DOCTOR OF PHILOSOPHY

Development of a Behavioural Marker System for the Non-Technical Skills used by Paramedics managing an Out-of-Hospital Cardiac Arrest

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Development of a Behavioural Marker System for the Non-Technical Skills used by Paramedics managing an Out-of-Hospital Cardiac Arrest

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Final Simulated Testing of the Student Paramedic Out-of-Hospital Cardiac Arrest Tool – POHCAT

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Abstract

Resuscitation guidance advocates the teaching of non-technical skills (NTS) to improve team performance for an out-of-hospital cardiac arrest (OHCA), which is critical to patient survival. To assist in the training and education of NTS, behavioural marker systems (BMS) provide a method for assessment and are common in other areas of healthcare, such as surgery and anaesthetic practice. Despite this, specific NTS have not been identified for the paramedic managed OHCA and no BMS exists. The primary aim of this study was to develop and evaluate a BMS for the paramedic managed OHCA.

A scoping review revealed a paucity of literature related to NTS and an OHCA. This identified a gap and to investigate further a mixed methods approach was used to inform the design and development of a BMS. An initial survey of student and qualified paramedics (n=70) at a central England university was conducted to explore the use of NTS in an OHCA. This was followed by four focus groups of student and qualified paramedics (n=16), which identified five NTS and the effect that an unfamiliar ad hoc team has on the effective management of an OHCA. Four NTS were validated using semi-structured interviews of subject matter experts, all with experience in prehospital medicine, NTS and OHCA management (n=7), before triangulation was performed to integrate the results of a narrative literature review of comparable BMS with the previously collected data. These results informed the design of the prototype Paramedic Out-of-Hospital Cardiac Arrest Assessment Tool (POHCAAT). It consists of four NTS categories: team coordination; situation assessment; communication; decision-making; each supported by three sub-components (elements) of each NTS category, behavioural markers, and a rating scale. Two evaluation phases were performed to measure the reliability, validity, and usability of the POHCAAT. After completing a day long workshop and two-hour online refresher session, a selection of HEMS clinicians, university staff and advanced paramedics all experienced in NTS and OHCA management acted as novice raters (n=25). The raters, using the POHCAAT across the two evaluation phases, observed a range of simulated OHCA scenarios. Preliminary results indicated an overall good

Cronbach's α (0.85-0.93) but with noted item duplication, a moderate level of inter-rater reliability for each NTS category (ICC 0.53-0.70), a moderate level of absolute agreement (ICC 0.44-0.67), as well as the ability to distinguish between poor and good behaviour. Following the preliminary evaluation, the POHCAAT was modified to improve the design, with results indicating a reduction in item duplication and an acceptable/good level Cronbach's α (0.71-0.81). Inter-rater reliability was measured as moderate-good for each NTS category (ICC 0.69-0.84), with substantial to almost perfect levels of agreement (ICC 0.69-0.84). Sensitivity was improved with raters able to distinguish poor – acceptable – good behaviour, and consistent test-retest results (ICC average for paired films 0.96-0.98), raters commenting that the POHCAAT was easy to use and applicable to practice.

This research has resulted in the identification of specific NTS for the paramedic managed OHCA, which has resulted in the development of a reliable, valid, and usable BMS that works well in simulated practice. Recommendations include the integration of the POHCAAT into undergraduate paramedic programmes and ambulance trusts as a method for training in the assessment of NTS in a paramedic led simulated OHCA. This will allow further evaluation to assess the generalisability of the POHCAAT's ability to provide structured feedback for a range of ambulance clinicians.

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Glossary

Term	Definition
Advanced Life Support (ALS)	A set of life-saving clinical algorithm and skills that extend beyond ILS/BLS, including CPR, defibrillation, advanced airway management including ETI or i-gel, IV/IO access drug administration
Advanced Paramedic (AP)	Qualified, HCPC registered paramedic with advanced level of clinical practice in terms of assessment, clinical decision making and diagnosis and have completed, or are working towards, a master's degree in Advanced Practice
Associate Ambulance Practitioner (AAP)	Ambulance apprenticeship, works as part of an ambulance crew responding to emergency (999) and urgent calls, providing emergency and urgent assistance, and driving safely, limited clinical interventions and ability
Automated External Defibrillator (AED)	A portable electronic device that automatically diagnoses life-threatening shockable heart rhythms and delivers a shock, can be used by the public and healthcare professionals
Basic Life Support (BLS)	Provided by public/health professionals including basic airway opening and clearance, ventilations, and chest compressions
Behavioural Marker System (BMS)	A framework that sets out observable, non-technical behaviours that contribute to superior or substandard performance within a work environment
Cardiopulmonary Resuscitation (CPR)	Combination of chest compressions and rescue breaths to pump blood around a person's body whose heart has stopped beating

Clinical Algorithms	A detailed step-by-step set of instructions of clinical tasks and decision-making to be performed by a clinician
Communication	The sharing and delivery of information within teams, to the public, and onward medical care using verbal and non-verbal methods with consideration to timing
Continuing Professional Development (CPD)	A method for healthcare professionals to continue their learning and development throughout their careers, keeping their skills and knowledge up to date to enable safe and effective practise
Crew Resource Management (CRM)	The effective use of all available resources for personnel to assure a safe and efficient operation, reducing error, avoiding stress, and increasing efficiency
Critical Care Paramedic (CCP)	Qualified, HCPC registered paramedic typically works on HEMS unit, response car and in-hospital. Perform interfacility transports, and emergency response for the very sick and injured. Have an expanded scope of practice including wider range of clinical interventions and medications, have completed, or are working towards, a master's degree in critical care and trauma
Decision-making	The process of making choices to reach a judgement when dealing with evolving, complex situations, by identifying decisions, gathering information, and assessing alternative options
Emergency Medical Technician (EMT)	Like an AAP and ACA/ECA they work with paramedics as part of an emergency ambulance crew, but have a wider range of clinical skills and

	scope of practice including limited range of drug administration
Emergency/Ambulance Care Assistant (ECA/ACA)	Work with EMTs and paramedics as part of an emergency ambulance crew in a support role. Role includes completing documentation, communication, and driving, limited clinical skills/scope of practice
Endotracheal Intubation (ETI)	Placement of a flexible plastic tube into the trachea to provide and maintain a secure airway
Finger thoracostomy	The small incision of the chest wall for the treatment of a tension pneumothorax. Releases trapped air/liquid from the space between the lung and chest wall, allowing the lung to re-expand
Followership	The ability or willingness to follow a leader, compliments and supports a leader, independently thinks, and challenges when needed
Helicopter Emergency Medical Service (HEMS)	Primarily charity run service that provides additional out-of-hospital clinical expertise and support. Consists of specialist doctors and critical care paramedics who provide enhanced clinical care and are trained in crew resource management
Human Factors	A scientific discipline to understand human interaction with other humans, equipment, organisations, and system design to ensure optimal performance and patient safety
i-gel	Supraglottic airway device that provides an airtight seal in the airway to assist with ventilations
Intermediate Life Support (ILS)	The same as BLS but includes defibrillation (manual and/or AED) and considers the cause of an OHCA

Intramuscular Access (IM)	Insertion of a needle into a muscle to deliver a range of drugs
Intraosseous Access (IO)	Insertion of hollow needle into bone to provide drug administration route
Intravenous Access (IV)	Insertion of needle and plastic tube into a vein to provide drug administration route
Leadership	The ability of an individual to influence and guide others, motivates, guides, supports and allocates tasks, directs others, delegates
Negative culture	The ideas, customs, and social behaviour of people, teams, organisations, or society. Can include a lack of motivation, harassment, lack of support, distrust, disregard for rules/policy/procedure, lack of commitment, disrespect, and egotistical behaviour
Non-Technical Skills (NTS)	Cognitive, social, and personal resource skills that complement technical skills, and contribute to the safe and efficiency task performance
Objective Structured Clinical Examination (OSCE)	A clinical skills assessment method that is based on objective testing and direct observation of student performance
Out-of-Hospital Cardiac Arrest (OHCA)	The severe reduction/cessation of breathing and cardiac output, resulting in a loss of pulse. May include a shockable or non-shockable heart rhythm. Occurs in a public/private place
Paramedic	A qualified, HCPC registered (protected title), independent healthcare professional who provides specialist care and treatment typically to people out of hospital who are either acutely ill or injured. They can perform a range of clinical skills with expertise in dealing with critically ill and injured patients using complex equipment and a range of

	medications whilst getting the patient to the right hospital for their ongoing treatment
Recognition of Life Extinct (ROLE)	Guidance for qualified paramedics on when, and when not to perform or discontinue CPR and ALS on patients
Return of Spontaneous Circulation (ROSC)	Spontaneous return of a palpable pulse resulting in a sustained heart rhythm that perfuses the body after a cardiac arrest
Scope of Practice	The limit of a paramedic's knowledge, skills, and experience, varies dependent on role, links to the HCPC standards of proficiency and standards of conduct, performance, and ethics
Situation Assessment	The process of understanding the needs and conditions of a scene and team to inform decisions and plan. Information gathering from the scene, patients, bystanders, other clinicians, making sense of the scene, uses knowledge and understanding of clinical algorithm to inform decisions
Situation Awareness	Information gathering, processing and comprehension combined with anticipation of future events to assist with decision-making
Subject Matter Expert (SME)	A person who possesses a deep understanding and expertise of a particular subject
Specialist Paramedic (SP)	Paramedics with additional education and training equipped for greater patient assessment and management skills. They can diagnose a wide range of conditions and treat many minor injuries and illnesses
Student Paramedic	A person studying full or part time on an approved university or apprentice BSc programme to become a qualified, HCPC registered paramedic.

	Can work as part of an ambulance crew as an AAP or in a supernumerary position as a full-time student. Can only perform certain clinical skills under direct supervision
Supraglottic Airway Device (SGA)	An airway device that can be inserted into the pharynx to allow ventilation and oxygenation, without the need for endotracheal intubation
Task Management	The management of resources and the organisation/planning of tasks to achieve goals
Team Coordination	The coordination and integration of a team, tasks, patient care, adaptability, and flexibility of roles to achieve a shared goal, shared responsibility, application of clinical knowledge to aid patient care, and management of tasks
Team Performance	The extent to which a team can meet its common goals with a collective responsibility for effectiveness
Teamwork	Effective working together of a group of people towards a shared goal

Abbreviations

ACA	Ambulance Care Assistant
AeroNOTS	Aero-Non-Technical Skills
ALS	Advanced Life Support
ANT-AP	Anaesthetic NTS-Anaesthetic Practitioners
ANTS	Anaesthetists Non-Technical Skills
AP	Advanced Paramedic
AAP	Associate Ambulance Practitioner
BSc	Bachelor of Science degree
BLS	Basic Life Support
BMS	Behavioural Marker System
CCP	Critical Care Paramedic
CPD	Continuing Professional Development
CPR	Cardiopulmonary Resuscitation
CRM	Crew Resource Management
ECA	Emergency Care Assistant
ECG	Electrocardiogram
EMS	Emergency Medical Service
EMT	Emergency Medical Technician
ETI	Endotracheal Intubation
FHEQ	Framework for Higher Education Qualifications
HART	Hazardous Area Response Team
HEMS	Helicopter Emergency Medical Service
ICC	Intra-class Correlation Coefficient
ILS	Intermediate Life Support

IMCBRS	Immediate Medical Care Behaviour Rating System
IM	Intramuscular Access
IO	Intraosseous route
IPO	Input-Process-Output
IQR	Inter Quartile Range
IRA	Inter-Rater Agreement
IRR	Inter-Rater Reliability
IV	Intravenous access
KMO	Kaiser-Meier-Olin
MSc	Master of Science degree
NOTSS	Non-Technical Skills for Surgeons
NTS	Non-Technical Skills
OHCA	Out-of-Hospital Cardiac Arrest
PGDip	Post Graduate Diploma
POHCAAT	Paramedic Out-of-Hospital Cardiac Arrest Assessment Tool
ROLE	Recognition of Life Extinct
ROSC	Return of Spontaneous Circulation
SGA	Supraglottic Airway Device
SME	Subject Matter Expert
SPLINTS	Scrub Practitioners List of NTS

Chapter 1 - Introduction

The chapter introduces the rationale for the topic of this study, the development of a behavioural marker system (BMS) to assess the non-technical skills (NTS) of a paramedic when managing an out-of-hospital cardiac arrest (OHCA). It begins with an overview of the thesis, including the aim, research question, and a summary of the research design and structure. This is followed by the contextual background of a paramedic managed OHCA, including the fundamental characteristics of an OHCA, current strategies to improve team performance and use of NTS. This chapter concludes with the concept of BMS in healthcare and the considerations needed to develop a BMS for a paramedic managed OHCA.

1.1 Overview of the Thesis

This thesis seeks to contribute new knowledge in the form of a BMS specific to the paramedic management of an OHCA. The overarching aim is to develop a reliable, valid, and usable BMS to assess the NTS used by paramedics when managing OHCA. It is supported by the following key objectives:

1. Identify specific NTS associated with a paramedic managed OHCA
2. Validate and integrate research findings to create a taxonomy for a paramedic managed OHCA BMS
3. Develop and evaluate a prototype BMS
4. Provide recommendations for the use of a Paramedic OHCA BMS

Using a mixed methods approach, this thesis is divided into three separate phases: research, design, and evaluation, all aimed at answering a single research question. Essential to the study design, a research question informs and directs a study's aims, objectives, and overall strategy (Sackett & Wennberg, 1997). It must be clear, logical, testable, feasible, and manageable (Ratan et al., 2019). Figure 1.1 presents a visualisation of the research process with data collected sequentially, starting with the research question; 'Can a behavioural marker system reliably evaluate the non-technical skills of paramedics managing a simulated out-of-hospital cardiac arrest?'.

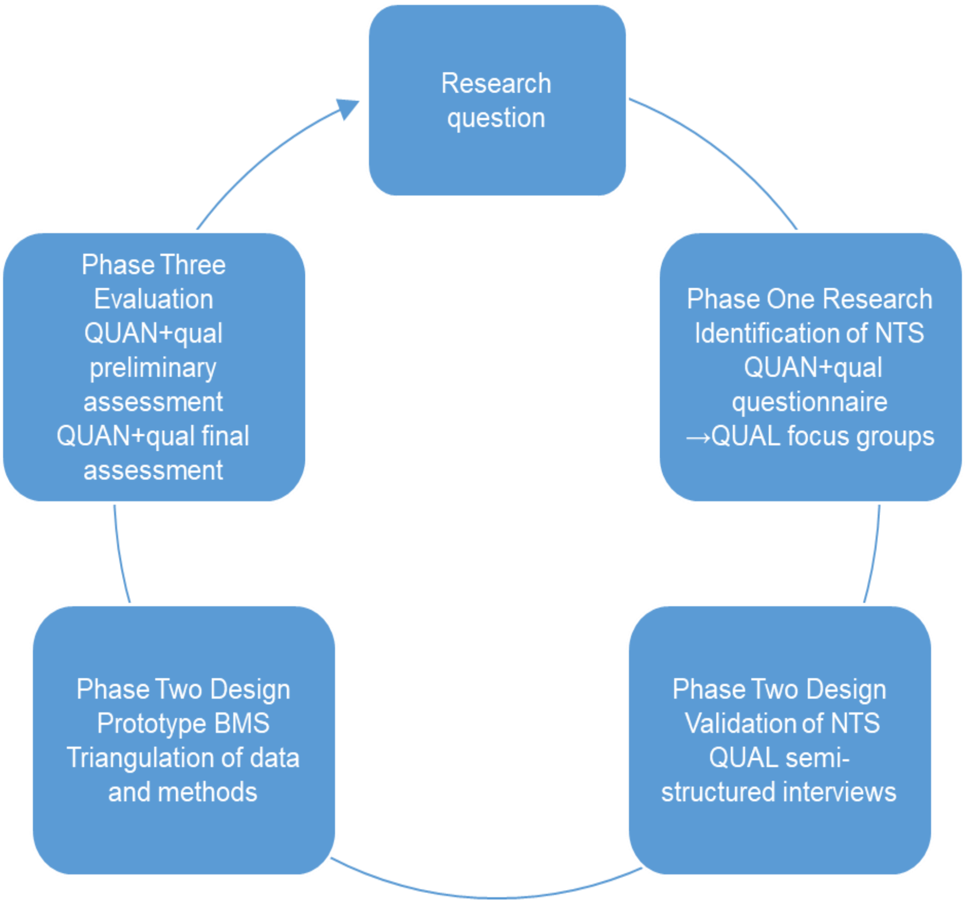

Figure 1.1 Mixed-method process (uppercase denotes emphasis on data collection method, arrow indicates sequential method)

To develop a reliable, valid, and usable BMS that can assess the NTS used by paramedics when managing OHCA, a sequential approach to data collection and analyses was used. With each phase informing the next, this process concluded with a final evaluation of the prototype BMS. Each phase is explained below, with a summary of the objective, rationale, and methods used. Chapter three provides a detailed explanation of the theoretical and methodological consideration that informed this study.

- Research Phase One Objective: explore student and qualified paramedics views of which NTS are considered specific to managing an OHCA. Explain the difficulties associated with a paramedic managed OHCA.
    - Rationale: the management of an OHCA is dynamic and complex, with teams rapidly formed on an ad hoc basis. The use of NTS by paramedics managing an OHCA have not previously been investigated.
    - Methods: cross sectional survey of student and qualified paramedics (undergraduate and postgraduate students). Followed by focus groups of student and qualified paramedics.
- Design Phase Two Objective: validate the specific NTS identified in research phase one to develop a NTS taxonomy. Integration of data and methods from research phase one with phase two semi-structured interviews and a narrative literature review of comparable published behavioural marker systems to design a prototype BMS.
    - Rationale: ensure the NTS identified were accurate and applicable. Subject matter experts were used based on their specialist

knowledge, understanding and significant experience. Triangulation provides a robust method to integrate a range of data and methods, strengthening the process.

  - Methods: Semi-structured interviews of subject matter experts. Use of a triangulation protocol based on Farmer et al (2006) work to integrate data and methods.

- Evaluation Phase Three Objective: Perform preliminary and final evaluations of BMS to measure reliability, validity, sensitivity, and usability.
  - Rationale: To identify if the prototype BMS could reliably rate the observed NTS of student paramedics managing a simulated OHCA. Results and feedback of the preliminary evaluation inform a revised BMS.
  - Methods: Use of recorded and live simulated OHCA scenarios observed by trained raters using prototype BMS to assess NTS. Statistical analysis to measure reliability, consistency, validity, and usability. Survey and semi-structured interviews of participants to provide comprehensive feedback and analysis.

This thesis is divided into eight chapters, with chapter one providing an introduction and background to the thesis: the paramedic managed OHCA. It also includes a summary of current practice, NTS, and BMS. Chapter Two presents the scoping review, including the search process, mapping and evaluation of the published literature associated with NTS, cardiac arrest management and their application to a paramedic managed OHCA.

Chapter three contains the theoretical and methodological considerations, and frameworks that informed the study design. It also includes the rationale for the methodology used for data collection and analyses. Chapter four comprises research phase one: questionnaire and focus groups to explore the NTS used by paramedics when managing an OHCA. It offers a detailed explanation and justification of the research phase as well as the ethical considerations, data collection and analysis before presenting the statistical and textual results. It also provides a discussion based on the questionnaire and focus group findings. Chapter five encompasses the design and development phase of prototype BMS. It describes and explains the methods used for data collection and analysis to validate the NTS taxonomy, as well as a narrative literature review of out-of-hospital BMS to complete the triangulation process to integrate a range of data, resulting in the prototype BMS.

Chapter six moves on to the evaluation phase that includes the preliminary and final evaluations of the prototype BMS. It includes details of the methods used to collect and analyse the statistical and textual results, including sensitivity, reliability, validity, and usability before a discussion of the key findings. Chapter seven presents the overall discussion, building on the preceding individual chapter discussions. It includes the interpretation of the key findings in relation to the relevant literature and difficulties associated with the paramedic managed OHCA presented in chapter one. It also includes recommendations for research and education, as well as the implications for paramedic practice. The final chapter offers a conclusion, restating the research problem, aim and question. It presents a summary of the main findings associated with the research aim, concluding with the study's contribution to research.

1.2 Characteristics and Definitions of an Out-of-Hospital Cardiac Arrest

The British Heart Foundation (n.d.) define an OHCA as when 'a person's heart stops pumping blood around their body, and they stop breathing normally'. This unexpected reduction in circulating blood results in collapse, ineffective breathing and if left untreated, death. Causes range from cardiac muscle damage and electrical conductivity problems to traumatic injuries resulting in a lack of oxygen reaching the brain (Myat et al., 2018). The most recent UK figures report that there are approximately 60,000-recorded cases of an OHCA, with resuscitation attempts by paramedics varying between 30,000-40,000 per year (Out of Hospital Cardiac Arrest Outcomes Project Team, 2019; The National Confidential Enquiry into Patient Outcome and Death, 2021).

Declared as 'a significant public health issue in the UK' (Out of Hospital Cardiac Arrest Outcomes Project Team, 2019, p.13), it is critical that medical assistance and treatment is provided as soon as possible. However, survival rates are low, with an average of one in ten surviving to discharge from hospital. Strategies for improvement include the chain of survival, which provides guidance for the public and medical professionals on a series of actions designed to contribute to a successful outcome (Cummins, 1993). Shown in figure 1.2 the current chain of survival includes the early recognition of an OHCA and call for the emergency services, coupled with early cardiopulmonary resuscitation (CPR) and defibrillation, followed by effective advanced life support (ALS), culminating in integrated post-resuscitative care (Institute of Medicine, 2015). These steps include the early recognition and call for help when someone has suffered a cardiac arrest. The focus moves then to good quality, continual chest compressions and the timely delivery of shocks using a defibrillator. Members of the public, as well as ambulance clinicians can perform these tasks. Yet, the management of the airway, administration of drugs by qualified paramedics and movement of the patient can sometimes result in interruptions in chest compressions, as there is not always enough staff to perform continual chest compressions, which have been evidenced as reducing the chances of survival (Dagnell, 2020).

Figure 1.2 Chain of Survival. Note. From Out-of-hospital Chain of Survival, by American Heart Association, 2021 (https://cpr.heart.org/en/resources/cpr-facts-and-stats/out-of-hospital-chain-of-survival).

The fourth part of the chain focuses on the delivery of effective ALS, provided in the UK by qualified paramedics, an individual who has successfully completed an approved educational programme and is registered with the Health and Care Professions Council (HCPC). The HCPC regulate the profession, providing standards of proficiency, and conduct, performance, and ethics (Health and Care Professions Council, 2014, 2016). Although not clinically focused, these standards incorporate elements of NTS to ensure safe, legal, and ethical practice.

In the UK, an ambulance response to an OHCA typically results in the attendance of a solo-qualified paramedic in an emergency response car and an emergency ambulance consisting of an additional qualified paramedic and an emergency medical technician (EMT) or an associated ambulance practitioner (AAP). Frequently the ambulance crew also comprises a university student paramedic as they attend clinical practice placement in a supernumerary capacity (McClelland et al., 2016). But this response can vary depending on the location of the patient and call pressures (Pilbery et al., 2019; Fisher, 2020), resulting in a range of between two to six ambulance clinicians all with different clinical competencies and experience. In addition to ambulance clinicians, an OHCA can also include members of the public, family, and police and fire officers, which can increase the numbers of people to manage and direct. As a result of operational demand and local responses that could include lay people performing CPR, an OHCA team forms in an ad hoc manner. Ambulance clinicians respond from different locations, arriving at varying times resulting in a team that needs to adapt, especially as more resources arrive, with table 1.1 presenting the characteristics of common ambulance clinicians who respond to an OHCA with qualified paramedics further subdivided into specialist clinical roles.

