We need to manage your records in specific ways for the research to be reliable. This means that we won’t be able to let you see or change the data we hold about you.

Where can you find out more about how your information is used?
You can find out more about how we use your information by asking one of the research team, by sending an email to [XXXX], by ringing us on [XXXX], or by contacting South Western Ambulance Service's Data Protection Officer [XXXX].

What are the possible risks and benefits of taking part?
There may be a risk that the interview discussions could cause emotional distress. Your participation will be used to help improve understanding of the challenges and opportunities that EOC staff have in recognising patients who are at imminent risk of out-of-hospital cardiac arrest.

If you have any concerns about this research, or it has caused you distress, please contact the Research Department., XXXX.

or;

East Midlands Ambulance Service Research Team
Email: xxxx

What will happen to the results of the study?
The results will not be known until late 2021. We aim to publish the results in professional journals, however all publications will only contain anonymised data, and it will not be possible to identify you from any published material. If you would like to receive a copy of the results, please let the researcher know and we will arrange to send you a copy.

Confidentiality and data storage
Any notes, documents, audio-recordings and information about the interview will be kept in the strictest confidence. Only members of the study team will have access to the data. Your personally identifiable information will be stored separately from any notes, documents, transcripts and audio-recordings. You will not be personally identifiable from any reports or outputs from the research. Your personally identifiable information will be securely erased on completion of the study. De-identified study data will be stored for 5 years after the end of the study.

Hard-copy data will be stored at the University of the West of England in a fireproof, lockable filing cabinet. Consent forms and identifiable information will be stored separately from study data. Hard copies of identifiable information will be destroyed when no longer required by the research team.

All electronic participant data will be stored on password protected, encrypted university computers. Participant contact information will only be stored only as long as is necessary, on password protected, encrypted laptops and USBs. All interviews will be recorded on an encrypted Dictaphone, and will be deleted once they have been moved to a computer.

Who has funded this research project?
The research is being funded by the National Institute of Health Research via a Clinical Doctoral Research Fellowship.

Who has reviewed the project?
The Research and Development Department of South Western Ambulance Service NHS Foundation Trust (SWASFT), University of the West of England Research Ethics Committee and the Health Research Authority have all reviewed and approved the project.

What do I do now?
If you would like to participate please contact Kim Kirby at SWASFT
Tel: xxxx
Email: xxxx

Thank you for taking the time to read this leaflet.

A9c: Participant Information Sheet (focus groups)

IMproving the Ambulance recognition and Response for patients who are at imminent risk of cardiac arrest. The IMARI Study

Participant Information Leaflet

What is the purpose of the study?

Out-of-hospital cardiac arrest occurs when a person's heart stops beating suddenly outside hospital. It is a catastrophic event requiring immediate treatment if the person is to have any chance of survival. OHCA remains a leading cause of death in the United Kingdom. In December 2018 only 8% of OHCA patients treated by the ambulance service survived to leave hospital.

Studying patients who are alive during a 999 call, but who go on to suffer a cardiac arrest before they reach hospital, can help to identify the features of a 999 call that suggest a patient is at high risk of having a cardiac arrest. The conversation that occurs between the person who calls 999 and the ambulance call handler is particularly important.

This research is being completed as part of a PhD which has been funded by the National Institute of Health Research. The purpose of this research study is to improve the recognition of patients contacting the 999 ambulance service who are critically ill, and at high risk of suffering a cardiac arrest before they reach hospital. Recognising these people when they dial 999 means the fastest possible ambulance response can be sent to them, to prevent them from having a cardiac arrest, or treat them immediately if a cardiac arrest does occur.

You are being invited to participate in this research by joining a focus group of staff members. The focus group discussions will gather the views of individuals who work in the Emergency Operations Centre on our research, and generate ideas as to how best to build on these research findings and improve call-taker recognition of patients who are at imminent risk of OHCA during a 999 call.

Why have I been chosen?

You have been invited to take part because you are employed in an NHS ambulance Trust Emergency Operations Centre (EOC). Your opinion and experiences are important to us because you have a practical understanding of working in the EOC. You can inform this research and help us understand the specific challenges faced by EOC staff, and also opportunities to improve practice and patient outcomes.

Who is in charge of this research?

The research is being conducted by Ms Kim Kirby a paramedic and PhD student at the University of the West of England, Bristol. Approval for the study has been granted by the research governance team at South Western Ambulance Service NHS Foundation Trust (SWASFT), East Midlands Ambulance Service, University of the West of England (UWE) Research Ethics Committee and the Health Research Authority. The focus groups will be carried out by Ms Kim Kirby.

Do I have to take part?

No, taking part is entirely voluntary. It is up to you whether you wish to contribute. Please read this information sheet and then decide. If you agree you will be asked to sign a consent form prior to the focus group. You are free to change your mind and withdraw your data from the study without giving a reason. However, due to the nature of focus groups it will not be possible for you to withdraw your data during or after the focus groups. It will not be possible for the researcher conducting the analysis to "forget" what he/she has heard in the focus group discussion. If you decide not to take part, you do not have to give a reason and it will not have any effect on your work.

What will I be asked to do if I do take part?

You are being asked to take part in a focus group. This is 4-6 people who will discuss this research and how the recognition, during the emergency call, of patients who are at imminent risk of out-of-hospital cardiac arrest can be improved. The discussion is expected to last approximately 60 minutes. Refreshments will be provided, and participants can claim reasonable travel expenses.

Before the focus group begins the participants will be asked to sign a consent form and will be asked to give consent to the discussion being audio recorded. The audio recording will be transcribed by a University of the West of England approved transcriber and a data sharing agreement will be in place. Everything that is said in the discussion will be treated in confidence and all data will be anonymised.

How will we use information about you?

We will need to use information from you for this research project. This information will include your name and contact details held by the site or sponsor for the research. People will use this information to do the research or to check your records to make sure that the research is being done properly. People who do not need to know who you are will not be able to see your name or contact details. Your data will have a code number instead.

We will keep all information about you safe and secure. Once we have finished the study, we will keep some of the data so we can check the results. We will write our reports in a way that no-one can work out that you took part in the study.

What are your choices about how your information is used?
You can stop being part of the study at any time, without giving a reason, but we will keep information about you that we already have. We need to manage your records in specific ways for the research to be reliable. This means that we won't be able to let you see or change the data we hold about you.

Where can you find out more about how your information is used?
You can find out more about how we use your information by asking one of the research team, by sending an email to [Kim.Kirby@uwe.ac.uk], by ringing us on [07870633268], or by contacting South Western Ambulance Service's Data Protection Officer [XXXX].

What are the possible risks and benefits of taking part?

There may be a risk that the focus group discussions could cause emotional distress. Your participation will be used to help improve understanding of the challenges and opportunities that EOC staff have in recognising patients who are at imminent risk of out-of-hospital cardiac arrest.

If you have any concerns about this research, or it has caused you distress, please contact Research Manager XXXX

or;

East Midlands Ambulance Service Research Team

Email: xxxx

What will happen to the results of the study?

The results will not be known until late 2021. We aim to publish the results in professional journals, however all publications will only contain anonymised data, and it will not be possible to identify you from any published material. If you would like to receive a copy of the results, please let the researcher know and we will arrange to send you a copy.

Confidentiality and data storage

Any notes, documents, audio-recordings and information about the focus group will be kept in the strictest confidence. Only members of the study team will have access to the data. Your personally identifiable information will be stored separately from any notes, documents, transcripts and audio-recordings. You will not be personally identifiable from any reports or outputs from the research. Your personally identifiable information will be securely erased on completion of the study. De-identified study data will be stored for 5 years after the end of the study.

Hard-copy data will be stored at the University of the West of England in a fireproof, lockable filing cabinet. Consent forms and identifiable information will be stored separately from study data. Hard copies of identifiable information will be destroyed when no longer required by the research team.

All electronic participant data will be stored on password protected, encrypted university computers. Participant contact information will only be stored only as long as is necessary, on password protected, encrypted laptops and USBs. All interviews will be recorded on an encrypted Dictaphone, and will be deleted once they have been moved to a computer.

Who has funded this research project?

The research is being funded by the National Institute of Health Research via a Clinical Doctoral Research Fellowship.

Who has reviewed the project?

The Research and Development Department of South Western Ambulance Service NHS Foundation Trust (SWASFT), University of the West of England Research Ethics Committee and the Health Research Authority have all reviewed and approved the project.

What do I do now?

If you would like to participate please contact Kim Kirby at SWASfT

Tel: xxxx

Email: xxxx

Thank you for taking the time to read this leaflet.

A9d: Consent Form (interviews)

IMproving the Ambulance recognition and Response for patients who are at Imminent risk of cardiac arrest: The IMARI Study

Participant ID

Consent Form (Interviews)

Please initial box:

1. I confirm that I have read and understood the information sheet version 1 (16th March 2021).

2. I understand that my participation is entirely voluntary and that I am free to withdraw from the study at anytime without my legal rights being affected. I do not have to offer an explanation for my withdrawal.

3. I agree to the following aspects of this research:

    I. To take part in an interview to discuss improving the IMARI findings to date.

    II. I agree for the interview to be audio recorded.

4. I understand that material including my contribution to the study may enter the public domain through reports and publications, but my identity will not be disclosed.

5. I understand that all research data will be anonymised in a form that will preclude me from being identified personally, and all data for this interview will be stored securely at the University of West of England, Bristol.

6. I agree to take part in this study.

Name of participant Date Signature

....

Researcher taking consent Date Signature

....

Kim Kirby
PhD Student
University of the West of England
Mobile: XXXX Email: XXXX

A9e: Consent Form (focus group)

IMproving the Ambulance recognition and Response for patients who are at Imminent risk of cardiac arrest: The IMARI Study

Participant ID

Consent Form (Focus Groups)

Please initial box:

7. I confirm that I have read and understood the information sheet version xxxx.

8. I understand that my participation is entirely voluntary and that I am free to withdraw from the study up until the beginning of the focus group discussion without my legal rights being affected. I do not have to offer an explanation for my withdrawal.

9. I agree to the following aspects of this research:

    I. To take part in a focus group to discuss improving the IMARI findings to date.

    II. I agree for the focus group to be audio recorded.

10. I understand that material including my contribution to the study may enter the public domain through reports and publications, but my identity will not be disclosed.

11. I understand that all research data will be anonymised in a form that will preclude me from being identified personally, and all data for this interview will be stored securely at the University of West of England, Bristol.

12. I agree to take part in this study.

Name of participant　　　Date　　　Signature

....

Researcher taking consent　　　Date　　　Signature

....

Kim Kirby
PhD Student
University of the West of England
Mobile: xxxx Email: xxxx

Appendix 10: Research Governance (removed due to personal information)

Publications

RESUSCITATION PLUS 8 (2021) 100173

Available online at www.sciencedirect.com

Resuscitation Plus

journal homepage: www.elsevier.com/locate/resuscitation-plus

Review

Features of Emergency Medical System calls that facilitate or inhibit Emergency Medical Dispatcher recognition that a patient is in, or at imminent risk of, cardiac arrest: A systematic mixed studies review

Kim Kirby[a,b,*], *Sarah Voss*[b], *Emma Bird*[b], *Jonathan Benger*[b]

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Abstract

Aim: To identify and appraise evidence relating to the features of an Emergency Medicine System call interaction that enable, or inhibit, an Emergency Medical Dispatcher's recognition that a patient is in out-of-hospital cardiac arrest, or at imminent risk of out-of-hospital cardiac arrest.

Methods: All study designs were eligible for inclusion. Data sources included Medline, BNI, CINAHL, EMBASE, PubMed, Cochrane Database of Systematic Reviews, AMED and OpenGrey. Stakeholder resources were screened and experts in resuscitation were asked to review the studies identified. Studies were appraised using the Mixed Methods Appraisal Tool. Synthesis was completed using a segregated mixed research synthesis approach.