Table 1.1 Characteristics of UK ambulance clinicians managing an OHCA (adapted from College of Paramedics Career Framework 2020)

Role/Title	*OHCA clinical skills*	*Education*	*Mode of transport and number of clinicians*
Critical Care Paramedic (CCP)	ALS, IV/IO access, advanced airway management (SGA/ETI), including surgical airway and ventilation, finger thoracostomy, manual defibrillation, ECG interpretation, CPR, drug administration including post ROSC sedation and vasopressors, clinical supervision/guidance	BSc/MSc HCPC registered HEMS course Level 3 Certificate in Emergency Response Driving	Helicopter (two individual clinicians) Emergency Response car (one clinician)
Advanced Paramedic (AP)	ALS, IV/IO access, advanced airway management and ventilation (SGA/ETI), manual defibrillation, ECG interpretation, CPR, drug administration, clinical supervision	BSc/MSc HCPC registered Level 3 Certificate in Emergency Response Driving	Emergency Response car (one clinician) Emergency Ambulance (two individual clinicians)
Specialist Paramedic (SP)	ALS, IV/IO access, advanced airway management and ventilation (SGA/ETI), manual defibrillation, ECG interpretation, CPR, drug administration including antibiotics	BSc/PGDip HCPC registered Level 3 Certificate in Emergency Response Driving	Emergency Response car (one clinician) Emergency Ambulance (two individual clinicians)
Paramedic	ALS, IV/IO access, advanced airway management and ventilation (SGA/ETI), manual defibrillation, ECG interpretation, CPR, drug administration	BSc HCPC registered Level 3 Certificate in Emergency Response Driving	Emergency Response car (one clinician) Emergency Ambulance (two individual clinicians)

Table 1.1 Continued…

Role/Title	*OHCA clinical skills*	*Education*	*Mode of transport and number of clinicians*
Student Paramedic	ALS, IV/IO access, advanced management, and ventilation (SGA), manual defibrillation, ECG interpretation, CPR (all under supervision of paramedic/mentor)	Full time student working towards BSc (mix of clinical practice placements and academic work)	Emergency Ambulance (supernumerary position, can work on emergency ambulance or emergency response car)
Emergency Medical Technician (EMT)	ILS, airway management and ventilation (SGA), manual defibrillation, basic ECG interpretation, CPR	Level 5 Diploma in First Response Emergency and Urgent Care Level 3 Certificate in Emergency Response Driving	Emergency Ambulance (two individual clinicians)
Associate Ambulance Practitioner (AAP)	ILS, basic airway management and ventilation, manual defibrillation, basic ECG interpretation, CPR (under supervision of paramedic/mentor or EMT)	Level 4 Diploma in Associate Ambulance Practitioner Level 3 Certificate in Emergency Response Driving Apprentice route (part time study) working towards BSc (mix of clinical practice placements and academic work)	Emergency Ambulance (two individual clinicians)
Emergency/ Ambulance Care Assistant (ECA/ACA)	BLS, basic airway management and ventilation, automated defibrillation, CPR (under supervision of paramedic or EMT)	FutureQuals level 3 diploma or Level 4 Certificate in First Response Emergency Care Level 3 Certificate in Emergency Response Driving	Emergency Ambulance (two individual clinicians)

Yet it is only HCPC registered qualified paramedics who can legally perform certain independent clinical interventions, such intravenous (IV) or intraosseous (IO) access and drug administration. This emphasises the need for a team approach to managing an OHCA, as there is minimal time for briefing and challenges to attaining 360-degree patient access. As the OHCA evolves and more ambulance clinicians arrive, there is a need to ensure clinical interventions such as chest compressions or ventilations are completed in a timely fashion (see figure 1.3 typical OHCA scenario), with resuscitation algorithms used to aid decisions (see figure 1.4).

Figure 1.3 Typical presentation of OHCA (simulated) scenario (Authors personal collection, 2017)

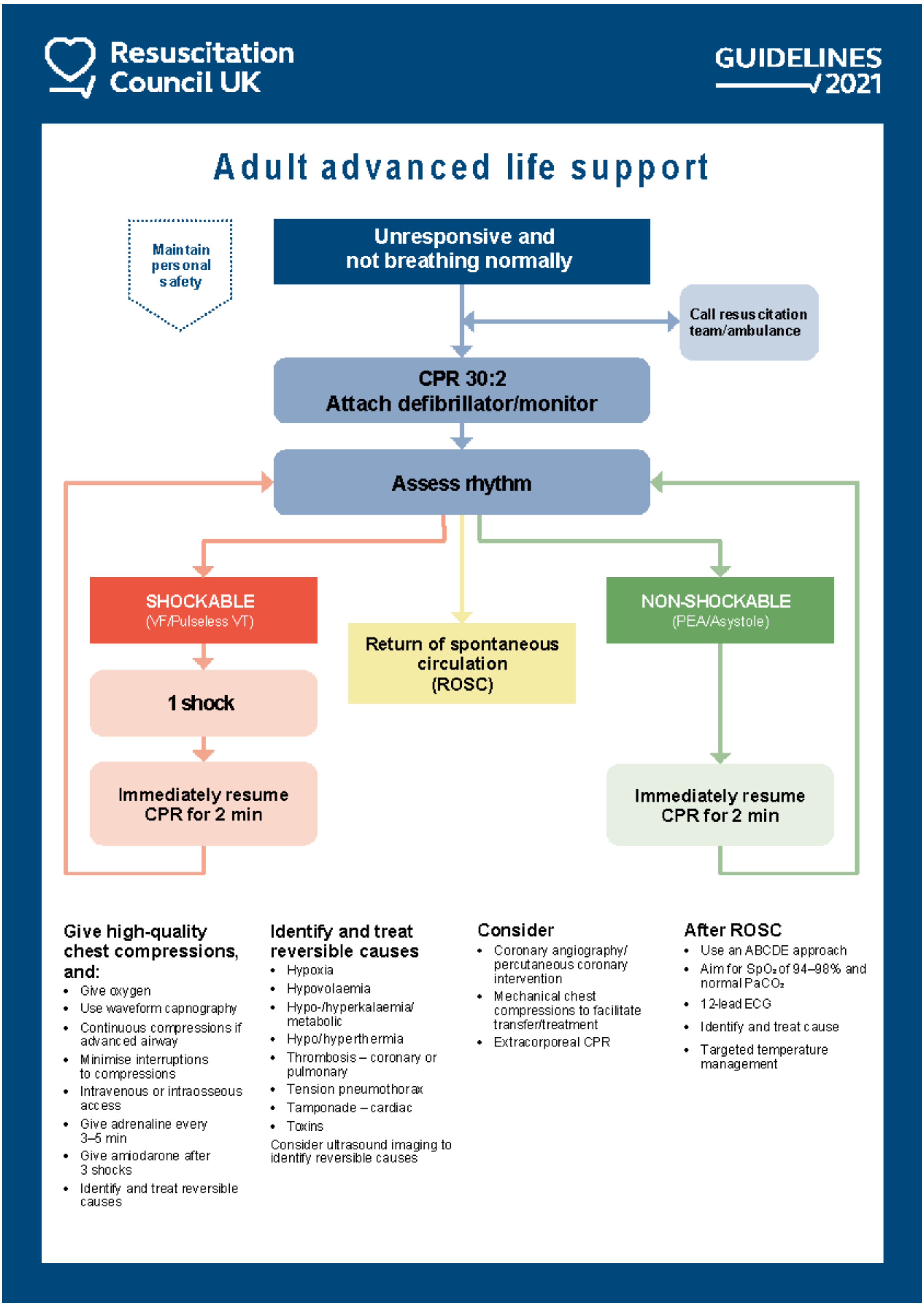

Figure 1.4 Advanced Life Support (ALS) Clinical Guidelines for cardiac arrest management. Note. From Adult Advanced Life Support Algorithm 2021, by

Resuscitation Council (UK), 2021a (https://www.resus.org.uk/sites/default/files/2021-04/Adult%20Advanced%20Life%20Support%20Algorithm%202021.pdf).

Although the ALS algorithm provides a structured method to aid decisions, the supporting text at the bottom of figure 1.4 emphasises the ongoing considerations needed, including the cause of the cardiac arrest, emergency and definitive treatment options, and the management of post cardiac arrest.

Despite clear clinical guidance for the management of an OHCA, an increased public awareness and the expansion of accessible defibrillators in the community (Perkins et al., 2016), UK survival rates remain low, at approximately 8-9% (Rajagopal et al., 2017). However, if the chain of survival is optimised and paramedics can commence CPR and defibrillation within minutes of their arrival, the chances of survival can increase to 40% (Out of Hospital Cardiac Arrest Outcomes Project Team, 2019, p.25). Nevertheless, The National Confidential Enquiry into Patient Outcome and Death (2021) suggests that there is limited OHCA data for the fourth link of effective ALS, and this may be a weakness in the chain.

Effective ALS may be reduced by low paramedic exposure rates to an OHCA, with literature indicating that paramedics respond to <5 OHCA per year (Clarke et al., 2014; McClelland et al., 2016). This is further compounded by low ambulance trust retention rates, with many UK qualified paramedics leaving an ambulance trust after five years to work in other healthcare areas, such as emergency departments and general practice (National Audit Office, 2017). In addition, the unpredictable nature of an OHCA appears to contribute to a lack of consistency in paramedic management.

No OHCA is the same, despite the standardised ALS algorithm (see figure 1.4), differences in the location, patient position, aetiology of the cardiac arrest, environment, and numbers of clinicians attending results in disparity (Brandling et al., 2017). There appears to be a need to improve the fourth link of effective ALS, and the use of simulated OHCA scenarios to assess paramedic NTS could provide a method to enhance effective team performance (Cooper et al., 2010a). Having discussed the incidence, characteristics, and definition of an OHCA, it is necessary to explain the paramedic management of an OHCA.

1.3 Paramedic Management of an Out-of-Hospital Cardiac Arrest

As of 2021 there were approximately 31,000 qualified paramedics (Health and Care Professions Council, 2021) in the UK and although there are different routes of education, all include the education and training in the delivery of ALS (College of Paramedics, 2019a). This comprises a range of coordinated clinical interventions such as advanced airway management, intravenous access, and intraosseous access (both involve the placement of a needle to access a patient's bloodstream for drug administration). It also requires the application of knowledge, the understanding of clinical algorithms, the timely delivery of the correct resuscitation drugs as well as the identification and treatment of reversible causes (Soar et al., 2021).

Yet, despite clinical guidance and training, the effectiveness of ALS has been challenged, with evidence suggesting that long-term survival rates are not improved by ALS (Jacobs et al., 2011; Tiah et al., 2014; Jentzer et al., 2016). It has been suggested that this is related to poorly performed clinical interventions such as endotracheal intubation (ETI), the process of placing a tube in a person's airway to facilitate ventilation. This complex intervention requires at least two competent clinicians such as a qualified paramedic and student paramedic/EMT/AAP, a range of equipment and good access to a patient's airway. Often performed in sub-optimal conditions, with locations including residential bathrooms and kitchens, the positions and location of the patient can make clinical intervention more difficult. It has also been established that there is poor recognition of incorrect placement, and long pauses in chest compressions when performed by paramedics (Benger et al., 2018). Yet it should be recognised that many clinical interventions are not performed in optimal conditions. An OHCA is considered as a stressful case, and the time constraints and challenging environments can make clinical interventions difficult. This then emphasises the need for effective teamwork, decision-making, and communication (Perona et al., 2019).

Despite the use of clinical algorithms by paramedics to aid decision-making, Brandling et al. (2016, 2017) established that interpersonal factors confound decision-making, resulting in poor communication and deviation from clinical algorithms. This disruption may contribute to errors, reducing the efficacy of ALS. It has long been established that a poorly performing team is linked to higher rates of errors (Barrett et al., 2001; Manser, 2009). In relation to an OHCA, errors include miscommunication, and a poor knowledge of clinical guidelines and equipment that result in poor ALS algorithm adherence and CPR quality (Panesar et al., 2014; Hinski et al., 2016). Low exposure rates also appear to contribute to skill fade, which amplifies errors (Smith et al., 2013; Brandling et al., 2017). Similar issues have been identified in the management of in-hospital cardiac arrests with results indicating that poor team dynamics, ineffective leadership and task overload reduce the quality of management (Norris & Lockey, 2012).

To reduce error and improve a paramedic managed OHCA, training in high-performance CPR is suggested (Lindner et al., 2011). This consists of regular training and the use of CPR feedback devices to provide performance evaluation on the quality of chest compressions. The application of 'Pit-stop CPR' also aims to reduce interruptions to chest compressions during a cardiac arrest by performing ALS in a choreographed way (Eisenberg et al., 2015). Adapted from in-hospital patient handover techniques influenced by the Formula 1 pit stop team system (Catchpole et al., 2007, 2010), there has been an acceptance in many UK ambulance trusts as a method to increase efficiency, providing a structure to paramedic teams managing an OHCA.

As presented in figure 1.5, a pit stop approach relies on 360˚ access to the patient, a minimum of four to six experienced ambulance clinicians, comprising of qualified paramedics, EMTs, and student paramedics (see table 1.1 for characteristics), working in designated roles to achieve a 'smooth, organised and strictly structured' response (Pemberton et al., 2019, p.4).

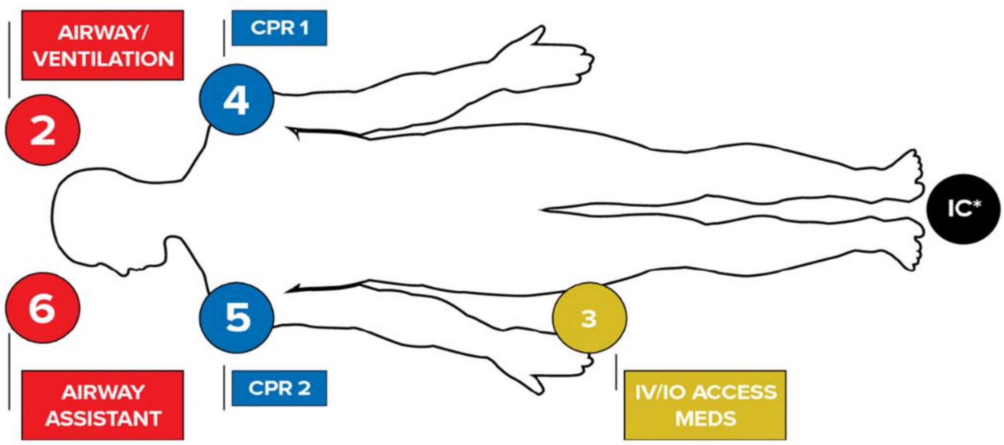

Figure 1.5 Example of pit stop positions and roles. Note. Adapted from The In-hospital Implementation of the Pit Crew Resuscitation Model, by J. Colquitt, A Walker, & N. Haney, 2017, (https://citizencpr.org/wp-content/uploads/2018/01/The-In-Hospital-Implementation-of-the-Pit-Crew-Resuscitation-Model.pdf).

Nevertheless, it has been suggested that the concept of pit stop CPR does not fully account for the complexities of OHCA management in the UK (Cormack et al., 2020a). As the majority of OHCA in the UK occur within a private residence (Out of Hospital Cardiac Arrest Outcomes Project Team, 2019) there is limited access to the patient and the ad hoc team formation, varying in number of ambulance clinicians from two to six, can result in difficulty achieving a true pit stop approach (see figure 1.3). Evidence to support its effectiveness in a paramedic managed OHCA is limited (Gonzales et al., 2019). Although Hopkins et al. (2016) established that while a pit stop approach can result in dedicated task allocation without the need for a team leader, other interventions such as CPR data feedback and a change in out-of-hospital and in-hospital life support protocols appear to be influential to survival outcome rather than task allocation alone. This correlates with Friesen et al. (2015) who suggest that although a pit stop approach could be beneficial, survivability is more likely to be associated with age, presenting rhythm and the occurrence of bystander CPR.

Still, there is an indication that an effective team improves communication, and the quality of CPR (Freytag et al., 2019). In response, some UK ambulance services have introduced a tiered approach, utilising specialist paramedics trained in NTS (Clarke et al., 2014; McClelland et al., 2016; Pilbery et al., 2019). Focusing on leadership, communication, and decision-making the use of such teams is feasible (Clarke et al., 2014). Despite unclear training procedures and the small numbers of specialist paramedics, improvements in the rate of return for a pulse (also known as a return of spontaneous circulation - ROSC), and survival rates were noted. However, due to operational pressures it appears these specialist teams are not routinely established across the UK (McClelland et al., 2016; Pilbery et al., 2019). Already indicated as beneficial for in-hospital cardiac arrest teams (Gabr, 2019), specific training and use of NTS for a paramedic managed OHCA could be valuable and a more detailed account of what is a NTS and their use in healthcare is provided in the next section.

1.4 Non-Technical Skills

Defined as the 'cognitive, social and personal resource skills that complement technical skills, and contribute to the safe and efficiency task performance' (Flin et al., 2015, p. 1), it has been identified that NTS contribute to team performance, particularly in stressful situations, such as an OHCA (Krage et al., 2017).

Originated from aviation, NTS have their foundation within crew resource management. Now in its fifth generation, this system promotes the optimal use of all resources to enhance team dynamics, error detection and avoidance (Helmreich et al., 1999a). With an increasing focus on patient safety and enhanced team performance, NTS training has been transposed into a variety of healthcare areas including acute medicine, surgery, intensive care, anaesthetics, and trauma teams (Flin & Maran, 2004; Yule et al., 2008; Reader et al., 2006; Flin et al., 2010; Repo et al., 2019). The subsequent training, use and assessment of NTS in healthcare has been shown to reduce error rates (Mishra et al., 2008). Yet paramedic NTS have received little attention in comparison (Bennett et al., 2020). Although the Resuscitation Council (UK) (2021b) education guidelines, UK Ambulance Service Clinical Practice Guidelines (Joint Royal Colleges Ambulance Liaison Committee and Association of Ambulance Chief Executives, 2016, 2019), and the College of Paramedics curriculum guidance (2019b) all advocate the teaching and use of NTS for the successful management of an OHCA, they appear to be based on dated in-hospital cardiac arrest management and education guidance. Guidelines include the NTS of teamworking (i.e., effective working together towards a shared goal), leadership (i.e., motivating and supporting others), situation awareness (i.e., information gathering, processing, and planning), decision-making (i.e., reaching a judgement when dealing with evolving, complex situations), and communication (i.e., sharing and delivery of information within teams, to the public, and onward medical care).

Despite the identification of certain NTS for ALS guidelines, Bennett et al. (2020) included 26 paramedic related NTS in their scoping review. This is in contrast to the five paramedic specific NTS identified by Shields and Flin (2013). It should be noted that several NTS included in the scoping review, such as ‘empathy’ and ‘mentor’ are not considered as NTS when compared against the standard definition; ‘social (teamwork, leadership, communication), cognitive (situation awareness, decision-making, cognitive readiness, task management) and personal management (stress and fatigue management) skills necessary for safe and effective performance’ (The Applied Psychology and Human Factors Group, n.d). It was also acknowledged that not all the literature considered team performance as a significant component of OHCA management (Johnson et al., 2018). Yet, there was a recognition that the NTS of communication, decision-making, leadership, teamwork, and situation awareness were associated with hospital-based teams that work in critical care areas, similar to that of an OHCA. However, OHCA management represents a special case, as the unscheduled nature of an OHCA and resulting ad hoc teams make a consistent approach challenging. Used in the context of an OHCA, NTS concentrate on individual behaviour to reduce the risk of team error. Even simple tasks such as the placement of equipment bags relate to the NTS of situation awareness, with a high risk of musculoskeletal injuries, and the identification that bag position can negatively affect CPR quality (Harari et al., 2020) as presented in figure 1.6.

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Figure 1.6 Image of equipment and bag positions for simulated OHCA (Authors personal collection, 2018)

As described by Dagnell (2020) paramedics normally work in a crew formed of two, normally a qualified paramedic and an EMT/AAP/ECA and can include a student paramedic in a supernumerary capacity, which results in a structured hierarchy. Yet, an OHCA results in larger teams, consisting of upwards of four ambulance clinicians, all with varying clinical skills (see table 1.1), abilities, experience, and exposure to an OHCA. This alters the team dynamics and although clinical guidelines include NTS, they appear to be based on the generic paramedic NTS (Shields & Flin., 2013) and it is unclear if these are specific to a paramedic managed OHCA, with little information or reference material to support their use (Resuscitation Council (UK), 2021b). Engel et al. (2008) suggest there is a need for 'specific instruction on how to develop' NTS, and although Bennett et al. (2020) identified 26 paramedic related NTS, a secondary aim of developing a BMS was to ensure that it could provide feedback to reinforce safe practice and effective individual and team performance. This emphasises the need to ascertain specific NTS for a paramedic managed OHCA to ensure an effective team performance, critical to the fourth link in the chain of survival.

Despite the identification of general paramedic NTS, it appears the training and assessment of NTS for paramedics is limited. Although the teaching of human factors and NTS is recommended in UK national paramedic curriculum guidance (College of Paramedics, 2019b), of the 15 endorsed paramedic programmes only one includes specific teaching of NTS. Yet it is unclear exactly which NTS are included, context for use, how the content is delivered or if they are assessed (University of Huddersfield, 2021). It should be recognised that not all 69 undergraduate paramedic programmes are endorsed by the College of Paramedics and although some programmes include teaching in clinical leadership, the HCPC standards of education and training do not include specific guidance for programme content (Health and Care Professions Council, 2018). There appears to be limited inclusion or understanding of human factors theory across professional and educational curricula. This may be explained by the apparent confusion between human factors and NTS, with paramedic specific literature focusing on ‘’personal, psychological and environmental issues which affect the individual’’ (Summers & Willis, 2013, pp. 424; Matheson, 2019) rather than the wider construct of “Enhancing clinical performance through an understanding of the effects of teamwork, tasks, equipment, workspace, culture and organisation on human behaviour and abilities and application of that knowledge in clinical settings” (Catchpole, 2010, as cited in Department of Health Human Factors Reference Group, 2012). This highlights the need to develop a BMS specific to a paramedic managed OHCA as emphasised in one of the current outputs of this study ‘Pitstops for paramedics’ (Cormack et al., 2020a) (see Appendix A), with an aim to inform paramedic education and training for OHCA management, building on the work of Shields and Flin (2013), focusing on NTS, one small part of human factors theory.

1.5 Behavioural Marker Systems

It is clear that a specific NTS taxonomic structure is needed to assess paramedic NTS when managing a simulated and potentiality real-life OHCA. The exact nature of that structure will be provided in detail in chapters two, four and five, as this chapter continues with the consideration to how NTS used by paramedics in an OHCA can be assessed.

In a scoping review of paramedic NTS by Bennett et al. (2020), only five articles that related to the paramedic assessment of NTS were identified, yet none appeared to use a reliable or valid assessment tool. In comparison, a review of emergency medical services clinician’s cognitive skills identified 30 publications related to the use and examination of situation awareness and decision-making (Sedlár, 2020). However, only three studies evaluated behaviour using a specific rating tool: Myers et al. (2016) adapted the Anaesthetists’ Non-Technical Skills BMS (Fletcher et al., 2003) to evaluate air ambulance clinicians performing critical care transfers. While Holly et al. (2017) developed a BMS to evaluate clinicians working in the rural/remote prehospital setting. The third rating tool developed was a global rating system for paramedic clinical competence (Tavares et al., 2013). However, this tool appeared to focus on clinical tasks and procedures, combining technical and NTS to provide an overall rating. Although no assessment tools were identified for the paramedic management of an OHCA, it appeared a BMS might be a suitable method to provide a structured assessment of a ‘set of behaviours indicative to some aspect of performance’ (Flin & Martin, 2001, p. 96).

Despite the lack of a BMS associated with paramedic practice, it appears the assessment of NTS is common for in-hospital teams. In a systematic review by Higham et al. (2019), 76 published NTS assessment tools were identified, though not all were BMS, and there appears to be a lack of a standardised approach. The review identified the existence of resuscitation performance assessment tools such as the OSCAR (Walker et al., 2011) and TEAM (Cooper et al., 2016). It is noted that these tools are designed more as a checklist, lacking elements and behavioural markers, and primarily aimed at in-hospital teams.

Since the first BMS for anaesthetists was introduced (Gaba et al., 1998), many more have been developed, ranging from operating theatres (Yule et al., 2006), to undergraduate medical education (Wright et al., 2009). It appears that there are varying methods for development and analysis, as well as techniques used to score individuals or teams. Although a BMS provides a framework, each one is different and it needs to be context specific, functional, and usable (Flin et al., 2015). It is recommended that when designing a BMS that the context, use for individual or team observations, and setting of a simulated or real environment should be considered (Klampfer et al., 2001). This could result in limited use and transferability of a BMS specifically aimed at real-life paramedic managed OHCA.

Yet as a unique area of clinical practice that is the result of an unscheduled incident and with often unfamiliar, ad hoc teams formed in a short and pressured timeframe, and with a noted lack of clear education and training, the need to develop a specific BMS for use in a simulated or real-life environment is considered as important. The design needs to include NTS categories, elements, descriptions of specific observable behaviours that are clearly defined, as well as a rating system to provide a measurement of the quality of behaviour observed. Having discussed the concept of a BMS the next part of this chapter will consider the design requirements based on the various work of Flin and Martin (2001), and Flin et al. (2015, 2016).

1.5.1 Unit of Assessment

Simply put the unit of assessment refers to who is being observed. Although a team approach is used when managing an OHCA, the varying number of paramedics and other ambulance clinicians would make observing the whole team difficult (see table 1.1). While a BMS can be used to observe a crew (Flin & Martin, 2001), the observation of an individual student or qualified paramedic is considered more beneficial, as it accounts for the varied team sizes, formation, and considers real-life practice where paramedics can be crewed with clinicians with different skill sets, similar to that of emergency medicine doctors (Mellanby, 2015; Myers et al., 2016). Fletcher (2006) considered that the assessment should be appropriate to the purpose, and as a paramedic can attend an OHCA as part of different ambulance crews or as a solo responder, observation of an individual in a simulated environment is logical and reasonable.

1.5.2 Conducting the Assessment

The sensitive and time critical nature of an OHCA would not make the assessment of paramedic behaviour during an actual real-life OHCA either feasible, moral, or ethical, with issues including consent and the sensitive nature of the type of incident. Fortunately, the education of paramedics involves simulation as part of their training, with many higher education institutions using specific simulation areas, designed to provide a realistic environment to train in (University of Wolverhampton, 2020; Coventry University, 2021). This allows for the assessment of performance to be conducted live or using recorded simulations, with the use of realistic simulation providing a suitable platform to conduct a controlled observable assessment (Hunziker et al., 2010). Yet there are limitations to using simulated practice, it can be difficult to control the scenario, and the use of mannequins as patients can result in a lack of engagement and interaction (Wisborg et al., 2009). Designing a simulated OHCA that considers the context of a real-life OHCA is important and has been recognised in other BMS where real-life observations are difficult, such as an OHCA (Mellanby, 2015; Myers et al., 2016).