Results: Thirty-two studies were included in the review. Three main themes were identified: Key features of the Emergency Medical Service call interaction; Managing the Emergency Medical Service call; Emotional distress.

Conclusion: A dominant finding is the diculty in recognising abnormal/agonal breathing during the Emergency Medical Service call. The interaction between the caller and the Emergency Medical Dispatcher is critical in the recognition of patients who suer an out-of-hospital cardiac arrest. Emergency Medical Dispatchers adapt their approach to the Emergency Medical Service call, and regular training for Emergency Medical Dispatchers is recommended to optimise out-of-hospital cardiac arrest recognition. Further research is required with a focus on the Emergency Medical Service call interaction of patients who are alive at the time of the Emergency Medical Service call and who later deteriorate into OHCA.

PROSPERO registration: CRD42019155458.

Keywords: Emergency Medical Service, Out-of-hospital cardiac arrest, Emergency medical dispatch

Introduction

Out-of-hospital cardiac arrest (OHCA) is a catastrophic event requiring immediate intervention if a patient is to have any chance of survival. Survival to hospital discharge following OHCA is poor and varies globally with 11.7% of patients surviving to hospital discharge in Europe compared to 4.5% of patients in Asia.[1] When an Emergency Medical Service (EMS) call is received regarding a patient who is in OHCA or at imminent risk of OHCA a crucial factor in the patient's survival is the recognition of the severity of the patient's condition. Early recognition by an Emergency Medical Dispatcher (EMD) that a patient is critically unwell instigates the rapid dispatch of EMS. Grading of EMS calls is an important part of the "Chain of Survival" in OHCA[2] and in 2005 the Chain of Survival was revised to acknowledge the importance of recognising critical illness and/or acute coronary syndrome and cardiac arrest prevention, both in and out of hospital.[3] When a patient suffers an OHCA the initial min-

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https://doi.org/10.1016/j.resplu.2021.100173
Received 11 March 2021; Received in revised form 22 September 2021; Accepted 23 September 2021
Available online xxxx

utes following collapse are critical.[4] Each second without resuscitation decreases that patient's chances of survival.[5] Early intervention by bystanders, guided by EMDs, is imperative and quality CPR and bystander defibrillation are dependent on the EMD or bystander recognising that the patient is in OHCA.[6]

Deakin[7] demonstrated that all links in the chain of survival are not equal in terms of the numbers progressing through each stage. Improving the first link in the chain of survival - early recognition and call for help - has the potential to have the largest impact on OHCA patients due to the comparative volume of patients at this stage. Recognition, during the EMS call, of patients who are at imminent risk of OHCA will ensure that EMS staff arrive as quickly as possible to either treat the cardiac arrest as soon as it occurs or, better still, prevent it from happening through the provision of early treatment.[8]

The International Liaison Committee on Resuscitation (ILCOR)[9] recognise studies which address knowledge gaps associated with OHCA recognition to be both high impact and high priority. ILCOR note that an area that requires further research is the optimal questions and instructional sequences to provide to callers to enhance recognition of OHCA and provision of CPR. Other systematic reviews have been completed in this area. Drennan et al.[10] reviewed quantitative papers concerning patients presumed to be in OHCA. The authors evaluated the diagnostic accuracy of dispatch centres to diagnose OHCA and investigated EMS call characteristics that impact on the ability of EMDs to diagnose OHCA. Findings indicated variance in the sensitivity and specificity of OHCA recognition across dispatch centres with no difference in accuracy between dispatch criteria/algorithm or with the level of education of the EMDs. Vaillancourt and colleagues[11] aimed to determine whether description of specific symptoms by the caller improved the accuracy of the identification of OHCA by systematically reviewing interventional and observational studies. Findings indicated the importance of enquiry regarding consciousness and breathing to determine OHCA. In addition, the review highlighted that abnormal breathing is a significant barrier to recognition of OHCA and the presence of seizures can be an indication of OHCA.

This systematic mixed studies review (SMSR) aimed to appraise evidence that investigates the features of an EMS call that facilitate or inhibit recognition by the EMD that a patient is in cardiac arrest, or at imminent risk of OHCA.

Methods

Protocol and registration

The protocol for this systematic review was registered on International Prospective Register of Systematic Reviews (PROSPERO), registration number: CRD42019155458 and can be accessed on https://www.crd.york.ac.uk/prospero/.

The protocol was registered on 5th November 2019.

Identification of studies

The search terms used in the SMSR were developed with a Clinical Research Librarian and reviewed amongst the authorship team. The search terms were developed using MeSh Headings where relevant and combined using Boolean Operators. The initial searches were performed between November and December 2019 and rerun in May 2021. The final MEDLINE search strategy developed is shown in appendix one.

Information sources

The following databases were searched by KK: Medline, BNI, CINAHL, EMBASE, PubMed, Cochrane Database of Systematic Reviews, AMED, OpenGrey. Stakeholder resources were also searched by KK and included: International Liaison Committee on Resuscitation, International Academies of Emergency Dispatch and NHS England. Three international resuscitation experts, with an interest in Emergency Medical Service dispatch, were identified to review the results of the systematic literature searches and provide expert opinion on any relevant additional resources that were not already identified during the search process. Any eligible literature was hand searched to ensure all relevant backward citations were identified from the papers.

Inclusion criteria

Study Design: Primary quantitative, qualitative and mixed methods research.

Types of participants: Studies investigating adults and children who are in out-of-hospital cardiac arrest, or at imminent risk of out-of-hospital cardiac arrest.

Types of outcomes: Studies investigating the features of an EMD/caller interaction that facilitate or inhibit recognition by the EMD that a patient is in out-of-hospital cardiac arrest, or at imminent risk of out-of-hospital cardiac arrest.

Date of publication: 1990 to May 2021.

Country: No restrictions were applied.

Language: Published in the English language.

Grey Literature: Included

Study selection and categorisation

Eligibility criteria were applied to the search results and studies identified in the searches were imported to Covidence literature screening software (Veritas Health Innovation, Melbourne, Australia). Title and abstract screening were completed by the first reviewer (KK) with a validation sample of 20% independently screened by a second reviewer (SV). This process was repeated when reviewing the full texts. There was an ongoing dialogue between the reviewers to resolve any uncertainties, and there was no disagreement between reviewers regarding the validation sample. The categorisation phase involved determining whether the papers were qualitative, quantitative, or mixed methods. The studies were split into the five types of study described in the Mixed Methods Appraisal Tool (MMAT).[12] The decision to categorise the studies in this way was a pragmatic one based on an intention to use the MMAT to assess the quality of included studies.

Data extraction

Data were extracted which addressed the features of the EMS call that enable, or inhibit, an Emergency Medical Dispatcher's recognition that a patient is in OHCA, or at imminent risk of OHCA. The first reviewer (KK) extracted data from the categorised studies into a table of findings and into an Excel spreadsheet. The second reviewer (SV) independently validated 20% of data extraction with no disagreement.

Planned methods of analysis

This SMSR set out to synthesise data and results produced from studies with diverse designs to include quantitative, qualitative and mixed methods designs[13,14]. A segregated mixed research synthesis approach as described by Sandelowski et al.[15] was the underlying method used to integrate the findings from both qualitative and quantitative research studies. The two mixed methods study identified during the search phase were fractionated, as described by Frantzen and Fetters,[16] into qualitative and quantitative data. The segregated design recognises the distinct differences between qualitative and quantitative research. The approach requires separate analysis of the quantitative and qualitative findings before synthesising into a set of conclusions. Quantitative and qualitative data were coded in Excel before synthesis into themes. This segregated design is appropriate for use in the context of this SMSR because the research found during the literature search was complementing rather than confirming, or refuting. The mixed research synthesis was defined as the configuration rather than the assimilation of research findings as described in Sandelowski et al.'s work.[15,17]

Quality assessment

The Mixed Methods Appraisal Tool (MMAT)[12] has been designed specifically for mixed research synthesis. The MMAT allows the critical appraisal of five types of studies, to include: qualitative research; randomised controlled trials; non-randomised studies; quantitative descriptive studies; mixed methods studies. Originally developed in 2006,[13] the tool was revised in 2011[18] The current version was further revised following a Delphi study, interviews with MMAT users and a literature review of critical appraisal tools.[12]

Each paper was scored using the MMAT. Quality scores were calculated by grading the papers from 0% to 100% based on the quality criteria met. The papers scored 20% for each of the quality criteria met and grading was completed by KK with 20% of the sample validated by SV, with no disagreement. This type of scoring using the MMAT has been used previously.[19–22] Papers scoring above 80% were graded as high certainty, scores of 80% were graded as moderate certainty and below 80% as low certainty. As recommended by Hong et al.[23] the context of individual scoring is included in the limitation sections of the certainty tables (supplementary Tables S3-S9).

Results

Thirty-two studies were included in the final review. The study flow diagram is shown in Appendix B and Table 1 details the study characteristics. These 32 studies were categorised using the MMAT categories[23] and are shown in their categories in supplementary Table S1. We set out to include all studies that investigated the features of an EMD/caller interaction for both patients already in cardiac arrest ("recognition" studies) and patients at risk of imminent cardiac arrest ("prediction" studies). Unfortunately no "prediction studies" met the inclusion criteria and investigated the features of the EMS call interaction for patients who were unequivocally alive (i.e. definitely not in cardiac arrest) at the time of the EMS call. "Recognition studies" therefore dominated this SMSR, and challenges associated with the recognition of cardiac arrest were apparent.

Quality assessment

Supplementary Table S2 shows the grading of papers grouped into quantitative, qualitative and mixed methods studies.

Overall synthesis

Fig. 1 displays the mixed methods synthesis of findings and is described further below. There were three main themes:

Key features of the EMS call interaction; Managing the emergency call; Emotional distress.

Key features of the EMS call interaction

Assessment of breathing

The recognition of abnormal/agonal breathing is critical in OHCA

Within the studies reviewed many had a focus on abnormal/agonal breathing for the reason that abnormal breathing, or respiratory distress, are indicators of OHCA.[24,29,46,50,53,54,35] Tamminen et al.[44] identified that 'not breathing' and 'abnormal breathing' are significant trigger phrases used to describe OHCA. Where breathing is adequately addressed on the EMS call an OHCA is more likely to be recognised.[32,33,36,40,47,35]

Abnormal/agonal breathing in out-of-hospital cardiac arrest is ambiguous and easy to misinterpret

Although the studies recognised the importance of recognising abnormal/agonal breathing a frequent reason for not recognising OHCA during the EMS call is the misinterpretation, or lack of clarity, regarding breathing status.[26,30,33,34,37,39,41,47,52,55] Assessment of breathing can be delayed in an OHCA presenting with seizure activity and in patients where an incorrect medical condition is described.[42,43] The addition of a question focused on regular breathing to the Medical Priority Dispatch System (MPDS) seizure protocol improved OHCA recognition.[31] EMDs are reliant on the caller's interpretation and communication of the situation[48,50] and EMDs describe trusting the caller's description of breathing until proved inaccurate.[50] However, EMDs also describe working with the descriptions provided by the witness, with some EMDs employing personalised intervention-based identification techniques in an attempt to identify abnormal breathing.[48] Alfsen et al.[51] noted that where a witness is near to the patient during the EMS call, they can better describe any abnormal breathing and assist the EMD with the recognition of OHCA.

Assessment of unconsciousness

Watkins and colleagues[53] found a description of unconsciousness to have high sensitivity and low specificity for OHCA and that assessing unconsciousness on the EMS call can be problematic. Tamminen[44] found 14% of trigger words were focussed on consciousness. A description of a fluctuating level of consciousness decreases the chance of the OHCA being recognised and in 54% of unrecognised cases the caller gave contradictory information regarding patient consciousness.[33]

Declarations of death

Riou et al.[56] identified that EMDs were quicker at recognising OHCA where there was a declaration of death, but this was more likely to occur in an unwitnessed event.