1.5.3 Content Requirements

To enable an individual rater to observe and provide an objective assessment of student or qualified paramedics NTS when managing an OHCA, Flin et al. (2016) describe three components: NTS taxonomy, behavioural markers with examples of poor and good behaviour, and a rating scale. Presented in figure 1.7 is an example of the categories, elements, and behavioural markers from the Anaesthetists' Non-Technical Skills system (ANTS) (Fletcher et al., 2003). The design of the ANTS BMS provides a basic structure to consider when designing a new BMS.

Figure 1.7 The Anaesthetists' Non-Technical Skills (ANTS) system. Note. From Anaesthetists' Non-Technical Skills (ANTS): evaluation of a behavioural marker system, by G. Fletcher, R. Flin, P. McGeorge, R. Glavin, N. Maran, & R. Patey, 2003. (https://academic.oup.com/bja/article/90/5/580/270031?login=true).

It has been acknowledged in section 1.3 of this chapter that the specific NTS categories needed for an OHCA BMS are yet to be identified and validated. Although general paramedic NTS have been presented (Shields & Flin, 2013), for a paramedic OHCA BMS it is advised that the NTS assessed must be specific, with specified categories, associated elements, behavioural markers, and exemplar behaviours included (Flin et al., 2015). Consideration to how the NTS categories group together is also important, as this could influence raters assessments. As a set of individual categories, the sum must complement each other. Each NTS category needs to be related to the observed individual displaying a range of behaviours during a simulated OHCA, which are also considered as essential to safe and effective practice, contributing positively or negatively to team performance.

Mellanby (2015) suggests that NTS categories can differ, depending on the context and environment. As it is unknown which NTS are specific or how many will be included, the decision to select associated elements, behavioural markers and descriptors will be considered once NTS identification is completed. To achieve this, the experiences of student and qualified paramedics (see glossary for definitions) will be used to design a basic taxonomy.

Rating scales provide a method to document the quality of observed behaviours, and although Flin et al. (2015) suggest that 'there are no fixed rules' (p. 275) to their design, they must be suitable and functional. A rating scale needs to allow for discrimination between poor and good behaviours, with five-point scales commonly used in aviation and healthcare BMS (Thomas et al., 2004).

1.5.4 Rater Training and Use

Essential to the use of a BMS is the rater. Considerations to the selection of raters, training requirements and use of the BMS are needed. All raters should have good knowledge and understanding of their domain and human factors principles. Although there are several definitions of human factors, in relation to healthcare, the Clinical Human Factors Group (n.d.) suggests that 'Human Factors are organisational, individual, environmental, and job characteristics that influence behaviour in ways that can impact safety'. This definition highlights the importance of effective NTS when managing an OHCA, including clinician familiarity with equipment, efficient management of the scene, and consideration to the environment that the OHCA occurs in. These factors can influence clinical competencies and teamwork with the potential to influence patient safety, emphasising the need for a specific BMS used by raters to enhance training and inform learning.

All raters should undertake a minimum of two days formal training to understand the design of the BMS, potential biases, methods of assessment and practical training (Klampfer et al., 2001). Flin et al. (2015) also advise that as BMS are specific, any training should reflect this, while considering the contextual factors such as rater distraction, workload, insufficient training, and the potential for some behaviours not demonstrated. When designing the BMS the rater workload, ability to observe and distinguish behaviours, use of common language and bias are common considerations. Rutherford (2015) suggested that raters can be prone to a range of bias and that a BMS needs to written in simple, recognisable language to aid their understanding of the behaviours observed.

1.5.5 Design Considerations

A BMS must be able to measure a range of observed behaviours. To ensure quality it must be evaluated and although there are a range of analysis methods to achieve this, Flin et al. (2015) consider that sensitivity, reliability, validity, and usability as fundamental components. A well-designed BMS should result in the rater being able to distinguish between different behaviours, provide consistent and accurate scores in comparison to other raters, as well as being suitable for the purpose intended (Flin et al., 2016). Further information on the design and contextual considerations is included in chapter five (see section 5.8.2).

Developing a BMS specific to the paramedic management of an OHCA is not foreseen as an easy task. Extensive research and testing is required to design a well-constructed BMS, capable of identifying areas of strength and weakness, which can then be improved with further consolidation of learning and practice. It is hoped that using an observational approach, a BMS will allow student and qualified paramedics to improve their use and understanding of NTS specific to managing an OHCA in a controlled yet naturalistic setting, for example, in a simulated public space or even in an ambulance (Cormack et al., 2020b).

1.6 Summary

This chapter has provided an overview of the thesis, including the aim, research question and summary of the design. It has confirmed that an OHCA has a poor survival rate and that there are unique challenges associated with a paramedic managed OHCA. Although there have been efforts to improve team performance and an importance placed on the use of NTS during an OHCA, there appears to be little improvement. Some difficulties associated with a paramedic managed OHCA have been explained, including possible reasons for poor management relating to ineffective NTS such as communication and teamwork. The concept and design of a BMS has also been presented, and how their use can contribute to the safe and effective management of an OHCA. In conclusion, an OHCA is unpredictable and as the UK ambulance response is varied, the effective paramedic management of an OHCA is critical. It is hoped that the output of this study can assist in some way in improving a paramedic managed OHCA. The next chapter provides a review of the available literature associated with NTS and cardiac arrest management, essential to the design of a specific BMS.

Chapter 2 - Scoping Review

2.1 Introduction

Chapter one provided an overview of the characteristics of an OHCA including current paramedic management. It established that although the use of NTS is advocated to enhance clinical management, there appears to be no consensus of the specific NTS associated with a paramedic managed OHCA. There also appears to be several challenges to the effective use of NTS in a paramedic managed OHCA. To explore these issues further, this chapter presents a scoping review, detailing the systematic approach used to identify and examine an extensive range of relevant literature associated with NTS and cardiac arrest management.

2.2 Method

2.2.1 Aim

As literature on the use of NTS in a paramedic managed OHCA appears to be limited, the aim of this scoping review was to perform a thorough examination of the identified literature to establish which NTS are pertinent to cardiac arrest management. The use of a scoping review provides a systematic method to explore the extent of the literature, as well as mapping and summarising the included articles needed to inform the NTS taxonomy and to achieve the overall aim of this study (Tricco et al., 2016; Munn et al., 2018).

2.2.2 Design

Previous studies on the recognition of an OHCA and care quality measurements have successfully used a scoping review method where high-quality published literature was limited (Viereck et al., 2017; Pap et al., 2018). Considered useful when concepts and specific questions require clarifying (Pham et al., 2014) a scoping review allowed for the examination of emerging literature. Guidance of conducting a systematic scoping review was utilised (Peters et al., 2015), and Arksey and O'Malley's (2005) five-point framework was used to provide a structured and systematic process to determine the identification, mapping, and thematic analysis of the literature. A summary of the five stages are presented below.

1. Identification of the research question to ensure comprehensive search strategy with clearly defined concepts
2. Identification of relevant studies, including published and unpublished, primary research, literature reviews, and conference proceedings suitable to answer the research question
3. Team approach to reviewing the results to increase familiarity and ensure appropriate literature is included
4. Charting of the data to provide a descriptive synthesis and interpretation of the included literature
5. Collation, summary, and report of the results. Emphasis was not placed on the quality of evidence, but focused on the implication of each study's findings to the development of a NTS taxonomy specific to the paramedic management of an OHCA

2.2.3 Search Process

In accordance with Arksey and O'Malley's (2005) framework, a research question was developed to aid the search process: 'Which NTS are associated with ad hoc teams in the management of a cardiac arrest?'. A search was performed in September 2016, as this was a starting point for the study, using six online databases (Medline, AMED, CINAHL, PsycINFO, PsycARTICLES and ScienceDirect) accessed via Coventry University library. These six electronic databases provided a variety of scientific and technical research relevant to healthcare and non-technical skills.

Search terms were generated using Medical Subject Headings (MeSH) (Baumann, 2016) with specific NTS informed by the general NTS paramedics previously identified by Shields and Flin (2013) and discussion with the study supervisors. This technique analysed text from the literature previously identified in chapter one to produce relevant subject headings The MeSH terms identified and used as keywords were:

> (Ambulance OR Emergency Medical Services OR Paramedic OR pre-hospital) AND (non-technical skills OR communication OR leadership OR situation awareness OR decision-making OR teamwork OR soft skills OR crew resource management OR team resource management OR human factors) AND (out-of-hospital cardiac arrest OR OHCA OR resuscitation OR cardiac arrest management).

All searches were limited to those published in English language, with publications limited to January 2003-September 2016, reflecting when the scoping review was performed due to the part-time nature of this research study. This rationale reflected the professional status that paramedics reached in 2003 (Whitmore & Furber, 2006) and the introduction of specific ambulance clinical guidelines (Joint Royal Colleges Ambulance Liaison Committee, 2006). Higher education curricula was not included as traditionally education and training was conducted ‘in-house’ with ambulance trusts delivering a six-week course focused on task-oriented skills and did not include NTS education or training (Petter & Armitage, 2013). Further consideration was also given to the stipulation that the standard paramedic education criteria of a BSc was only implemented in 2019 and therefore not relevant at the time of this review (Givati et al., 2017).

Unlike a systematic review, inclusion and exclusion criteria were defined once the search was complete and an initial review performed. This facilitated an increased familiarity of the results, ensuring only literature specific to the research question and clinical applicability were included. Criteria were selected by the lead researcher and study supervisor and are presented in table 2.1.

Table 2.1 Inclusion and exclusion criteria

Inclusion Criteria	
Types of studies	All study types that reflected a team approach and/or use of NTS in advanced life support guidance or cardiac arrest management. In or out-of-hospital based studies
	Studies from any geographical location
	English language
Types of participants	Adults (over 18 years), humans, healthcare professionals
Context	NTS in cardiac arrest management; real world or simulated exercises
Publication Type	Published and grey literature including journal articles, conference proceedings and professional magazines
Exclusion Criteria	
Types of Studies	Duplicated articles
Types of participants	Under 18 years of age
Context	Literature that did not include NTS or related to cardiac arrest management
Publication Type	Non-peer reviewed/examined literature due to potential bias, lack of validity

2.3 Results

The search identified 421 potentially relevant sources. Following the removal of duplicate articles (n=9) the titles and abstracts were screened for eligibility based on the inclusion and exclusion criteria. The results were screened by the lead researcher and reviewed by the supervisory team. A total of 391 articles were rejected due to a lack of relevance to the subject. The full text of 21 articles were reviewed, resulting in 12 articles identified for inclusion. Figure 2.1 presents a PRISMA flow diagram (Moher et al., 2009) of the selection process, with a summary of the included articles presented in table 2.2. Each article was also reviewed to identify the NTS categories associated with cardiac arrest management, with the results presented in table 2.3.

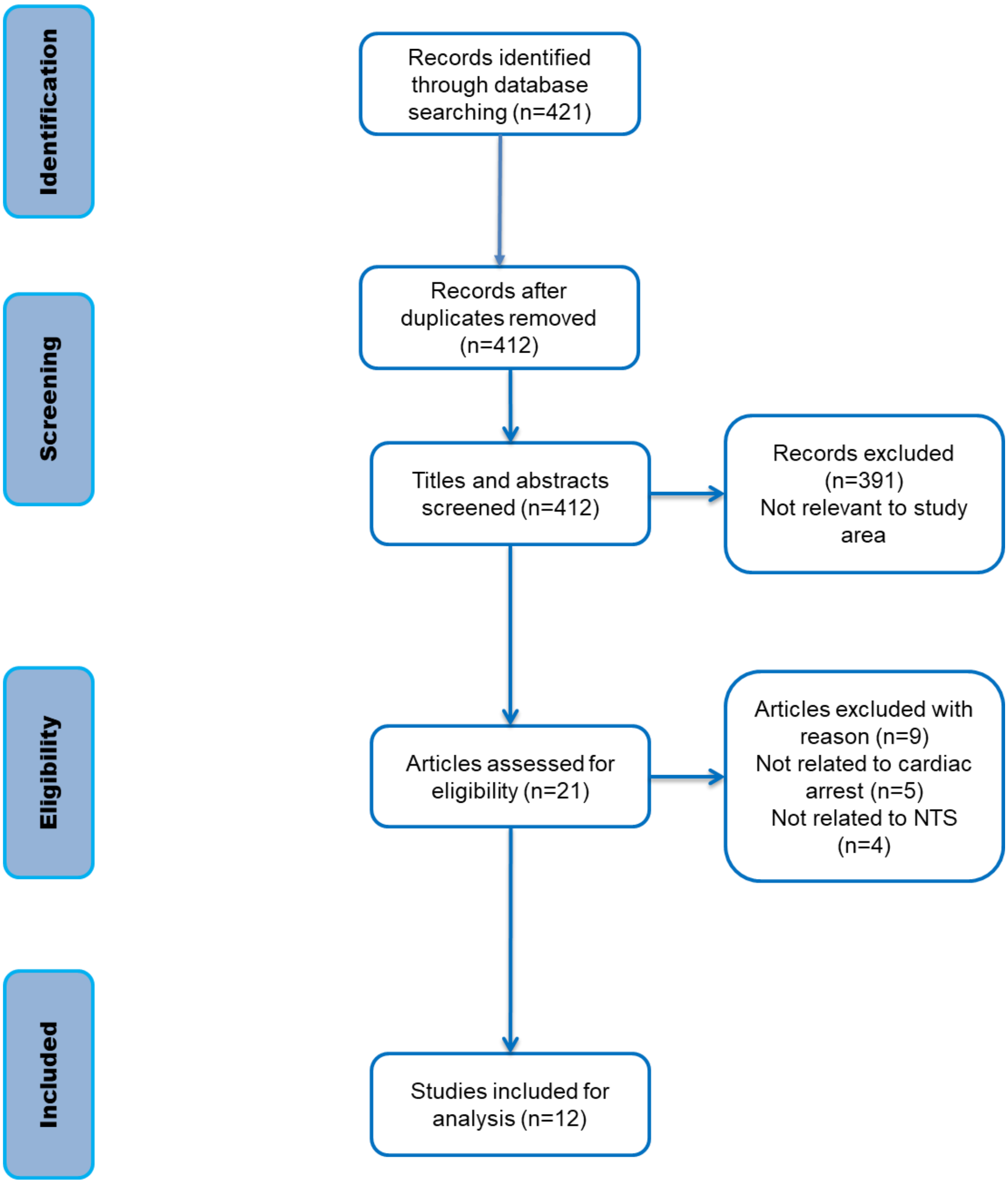

Figure 2.1 Flow chart of article selection in accordance with PRISMA guidelines

Table 2.2 Summary of included articles

Author, year of publication and location	*Study Aim*	*Study Methodology*	*Study Outcomes*	*Limitations*
Marsch et al., (2004) Switzerland	Do human factors affect CPR quality	48 anaesthetic participants in simulated cardiac arrest management workshop	Poor basic life support, leadership, task distribution and advanced life support knowledge related to poor team performance and CPR quality	Lack of previous experience of simulation and lack of familiarity may have altered results
Tschan et al., (2006) Switzerland	Does leadership behaviour enhance in-hospital cardiac arrest team performance	Observational study using high-fidelity simulation (109 staff)	Training should include technical training as well as aspects of group coordination with adaptation to the situation and professional roles	Simulation based study. Potential for Hawthorne effect on participants. Chance of task-related functions may be of different importance
von Wyl et al., (2009) Switzerland	Assessment of technical and NTS of paramedics during simulated OHCA	Observational study of 30 paramedics using checklists	Assessing technical and NTS in a simulated scenario is feasible, needs two assessors	Unclear which NTS assessment tool was used to assess paramedics
Andersen et al., (2010) Denmark	Improvements and barriers to NTS in hospital cardiac arrest teams	Semi-structured interviews over 7 months of 11 advanced life support staff	Performance improves with hands-off experienced team leaders, structured approach to communication, use of checklists to avoids task overload	Small number and participants potential for bias and hierarchy

Table 2.2 continued…

Author, year of publication and location	*Study Aim*	*Study Methodology*	*Study Outcomes*	*Limitations*
Hunziker et al., (2010) Switzerland	Simulation effectiveness for assessing in-hospital cardiac arrest team's human factors	Narrative review of human factors evidence from simulation	Team interaction, communication and leadership affect CPR. Simulation provides a safe, controlled, and realistic environment to assess human factors	No critical appraisal of literature included. Potential for Hawthorne effect in simulator studies
Hunziker et al., (2011) Switzerland	Teamwork and leadership in cardiac arrest	Literature review of high-fidelity simulator studies	Unfamiliar teams and poor leadership behaviour are associated with shortcomings in CPR. Teamwork training improves team performance	Search process was unclear. Difficulty translating findings to actual practice
Riem et al., (2012) Canada	Technical and non-technical skills in a simulated cardiac arrest	Simulated cardiac arrest (50 anaesthetists) using checklists	Poor NTS results in poor technical ability. Training in NTS can improve technical skills	Limited simulated scenario and time. Only one clinician, actors used in other roles
Fernandez Castelao et al., (2013) Germany	Team coordination during resuscitation	Systematic literature review	An effective team leader is beneficial for planning. Planning, leadership, and communication affects clinical outcomes	Results consider the majority of included literature as low quality. Limited literature available

Table 2.2 continued…

Author, year of publication and location	*Study Aim*	*Study Methodology*	*Study Outcomes*	*Limitations*
Clarke et al., (2014) UK	Feasibility of additional specialist paramedic to OHCA	Small feasibility study for additional specialist paramedic	Specialist paramedic feasible, noted need for 'hands-off' leader and leadership on scene, no impact on response times	Only eight participants. Training unclear and limited patient outcome data
Fernandez Castelao et al., (2015) Germany	Crew resource management team leader training on CPR performance	Randomised, controlled simulator study (224 participants)	Team performance and technical skills improved with hands-off crew resource management trained leader	Familiar teams, unknown pre-training measurements or experience. Only team leader communication considered
Miller (2015) UK	Ambulance staff views of human factors in resuscitation	Anonymous online survey, 111 participants	Staff were confident in technical skills, but difficulties included poor communication, leadership, and number staff on scene	Poster abstract only, limited information
Lowe et al., (2016) UK	Benefits of video review for OHCA management	Narrative review of video footage of resuscitation attempts in emergency department and OHCA	Video footage with robust governance is beneficial for observation of behaviour which improves feedback	Unclear methodology. No inter-rater reliability of reviewers reported. Use of validated tools limited

*Table 2.3 Common NTS themes (*communication) Y = non-technical skill present, grey highlight = non-technical skill absent*

	Identified non-technical skills						
Citation	Leadership	Comms*	Teamwork	Situation awareness	Decision-making	Team performance	Team Coordination
von Wyl et al., (2009)	Y	Y	Y	Y			
Clarke et al., (2014)	Y	Y	Y			Y	
Marsch et al., (2004)	Y	Y	Y			Y	
Tschan et al., (2006)	Y	Y	Y	Y		Y	Y
Anderson et al., (2010)	Y	Y	Y	Y			Y
Hunziker et al., (2010)	Y	Y	Y			Y	Y
Hunziker et al., (2011)	Y	Y	Y	Y		Y	
Riem et al., (2012)			Y		Y		
Fernandez Castelao et al., (2013)	Y	Y	Y				Y
Fernandez Castelao et al., (2015)	Y	Y				Y	Y
Miller (2015)	Y	Y	Y				
Lowe et al., (2016)	Y	Y	Y	Y	Y	Y	

The results identified a limited evidence base for NTS and an OHCA, with only four articles directly related (von Wyl et al., 2009; Clarke et al., 2014; Miller, 2015; Lowe et al., 2016). Despite this, there was a range of in-hospital literature that demonstrated a positive association between NTS and cardiac arrest team performance. Although there was a mix of study types, narrative literature reviews and simulation accounted for most of the included articles (n=8), highlighting the difficulties associated with performing prehospital research, in particular cardiac arrest management (Pocock et al., 2016; Maurin Söderholm et al., 2019). Across all articles, only three NTS were common: leadership, communication, and teamwork, with other NTS such as decision-making and situation awareness less commonly discussed (see glossary for definitions). Although similar to those NTS included in the Resuscitation Council (UK) education guidelines and e-ALS course (2021b, 2021c) there was no comprehensive description of paramedic NTS for OHCA management. As there was a focus on only three key NTS, the use of simulation, and the formation and associated dynamics of teams, these will be considered in relation to a paramedic managed OHCA. The implications of the key findings to the development of a NTS taxonomy for a paramedic managed OHCA will now be discussed.

2.3.1 Leadership

Leadership was considered as an essential NTS in all but one article and has previously been linked to effective teamwork (Salas et al., 2005). An important finding was the association between effective leadership and a leader remaining hands-off, therefore not performing any clinical tasks such as CPR or airway management. This resulted in fewer interruptions and an improvement in the quality of chest compressions (Fernandez Castelao et al., 2015). This method was associated with improved team performance, greater communication, and a correlation with increased rates of a ROSC (Fernandez Castelao et al., 2013). However, it is important to recognise that this did not translate into long-term survival rates for patients suffering a cardiac arrest and was only indicated with in-hospital teams. It was also noted where additional leadership training had been undertaken; teamwork was improved and was reflected in reduced error rates, such as reduced CPR interruptions and incidents of miscommunication (Marsch et al., 2004; Andersen et al., 2010; Hunziker et al., 2010; Fernandez Castelao et al., 2015).

Yet there were noticeable differences to the formation of in-hospital and out-of-hospital cardiac arrest teams, which affect the ability for a leader to remain hands-off. An in-hospital cardiac arrest team appeared to have a more organised approach to team development, with staff arriving in shorter time frames and in general, there were more staff, allowing one to remain in hands-off and act as a dedicated leader. The role allocation for these teams seemed to be determined by clinical and specialist ability, and whilst it could be argued that an additional team leader is feasible for an OHCA team, it is dependent on operational demand (Clarke et al., 2014). The formation of an OHCA team is very different and in general, each member has a similar clinical skill set (see table 1.1) as members are either student or qualified paramedics (Smith et al., 2013; McClelland et al., 2016; Dyson et al., 2016). Due to the unscheduled nature, varied locations of an OHCA, and ambulance crewing, paramedics generally arrive on scene in pairs in an ambulance. This results in an expectation that those managing the OHCA must form and function in incredibly short and critical timeframes (Ong et al., 2018; Anderson et al., 2018). The reduced number of staff and varying time of arrival results in paramedics having to perform multiple tasks such as airway management, CPR, defibrillation, information gathering, and scene management before additional clinicians arrive. This results in an increased cognitive load, as multiple tasks need to be managed, reducing their ability to remain situationally aware. These constraints appear to result in a lack of leadership and reduced communication, as identified in the survey by Miller (2015). This contrasts with the literature from in-hospital studies that established the benefits of a hands-off leader including reduced task focus and overload and improved situation awareness (Tschan et al., 2006; von Wyl et al., 2009; Andersen et al., 2010; Lowe et al., 2016). Although it is recognised that additional staff may make it possible to have a dedicated hands-off leader, training in team leadership and communication for all team members was associated with improved team performance as there was a greater understanding of roles and importance of NTS.

2.3.2 Communication

Communication was often acknowledged as a barrier to effective teamwork and was connected to a poor understanding of roles, unclear task allocation and cognitive overload, resulting in a poorly performing team (Andersen et al., 2010; Hunziker et al., 2011; Miller, 2015). A poor understanding of closed loop communication was highlighted, with staff often asking questions at critical periods of the arrest resulting in unnecessary interruptions and delays (Andersen et al., 2010). Of particular relevance to paramedics was the identification of a lack of confidence in communicating with others in an unfamiliar team and a lack of training in NTS (Miller, 2015).

A corresponding finding from Clarke et al. (2014) and Andersen et al. (2010) was that all team members found it difficult in challenging a more senior or authoritative confident team member, resulting in poor task distribution, and poorly performed CPR. Effective communication was more common where a team was familiar, had received training in NTS and where a team used an identified team leader (Fernandez Castelao et al., 2013; Fernandez Castelao et al., 2015). This resulted in the encouragement of team members to verbalise their clinical findings, allowing for a shared understanding and provided a challenge and response mechanism (Hunziker et al., 2010; Hunziker et al., 2011; Fernandez Castelao et al., 2013; Fernandez Castelao et al., 2015).

This lack of confidence and poor communication may be associated with limited OHCA exposure, highlighting a need to practice cardiac arrest management using NTS and establish a hands-off leader early. The study by Clarke et al. (2014), established that despite targeted responses to OHCA, the eight paramedics trained as team leaders attended approximately two OHCA each month during the study. This relatively low number corresponds with the low exposure rate highlighted by Dyson (2016). It was noted that initially paramedics already on scene were not receptive to the additional team leader but following team debriefs and increased educational sessions guidance was accepted more.

2.3.3 Teamwork and Team Formation

The Resuscitation Council (UK) (2021b) advocates that a team approach is needed to achieve high quality CPR, ensuring the best chance of survival. Teamwork can be broken into several components, including mutual trust and a shared mental model that result in the effective partnership to achieve a shared goal. In the case of an OHCA, this includes scene assessment, the delivery of clinical care, and the movement of patients to a suitable hospital (Patterson et al., 2016). The four prehospital studies all indicated that teams are unfamiliar and rapidly formed, resulting in poor teamwork. The study by Tschan et al. (2006) observed that hospital teams are usually familiar and experienced at working together. Conversely, this is not the case for an OHCA response, a noted difference to the OHCA team is clinical ability, and it was apparent that where a leader becomes hands on, especially when technical problems occur, teamwork suffers regardless of clinical expertise or experience (Clarke et al., 2014; Miller, 2015). The resulting task and role re-allocation can result in task overload, and it appears that paramedics find it difficult in respecting less experienced member's decision-making processes. Contributing factors to poor teamwork appear to be a lack of planning and poor communication, both considered as key factors in effective group performance (Helmreich & Merritt, 2000). This is corroborated by Patterson et al. (2012) who found that when coupled with frequent changes to crews; team cohesiveness can be disrupted resulting in a lack of leadership or ownership of the cardiac arrest.