Declarations of colour change

When a patient suffers an OHCA the witness may recognise colour changes in the patient. Berdowski et al.[24] found that in 16.5% of OHCAs the witness described a patient's colour as blue/purple and this finding is supported by Tamminen et al.[44] who identified that the description, 'the patient is blue' occurred in 18% of the true cardiac arrest group. Schwarzkoph and colleagues[42] found that patients who have a seizure and OHCA are often described as turning blue,

Table 1 – Study Characteristics.

First Author	Date of data collection/ publication	Country	Design	Number and types of participants	Main themes identified	Quality grade
High certainty quantitative papers						
Berdowski[24]	2004/2009	Netherlands	Prospective observational study	11,416 high priority emergency, non traumatic EMS calls	Key features of the EMS call interaction; Managing the emergency call; Patient colour	High
Meischke[25]	2013–2016/2017	United States	A parallel prospective randomised controlled trial	128 Emergency Medical Dispatchers	Managing the emergency call	High
Chien[26]	2015–2016/2019	Taiwan	Retrospective cross-sectional study	424 EMS calls for non-traumatic adult OHCA	Key features of the EMS call interaction; Emotional distress	High
Moderate certainty quantitative papers						
Castren[27]	1996/2001	Finland	Prospective study	328 EMS calls reporting non-traumatic OHCA that were witnessed or had bystander-initiated CPR ongoing.	Managing the emergency call; Emotional distress	Moderate
Garza[28]	2000/2003	US	Retrospective Review of EMS Dispatch Data	520 OHCA EMS calls	Managing the emergency call	Moderate
Nurmi[29]	1996/2006	Finland	Prospective Study	776 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call	Moderate
Ma[30]	2004/2007	Tapei	Retrospective Observational Study	301 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call	Moderate
Clawson[31]	2004–2006/2008	United Kingdom	Retrospective Comparative Study - before and after study	2.33 million EMS calls	Key features of the EMS call interaction; Managing the emergency call	Moderate
Roppolo[32]	Unclear/ 2009	United States	Prospective before and after study	962 OHCA patients	Key features of the EMS call interaction; Managing the emergency call	Moderate
Lewis[33]	2011/2013	United States	Retrospective cohort study	590 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call	Moderate
Hardeland[34]	2007–2011/2014	Norway	Observational Study	414 OHCA patients	Key features of the EMS call interaction; Managing the emergency call	Moderate
Travers[35]	2012/2014	France	Prospective Observational Study	144 OHCA patients	Key features of the EMS call interaction; Managing the emergency call	Moderate
Moller[36]	2013/2016	Sweden	Observational Registry Study	930 OHCA patients	Key features of the EMS call interaction; Managing the emergency call	Moderate
Biancardi[37]	Unclear/ 2017	Malta	Simulation study	52 nurses	Key features of the EMS call interaction; Managing the emergency call	Moderate
Mirhaghi[38]	2015/2017	Iran	Content analysis OHCA emergency calls	80 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call	Moderate
Hardeland[55]	2014/2017	Norway	Prospective, interventional study	561 OHCA calls	Key features of the EMS call interaction; Managing the emergency call	Moderate
Riou[39]	2014–2015/2018	Australia	Retrospective Linguistic Analysis	176 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call	Moderate
Derkenne[40]	2012–2018/2020	France	Repeated cross-sectional study	321 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call	Moderate

Table 1 (continued)

High certainty quantitative papers

First Author	Date of data collection/ publication	Country	Design	Number and types of participants	Main themes identified	Quality grade
Mao[41]	2018/2020	Singapore	Prospective before and after study	513 EMS calls for unconscious patients	Key features of the EMS call interaction; Managing the emergency call	Moderate
Schwarzkoph[42]	2014–2018/2020	United States	Retrospective cohort study	3502 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call; Patient colour	Moderate
Stangenes[43]	Unclear/ 2020	United States	Analysis OHCA EMS calls	434 OHCA EMS calls	Managing the emergency call	Moderate
Tamminen[44]	2017/2020	Finland	Descriptive pilot study - retrospective registry study	80 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call; Patient colour	Moderate
Gram[45]	2017–2020/2021	Denmark	A quality assessment study	673 OHCA EMS calls	Managing the emergency call	Moderate
Riou[56]	2014–2015,2021	Australia	Retrospective cohort study	422 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call	Moderate
Low certainty quantitative papers						
Bang[46]	2000–2001/2003	Sweden	Prospective study	100 OHCA EMS calls	Key features of the EMS call interaction; Managing the emergency call; Emotional distress	Low
Bohm[47]	2004–2006/2009	Sweden	Before and after study	570 OHCS EMS calls	Key features of the EMS call interaction; Managing the emergency call	Low
High certainty qualitative papers						
Bang[48]	Unclear/ 2002	Sweden	Qualitative semi-structured interview study	10 Emergency Medical Dispatch staff	Managing the emergency call	High
Riou[49]	2014–2015/2018	Australia	Conversation Analysis	66 OHCA EMS calls	Managing the emergency call	High
Moderate certainty qualitative papers						
Jensen[50]	2009/2012	Canada	Qualitative telephone interview study using the Theory of Planned Behaviour	24 Ambulance Communication Officers	Key features of the EMS call interaction; Managing the emergency call	Moderate
Alfsen[51]	2021/2015	Denmark	Inductive thematic analysis EMS calls	21 OHCA EMS calls	Managing the emergency call; Emotional distress	Moderate
High certainty mixed methods papers						
Hardeland[52]	2013–2014/2016	Norway	Observational study, non-participant observation and in-depth interviews	1095 OHCA EMS calls, Non-participant observations at 3 Emergency Medical Communication Centres, 19 interviews with EMDs	Key features of the EMS call interaction; Managing the emergency call	High
Moderate certainty mixed methods papers						
Watkins[53]	2013–2014/2021	United Kingdom	Mixed methods retrospective study–qualitative call analysis and OHCA data analysis	39,136 EMS dispatches	Key features of the EMS call interaction; Managing the emergency call	Moderate

purple or red. Conversely Mirhaghi et al.[38] removed ‘turning blue’ from their checklist because of a lack of frequency of occurrence, suggesting that there may be ethnic and cultural differences in the way colour change is recognised and reported during an EMS call.

Managing the emergency call

The interaction between the caller and the EMD is vitally important and allows the EMD to triage the EMS call effectively. The EMD may not always interview the caller in the most effective way to elicit identification of OHCA.[26,30,38,43,46,49] Significant differences have been found in the way EMDs adhere to the dispatch protocol[52] and poor adherence to the dispatch protocol has been found to be one of the main reasons why OHCA is not identified.[53,55] Research found simulation training in the management of the emergency call improved OHCA recognition and was useful for performance improvement[25,55].

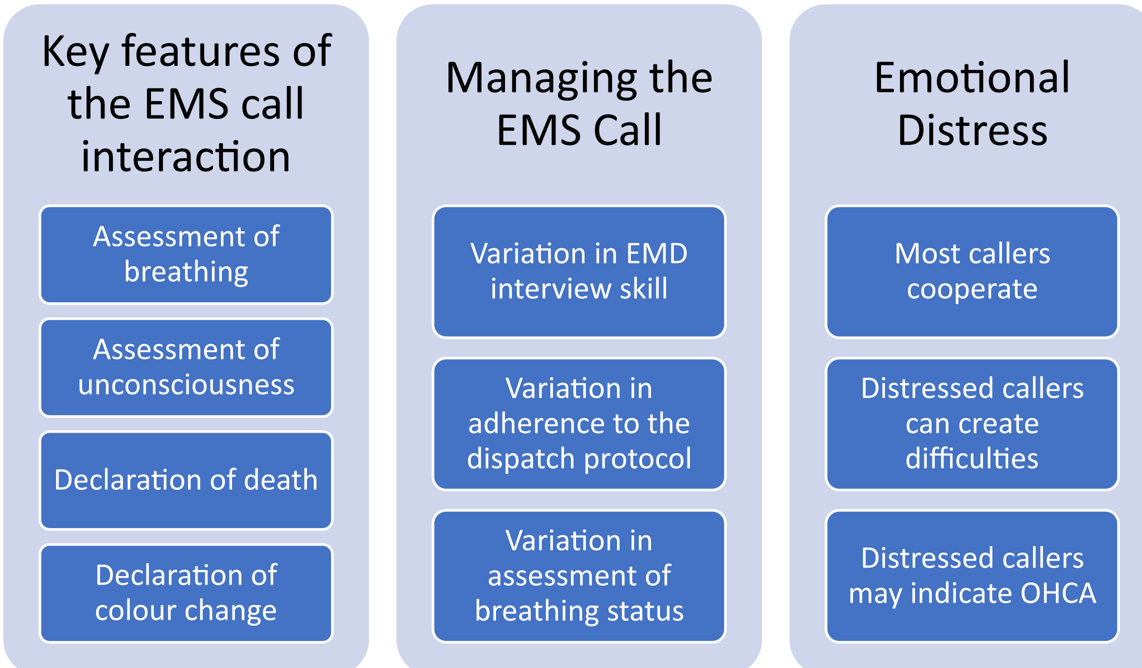


Fig. 1 – Mixed Methods Synthesis of Findings: Main Themes.

Stangenes and colleagues[43] sought to investigate whether the caller reporting a symptom versus a diagnostic condition influences EMD behaviour. The authors found that where the EMD pursued the caller's chief complaint description before investigating breathing and consciousness there was a delay in the recognition of OHCA and the instigation of telephone CPR (tCPR). In a similar way there are significant delays to EMDs asking consciousness and breathing questions in patients who have seizure activity related to OHCA leading to delays in OHCA recognition[42]. The complete omission of questions about a patient's breathing status was found to be a particular issue contributing to non-identification of OHCA during the EMS call.[24,30,46,36] In contrast, Nurmi[29] reported that the dispatch protocol was only followed in relation to consciousness and breathing in 52% of cases, but that OHCA recognition was not higher when the protocol was adhered to. Some EMDs utilise strategies to better clarify breathing status.[48,50,35] The Hand on Belly (HoB) technique for assessing breathing has been found to improve OHCA recognition[40] as has the 10 s interval to assess breathing rate.[32] Gram et al.[45] completed a quality assessment study focussed on the introduction of a 'No,No,Go algorithm' (Not breathing normally, Not awake, Immediate EMS dispatch). The 'No,No,Go algorithm' did not improve time to asking the key questions, but the time to recognition of OHCA did improve.

Where the caller is a healthcare professional the dispatch protocol is less likely to be followed, and OHCA less likely to be recognised.[27] Riou et al.[49] highlight the disruption that caller pre-emption causes during the emergency call and the positive way that some EMDs employ communication techniques that help manage the pre-emption so that vital information is not lost during the call. EMDs have described the inflexibility of the dispatch protocol and a desire to ask additional questions, or to change the ordering of questions based on individual circumstance so that they can better identify OHCA.[50]

Emotional distress

Understandably many callers who contact EMS are distressed. The studies reviewed found that in general callers are calm and cooperative during the EMS call.[26,27,30,46] However, relatives of the patient could only adequately describe what happened in 54% of cases compared to 72% of unrelated callers, where the caller was a doctor or nurse.[27] Chien[26] identified that the rate of OHCA recognition was greatest when the Emotional Content and Cooperation Score (ECCS) was the highest at 5 or 4 (ECCS 5:uncontrollable, hysterical; ECCS 4:uncooperative, not listening, yelling,[57] suggesting that a high ECCS may indicate the presence of OHCA. These findings are supported by Hardeland et al.[52] and Mirhaghi[38] who report that callers convey their emotional response to the EMD indicating where the patient is in a critical condition. Conversely, the emotional response of the caller has been found to create uncertainty for EMDs[46,48,51,52] and make the EMS call very difficult to manage[48] Travers and colleagues[35] found that a calm caller can create a false reassurance and together these findings highlight the difficulties that EMDs face interpreting and navigating EMS calls.