In relation to team formation, it was identified that although hospital-based teams are sometimes formed on an ad hoc basis, overall team members had improved levels of cooperation and task allocation/awareness/completion as there was time for a briefing and allocation of roles. In comparison, the four OHCA studies confirmed that a paramedic team is unfamiliar, rapidly formed with frequent changes as additional clinicians arrive. This was linked to limited briefings, a lack of role allocation, and limited experience in leading an OHCA (Clarke et al., 2014; Miller, 2015). Paramedics appeared to have a poor understanding of individual abilities, a lack of procedural knowledge and did not use effective communication methods. These difficulties emphasise the need for effective teamwork, even where a dedicated hands-off leader is not possible.

2.3.4 Use of Simulation

The unscheduled nature of an OHCA is associated with the recognition that early leadership and task distribution is required to achieve an improved outcome (Hunziker et al., 2011). High-fidelity simulation and video debriefing appear to validate the positive effect of teamwork and leadership (Lowe et al., 2016), while the use of simulation has been effectively transferred to OHCA training (Power et al., 2013a). Although there are accepted limitations with high-fidelity simulation, such as cost, logistical challenges, and technology issues (Power et al., 2013b) the results of the scoping review indicate that high-fidelity simulation can recreate a realistic environment, and that this allows for a controlled and standardised situation (Hunziker et al., 2010). Although there are benefits associated with leadership and effective teamwork, Hunziker et al. (2011) highlighted the need for further research on team hierarchies and error management. The use of observed simulation for training and assessing NTS appears to provide a controlled environment, but it is difficult to reproduce realistic situations as simulations and participant performance may vary. Consideration is needed in the design of OHCA scenarios to the use of high-fidelity mannequins and a fundamental knowledge that the scenario was not real (Smith, 1987; Young et al., 2017).

A further benefit to using simulation is the use of video recording, which offers an objective analysis of the scenario (Lowe et al., 2016). Yet, there are limitations, cardiac arrests are unpredictable and performance within a simulated environment may be influenced by stress, resulting in the possibility of altered behaviour due an awareness of being studied (Smith, 1987). Conversely, Hunziker et al. (2010, 2011) reasoned that with high fidelity simulation behaviour was similar to real-life, as participants forgot that they were observed. However, recreating a realistic OHCA environment is challenging. Power et al. (2013a) claim that it is unclear if the high costs, lengthy planning, and resource heavy logistics outweigh the associated benefits. Nonetheless the findings of this scoping review suggest that training and education in leadership and teamwork using simulation is an effective method (Hunziker et al., 2010, 2011) and can improve task performance and teamwork, which are associated with a reduction in adverse events (Weaver et al., 2014).

It is evident that the use of simulation is a useful method to practice infrequently used clinical and non-clinical skills, and it appears to improve team members' awareness and understanding of NTS (von Wyl et al., 2009; Riem et al., 2012). Simulation has been utilised across several areas of healthcare and is associated with an increased familiarity of roles, improved confidence, and reduced cognitive load, all associated with a reduction in human error within resuscitation teams

(Reeve et al., 2013; Myers et al., 2016; Langdalen et al., 2018; Gaba, 2019). The use of simulation in combination with an observational behavioural marker system could provide paramedics with detailed feedback on their level of NTS, potentially improving their understanding and knowledge.

2.3.5 Summary

As an emerging aspect of OHCA management, the identification of specific NTS for an OHCA are important, and link to an additional aim of developing a BMS that could provide feedback to reinforce safe practice and effective team performance. This could result in potential difficulty in applying hospital based NTS to an OHCA scenario, as there are subtle differences including little medical knowledge of the patient, varied numbers of team members and a need to remain focused on providing support to a patient in a varied environment (Ågård et al., 2012; Krage et al., 2017). However, regardless of these differences, the ad hoc formation of both teams and use of ALS algorithms appears to be similar. These similarities result in the potential application of the three key NTS identified in this review to an OHCA, as when an individual identifies as a leader early on, and the team achieves effective communication, teamwork is improved and these NTS appear to positively influence individual and team performance.

Several barriers to the use of NTS in a cardiac arrest situation were identified and included difficulties with team formation, poor communication, ineffective leadership, and low confidence levels. However, this review, also published in the Australasian Journal of Paramedicine (Cormack et al., 2020b) (see Appendix B), has identified several positive effects of effective NTS on team performance. These include the use of a hands-off team leader at an OHCA, the use of simulation for NTS and team training and the three key NTS of leadership, communication, and teamwork.

2.4 Conclusion

This scoping review followed an evidenced based approach to identify a range of literature associated with NTS and cardiac arrest management. It has resulted in a comprehensive review of the available literature relating to NTS in an OHCA scenario as well as in ad hoc teams managing a cardiac arrest. Despite only 12 articles identified, there is a clear body of knowledge from in-hospital practise, yet there was a paucity of literature specifically related to NTS and an OHCA. It is recognised that the use of doctors and nurses in many of the articles may not reflect the same cardiac arrest exposure rates or necessarily the same clinical skill sets when compared to paramedic practice. Yet, it appears the NTS identified are transferable (Marsch et al., 2004; Andersen et al., 2010; Hunziker et al., 2010; Fernandez Castelao et al., 2015). However, no comprehensive description of paramedic NTS for OHCA management was identified and there appeared to be a lack of consensus for NTS specific for an OHCA. The next chapter describes the theoretical, philosophical and methods used for the research phases of this study.

Chapter 3 - Theoretical and Methodological Considerations

3.1 Introduction

The overall aim of this study was to design and evaluate a BMS for the paramedic managed OHCA. The preceding chapters have identified limited relevant literature and established that no specific BMS exists. As a BMS needs to be designed for a specific work domain and environment, it was important to use an appropriate methodology to support this (Flin et al., 2016). This chapter explains and justifies the theoretical and methodological approaches undertaken for the overall research process, with details of individual data collection and analyses methods for each research phase provided in chapter four.

3.2 Theoretical Framework

Several theoretical and philosophical considerations influenced the overall research design, as managing an OHCA is a social, real-life issue, informed by personal experiences of the lead researcher and participants. It should be recognised that the positionality of the researcher might result in personal and participant bias. Although this research area stems from personal experiences, an awareness of bias and preconceptions is important to reduce the influence this may have on understanding the data (Maykut & Morehouse, 1994). As an insider (research area within own clinical practice area), remaining objective is an important aspect, although commonality can result in participant acceptance, increased levels of legitimacy and a greater depth of information gathered (Dwyer & Buckle, 2009). Yet the risk of research participation effects can result in bias and reduce internal validity. Efforts to recognise research positionality, adoption of a participant centred perspective and the use of mixed methods can reduce the influence of conducting research as an insider (McCambridge et al., 2009). The roles as a qualified HEMS critical care paramedic, university lecturer and part time PhD student, all influenced the study design, with direction and outcome considered, and efforts made to ensure that the lead researcher's position as a PhD student was emphasised throughout the study. Reflection on previous experience as a HEMS critical care paramedic was also included and recognised as a key driver in the methodology. Nevertheless, it was recognised that a BMS needs to provide a structure to observe 'man's behaviour in relation to his work', built on the influence of previous experiences (Grandjean, 1980, pp. 9) and human factors theory was used to help inform the overall research design. Defined as a scientific discipline designed to understand human interaction with other humans, equipment, and system design to ensure optimal performance (International Ergonomics Association, 2020) this theory provided a focus to inform the theoretical and methodological considerations, acting as a balance to the researcher positionality.

Selecting a suitable paradigm was important, as this would inform the overall research design and methods used to collect and analyse data. The BMS needed to be applicable to clinical practice yet allow for the observation and assessment of behaviour and actions of student and qualified paramedics managing a simulated OHCA (Goldkuhl, 2012). As such it was considered that positivism or interpretivism alone would not provide sufficient explanations of independent views to identify, understand or evaluate a BMS specific for paramedic NTS when managing an OHCA.

A pragmatic paradigm was chosen, considered as an ‘umbrella foundation’ (Creswell & Plano Clark, 2011, pp. 101) as it provides a framework orientated to solving real life problems based on human experience, essentially considering ‘what works’ and focusing on providing an answer to a research question that is applicable to practice (Johnson & Onwuegbuzie, 2004).

The use of pragmatism also enabled a detailed understanding of social conflicts, affording an evaluation of real world psychological, social, and educational phenomena by providing a richer understanding of participant’s experiences of managing an OHCA. Johnson and Onwuegbuzie (2004) consider that a mixed methods approach complements pragmatism, ensuring the design and evaluation of a BMS is based on scientific enquiry, statistical analysis, and re-analysis, incorporating the opinions, feelings, and interpretation of behaviour that evolved from the qualitative aspects of data (Feilzer, 2010). Creswell and Plano Clark (2011) also advise that pragmatism can be used with a mixed methods approach as it provides a complete understanding and identifies several classifications of mixed methods.

After reviewing various typologies, a synergistic approach was adopted, as it provided a systematic approach, with consideration of the researcher's position and the study design. It also allowed for a flexible structure, balancing philosophical considerations and methods (Hall & Howard, 2008). As the objectives of this research could be separated into three distinct phases and after reviewing mixed methods designs, a multiphase sequentially timed approach was considered (Creswell & Plano Clark, 2011; Creswell, 2014). This design enabled the ability to perform a comprehensive exploration and integration of the data

(McManamny et al., 2015). The collection and analysis of different data sets using a sequential approach enabled different perspectives of the research area, increasing the validity and reliability (Onwuegbuzie & Johnson, 2006). It also meant that the use of different methods to collect and analyse data in a sequential order, allowed for the quantitative phase to inform the qualitative phase; beginning with a 'broad survey…to generalise results…and a second phase, focuses on qualitative' to explain the quantitative findings (Creswell, 2014, pp. 19).

Deciding where to 'mix' the methods was also important as there is no specific BMS for the paramedic managed OHCA, therefore NTS would need to be identified and validated before a taxonomy could be created. After considering different typologies for mixing methods (Bryman, 2006), triangulation was considered appropriate as it allowed for an integration of all data, providing a 'coherent justification' for the taxonomy (Creswell, 2014, pp. 201). It was also considered to increase the credibility of qualitative data, and internal validity of quantitative data, providing a deeper understanding of the BMS (Schoonenboom & Johnson, 2017). To aid visualisation of the research design, figure 3.1 shows the conceptual framework and organisation of each phase. This is followed by figure 3.2 provides a diagram of the objectives, associated methods and timeline, and type of participant recruited.

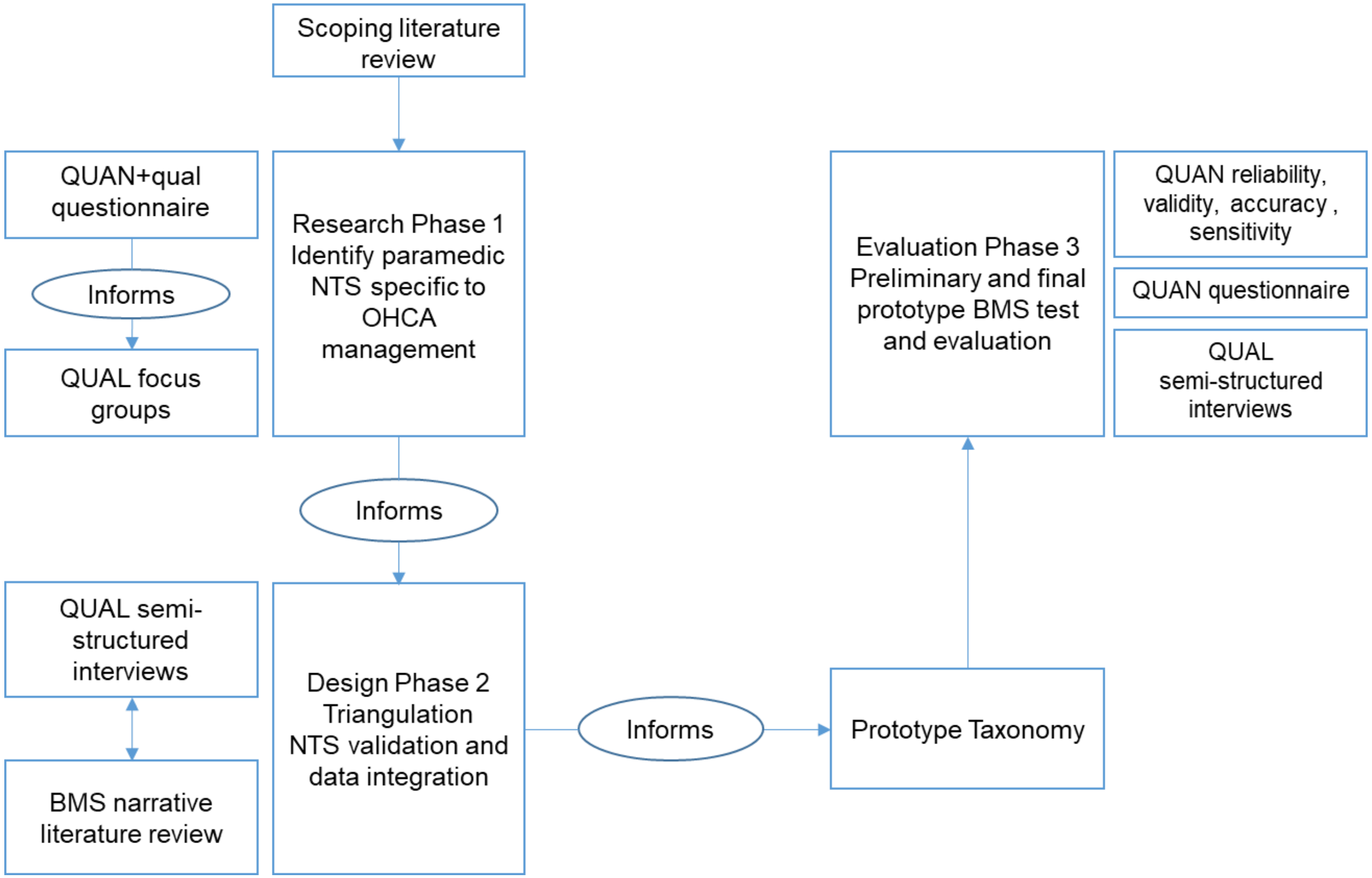

Figure 3.1 Conceptual Framework of multiphase mixed methods research (uppercase denotes emphasis on data collection method, arrow indicates sequential method)

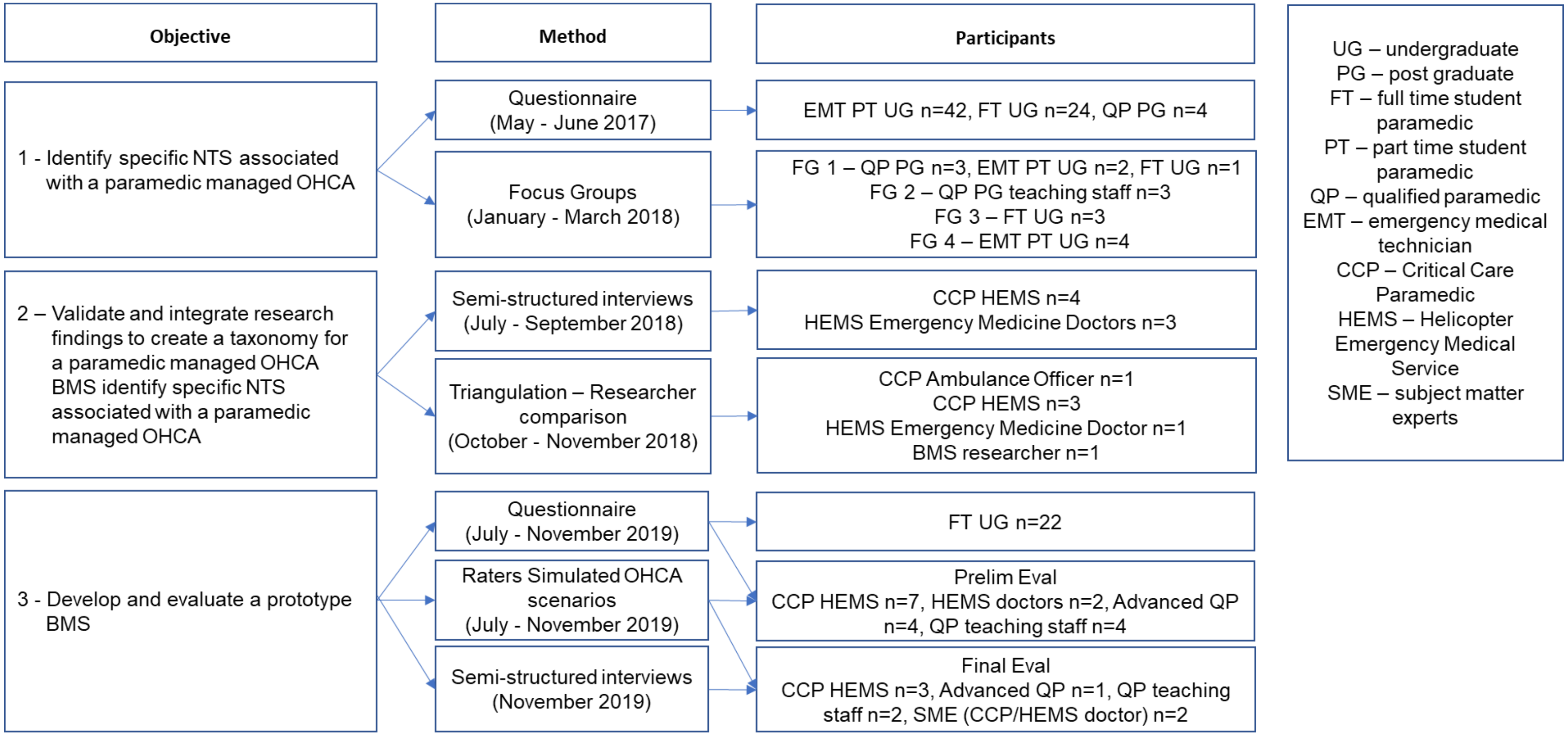

Figure 3.2 Map of objectives, methods (with timings), and participants

3.3 Methodological Overview

A pragmatic paradigm, using a mixed method, multiphase design was used and consisted of three distinct phases. This design allowed for separate data collection and analyses methods, with each one informing and building on the next. It provided flexibility, addressing additional research questions as the research evolved, resulting in the evaluation of a prototype BMS.

Phase one (research) consisted of quantitative (questionnaire) and qualitative (focus groups) data collection and analyses to explore and explain student and qualified paramedic opinions of non-technical skills (NTS) used when managing an OHCA. Collected sequentially, the questionnaire results informed the qualitative focus groups (Creswell et al., 2011; Creswell, 2014) with textual data used to explain and build on the numerical data collected in phase one.

Phase two (design) triangulation comprised the validation of the findings from phase one, using a qualitative approach (semi-structured interviews). These results were integrated with data from comparable BMS identified from a narrative literature review. This resulted in the connection of all data to provide a greater understanding of the research aim and informed the design of the prototype BMS.

The final third phase (evaluation) assessed the draft prototype BMS using a combination of quantitative and qualitative methods to measure the reliability, validity, sensitivity, accuracy, and usability of the prototype BMS. Figure 3.2 provides a visual representation of the progression of each research phase.

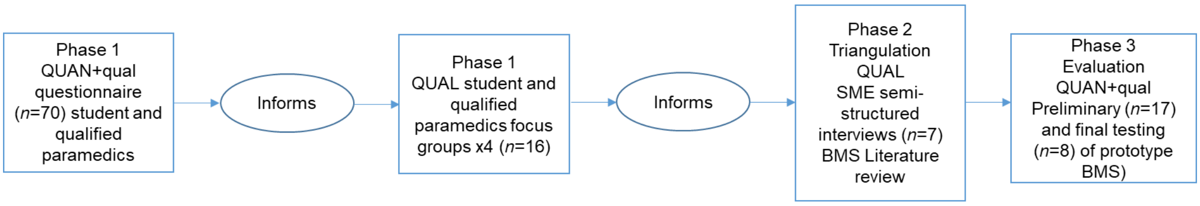

Figure 3.3 progression of research phases 1-3 (uppercase denotes emphasis on data collection method, arrow indicates sequential method)

3.4 Methodology

This section will describe the methodology used, with a detailed explanation of data collection and analyses methods for individual research phases provided in Chapter four. The use of a mixed methods design utilised questionnaires, focus groups, semi-structured interviews, and observation of simulated scenarios to evaluate the prototype BMS (Armitage, 2007), combining factual, objective, and deductive logic with subjective and inductive logic (Morgan, 2007; Kaushik & Walsh, 2019). This resulted in an approach that aligned the research question and aimed to represent work as done rather than work as imagined (Shorrock, 2020). Recognised across a range of domains including healthcare, a mixed methods approach has several advantages (Schoonenboom & Johnson, 2017; Tashakkori & Creswell, 2007; Teddlie & Tashakkori, 2009). When combined with a sequential approach it allowed for the identification of divergent and complementary data, ensuring further exploration and corroboration of findings from each phase (Greene, 2007). Key benefits for this approach are that it:

- Provides answers that quantitative or qualitative methods could not answer alone

- Allows for a better understanding of connections or contraindications between different data
- Enriches data and establishes credibility, contributing to trustworthiness
- Combines results providing a more comprehensive picture
- Allows for corroboration of data, reducing individual method limitations
- Converges data by integrating multiple data sources/samples
- Provides different views for same question/aim
- Enhances transferability of findings from qualitative data
- Enhances the validity and generalisability of quantitative data
- Increases the credibility of qualitative data
- Complementary combination of positivism, constructivism and interpretivism
- The use of two data collection methods means the disadvantages of one method can be balanced by the other
- A mixed questionnaire can be used to validate and expand on quantitative answers by embellishing with qualitative questions and answers
- Can combine questionnaires and interviews in one single piece of research to provide a complete picture, expanding on a questionnaire set of answers

Although there are many advantages to using a mixed methods approach, limitations were also considered, and these were incorporated into the planning of the research study, with considerations listed next (adapted from Wisdom & Creswell, 2013; Wisdom et al., 2011).

- Using a multiphase approach resulted in complex data collection and analysis, affecting the timeframe of the study. A combination of checklists, Gantt charts and deadlines were used to track timing and progression
- The study was resource heavy, requiring careful planning, equipment, rooms, and IT resources. Lists of equipment, rooms and staff needed were utilised to aid planning. Schematics were used to visualise each phase and integration
- Data analysis and interpretation needed the assistance of statisticians and coding software to cope with the large amounts of statistical and textual data produced. Quantitative and qualitative workshops were attended to improve underpinning knowledge. Individual meetings with statisticians were used to discuss quantitative data management and analyses
- Researcher bias needed to be accounted for. The use of data from previous phases informed the next with questions developed to guide focus groups, semi-structured interviews, and questionnaires. Researcher and subject matter expert comparison were used to validate interpretations
- Additional skills were required to enable the lead researcher to gather a broad range of data. Attendance of several workshops and meetings on topics including human factors, crew resource management, use of simulation and data protection were used to improve researcher knowledge

For this research, the benefits of a mixed methods approach outweighed the limitations, and the combination of quantitative and qualitative methods meant that individual weaknesses could be minimised whilst maximising strengths, thus allowing for a greater understanding of problems encountered and answers generated (Kelle, 2006).

Flin et al. (2015) suggest a two-stage approach for the development of a BMS, and it was acknowledged that specific NTS would need to be identified to inform the overall design before an evaluation of the BMS. It was considered that paramedic experiences, attitudes, and opinions of NTS associated with an OHCA were important, and they would provide an understanding of specific NTS associated with an OHCA as well as identifying any difficulties (Cooper et al., 2010a). As a set of interconnected characteristics, an opinion provides a personal view, while an attitude reflects day-day feelings, both considered relevant to the identification and interpretation of relevant NTS (Bergman, 1998: Sinha, 2008). This relates to a view of 'human activity in context' (Ormerod, 2016, pp. 893) and was an important aspect of the design process. It was also important to ensure an objective and scientific analysis, to inform the design and ultimately measure the validity, reliability, and sensitivity of the BMS. The combination of data collection and analysis methods added a richness to the data, providing a comprehensive picture, as well as reducing individual method limitations such as differing sample sizes and weighting (Onwuegbuzie & Johnson, 2006). Table 3.1 details the benefits of using a combination of research methods for data collection and analyses.

Table 3.1 Quantitative and qualitative research methods benefit (adapted from Lincoln & Guba, 1985; Tashakkori & Teddlie, 1998).

Quantitative	*Qualitative*
Validity – data provides measurements and statistical data	*Credibility* – establishes if results are believable
Generalisability – results are applicable to other settings (dependent of sample)	*Transferability* – applicable to other research settings
Reliability – data is replicable or repeatable	*Dependability* – confidence in the findings, overlapping methods
Objectivity – researcher has limited interaction with participants to reduce influence of own bias	*Reflexivity* – researchers reflect on their biases, making others aware

3.5 Conclusion

This chapter has explained and justified the theoretical considerations and methodological approaches used to research, design, and evaluate a BMS for assessing the NTS of a paramedic managed OHCA. The use of a mixed method multiphase approach using triangulation has been identified as the most appropriate method. It allows for separate data collection and analysis stages that inform each other, with each phase building on the last, resulting in a comprehensive integration that ensures an in-depth exploration and explanation of the NTS specific to a paramedic managed OHCA. A pragmatic paradigm works well as a complementary supporting framework, as it ensures a complete understanding of the social and scientific issues associated with developing a BMS. The succeeding chapters provide a detailed explanation of the methods used, results and discussion for research phases one to three.

Chapter 4 - Research Phase One Questionnaire and Focus Groups

4.1 Introduction and Aim

This chapter provides a detailed explanation and justification of individual research data collection and analysis methods used to investigate the use of NTS used by paramedics managing an OHCA. The first part details the questionnaire method, followed by an explanation of the focus groups, with the combined results informing the design phase. This chapter builds on chapter three and provides an in-depth explanation of the methods used, the results, and a discussion of the findings from each data collection phase. The aim of this chapter was to identify the specific NTS associated with a paramedic managed OHCA.

4.2 Context and Purpose

As previously identified, there is limited literature for paramedic NTS and no identifiable BMS specific to the paramedic management of an OHCA. This resulted in the need to explore student and qualified paramedic and expert views to identify which NTS are considered specific to managing an OHCA to inform the design of the BMS.

Previous literature has advocated that good NTS are vital to managing a successful cardiac arrest (Andersen et al., 2010; Marsch et al., 2004). Gold and Eisenberg (2009) suggest increased experience and higher levels of exposure to an OHCA can improve team performance, which has been associated with increased rates of spontaneous circulation (Weiss et al., 2017). To achieve objective one (Identify specific NTS associated with a paramedic managed

OHCA) a questionnaire was designed to measure the attitudes and opinions of student and qualified paramedics to which NTS they considered important to the management of an OHCA, and whether increased exposure rates of an OHCA influence this. The use of a questionnaire offered a relatively cost efficient, timely and practical method to establish a user-centred knowledge base (Jones et al., 2013).

Like other healthcare BMS, such as SPLINTS (Mitchell, 2011) and ANTS-AP (Rutherford, 2015), focus groups were considered as an appropriate method to collect in-depth, candid responses, allowing for a broad discussion of the results from the questionnaire. This provided an explanation of the results, clarifying, and identifying specific NTS associated with an OHCA, adding context to a paramedic managed OHCA.

As the purpose of this phase was to identify specific NTS for a paramedic managed OHCA, the combination of numerical and textual data provided a comprehensive view of two different, yet complementary methods. The results informed design phase two, the purpose of which was to validate and integrate all results to create a taxonomy for a paramedic managed OHCA BMS.

The section below provides the ethical considerations for each phase, followed by details of the methods and results for the questionnaire and focus group. A short discussion precedes the methods and results of the semi-structured interviews and triangulation before a final discussion and inclusion of the prototype BMS.

4.3 Ethical Considerations

The University Research Ethics Committee granted ethical approval for the questionnaire and focus groups, with separate ethics applications detailing individual study design, methods, and data security (P48036 see Appendix C; P65504 see Appendix D). All data were collected and managed in accordance with the General Data Protection Regulations (Information Commissioner's Office. (n.d.) and the Data Protection Act (1998).

As participants included students at the researcher's employing University, to mitigate against any bias all were informed that any involvement had no bearing on their academic study, data were anonymised, and all had the option to withdraw from individual phases of the study. All participants were provided with participant information and consent forms specific to each data collection phase, with contact details for the supervision team and doctoral college included.

4.4 Questionnaire and Focus Groups Sample and Setting

The sample for both the initial questionnaire and subsequent focus groups included student and qualified paramedics enrolled on undergraduate and postgraduate programmes at large urban University in central England. The questionnaire was completed and collected over a two-month study period (May–June 2017), with the focus groups conducted over a three-month period (Jan–March 18) (see figure 3.2). Participants in both stages included student and qualified paramedics, including some colleagues, if they met the inclusion criteria (see table 4.1).

Table 4.1 Inclusion and exclusion criteria for questionnaire and focus group participants

Inclusion Criteria	*Exclusion Criteria*
Student or qualified paramedic enrolled on undergraduate or postgraduate paramedic programme	Student on nursing, operation department practitioner, midwifery programme
Qualified paramedic employed in paramedic teaching role if enrolled on postgraduate programme	Staff without paramedic qualification enrolled on postgraduate programme
Currently studying at university where research was conducted	Not enrolled at university where research was taking place
Experience of managing an OHCA in operational practice	Only managed a simulated OHCA

To reduce any influence on participants, the study was advertised, and data collected with an emphasis on the researcher's position as a PhD student rather than educator or colleague, although it is recognised that bias may have occurred, despite efforts to limit.

There was no predetermined sample size for the questionnaire, with approximately 250 students enrolled on paramedic programmes but only 110 considered eligible (see table 4.1) due to exposure to operational practice placement and therefore experience of managing a real-life OHCA. Student paramedics were considered for the sample, as they could provide a unique view of OHCA management due to their supernumerary role when in clinical practice, regular training, and assessment in OHCA management. Qualified paramedics provided an alternative view as their operational experience resulted in greater levels of exposure rates to an OHCA. This combination created a mix of novice and expert opinion, which provided varied views and considerations of NTS and OHCA management.

Convenience sampling was used as it provided a cross section of applicable participants, with varying backgrounds, exposure, perceptions, and experience of managing an OHCA. This non-probability sampling method was considered effective, as it was relatively quick and easy to manage, beneficial in homogeneous groups and the wider context of the overall study (Jager et al., 2017). Both the questionnaire and focus groups included demographic data (age range, gender, type, and length of operational and clinical experience) to aid an understanding of each group's composition.

Study information was advertised using the University online learning platform and copies of participant information sheet were posted in classrooms where paramedic lectures were taking place. All participation was voluntary, and students were invited to attend a selection of researcher-led question and answer sessions.

4.5 Questionnaire Methods

4.5.1 Design and Distribution

A questionnaire of 25 closed questions, answered using a five-point Likert scale (strongly disagree 1, to strongly agree 5) was constructed, it also included two additional open-ended questions designed to explain problems encountered at an OHCA and were included to provide an alternative view (Schoonenboom & Johnson, 2017; Singer & Couper, 2017). The questionnaire (see table 4.2 for questions) was developed using questions from existing validated in-hospital cardiac arrest team-based questionnaires as there were none specific to paramedics and they provided a structured and reliable set of questions (Malec et al., 2007; Cooper et al., 2010b; Chiu, 2014). It is recognised that the question design may result in the examination of attitudes and opinions, and although the cognitive and affective components can result in similar attitudes, they may be perceived and comprehended differently. However, as noted in chapter three, attitudes and opinions appear to be closely associated (Bergman, 1998). As the questionnaire aimed to explore which NTS were considered important to the management of an OHCA, with answers expanded upon in the focus groups, it was considered that the questions were suitable.

A five-point Likert scale was used as it provided a set scale for answers, with frequent use in healthcare increasing familiarity and the potential for completion (Rattray & Jones, 2007). Despite the risk of central tendency or social desirability bias, potential for a forced choice and as a result of questions adapted from other questionnaires already using five-point scales (Allen & Seaman, 2007), a five-point scale provided an expression of attitude/opinion, and a method to produce quantifiable data (Chyung et al., 2017). A paper copy of the questionnaire was delivered face-to-face to reduce the chance of ambiguity, as this allowed for any questions to be asked before the lead researcher left the participants to answer the questions alone, increasing the chance of completion. The effect of researcher participation was considered, and although the chance to ask questions may have resulted in pressure or bias to answer, an emphasis was placed on the position as a PhD student with participants were left to complete the questionnaire on their own. Data was also collected during sessions not associated with the lead researcher and statements were included in all advertising that participation had no bearing on individual study results or progression. All participants were provided with participant information and consent forms, with questionnaires collected by the lead researcher once participants had completed and scanned for digital storage if consent was provided. All paper copies destroyed using the University confidential waste disposal method.

4.5.2 Data Analysis

Statistical analysis was performed using SPSS software (IBM SPSS Statistics for Windows, Version 25, 2017), with descriptive statistics reported as median and interquartile range [IQR] and mean (standard deviation). It was identified in the literature that teams with higher levels of training in NTS and OHCA simulated practice demonstrated a greater understanding of NTS. As paramedic OHCA exposure and simulation is limited (Dyson et al., 2015) it was hypothesised that higher exposure rates of an OHCA result in a more positive perception of NTS and an independent t-test was performed to examine if a difference existed. This is linked to the need to identify specific NTS associated with a paramedic managed OHCA as it is unclear if exposure influences this. Exposure rates were grouped into the number of OHCA attended per year (<10 and ≥ 10 per year) based on median OHCA figures by Dyson et al. (2016) and Weiss et al. (2017) with a value of $p=<.05$ considered statistically significant (Grabowski, 2016).

To analyse the open answer data, thematic analysis was performed using NVivo 12 software (QSR International Pty Ltd, 2018). This method provided a flexible approach, with descriptive and interpretative analysis, and the identification of unexpected insights (Saldana, 2016). Surface level content analysis was used to organise the data into patterns (Gibbs, 2018) as it ensured data were not just described but were also summarised, reviewed, and interpreted providing contextual meaning. Braun and Clarke's (2006) six-step approach was used, with data inductively coded by topic to identify codes, categories, and emergent themes. A codebook was created to review and discuss data with the director of studies as part of peer debriefing, allowing for comparison. Results are reported in a narrative format supported with exemplary quotes, with identifiable information anonymised and corrections included for spelling and typos.

4.6 Questionnaire Results

A total of 70 undergraduate and postgraduate student paramedics completed the questionnaire (see figure 3.2 for additional information). More male students (61%) completed the questionnaire than females, half of the participants were aged between 18-29 years ($n=35$), most participants were enrolled as a part time undergraduate student with experience of working as an EMT in an operational role with an ambulance trust ($n=42$), and most respondents attended <10 OHCA per year ($n=46$). The mean OHCA attended in one year by all participants was M=8.57 (SD=7.90), Mdn=6 (IQR=3-12). Based on data from the National Audit Office (2017), operational experience was divided into <5 years and ≥5 years as this reflected the 'average lifespan' of a UK paramedic, with 78% with <5 years operational experience. Based on this, years of experience did not appear to be associated with a higher number of OHCA attended per year. A breakdown of demographic results presented in table 4.2.

Table 4.2 Questionnaire participant demographic data

	Total n (%)	*Full Time UG Student Paramedic n (%)*	*Part Time UG EMT Student Paramedic n (%)*	*Qualified Paramedic PG n (%)*
Participant type	*n=70* (100)	*n=24* (34.3)	*n=42* (60)	*n=4* (5.7)
Gender				
Male	*n=43* (61.4)	*n=13* (18.5)	*n=27* (38.6)	*n=3* (4.3)
Female	*n=27* (38.6)	*n=11* (15.8)	*n=15* (21.4)	*n=1* (1.4)
Total	*n=70* (100)	*n=24* (34.2)	*n=42* (60)	*n=4* (5.7)
Age Range				
18-29	*n=35* (50)	*n=21* (30)	*n=13* (18.6)	*n=1* (1.4)
30-39	*n=22* (31.4)	*n=1* (1.4)	n=19 (27.1)	*n=2* (2.9)
40-49	*n=11* (15.7)	*n=2* (2.9)	*n=8* (11.4)	*n=1* (1.4)
50+	*n=2* (2.9)	*n=0* (0)	*n=2* (2.9)	*n=0* (0)
Total	*n=70* (100)	*n=24* (34.3)	*n=42* (60)	*n=4* (5.7)
Operational Experience				
<5 years	*n=55* (78.6)	*n=24* (34.3)	*n=29* (41.4)	*n=2* (2.9)
≥ 5 years	*n=15* (21.5)	*n=0* (0)	*n=13* (18.5)	*n=2* (2.9)
Total	*n=70* (100)	*n=24* (34.3)	*n=42* (60)	*n=4* (5.7)
No. OHCA per year				
<10	*n=46* (65.7)	*n=21*(30)	*n=22* (31.4)	*n=3* (4.3)
≥10	*n=24* (34.3)	*n=3* (4.3)	*n=20* (28.6)	*n=1* (1.4)
Total	*n=70* (100)	n=24 (34.3)	*n=42* (60)	*n=4* (5.7)

The levels of operational experience reflect the route of study as expected as those participants enrolled on a part time UG paramedic programme employed as an EMT prior to their study and therefore increasing their level of operational experience. It was noted that these participants studying also self-reported higher numbers of OHCA attended per year. Figure 4.1 provides a visual representation of the number years of operational experience and number of OHCA attended per year.

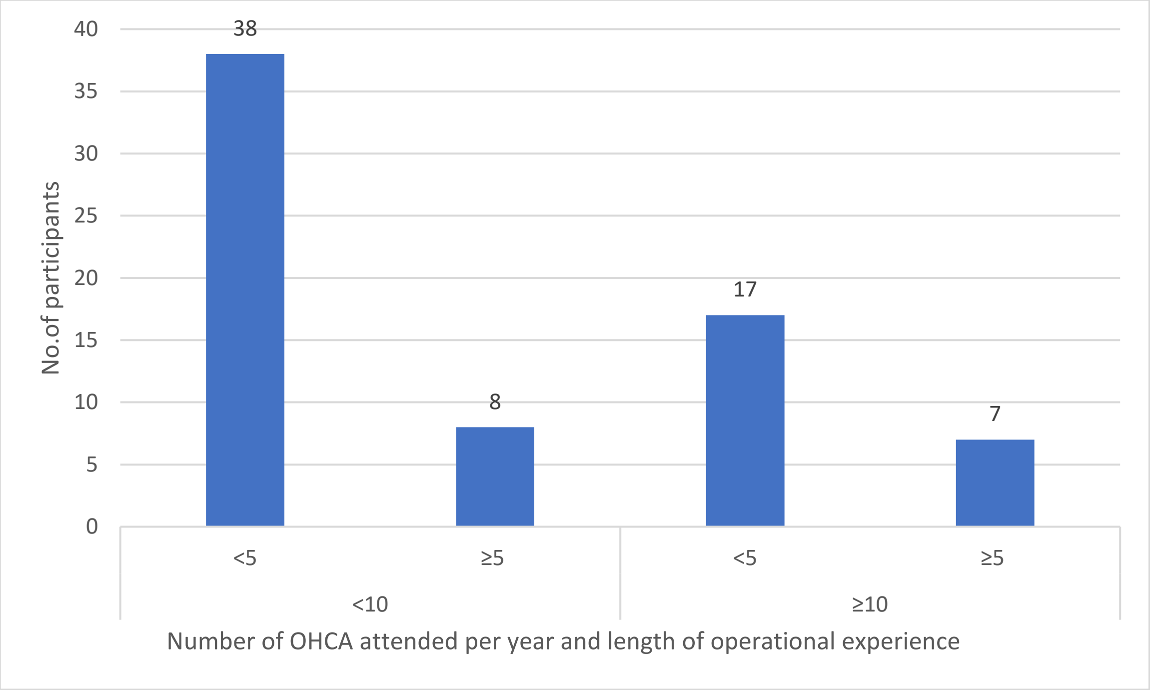

Figure 4.1 Bar chart of years of operational experience and number of OHCA attended per year (<5, ≥5 year of operational experience, <10, ≥10 OHCA per year)

When the operational experience and number of OHCA attended per year were reviewed, it appears that those participants with less operational experience attend fewer OHCA per year in general.

4.6.1 Statistical Results

Descriptive statistics for each question are presented in table 4.3 with minimum and maximum Likert scale scores ranging from strongly disagree 1, to strongly agree 5, mean Likert score with standard deviation, range for individual questions, and median with interquartile range included.

*Table 4.3 Descriptive statistics for individual questions (*Standard Deviation)*

Question	*Scale strongly disagree 1, to strongly agree 5*						
	Min	*Max*	*Mean*	*Std. Dev**	*Range*	*Median*	*IQR*
1. A leader is required in an OHCA (leadership)	3	5	4.61	.546	4.06-5.15	5	1
2. Roles are assigned before clinical interventions start in an OHCA (leadership/communication)	1	5	3.37	1.092	2.28-4.46	4	2
3. Using a checklist during an OHCA reduces mistakes (task management/situation awareness)	1	5	4.00	.799	3.20-4.79	4	1
4. A debrief after an OHCA is common (leadership/teamwork)	1	5	3.19	1.289	1.91-4.47	4	2
5. I understand my role during an OHCA (teamwork/task management)	2	5	4.06	.634	3.43-4.69	4	1
6. Other crewmembers demonstrate an understanding of their role during an OHCA (teamwork/task management)	2	5	3.87	.760	3.11-4.63	4	0
7. I do not switch my role during an OHCA (teamwork/task management)	1	5	2.24	.955	1.29-3.19	2	1
8. Other crewmembers do not switch their role during an OHCA (teamwork/task management)	1	4	2.33	.829	1.51-3.15	2	1
9. I work effectively as part of an ambulance crew/ team during an OHCA (teamwork/task management)	3	5	4.37	.569	3.81-4.93	4	1

Table 4.3 continued…

Question	*Scale strongly disagree 1, to strongly agree 5*						
	Min	*Max*	*Mean*	*Std. Dev**	*Range*	*Median*	*IQR*
10. Other crewmembers work effectively as a crew/ team during an OHCA (teamwork/task management)	2	5	4.06	.639	3.43-4.69	4	0
11. I delegate tasks during an OHCA (teamwork/task management/communication)	1	5	3.34	1.020	2.32-4.36	4	1
12. Other crewmembers delegate tasks during an OHCA (teamwork/task management/communication)	2	5	4.11	.553	3.55-3.89	4	0
13. I am aware of my surroundings and people during an OHCA (situation awareness)	2	5	4.13	.700	3.43-4.83	4	1
14. Other crewmembers are aware of their surroundings during an OHCA (situation awareness)	2	5	3.79	.759	3.04-4.54	4	1
15. I verbalise my actions aloud to other crewmembers during an OHCA (communication)	2	5	4.19	.906	3.29-5.09	4	1
16. Other crewmembers verbalise their actions aloud during an OHCA (communication)	1	5	3.64	1.091	2.55-4.70	4	1
17. I refer to memory aids such as pocketbooks to assist local / national resuscitation guidelines and algorithm observance during an OHCA (task management/ situation awareness)	2	5	3.50	1.060	2.44-4.56	3.5	1

Table 4.3 continued…

Question	*Scale strongly disagree 1, to strongly agree 5*						
	Min	*Max*	*Mean*	*Std. Dev**	*Range*	*Median*	*IQR*
18. Other crewmembers refer to memory aids such as pocketbooks to assist local/national resuscitation guidelines and algorithms observance during an OHCA (task management/situation awareness)	1	5	3.30	.983	2.32-4.28	3	1
19. I use a checklist during an OHCA (task management/situation awareness)	1	5	2.81	1.207	1.71-4.01	3	2
20. Other crewmembers use a checklist during an OHCA (task management/situation awareness)	1	5	2.74	1.188	1.64-3.84	3	2
21. I am open to other crewmember's suggestions during an OHCA (teamwork/team coordination)	3	5	4.64	.512	4.13-5.15	5	1
22. Other crewmembers are open to suggestions during an OHCA (teamwork/team coordination)	1	5	3.99	.860	3.13-4.85	4	1.25
23. I ask for assistance if tired or unable to complete an intervention during an OHCA (teamwork/communication/ situation awareness)	4	5	4.61	.490	4.12-5.10	5	1
24. Other crew members ask for assistance if tired or unable to complete an intervention during an OHCA (teamwork/ communication/situation awareness)	1	5	4.09	.864	3.14-4.95	4	1
25. I actively debrief after with crews/ teams attending an OHCA (teamwork)	1	5	3.46	1.138	2.33-4.59	3.5	1

The descriptive data provided a level of agreement for each question, separated into individual and overall favourable opinions/attitudes, and differences in answers with respect to OHCA exposure rates, assessed with an independent t-test.

Overall, there appears to be a mixed perception to the use of NTS during a paramedic managed OHCA. Based on the mean data, just under half the questions were agreed with, including that a leader is required, respondents understood their roles, were aware of their surroundings, that they verbalise their actions and are open to others suggestions. Although some questions were disagreed with (roles change, checklists are not used) or answered neutrally (debriefs are common, delegation of tasks, other's awareness of surroundings), there was no indication that the associated NTS were not considered important. Answers highlighted that a leader is required, that roles change, and checklists are not used in an OHCA.

4.6.1.1 Independent T-test

Upon completion of an independent t-test for each question and the number of OHCA attended per year, only question seven was found to be statistically significant. A breakdown of results is presented in table 4.4 including mean, standard deviation and *p*-values presented with $p<.05$ highlighted yellow.

*Table 4.4 t-test Q1-25 Number of OHCA attended per year mean, *standard deviation and p-value*

Question	*n=<10*	*Mean*	*Std. Dev**	*n=≥10*	*Mean*	*Std. Dev**	*p-value*
1. A leader is required in an OHCA (leadership)	46	4.61	.537	24	4.63	.576	.907
2. Roles are assigned before clinical interventions start in an OHCA (leadership/communication)	46	3.46	1.026	24	3.21	1.215	.398
3. Using a checklist during an OHCA reduces mistakes (task management/situation awareness)	46	3.98	.774	24	4.04	.859	.763
4. A debrief after an OHCA is common (leadership/teamwork)	46	3.24	1.303	24	3.08	1.283	.635
5. I understand my role during an OHCA (teamwork/task management)	46	4.09	.551	24	4.00	.780	.630
6. Other crewmembers demonstrate an understanding of their role during an OHCA (teamwork/task management)	46	4.00	.667	24	3.63	.875	.074
7. I do not switch my role during an OHCA (teamwork/task management)	46	2.39	1.064	24	1.96	.624	.036
8. Other crewmembers do not switch their role during an OHCA (teamwork/task management)	46	2.33	.845	24	2.33	.816	.973
9. I work effectively as part of an ambulance crew/team during an OHCA (teamwork/task management)	46	4.30	.511	24	4.50	.659	.212
10. Other crewmembers work effectively as a crew/team during an OHCA (teamwork/task management)	46	4.13	.505	24	3.92	.830	.251
11. I delegate tasks during an OHCA (teamwork/task management/communication)	46	3.24	1.037	24	3.54	.977	.242

Table 4.4 continued…

Question	*n=<10*	*Mean*	*Std. Dev**	*n=≥10*	*Mean*	*Std. Dev**	*p-value*
12. Other crewmembers delegate tasks during an OHCA (teamwork/task management/communication)	46	4.17	.608	24	4.00	.417	.164
13. I am aware of my surroundings and people during an OHCA (situation awareness)	46	4.22	.629	24	3.96	.806	.178
14. Other crewmembers are aware of their surroundings during an OHCA (situation awareness)	46	3.85	.759	24	3.67	.761	.349
15. I verbalise my actions aloud to other crewmembers during an OHCA (communication)	46	4.20	.910	24	4.17	.917	.900
16. Other crewmembers verbalise their actions aloud during an OHCA (communication)	46	3.74	1.084	24	3.46	1.103	.310
17. I refer to memory aids such as pocketbooks to assist local/national resuscitation guidelines and algorithm observance during an OHCA (decision-making/situation awareness)	46	3.48	1.090	24	3.54	1.021	.811
18. Other crewmembers refer to memory aids such as pocketbooks to assist local/national resuscitation guidelines and algorithms observance during an OHCA (decision-making/situation awareness)	46	3.41	1.024	24	3.08	.881	.166
19. I use a checklist during an OHCA (task management/situation awareness)	46	2.76	1.233	24	2.92	1.176	.612
20. Other crewmembers use a checklist during an OHCA (task management/situation awareness)	46	2.72	1.186	24	2.79	1.215	.806

Table 4.4 continued…

Question	*n=<10*	*Mean*	*Std. Dev**	*n=≥10*	*Mean*	*Std. Dev**	*p-value*
21. I am open to other crewmember's suggestions during an OHCA (teamwork/team coordination)	46	4.72	.455	24	4.50	.590	.123
22. Other crewmembers are open to suggestions during an OHCA (teamwork/team coordination)	46	4.00	.894	24	3.96	.806	.849
23. I ask for assistance if tired or unable to complete an intervention during an OHCA (teamwork/communication/situation awareness)	46	4.59	.498	24	4.67	.482	.519
24. Other crew members ask for assistance if tired or unable to complete an intervention during an OHCA (teamwork/communication/situation awareness)	46	4.13	.833	24	4.00	.933	.553
25. I actively debrief after with crews/teams attending an OHCA (teamwork)	46	3.46	1.206	24	3.45	1.021	.995

Overall, the results established that perceptions of NTS are similar regardless of exposure rates to an OHCA. Only question seven (I do not switch my role during an OHCA), was found to be statistically significantly different in scores for participants who attended <10 OHCA per year (M = 2.39, SD = 1.064) and participants who attended ≥10 OHCA per year (table 4.3). The magnitude of the difference in the means (mean difference =.433, 95% CI: .030 to .836) was moderate (eta squared =.06). This suggests that even though all participants disagreed with the question, those who attend ≥10 OHCA per year strongly disagreed that they switch their roles during an OHCA.