Discussion

This systematic mixed studies review (SMSR) set out to identify and appraise the evidence focussing on the features of the EMS call interaction that enable or inhibit an Emergency Medical Dispatcher's recognition of a patient in out-of-hospital cardiac arrest, or at imminent risk of out-of-hospital cardiac arrest. The SMSR reviewed a broad range of evidence identifying the three main themes: Key features of the EMS call interaction, Managing the emergency call and Emotional distress.

The studies analysed demonstrate variation in practice and results across EMS systems, however a dominant finding included in the theme, "key features of the EMS call" was the importance of (and difficulty in) recognising abnormal/agonal breathing during the EMS call. Qualitative data provides context to this, describing the barriers that EMDs face in interrogating callers and recognising abnormal/agonal breathing. Qualitative data also indicates variability in practice amongst EMDs, with EMDs describing tailoring an approach to the EMS call dependent on the situation presented. It is interesting to note the focus on difficulties determining breathing status over consciousness status in the published research.

The way in which the EMD manages the EMS call is a critical factor in their ability to recognise OHCA and the deteriorating patient. Adherence to the dispatch protocol and the asking of key questions is variable with associated impacts on triage. The manner in which the caller interacts with the EMD effects the approach of the EMD to managing the EMS call and the subsequent trajectory and outcome. In addition, in some EMS systems there are strategies to clarify breathing status with varying levels of success.

The caller's level of emotional distress impacts on the EMD and their assessment of the EMS call. The majority of callers are calm and cooperative, but high levels of emotional distress may indicate an OHCA and calm callers may create uncertainty. A highly distressed caller can make it challenging for the EMD to manage the EMS call in the most effective way.

The research question included patients who are already in OHCA at the time of the EMS call ("recognition studies"), and those patients who are not in OHCA at the time of the EMS call, but who suffer OHCA subsequently ("prediction studies"). Patients at imminent risk of cardiac arrest may be harder to identify, and it can be difficult to distinguish deteriorating and peri-arrest patients from those already in OHCA. When a patient is reported to be breathing abnormally, they could be in OHCA with agonal breathing, or they might not yet have suffered an OHCA and be breathing abnormally for other reasons. The current European Resuscitation Council Guidelines state that where there is an 'unresponsive person with absent or abnormal breathing' they should be assumed to be in OHCA.[58]

Unfortunately, no studies of patients at imminent risk of cardiac arrest ("prediction studies") met the SMSR inclusion criteria. This SMSR therefore comprised studies examining EMD recognition of OHCA where the patient was known to be in cardiac arrest or their status at the time of the call was uncertain ("recognition studies"). Further research could usefully examine the features of an Emergency Medicine System call interaction that enable, or inhibit, a call taker's recognition that a patient who is unequivocally alive during the EMS call is at imminent risk of OHCA. The effective identification of a person at imminent risk of OHCA will allow EMS to respond in an optimum way with the aim of improving survival in this important patient group.

Meta-analysis of quantitative findings and meta-synthesis of qualitative findings in systematic reviews consists of well-established methods for combining results and data across studies.[16] Completing systematic reviews where the results of qualitative, quantitative and mixed methods studies are presented in a single systematic review is relatively new and presents the challenge of data integration between these diverse study types.[16] In SMSRs there is methodological diversity, within and between studies.[15]

A strength of this SMSR is the diverse range of papers included. Papers were included from a range of different regions, cultures and EMS systems. International EMS systems are adapted to local societal, cultural and financial factors[53] and some findings may not be generalisable to alternative cultures and EMS settings. The quantitative papers identified did not lend themselves to meta-analysis due to heterogeneity of studies. Similarly, qualitative papers did not lend themselves to meta-synthesis. The many different types of studies included in this SMSR reflect the wide range of approaches researchers have taken to generate knowledge in this area. Although challenging, it is important to synthesise all available knowledge so that fully evidence-based recommendations can be made.

Due to the heterogeneity of the studies included, the most recent version of the MMAT[23] was used to critically appraise the included papers. The reliability of the previous MMAT (2011 version)[59] has been appraised by Souto and colleagues and Pace and colleagues.[18,60] The appraisal confirmed the MMAT as an efficient tool, but with improvements required in its reliability. Discrepancies were found in reviewers' interpretations of aspects of the tool. Also, some qualitative research papers had limited mention of some items, including the documentation of reflexivity and how findings relate in the context. In this SMSR there was no disagreement between reviewers regarding quality assessment. The MMAT 2018 has been revised to reflect appraisal of the MMAT 2011, but the authors acknowledge the requirement for further testing of reliability and validity in the future.[12]

A quantifiable scale was chosen to score the included papers using the MMAT. However this is discouraged in the MMAT manual, with a preference for reviewers to provide more details of the ratings for each paper.[23] Other SMSR reviewers have set a precedent of scoring using the MMAT in the way that was followed in this review.[19–22] The decision to use quantitative scoring was compensated for by providing detail in the limitations section for each paper recorded in the results, supplementary Tables S3–9.

A limitation to consider is that this SMSR was limited to English language studies. The PRISMA study flow diagram in Appendix Two indicates two papers were excluded because they were non-English, and this data has been lost to this review.

Recommendations for further research

Further research that investigates the EMS call interaction of those patients who are not in OHCA at the time of the call and then deteriorate into OHCA subsequently is required to better understand the features of this patient group, and improve dispatch. Larger studies are recommended that investigate which communication strategies and interventions in which context allow the EMD to interrogate the caller most effectively. EMD training is important, and further research is required to investigate which methods of training are most appropriate to enable EMDs to manage the challenges of triage in this high-risk patient group. This review highlights the relative absence of research focusing on consciousness in OHCA compared to abnormal breathing, with a need for more research in this area.

Conclusions

The first link in the chain of survival; early recognition of OHCA and call for help, is a critical first stage as it enables a sequence of events to be put into action that can ultimately save a person's life. This SMSR reviewed 32 primary research studies. A main finding was the importance of recognising abnormal/agonal breathing and the difficulties that EMDs face in recognising abnormal/agonal breathing during the EMS call.