4.6.2 Themes from Open Questions

Following the quantitative data analysis, the answers from the open question were analysed and three themes relating to the use of NTS during an OHCA were identified: barriers to effective NTS, teamwork, and leadership.

4.6.2.1 Barriers to effective NTS

Barriers to effective NTS had the highest number of phrases (n=95), with some comments sometimes relating to several codes. It was divided into two categories, environmental ergonomics, and team members.

Barriers to effective NTS (Figure 4.2) included specific phrases that related to the scene and team members, with a negative perception of team performance if there was no leader noted. Frequent and specific phrases related to the unscheduled nature of an OHCA, with comments emphasising difficulties in working in an environment that was small, noisy, and in view of relatives or bystanders. Other comments included difficulty in moving patients and working with paramedics who demonstrated poor equipment knowledge. Together these codes formed the category of environmental ergonomics as they linked human performance to the work environment. Other comments that had a high frequency included difficulty in working together and communication when working with clinicians who were perceived to have a strong personality, inflated opinion of their clinical ability, or demonstrated egotistical behaviour. When the codes were combined, they formed the category team members as they reflected the team make up and difficulties managing others in the team.

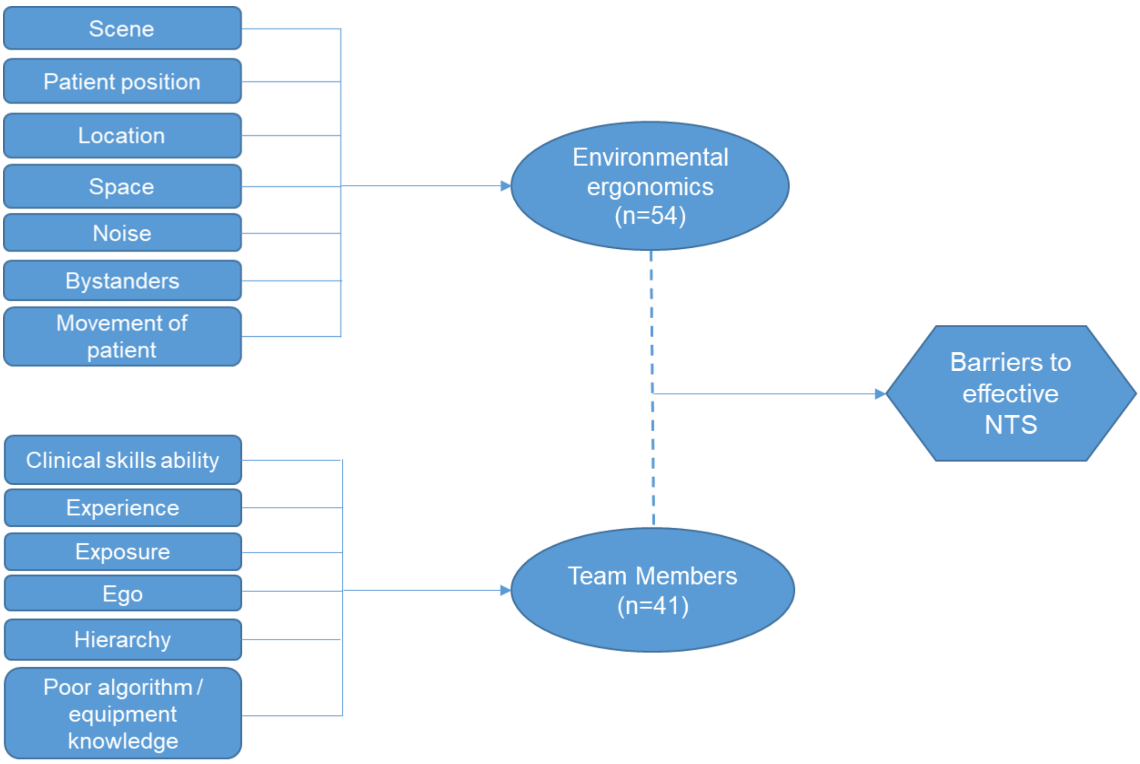

Figure 4.2 Barriers to effective NTS codes-to-theme model

Example quotes are presented in table 4.5 below with corresponding codes and categories and describe OHCA management that can be interpreted as disorganised with limited space.

Table 4.5 Barriers to effective NTS example quotes, codes, categories and associated non-technical skill

Example quote	*Code*	*Category*
''lack of resources, access and egress can be difficult, position of patient makes arrest difficult, difficult to get full history'' (PN5)	Scene, Patient position, Movement of patient	Environmental ergonomics
''logistical issues, removing patient from room, home address whilst effectively working CPR'' (PN7)	Patient position, Location, Movement of patient	Environmental ergonomics
''different skilled people tend to work against each other, due to wanting to take control, thinking they know more about the situation'' (PN9)	Clinical skills ability, Ego	Team Members
''Situation is never ideal often there are problems with space and access, room to move''(PN10)	Space, Movement of patient	Environmental ergonomics
Location of patient in tight, immovable spaces'' (PN14)	Scene, Location, Space, Patient position	Environmental ergonomics
"sometimes find it difficult to know which tasks I am expected to complete if roles haven't been given before-hand'' (PN16)	Clinical skills ability Experience, Exposure	Team Members
''confusion of equipment locations and sizes…egos for skill such as ETT'' (PN22)	Ego, Poor algorithm/equipment knowledge	Team Members
''sometimes I feel I can't suggest or challenge people with a higher skills level or longer service'' (PN24)	Experience, Ego, Hierarchy, Exposure	Team Members

Table 4.5 continued…

Example quote	*Code*	*Category*
''difficult to continue chest compressions whilst extricating a patient'' (PN25)	Scene, Location, Movement of patient	Environmental ergonomics
''approx. 8 people…confusion, three defibs, no clear leader, people wanting to do skills themselves for own competence'' (PN26)	Clinical skills ability, Experience, Ego, Hierarchy	Team members
''occasional stubbornness, pride in others when performing interventions'' (PN41)	Clinical skills ability, Experience, Ego, Hierarchy, Exposure	Team members
''confusion, lack of a clear leader, staff want to do clinical skills for their own competence'' (PN60)	Clinical skills ability, Ego, Hierarchy, Exposure	Team members
''more people equals more noise'' (PN60)	Scene, Bystanders	Environmental ergonomics
''poor access, very little room to work'' (PN61)	Scene, Space	Environmental ergonomics
''difficulty in ALS, difficulty in getting patient out of house after ROSC due to patient upstairs in restricted space, family/friend intervention sometimes hinders crews'' (PN61)	Scene, Space, Bystanders, Movement of patient	Environmental ergonomics

4.6.2.2 Teamwork

Teamwork included team related and personal factors categories, with a high number of phrases identified (n=65). Teamwork appeared to be based on individual and team factors, with phrases specifically linking a lack of knowledge of equipment and clinical algorithms to stress and confidence. There also seemed to be association with experience and exposure rates of an OHCA, with frequent comments suggesting an assumption that teams, formed of ambulance crews, knew each other, and were experienced. Phrases suggested that assumption and a lack of familiarity negatively affects teamwork and could be separated into team and personal factors. Although this could be a result of student paramedics acting in a supernumerary capacity and different perceptions of confidence, and personalities, participants included a mixture of full time and part time employed student paramedics, either working as part of an ambulance crew and embedded into ambulance trust hubs. Example phrases, codes, and categories are presented in table 4.6 after the streamlined codes-to-themes figure 4.3.

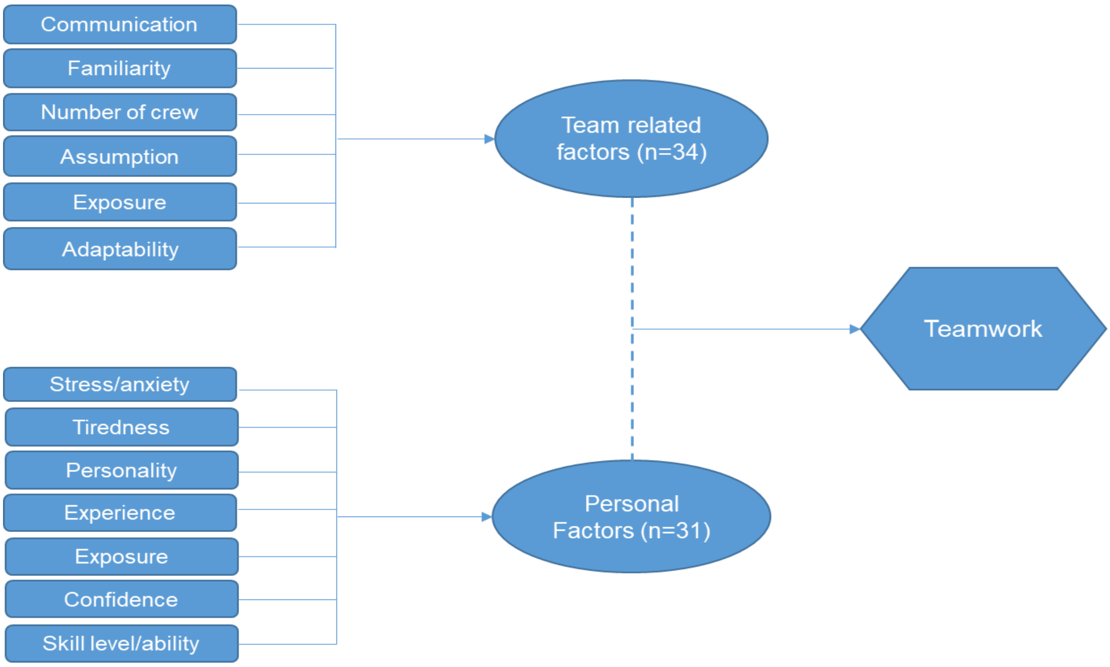

Figure 4.3 Teamwork codes-to-theme model

Table 4.6 Teamwork example quotes, codes, categories and associated non-technical skill

Example quote	*Code*	*Category*
''clinicians rushing or having high levels of anxiety that is not conductive to good scene, patient management'' (PN1)	Stress/anxiety, Experience, Confidence	Personal factors
''crewmembers are not always receptive to feedback such as performing CPR more quickly. They take it personally and communication breaks down'' (PN1)	Personality, Experience, Skill level/ability	Personal factors
''sometimes there aren't enough paramedics, ALS providers meaning one person's role has to change during resus'' (PN2)	Number of crew, Adaptability,	Team related factors
''Feel I'm a hindrance, in the way of better skilled clinicians'' (PN5)	Stress/anxiety, Skill level/ability, Confidence	Personal factors
"Uncommon nature means minimal exposure and experience'' (PN6)	Experience, Exposure	Personal factors
''Checklists - other than paeds I've seen, tend to be difficult to use in high stress'' (PN10)	Stress/anxiety, Experience, Exposure	Personal factors
''working with people you may have not met before'' (PN15)	Communication, Familiarity	Team related factors

Table 4.6 continued…

Example quote	*Code*	*Category*
''other staff not being as open with skills they are not confident in'' (PN15)	Personality, Skill level/ability, Confidence	Personal factors
''assumption that everyone knows what is going on'' (PN17)	Familiarity, Assumption	Team related factors
''Often the crew who back you up are randomly selected, won't have worked with them'' (PN24)	Familiarity, Assumption, Adaptability	Team related factors
''Info to second crew is limited, somebody normally assumes control and delegates jobs. No one is sure of who is going to do what'' (PN25)	Communication, Assumption	Team related factors
''lack of knowledge of other people, lack of personnel'' (PN35)	Familiarity, Number of crew	Team related factors
''Different skilled people tend to work against each other, due to wanting to take control/thinking they know more about the situation'' (PN40)	Personality, Experience, Confidence	Personal factors
''problems with poor comms, no comms of what needs to be done or doing. Unclear roles'' (PN43)	Communication, Assumption	Team related factors
''fatigue - may be in 12th hour of a shift/night shift'' (PN55)	Tiredness, confidence	Personal factors

4.6.2.3 Leadership

Leadership also had a high number of phrases (n=63) and often linked communication and decision-making. Although a leader was identified as needed in the closed answers, the open answers appeared to contradict this. Specific phrases related to disorganisation, poor communication, and a lack of confidence in others, while others highlighted difficulties with task management, role allocation and a poor clinical/equipment knowledge (see figure 4.4).

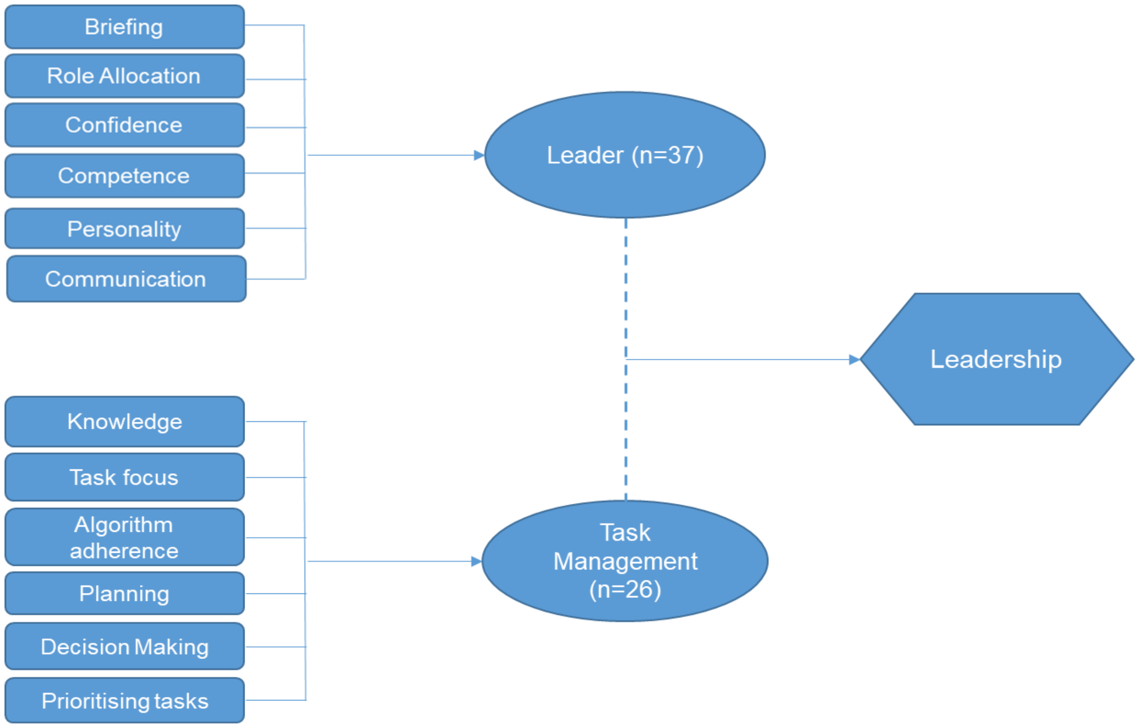

Figure 4.4 Leadership codes-to-theme model

Example phrases, codes, and categories in support of this theme are presented in table 4.7.

Table 4.7 Leadership example quotes, codes, categories and associated non-technical skill

Example quote	*Code*	*Category*
''different/non-standardised skill sets can affect role allocation'' (PN1)	Briefing, Role allocation,	Leader
''Depending on the clinician on scene sometimes it's like a free for all at OHCA'' (PN7)	Confidence, Personality,	Leader
''decision making and time performing CPR varies'' (PN8)	Decision-making, prioritising tasks	Task Management
''Sometimes little or no management on scene, poor leadership'' (PN15)	Briefing, Role allocation, Communication	Leader
''Too many people trying to do the same thing, unclear roles'' (PN18)	Briefing, Role allocation, Communication	Leader
''An extra pair of hands is always useful…dealing with bereaved friends/relatives trying to keep them calm during OHCA'' (PN21)	Prioritising tasks, Decision-making	Task Management
''poor clinical knowledge, using etc02 (unfamiliar kit)'' (PN27)	Knowledge, Algorithm adherence	Task Management
''problems with poor comms, no comms of what needs to be done or doing. Unclear roles'' (PN31)	Briefing, Role allocation, Communication	Leader
''not all staff work well together sometimes there appears to be a leadership disagreement'' (PN33)	Personality, Communication	Leader

Table 4.7 continued…

Example quote	*Code*	*Category*
''somebody normally assumes control and delegates jobs. No one is sure of who is going to do what'' (PN36)	Briefing, Role allocation, Communication	Leader
''Can be chaotic with no lead or id roles'' (PN38)	Briefing, Role allocation, Communication	Leader
Can get task fixated and miss basics'' (PN38)	Task focus, Algorithm adherence	Task Management
''no clear leader and people are delegated multiple things, chaotic, multiple practitioners trying to take the lead'' (PN40)	Role allocation, Personality	Leader
''too many clinicians taking lead being asked to do a new task while carrying out a previous task'' (PN45)	Prioritising tasks, Decision-making	Task Management
''Staff become task focused'' (PN55)	Task focus	Task Management
''People lack a shared mental model and stepwise approach, don't adhere to protocol'' (PN69)	Knowledge, Algorithm adherence	Task Management

4.6.2.4 Summary of questionnaire results

When the textual data were reviewed, they provided insight into the closed answers from the questionnaire. Compared to the questionnaire by Miller (2015) that sought to investigate areas for improvement in resuscitation, the answers here focused on NTS associated with a paramedic managed OHCA. The results identified that although participants agreed that a leader is required, it appears difficult to assign one and the comments suggest there is a lack of leadership. It appears that Question seven – 'I do not switch my role during an OHCA' is connected to environmental ergonomics and is reflected in comments about varied team sizes. When the findings of this questionnaire were compared to general paramedic NTS identified in the literature review by Shields and Flin (2013), it appears that leadership, teamwork, and potentially communication could be applied to a paramedic managed OHCA. The themes identified in this part of the research phase informed the focus groups, providing two NTS leadership and teamwork, and barriers to effective NTS that needed a detailed explanation to understand how they affect and can be applied to a paramedic managed OHCA.

4.7 Focus Groups Method

4.7.1 Aim

The aim of the focus groups were to build on the findings from the questionnaire and examine in-depth the specific NTS associated with a paramedic managed OHCA. Although the questionnaire provided some insight, the focus groups provided a means to explore further, providing explanation for the difficulties associated with a paramedic managed OHCA and strengthen the specificity of the NTS.

4.7.2 Design and Process

Following research phase one, focus groups were advertised using the university online platforms, with participants who had completed the questionnaire invited via a link on the participant information sheet. Inclusion and exclusion criteria were the same as for the questionnaire (see table 4.1). A topic and question guide was created from the questionnaire analyses for the focus groups (See Appendix E) and four focus groups were facilitated over a three-month period (Jan–March 18), at an agreed time and location with participants. The lead research acted as a moderator, as this provided some distance between the researcher and participants, enabling discussion between the group, rather than the researcher leading the session (Ochieng et al., 2018). Although present, the lead researcher emphasised their role as a PhD student and researcher, reiterating that participation had no bearing on participants' academic programmes. Each focus group was limited to a maximum of six participants, to effect greater discussion, encouraging open interaction in the hope of generating honest opinions, feelings, and attitudes (Krueger, 1994; Morgan, 1997; Parker & Tritter, 2006). Each focus group lasted approximately one hour in length and used private rooms in the participant’s university away from distraction or influence of others. All focus groups were audio recorded using an encrypted device and additional field notes taken, with a topic and question guide used to generate discussion when necessary.

At the start of each focus group, all participants were welcomed and provided with refreshments and an explanation of how the group would proceed. The participant information sheet and consent form were reviewed at the start of each focus group and an opportunity provided for each participant to ask questions or withdraw from the study. Once all participants had consented and were comfortable, an introductory request was posed to the group; 'Tell us who you are, which area you work in and what is your favourite thing to do when not at work''. Designed to provide participants a chance to speak and interact with each other, this was followed by an introductory question; ''Can you describe your overall experience of an out-of-hospital cardiac arrest?''. Three transition questions were used to link participant's experiences of OHCA management and NTS and were followed by six questions, listed below, with a full copy of the topic guide and questions available in Appendix E:

Q1. Do you feel a leader is feasible at an out-of-hospital cardiac arrest? Can you expand?

Q2. Do you feel that an out-of-hospital cardiac arrest is organised/events anticipated?

Q3. Can you describe your experiences of teamwork during an out-of-hospital cardiac arrest?

Q4. In your experience, do you feel people communicate well during an out-of-hospital cardiac arrest?

Q5. In your experience, what do you consider are the main barriers to an effective team managing an out-of-hospital cardiac arrest?

Q6. In your experience, what would you say are the most important non-technical skills for managing a paramedic led out-of-hospital cardiac arrest?

Each focus group concluded with a final question; 'Is there anything else you would like to say, or feel has been missed?' before each group was thanked and reminded of the purpose of the focus group and data use. It was important to ensure each focus group was conducted using the same method and analysis techniques to ensure clarification of the aim, procedural rigour, and sampling strategy for representativeness (Kitto et al., 2008).

4.7.3 Data Analysis

A grounded theory, inductive approach was used as it allowed for the comparison and interaction of the collected data. All recordings were transcribed verbatim to reduce any risk of inaccuracy (Krueger & Casey, 2009), while the use of a structured method for data analysis ensured that analysis was trustworthy, practical, and effective with details of this explained in the next paragraph (Nowell et al., 2017).

Open, axial, and selective coding was used to identify patterns, categories, and themes, with a reflective loop process used to summarise all data (Strauss & Corbin, 1998). Text was organised using NVivo software (QSR International Pty Ltd, 2018) with codes constructed using in vivo coding as it emphasised the words of the participants, providing meaning to the data. Data were analysed following each group, as a method to identify data saturation points, which was reached at focus group four (Guest et al., 2016). Coding was supplemented with field notes to provide context for codes and categories, as it was important to ensure they were applicable to specific NTS associated with managing an OHCA (Phillippi & Lauderdale, 2018; Onwuegbuzie et al., 2009).

Based on guidance from Morgan (1997), following individual group analysis, data was combined into one complete transcript and reviewed for levels of frequency, extensiveness, and specificity. This allowed two levels of analysis that provided a balance of codes and interpretation of the data. To increase validity and reduce bias, codes, categories, and themes were discussed with the supervisory team and reviewed to ensure the findings were from the participants whom the data was collected. This method allowed for increased dependability as individual interpretation was crosschecked (Saumure & Given, 2008) demonstrating rigor. The review combined initial reading and re-reading of the textual data to ensure pattern recognition prior to discussion about the process of interpretation. Discussion took place about the perception and interpretation of categories, with emphasis placed on the lead researcher's rationale for coding. Codes and categories were reviewed for specificity, extensiveness, and appropriateness of allocation before checking that they represented the initial data analysis. Finally, the themes were reviewed to ensure they captured the participant's experiences and emergent concepts.

4.8 Focus Group Results

Results include a summary of demographic data followed by details of each theme identified from the data, supported by streamlined codes-to-theme models. Sixteen student and qualified paramedics were interviewed across four focus groups (see section 4.4). Experience varied and included previous work in non-ambulance roles such as an emergency department (see figure 3.2 for more detail). Presented in table 4.8, the participant's gender and operational experience were similar to the results from the questionnaires. After reviewing the frequency, specificity, and extensiveness of phrases, 10 categories were constructed (Morgan, 1997). These included teamwork, leadership, assessment of the scene, awareness of others, ad hoc team formation, team dynamics, effective, ineffective communication, ego/hierarchy, and experience/exposure. Five emergent themes were identified and included team coordination (phrases n=139), situation assessment (phrases n=124), teamworking (phrases n=121), communication (phrases n=84) and negative culture (phrases n=76).

Table 4.8 Focus group participant demographic data

Gender n (%)		*Operational Experience n (%)*		*Age Range n (%)*	
Male	Female	<5 years	12 (75%)	18-29	11 (69%)
11 (69%)	5 (31%)	≥5 - <10 years	3 (19%)	30-39	3 (19%)
		≥10-15 years	1 (6%)	40-49	2 (12%)

All participants discussed personal experiences of working as part of a team managing an OHCA, with many expressing similar opinions. The themes are divided into four NTS and barriers to effective team performance, with each theme explained below, including figures for the visualisation of the codes, categories and themes and example quotes to support.

4.8.1 Team Coordination

A key emergent theme was team coordination, combining leadership and teamwork, with frequent and extensive phrases relating to ineffective teamwork, and negative comments about leadership. Phrases included a stressful and chaotic scene, a lack of knowledge and understanding of clinical tasks, ineffective allocation of roles and tasks and an assumption of ability and clinical skills. All groups emphasised that the term ‘leader’ was not liked, and was associated with an autocratic style, often combined with poor communication and a lack of consideration of others. The term team coordination was preferred, as a leader was not always possible, and an effective team was considered essential.

Comments about teamwork suggested that smaller, familiar teams were considered as more effective, even when there was no identified leader. There was a perception of increased shared information resulting in a better understanding of the whole cardiac arrest. It was remarked that teamwork was poor where a more ‘senior’ paramedic attempted to lead the cardiac arrest, with clinical tasks often performed by the same paramedic resulting in a disjointed approach to the cardiac arrest with missed rhythm checks, shocks, or clinical observations. Example phrases suggested that leadership is assumed and linked to whoever was first on scene, with poor leadership perceived as a lack of role allocation and confusion in other’s clinical ability. Teamwork was perceived to be improved where information was shared including a clear understanding of roles and tasks, the recognition of stress or a low confidence in others and an ability to adapt. Figure 4.5 presents the codes, categories and theme with example quotes, codes, and categories included in table 4.9 after.

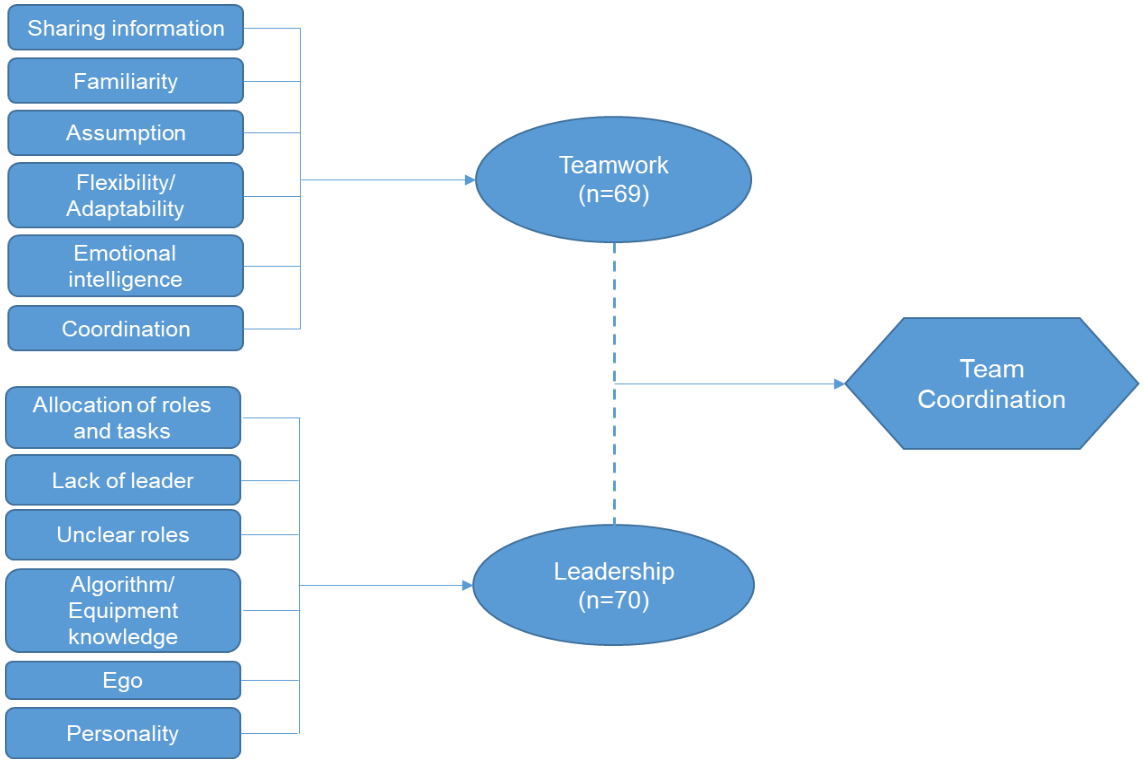

Figure 4.5 Team coordination codes-to-theme model

Table 4.9 Team coordination example quotes, codes, categories

Example quote	*Code*	*Category*
''a leader is definitely helpful, but they need to know ALS algorithm, better if they are the first on scene'' (PN1 group 1)	Algorithm/equipment knowledge	Leadership
''it's not so much leadership, you don't really need a definite leader but someone to coordinate and make sure stuff is done'' (PN2 group 1)	Allocation of tasks and roles, Coordination	Teamwork
''It was hard trying to run arrest and do stuff'' (PN3 group 1)	Allocation of tasks and roles	Leadership
''turned up at an arrest and there's been a manager, a double para crew, me, and my mentor, it's just a nightmare. (PN4 group 1)	Emotional intelligence, Coordination	Teamwork
Too many people not knowing what they're doing, and there's no delegation'' (PN4 group 1)	Allocation of tasks and roles, lack of leader	Leadership
''The issue is too many people want to interfere, there's no leadership'' (PN5 group 1)	Lack of leader, Ego, Personality	Leadership
''You need more of a scene coordinator, someone who can step back not take over'' (PN6 group 1)	Coordination	Teamwork
''arrived with CPR in progress and had a clear mind-set, was trying to direct second crew but they just did their own thing and ignored me'' (PN7 group 2)	Flexibility/adaptability, Coordination	Teamwork
''it's like a bunch of individuals working as a team, can be disjointed'' (PN8 group 2)	Flexibility/Adaptability, Emotional intelligence, Coordination	Teamwork

Table 4.9 continued…

Example quote	*Code*	*Category*
End up just being on the chest, never rotate, it's rubbish. Been to several and they are disorganised with kit everywhere (PN10 group 3)	Lack of a leader, unclear roles	Leadership
''The person at the head should be in charge, def need someone in charge when moving the patient'' (PN10 group 3)	Allocation of tasks and roles	Leadership
''It's a two-way street… a good definition of a leader, it's not someone who dictates to the rest'' (PN11 group 3)	Ego, Personality	Leadership
''isn't necessarily leadership, more like team coordination'' (PN11 group 3)	Coordination	Teamwork
''some paramedics are like I'm better than all of you so I'm going to lead it'' (PN12 group 3*)*	Ego, Personality	Leadership
''leadership is a problem, lots of personality clashes, confrontations'' (PN13 group 4*)*	Emotional intelligence, Ego	Leadership
''it's weird I had a cardiac arrest, last week, and it was in a public place, and…it was like organised chaos'' (PN14 group 4)	Assumption, Unclear roles, Lack of leader	Leadership
''Paras only lead and take control if others are incompetent and arrest is not going well, not natural to lead'' (PN16 group 4)	Algorithm/equipment knowledge, Personality	Leadership

4.8.2 Situation Assessment

Situation assessment in relation to an OHCA can be defined as 'a process of understanding the needs and conditions of the scene, patient and team to inform decisions and assist with planning'. As a specific NTS, it was considered as a significant and representative theme, as it reflected the assessment and sense making of the scene by individual paramedics that appeared to be restricted to clinical patient information, with decisions influenced by the use of clinical guidelines and algorithms. Although it was noted that there was some understanding of the scene and 'the ability to think further ahead', situation awareness was limited. Specific comments suggested a focus on clinical interventions that appeared to limit information gathering and anticipation or prediction, resulting in a stressful scene. Patterns formed from frequent and extensive comments of how poor algorithm knowledge appeared to affect paramedics' ability to plan and make decisions, with comments interpreted as a limited capacity to comprehend the whole scene. As suggested by Flin et al. (2015, p9. 23) the need to consider 'What', 'So What' and 'Now what' are important aspects of OHCA management that not only reflect, but can also be applied to real-life practice. It is recognised that situation awareness influences decision-making, focusing on the outcome of information gathering, linking to tacit and implicit knowledge to form an understanding, accumulating in anticipation or prediction. Yet comments emphasised the need to assess and make sense of the scene rather than being situationally aware. Situation assessment was considered as an important and appropriate theme that developed from comments, codes, and categories. As a foundation of situation awareness

(Noble, 1993; Prince & Salas, 1997), itself a precursor to decision-making, it reflected the different environments, and varying team sizes, emphasising the need for a good understanding of the scene and therefore considered critical to a paramedic managed OHCA. Streamlined codes, categories and overall theme are presented below (figure 4.6), supported by example quotes, codes, and categories in table 4.10 after.

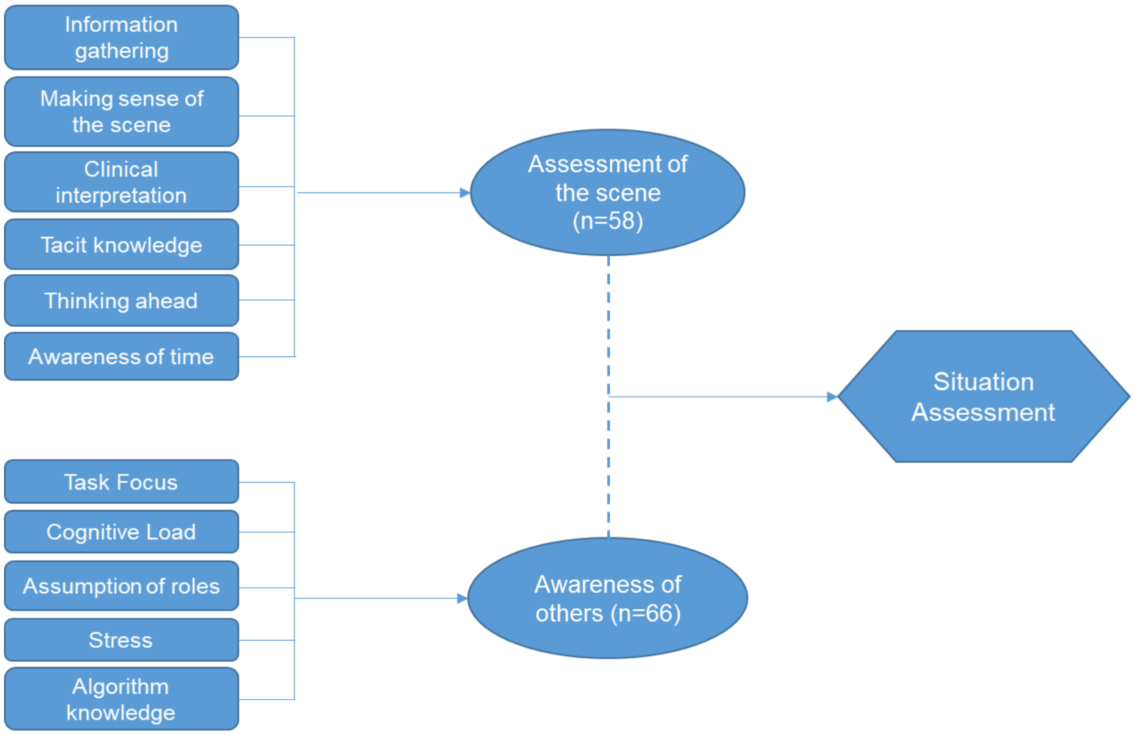

Figure 4.6 Situation assessment codes-to-theme model

Table 4.10 Situation assessment sample quotes, codes, and categories

Example quote	*Code*	*Category*
''Had a bad out-of-hospital cardiac arrest where it was difficult to know what was going on, got task focused'' (PN2 group 1)	Task focus	Awareness of others
''people don't know algorithm order and do things when they they're not supposed to'' (PN3 group 1)	Algorithm knowledge	Awareness of others
''You have to understand what's going on, everyone needs to know what's happening and have a shared mental model, but we're not used to doing OHCA, they don't happen that often''	Information gathering, Making sense of the scene	Assessment of the scene
''everyone wants to do something, especially skills like intubation or IV/IO. No situational awareness, everything is hyped up'' (PN7 group 2)	Assumption of roles, Stress	Awareness of others
''being calm, listening, I would say anticipation and awareness in that having an, err, an ability to think beyond the task at hand, so thinking two to three steps down the line'' (PN8 group 2)	Tacit knowledge, Thinking ahead	Assessment of the scene
''bad out-of-hospital cardiac arrest poor SA, had an airway problem and it became difficult to move on from that as everyone became task focused. CPR suffered'' (PN9 group 2)	Task focus, Stress	Awareness of others

Table 4.10 continued…

Example quote	*Code*	*Category*
''you know whether that be the next round of drugs, whether that's egress whether that's additional resources required, having that, yeah having that ability to think further ahead'' (PN11 group 3)	Clinical interpretation, Thinking ahead	Assessment of the scene
''doing clinical procedures, focus on my task and then five mins gone by and lost track of time'' (PN12 group 3)	Awareness of time	Assessment of the scene
''you learn each bit individually, not together so it's hard to know whole ALS algorithm, and difficult to plan'' (PN13 group 4)	Cognitive load, Algorithm knowledge	Awareness of others
''yeah, how can you think of all these things, at the same time, wasn't aware of algorithm'' (PN15 group 4)	Stress, Algorithm knowledge	Awareness of others
They teach you everything but individually, don't put stuff together, so you can't plan'' (PN15 group 4)	Clinical interpretation, Thinking ahead	Assessment of the scene
"It's quite easy to kind of get to the end where you think everything has been done'' (PN16 group 4)	Making sense of the scene, Awareness of time	Assessment of the scene
''kind of making the assumption that someone else has done something'' (PN16 group 4)	Assumption of roles, Cognitive load	Awareness of others

4.8.3 Teamworking

The theme teamworking developed from the categories of ad hoc team formation and team dynamics. Codes were formed from frequent comments about the difficulties working with unfamiliar paramedics, and varied numbers of clinicians responding to an OHCA. The combination of unfamiliar crews resulted in a larger, uncoordinated team, with a focus on clinical interventions. However, even if crews were unfamiliar, teamworking was perceived as 'better', if it was a smaller team and experienced in managing an OHCA. It was interpreted that an unfamiliar ad hoc and inexperienced team resulted in assumption, less support and the varied arrival times resulted in disruption, negatively influencing an ability to work effectively. Communication and general coordination of teams appeared to deteriorate as teams expanded emphasising the importance of teamworking. Considered as an important characteristic of OHCA management, the theme of teamworking materialised as a clear reflection of some of the difficulties experienced by the participants managing an OHCA. A summary of the interpretation including a streamlined code-to-themes model are presented in figure 4.7 and table 4.11.

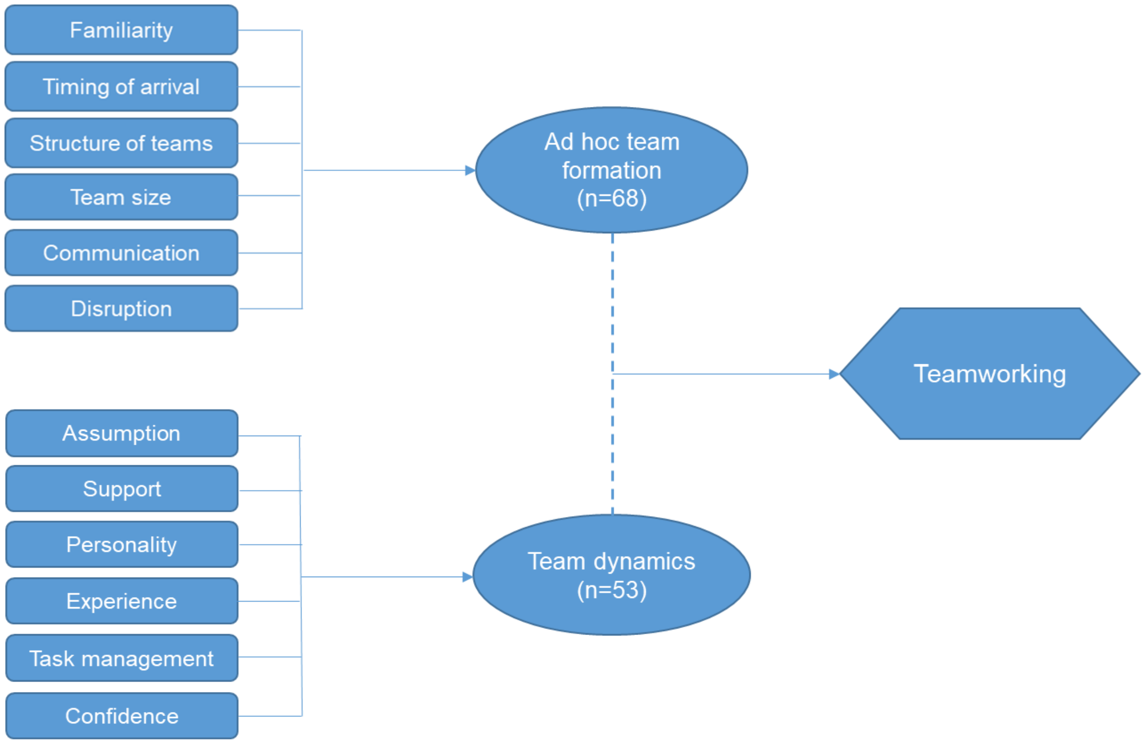

Figure 4.7 Teamworking codes-to-theme model

Table 4.11 Teamworking example quotes, codes, and categories

Example quote	*Code*	*Category*
''for an out-of-hospital cardiac arrest you could have two, four or six people and you don't know everyone which makes it hard'' (PN1 group 1)	Familiarity, Team size	Ad hoc team formation
''you could turn up at a cardiac arrest with a crew you've never met before, and they work to their own methods and that's where it can go wrong'' (PN4 group 1)	Task management	Team dynamics
''Better if crews know each other, work better'' (PN6 group 1)	Familiarity	Ad hoc team formation
''some are protective of roles though and only do their own clinical tasks'' (PN6 group 1)	Personality	Team dynamics
''Arrest depends on the crew, some handover, some delegate but it's often unstructured. You have to explain yourself all the time'' (PN7 group 2)	Communication	Ad hoc team formation
''It's better if you know each other as you're used to working together, much better with fewer people'' (PN 8 group 2)	Familiarity	Ad hoc team formation
''Older paras tend to be more calm, more structured'' (PN9 group 2)	Experience	Team dynamics

Table 4.11 continued…

Example quote	*Code*	*Category*
''it gets more difficult when second crew turns up, depends on dynamics of crews'' (PN9 group 2)	Personality, Experience	Team dynamics
''one crew tend to do A, B, C, then as more turn up they want to do something like an IV but not CPR'' (PN11 group 3)	Team size, Disruption	Ad hoc team formation
''Paras always want to do clinical skills rather than sort things out'' (PN11 group 3)	Task management	Team dynamics
''Less confidence if you haven't got the experience, less confident in your own ability and less likely to lead'' (PN12 group 3)	Confidence, Experience	Team dynamics
''depends on who's there, who rocks up, it's either disorganised, frantic or quite smooth, no middle ground'' (PN13 group 4)	Disruption	Ad hoc team formation
''My two best OHCA were just with three of us, a solo para and me and my crewmate who was a para. We didn't know each other but it was easy to manage with fewer people'' (PN14 group 4)	Familiarity, Team size	Ad hoc team formation
''It's better if there are less and you know each other, easier to speak to each other and know what each other is thinking'' (PN15 group 4)	Familiarity, structure of team	Ad hoc team formation

4.8.4 Communication

All groups frequently discussed communication and although it appeared to overlap with the other categories and themes, the specificity and extensiveness of comments emphasised its importance. There was significant discussion about verbal communication methods, the recognition of task load and timing of communication, and difficulties in achieving effective communication. Participants from group three commented extensively on this, highlighting the use of closed loop communication, simple clear instructions, active listening, and timing for effective communication (Härgestam et al., 2013). Considered as a valuable NTS, communication materialised as an important aspect and specific NTS for managing an OHCA. Figure 4.8 illustrates streamlined codes-to-theme model, supported by table 4.12 displaying example quotes, associated codes, and categories.

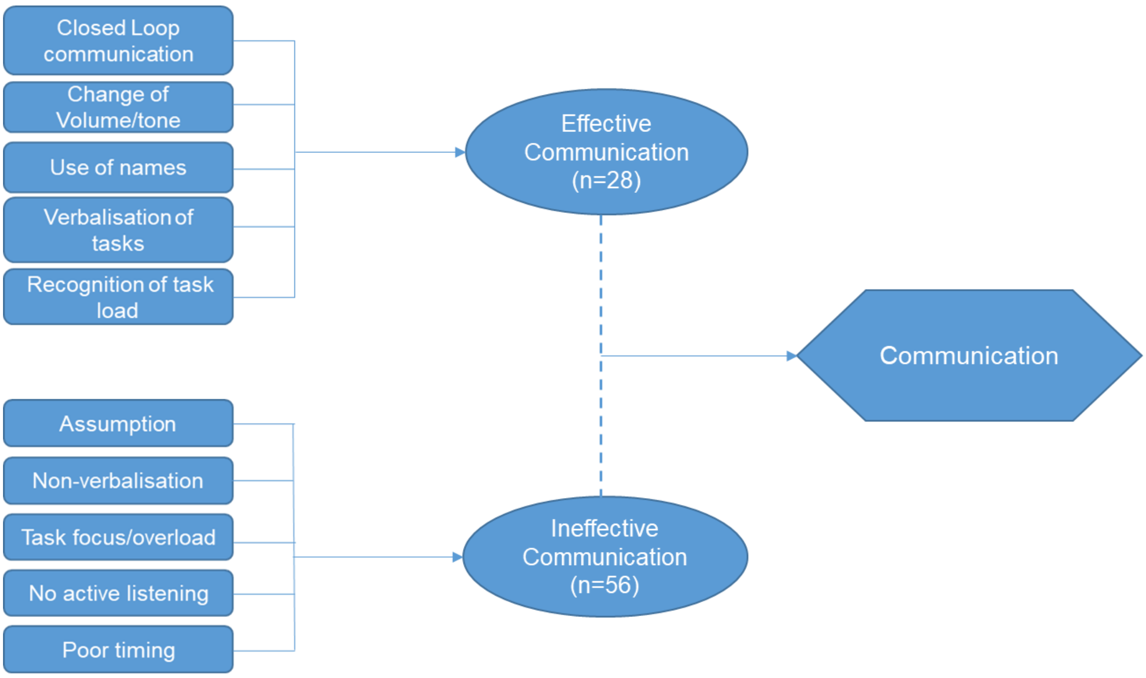

Figure 4.8 Communication codes-to-theme model

Table 4.12 Communication NTS example quotes, codes, and categories

Example quote	*Code*	*Category*
''you shouldn't assume that someone has heard you or that they know the ALS algorithm, you need to check and confirm stuff'' (PN3 group 1)	Closed Loop communication	Effective Communication
''it's hard as well when you are doing a task like intubation or an IO, coz you have to concentrate, and you can't listen. No good if someone is just talking at you'' (PN5 group 1)	Task focus/overload, No active listening	Ineffective Communication
''if crews know each other, then the communication is much better, everyone understands each other's clinical ability and experience, you can see when someone is overloaded'' (PN6 group 1)	Use of names, Recognition of task load	Effective Communication
''Comms is important, you see someone is quiet or fumbling round, you need to say something but there is a real lack of talking and verbalising tasks, no one even counts CPR'' (PN9 group 2)	Non-verbalisation	Ineffective Communication
''sometimes they don't confirm back to you because you've checked it in your head'' (PN7 group 2)	Assumption	Ineffective Communication
"communication that, that's verbalising stuff and two ways but also actively listening'' (PN10 group 3)	Closed Loop communication	Effective Communication

Table 4.12 continued…

Example quote	*Code*	*Category*
''he said we could get it on the truck, had to say it like five times, but he didn't alter anything he was saying. like second, third time, he got a bit louder, but he just kept repeating himself, no closed loop comms (PN10 group 3)	No active listening, Poor timing	Ineffective Communication
''one of the paramedics went over to him and explained the situation but I wasn't really listening to what was being said'' (PN10 group 3)	No active listening	Ineffective Communication
"It's like your ears can't like turn on. I've found that a couple of times and gone can you do this now and they've had to say it again coz I was focused on what I was doing'' (PN11 group 3)	Task focus/overload	Ineffective Communication
''closed loop communication where you say, 'Peter can you do the BM for me and confirm when you've done it please' rather than giving an order to an empty room'' (PN12 group 3)	Closed Loop communication	Effective Communication
'If you speak to someone who's intubating and you start talking to them and they're not listening properly, that's your fault, it's not their fault'' (PN12 group 3)	Recognition of task load	Effective Communication
''getting someone to use names, saying yes I will do that confirm that that will happen'' (PN13 group 4)	Closed Loop communication, Use of names	Effective Communication

4.8.5 Negative culture

The theme of negative culture was considered as a significant pattern throughout each focus group. It represented a mix of barriers that evolved from extensive and specific comments about egotistical behaviour, ineffective communication, perceived seniority, and the resulting effect on confidence. Although it was considered that there is a flat hierarchical gradient for paramedic clinical skills, with all paramedics possessing the same clinical skill set, it was clear there were power hierarchical difficulties, emphasised in comments that described a divide between those considered as senior paramedics and those with less experience. It was interpreted that there was an element of organisational culture generated by the view that paramedics who were qualified, more senior in rank or perceived to have more experience were considered as more autocratic in their behaviour. This was regardless of the participant's clinical grade, and was reflected in comments from student paramedics, including those working as EMTs and studying part time, and qualified paramedics, either working in a full time clinical or educational role. Comments also drew attention to what was interpreted as a knowledge gap, encompassing equipment, clinical algorithms, and confidence. All groups discussed the influence that experience and exposure rates of OHCA had on team performance, with groups one and three emphasising the negative effects that strong personalities and egotistical behaviour had on teamwork. It became clear that the combination of codes formed the categories ego/hierarchy and experience/exposure, and when reviewed presented as an overwhelming pattern that was characterised by the theme of negative culture.

This theme was important as it identified the key difficulties associated with effective NTS, including team coordination, teamwork, task management, decision-making, and communication. Figure 4.9 provides a streamlined codes-to-theme model, followed by table 4.13 of example quotes, codes and categories.