This SMSR highlights an absence of research examining the EMS call interaction with patients who are not in OHCA when the EMS call is made, but who deteriorate into OHCA subsequently. Recommendations for future research focus on EMD communication strategies, EMD training and the development of interventions that allow EMDs to better predict which patients will deteriorate into OHCA following an EMS call.

Role of the funding source

The lead author, Kim Kirby, is completing a Clinical Doctoral Research Fellowship funded by the National Institute for Health Research in the UK (ICA-CDRF-2018-04-ST2-007). This manuscript is an output from this fellowship funding.

Declaration of conflicts of interest

Conflicts of interest: none.

Source of Support

The lead author is completing a Clinical Doctoral Research Fellowship funded by the National Institute for Health Research in the UK.

Acknowledgements

The authors would like to acknowledge Professor Charles Deakin, Member of the International Liaison Committee on Resuscitation; Professor Judith Finn, Member of the International Liaison Committee on Resuscitation and Dr Benjamin Leong, EMD Researcher and Expert, Singapore for reviewing the results of the systematic review searches. The authors would also like to acknowledge Louise Todd, International Academy of Emergency Dispatch for her advice during the initial stages of this systematic review.

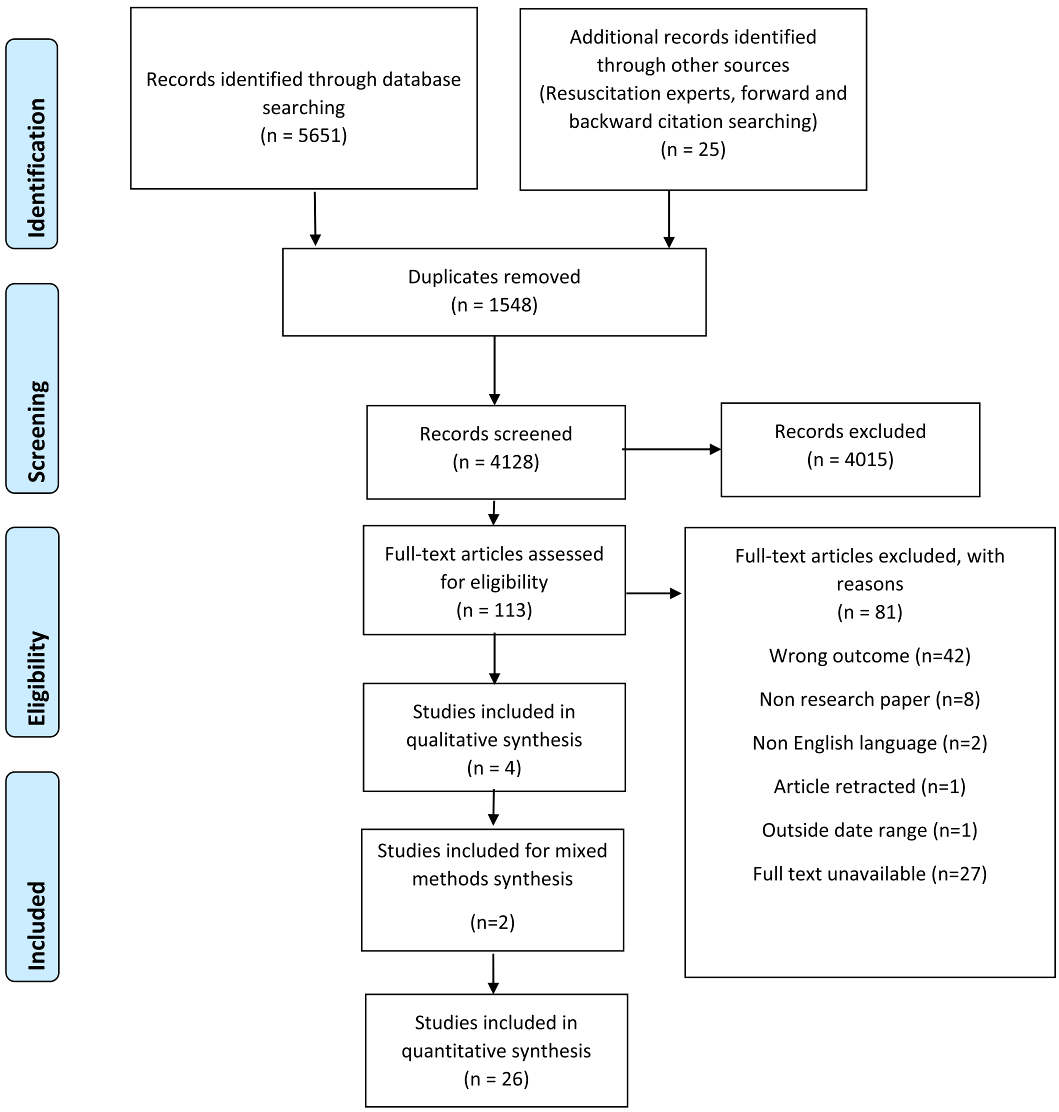
Appendix A

MEDLINE search strategy

Medline Search Strategy May 2021		
1	"HEART ARREST"/ OR "OUT-OF-HOSPITAL CARDIAC ARREST"/	34,081
2	(out-of-hospital cardiac arrest).ti,ab	6,982
3	(out of hospital cardiac arrest).ti,ab	7,467
4	(heart arrest).ti,ab	10,721
5	(out-of-hospital heart arrest).ti,ab	779
6	(out of hospital heart arrest).ti,ab	905
7	(cardiac arrest).ti,ab	39,902
8	(OHCA).ti,ab	2,913
9	(OOHCA).ti,ab	76
10	*(1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9)*	57,295
11	("EMS call").ti,ab	72
12	("Emergency Medical Service call").ti,ab	12
13	("999 call").ti,ab	29
14	("112 call").ti,ab	7
15	("911 call").ti,ab	72
16	("emergency call").ti,ab	469
17	("emergency medical system call").ti,ab	2
18	("emergency medical call").ti,ab	11
19	(dispatch*).ti,ab	3504
20	*(11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19)*	3991
21	*(10 AND 20)*	810

Appendix B

PRISMA study flow diagram



Appendix C. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2021.100173.

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