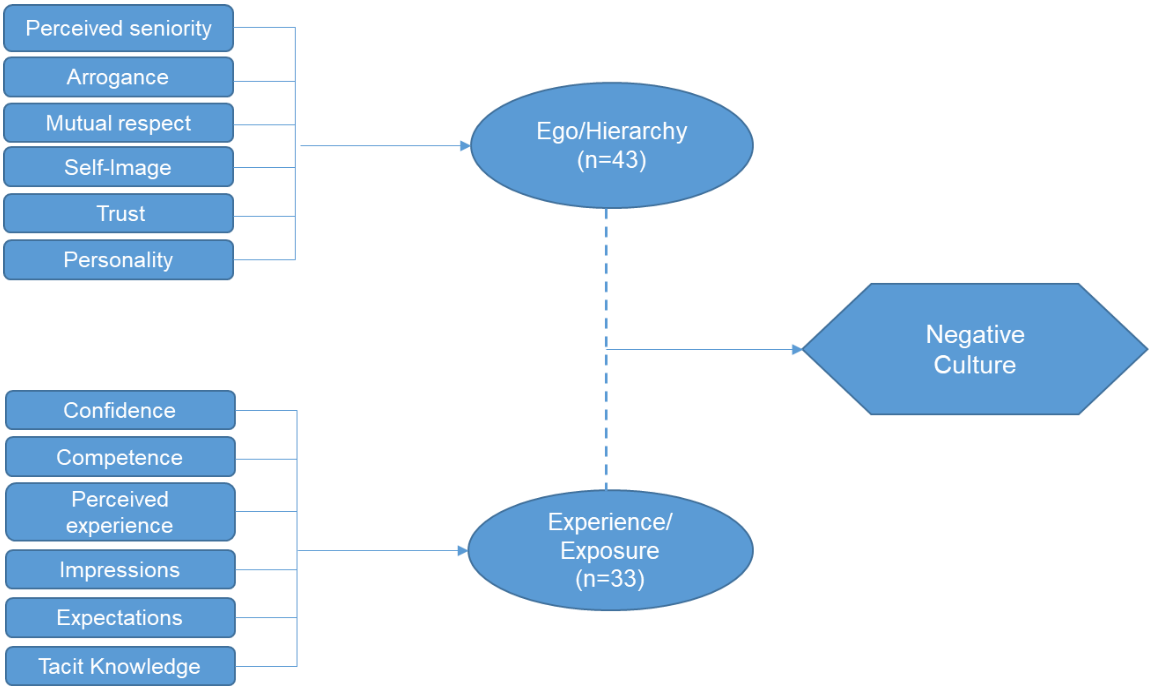

Figure 4.9 Negative culture codes-to-theme model

Table 4.13 Negative culture example quotes, codes, and categories

Example quote	*Code*	*Category*
''sometimes you don't trust yourself, others are more competent coz they've got more experience and confidence'' (PN1 group 1)	Competence, Confidence	Experience/ Exposure
''def new versus old, ego is a big thing. If you're new, you have your comfort zone'' (PN3 group 1)	Confidence, Perceived experience	Experience/ Exposure
''if you have more experience of arrests, you feel more confident'' (PN6 group 1)	Confidence	Experience/ Exposure
''but then you get these paras on an ego trip, and they just don't listen'' (PN4 group 1)	Arrogance, Personality	Ego/Hierarchy
''lots of people have egos, OHCA are rare and seen as a glory job'' (PN6 group 1)	Arrogance, Personality	Ego/Hierarchy
"it's a cultural thing – not being confident'' (PN8 group 2)	Confidence	Experience/ Exposure
''culture is a big thing, it's not being confident, it's personality'' (PN9 group 2)	Personality	Ego/Hierarchy
It depends on the person, some are able to speak up others can't. You need to feel safe to speak up. You need people to leave their egos at the door'' (PN9 group 2)	Mutual respect, Trust	Ego/Hierarchy

Table 4.13 continued…

Example quote	*Code*	*Category*
‘’yeah, those who think they have loads of experience have big egos and they’re difficult to work with’’ (PN10 group 3)	Perceived seniority, Arrogance	Ego/Hierarchy
‘’Just go on the chest, whereas the old school ones, let you do everything’’ (PN10 group 3)	Expectations	Experience/ Exposure
‘’you sort of feel a bit different to everyone else coz you’re in a different uniform, you can tell that you’re new coz you’re not as confident’’ (PN11 group 3)	Confidence, Impressions	Experience/ Exposure
‘’it’s very easy to push a student out the way, and just happens’’ (PN11 group 3)	Expectations	Experience/ Exposure
‘’Ego is a big thing, there’s a stigma to being new’’ (PN12 group 3)	Mutual respect, Personality	Ego/Hierarchy
‘’get personality clashes, can get confrontations if people have big egos’’ (PN12 group 3)	Self-image, Impressions	Experience/ Exposure
‘’equipment - It’s a fear thing, if something is working, leave it alone’’ (PN15 group 4)	Competence, Tacit knowledge	Experience/ Exposure
‘’I don’t know how to use a lot of equipment, I think I'm unconsciously incompetent’’ (PN16 group 4)	Competence, Tacit knowledge	Experience/ Exposure

The results of the focus groups provided an in-depth understanding of findings from the questionnaire, building on an explanation of the barriers to negative team performance, which appear to be associated with what was interpreted as a negative culture. When the themes are compared to the general paramedic NTS of situation awareness, decision-making, communication, team working and leadership (see glossary for definitions) as suggested by Shields and Flin (2013) it appears that four slightly different NTS exist: team coordination, situation assessment, team working, and communication. Table 4.14 presents a comparison of the number of articles from the scoping review and primary research phases that included each NTS (see glossary for NTS definitions). Although several articles included team performance, this was not mentioned as a NTS in this research phase. Similarly, some NTS identified from the questionnaire and focus groups were not included in any of the scoping review articles but were felt to be important, and specific to the paramedic managed OHCA, perhaps reflecting the in-hospital nature of much of the literature.

Table 4.14 Comparison of NTS identified from literature and primary research areas

NTS	*Scoping Review articles (n=)*	*Primary Research*
Leadership	11	Questionnaire/Semi-structured interviews
Communication	11	Focus groups/ Semi-structured interviews
Teamwork	11	Questionnaire/Focus groups
Situation Awareness	5	Focus groups/ Semi-structured interviews
Decision-making	2	Semi-structured interviews
Team Performance	7	N/A
Team Coordination	5	Focus groups/ Semi-structured interviews
Situation Assessment	0	Semi-structured interviews
Task Management	0	Questionnaire/Semi-structured interviews

Overall, the results of the questionnaire and focus groups highlight an inconsistency in team formation and structure, low OHCA exposure rates and five emergent themes that could provide a basis for NTS domains. Having presented the methods and results of the questionnaire and focus groups, the next section will provide a short discussion of how the results are interpreted in comparison to other literature, limitations, and the significance of the key findings.

4.9 Discussion

The significant results interpreted from the questionnaire and focus groups included that a leader is required, that roles change during an OHCA, and that leadership is lacking, with several difficulties identified that affect team performance. The aim of this research phase was to identify NTS associated with a paramedic managed OHCA and it appears that connections exist between these results and the general paramedic NTS suggested by Shields and Flin (2013). Before considering these five NTS, the statistical results of the questionnaire will be considered.

4.9.1 Exposure rates

Despite prior studies suggesting that higher OHCA exposure rates can improve team performance (Gold & Eisenberg, 2009), and patient survival (Dyson et al., 2016), it appears the only statistical difference between exposure rates was that participants who attend ≥10 OHCA per year change roles less than those who attend <10 OHCA per year. The lack of statistical significance in the difference of exposure rates was not expected, and may be explained by the textual data from the questionnaire and focus groups. Comments suggest that paramedics with higher exposure rates appear to be more confident, regardless of the length of operational experience. However, one participant identified that the ‘uncommon nature means minimal exposure’ (PN6) when coupled with an unfamiliar ad hoc team and varying sizes appears to result in a disjointed approach. The results of the questionnaire in section 4.6 appear to suggest that there is little association with operational experience and the number of OHCA attended per year, with some participants indicating that they attended ≥10, even as a full time UG student paramedic. The focus group data provided further detail and some explanation of the difficulties in assigning a leader with several possible explanations.

4.9.2 Leadership and Team coordination

The lack of a leader can affect team performance and has previously been linked to poor patient outcomes (Schmutz & Manser, 2013), indicating that effective leadership is a key aspect of clinical care. Hunziker et al. (2010) and Fernandez Castelao et al. (2015) previously identified that team performance was improved when the team was familiar, particularly when there was a hands-off team leader. However, despite an agreement that ‘A leader is required in an OHCA’ in the questionnaire (see table 4.3), the textual data suggests that leadership is limited, often affected by unfamiliar ad hoc teams that vary in size. It appears this results in difficulty with role allocation, task management and is interpreted as a disorganised scene (see tables 4.5 and 4.7).

Interestingly, focus group participants did not like the term ‘leader’ and implied that it was associated with an autocratic, egotistical person. Comments emphasised a need for team coordination, recognising that roles change as other clinicians arrive, altering the team size and dynamic (see table 4.9). Comments from a range of participants suggested that team members with less experience and lower OHCA exposure rates were less likely to lead as they lacked confidence and could become task focused and overloaded. As a result, team coordination was considered as a specific NTS as it appeared to encompass the complexity of an OHCA such as the need for an adaptable and flexible team that reflected in the varied environments, evolving nature of the team, clinical and non-clinical tasks, and the sensitive nature of the emergency.

4.9.3 Situation Assessment

Presented in figure 4.5 and table 4.10, the theme of situation assessment; ‘’the process of understanding the needs and conditions of a scene and team to inform decisions and plan’’ was informed by comments that suggested limitations in comprehending the scene, a focus on clinical interventions and decisions restricted to clinical algorithms. The limited exposure to an OHCA identified in research phase one and previous literature (Clarke et al., 2014; Dyson et al., 2016; McClelland et al., 2016) also appears to negatively influence the ability to effectively gather and process information, resulting in little anticipation. Situation assessment was identified from the textual data, and although decision-making is often included in other emergency medicine related behavioural maker systems (Flowerdew et al., 2012; Holly et al., 2017) as a precursor to situation awareness that links to decision-making, it appears that for a paramedic managed OHCA, clinical algorithms contribute to clinical decisions and team performance may be improved if situation assessment was included as a specific NTS. It was considered that the observable outputs of situation assessment such as altering the scene to enable advanced life support, ensuring adequate light, sharing of information, use of checklists and memory aids would provide a greater learning opportunity for paramedics.

4.9.4 Teamworking

Identified in both the questionnaire and focus group textual data, teamwork could be divided into personal and team factors. It appears that personal components, such as confidence, exposure, and personality influence team dynamics, resulting in an assumption of tasks, poor communication, and a focus on individually performed clinical skills (see tables 4.5 and 4.11). Comments also appeared to link to the theme's barriers to effective team performance and negative culture, with comments emphasising the difficulties associated when working with unfamiliar people. Exposure rates may be a factor as the varied levels of experience and exposure appear to influence confidence. As patient outcome can be dependent on effective teamwork (Leggat, 2007) it is critical that the input of personal, team and environment factors are considered to ensure that an OHCA is effectively managed. Teamworking incorporates the need for effective leadership and followership, resulting in a coordinated response. It has been established that a lack of leadership has been linked to poor patient outcomes (Schmutz & Manser, 2013), emphasising the need for good NTS regardless of individual or team factors.

4.9.5 Communication

Communication was not identified as a theme in the questionnaire textual data but was commented on frequently in all focus groups. Comparable to in-hospital literature, difficulties included misunderstood requests, poor recognition of task focus resulting in poorly timed questions and an assumption of task completion

(Andersen et al., 2010; Hunziker et al., 2011; Fernandez Castelao et al., 2013). Comments emphasised the importance of effective communication, as it appears to influence the coordination of the whole cardiac arrest, including clinicians, clinical algorithm adherence, and the reduction in the risk of errors such as assumed patient observations that can result in poor decision-making.

Although communication contributes to other NTS, such as team coordination and situation assessment, the extensiveness and specificity of comments highlighted the importance as an individual NTS for paramedic managed OHCA (see table 4.12). This is strengthened by Dagnell (2020) who stated that paramedics are used to and feel more comfortable working in teams of two, with ad hoc OHCA teams resulting in difficulty in maintaining a consistent approach. Even though paramedic OHCA teams initially consist of two clinicians, numbers can increase to between six and eight people with a range of clinical skills and scope of practice and can include doctors and police officers (von Vopelius-Feldt et al., 2016). A need to communicate with non-medical persons results in the need to adapt language, enabling increased information gathering, sharing and direction of others on scene. When reviewed in conjunction with the other themes, there was a clear importance for the inclusion of communication as a specific NTS.

4.9.6 Barriers to effective team performance and Negative culture

The themes barriers to effective team performance and negative culture were not unexpected and explained the problems associated with egotistical behaviour and perceived hierarchy as well as lack of knowledge and understanding of clinician’s abilities relative to levels of experience and exposure to OHCA. This result may be explained by the decrease in ambulance trust retention rates, and the subsequent average 'lifespan' of a paramedic measured at five years (National Audit Office, 2017) that is reflected in the demographic data (see table 4.2). When coupled with low OHCA exposure rates, comments provided some explanation to the difficulties working within an unfamiliar ad hoc team.

4.9.7 Summary of findings

The findings from the questionnaire and focus groups highlight the difficulties encountered by paramedics when managing an OHCA. The concepts of individual themes that can be interpreted as NTS include teamwork, leadership, team coordination, situation assessment, and communication, and appear to influence each other. Comments suggest how the environmental, team formation and individual factors appear affect team performance and potentially patient care and outcome. Based on the textual data, an initial Input-Process-Output model (IPO) (figure 4.10) provides a summary of how the factors of a paramedic managed OHCA appear to link to the considered NTS identified for potential inclusion in the BMS below.

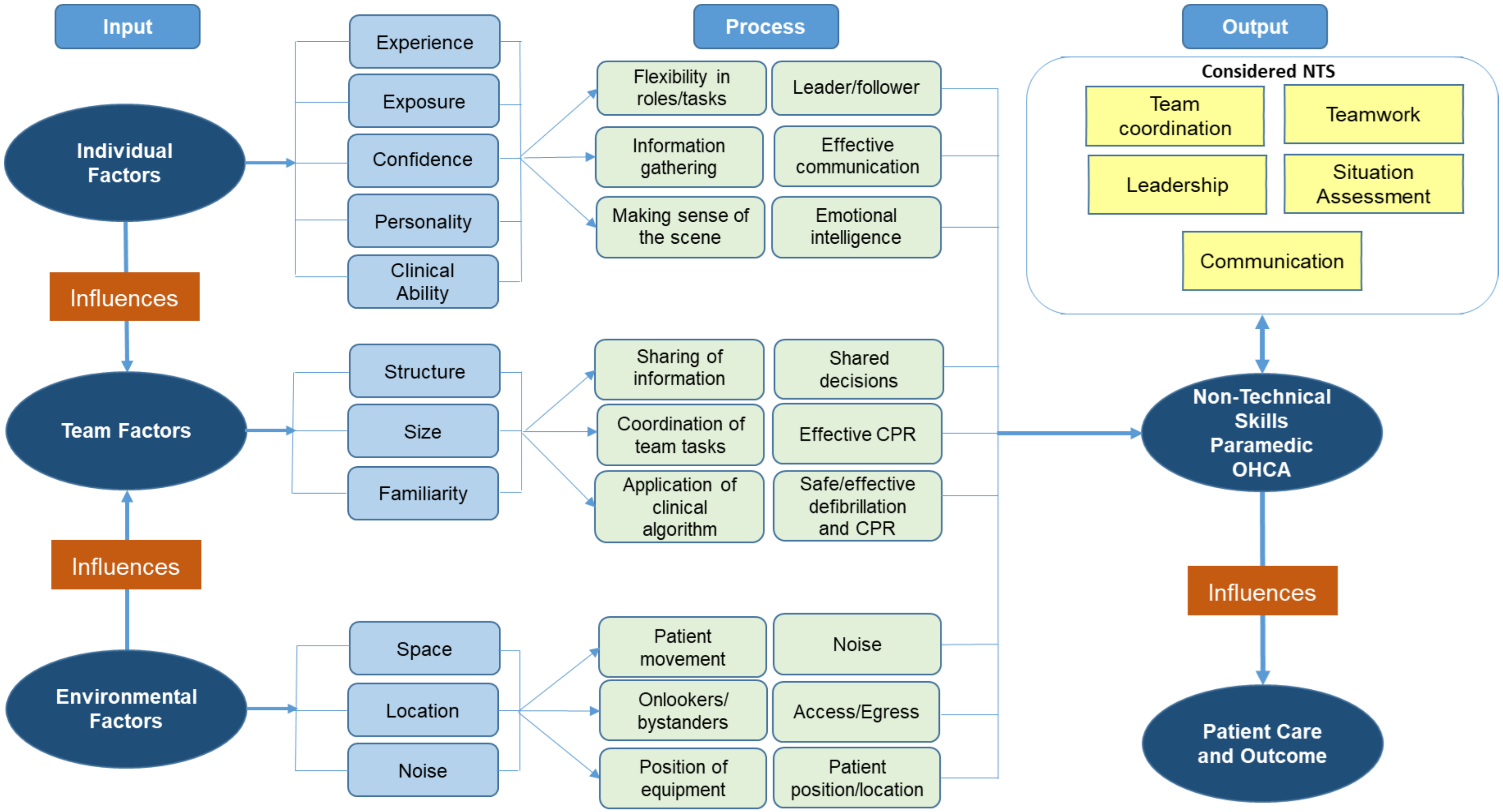

Figure 4.10 Initial Input-Process-Output model

4.9.8 Limitations

Limitations include the small sample size and the use of an adapted questionnaire resulting in the questions lacking specificity and reflection of the OHCA environment. It is noted that a more diverse variety of participants could have provided a greater range of comments, but comments provided a rich amount of data and identified key issues to managing an OHCA. It was recognised that there is a risk of bias from participants and in data interpretation. However, it was the opinions/attitudes and experiences of the participants that were key to this research phase with a systematic approach to thematic analysis used to increase rigour.

4.10 Conclusion

The aim of this research phase was to identify which NTS are considered specific to managing an OHCA to inform the design of the BMS. The textual data has provided an insight into the closed answers from the questionnaire, with comments providing a greater understanding of participant's perceptions of NTS. Five specific NTS have been identified: teamwork, leadership, team coordination, situation assessment, and communication. However, barriers to the effective management of an OHCA exist, including ad hoc unfamiliar teams, egotistical behaviour that appears to affect confidence, influencing communication and teamwork, regardless of exposure rates of an OHCA. Having identified five specific NTS, the next section; design phase two provides an explanation of the methods used to validate and design the prototype BMS.

Chapter 5 - Design and Development of Prototype Behavioural Marker System

5.1 Introduction and Aim

This chapter explains the design phase, starting with the validation of the NTS required to produce a NTS taxonomy for a prototype BMS. The aim of this chapter was to validate and integrate the previous chapter results to create a taxonomy that informed the design of a BMS for a paramedic managed OHCA. An additional aim identified as the study progressed was that the BMS should provide feedback to reinforce safe individual practice, improving overall team performance. It includes a description of the methods used to conduct semi-structured interviews of subject matter experts (SME), the results, and a discussion before proceeding to explain data integration and triangulation. However, before explaining these sections it is important to consider the practical application of the identified NTS and provide context in relation to other BMS and crew resource management (CRM).

5.2 Context of Non-technical skills in a Paramedic Managed Out-of-Hospital Cardiac Arrest

As previously acknowledged in chapter one, there are a variety of healthcare BMS, each with specific NTS and these could be considered for a paramedic managed OHCA BMS. Healthcare BMS range from anaesthetic to undergraduate medical and nursing teams, with only two specific to prehospital practice. Each BMS include slightly different domains, with common NTS including communication although not always separately, teamwork, leadership, situation awareness, task management, and decision-making. Table 5.1 displays examples of key healthcare BMS and NTS used to observe individuals across a range of disciplines based on the systematic review by Dietz et al. (2014a). As this review was published in 2014, the table also includes three subsequently published BMS considered relevant due to their practice areas, for inclusion.

Table 5.1 Common NTS domains from healthcare BMS

Behavioural Marker System	*Non-technical skill domains*
Anaesthetists' Non-Technical Skills ANTS Fletcher et al (2003) Individual	Task management Team working Situation awareness Decision-making
Non-Technical Skills for Surgeons NOTSS Yule et al (2006) Individual	Situational awareness Decision-making Communication and teamwork Leadership
Scrub Practitioners List of NTS SPLINTS Mitchell et al (2012) Individual	Situational awareness Communication and Teamwork Task Management
EM Physicians NTS Flowerdew et al (2012) Individual	Management and supervision Teamwork and Cooperation Decision-making Situational awareness
Anaesthetic NTS-Anaesthetic Practitioners ANTS-AP Rutherford (2015) Individual	Situation awareness Task Management Teamwork and communication
Aero-NOnTechnical Skills AeroNOTS Myers et al (2016) Individual	Task management Team working Situation awareness Decision-making
Immediate Medical Care Behaviour Rating System IMCBRS Holly et al (2017) Individual	Gathering information Decision making and leadership Communication and teamwork Personal resources

Despite the noted similarity of NTS domains between each BMS, the majority are designed for in-hospital teams and do not focus on cardiac arrest management. Based on the textual data from research phase one, there are several important differences of a paramedic OHCA team including team formation, the unscheduled nature and unpredictable environment of an OHCA, and the need to extricate a patient from the place of cardiac arrest while continuing care (Cormack et al., 2020b). As previously recognised in chapter three, a BMS must be specific to the work domain and environment. When individual NTS were considered against the features of CRM, which Seager et al. (2013) suggest as cooperation, leadership, workload management, situation awareness and decision-making, the sum provides context to how teams interact and influence performance when managing an OHCA. The initial IPO model (see figure 4.9) in the previous chapter provides a visual representation of the considered NTS as an output of the inputs and processes needed to manage an OHCA. Although five NTS were included in this model, to aid the validation procedure and ensure that the most relevant NTS were considered, the common NTS included in table 5.1 were integrated, to provide a template for textual data analysis, details of which will be provided in the data analysis section.

The following part of this section provides greater detail on the semi-structured interviews of SME methods, results, and discussion.

5.3 Ethical Considerations

The University Research Ethics Committee granted ethical approval for the semi-structured interviews (P72923 see Appendix F; P75774 see Appendix G). All data were collected and managed in accordance with the Information Commissioner's Office. (n.d.) and the Data Protection Act (1998; 2018).

5.4 Semi-Structured Interviews Methods

After reviewing other healthcare BMS (Rutherford, 2015; Mellanby, 2015) the use of SME was considered as a reliable and valid method to achieve the aim of this design phase. Semi-structured interviews are commonplace in healthcare research and allow for a guided dialogue between the researcher and participant (DeJonckheere & Vaugh, 2019). This method ensured a flexible, yet guided interview using healthcare professionals experienced in NTS and management of an OHCA (Jamshed, 2014). The use of SME ensured that a range of expertise and guidance needed to develop a BMS was achieved (Larmore, 2011).

5.4.1 Sample and Setting

Convenience sampling was used to recruit SMEs. As the aim of this phase was not to generalise results but to utilise SMEs to validate the previously identified NTS, this sampling strategy was considered as an appropriate method (Elfil & Negida, 2017). A convenience sample was identified from selection of Helicopter Emergency Medical (HEMS) doctors, critical care paramedics and educators, identified via their professional biographies and previous contact with the lead researcher. As a recognised medical subspecialty (Royal College of Surgeons of Edinburgh, 2021) all participants were considered as experts if they had significant experience and exposure in prehospital care, crew resource management including NTS, management of OHCA and experience in assessment.

The use of HEMS clinicians and paramedic educators from different institutions resulted in individuals with a deep understanding of a paramedic managed OHCA, including clinical algorithms, and equipment with the added context of training and use of NTS. This resulted in the application of their knowledge and understanding, while remaining flexible to the use of a newly developed BMS. Twelve SME were contacted, with seven SME available for interview. As this data would be integrated with the previous research phases during triangulation, this was considered sufficient for this design phase. A summary of roles and areas of expertise presented in table 5.2.

Table 5.2 Subject matter expert information

SME	*Area of expertise*
Emergency Medicine Consultant HEMS Critical care doctor, lecturer prehospital critical care, retrieval, and transfer	Emergency medicine, HEMS CRM, critical care, and paramedic education
Emergency Medicine Consultant HEMS Critical Care Doctor Honorary Professor prehospital critical care, retrieval, and transfer	Emergency medicine, OHCA, HEMS CRM, critical care, and paramedic education, active in prehospital research
Consultant in Anaesthesia and Prehospital Emergency Medicine Associate Medical Director and Clinical Lead for Resuscitation	Prehospital medicine, OHCA, HEMS CRM, resuscitation education, human factors
Critical Care Paramedic HEMS Assistant Professor Emergency and Critical Care	Prehospital emergency care, OHCA, HEMS CRM, critical care education and prehospital research clinical trials

Table 5.2 Continued…

SME	*Area of expertise*
Critical Care Paramedic HEMS Honorary Research Associate Lecturer Emergency and Critical Care	Prehospital emergency care, OHCA, HEMS CRM, paramedic education and prehospital research
HEMS Paramedic Honorary educational coordinator	Paramedic Education, HEMS, prehospital practice, CRM, human factors education
HEMS development manager Critical Care Paramedic HEMS	Prehospital emergency care, OHCA, HEMS CRM

All SME were sent a participant information sheet and consent form prior to interview. The participant information sheet contained information about the purpose of the study, risks and benefits and details about how the interviews would be conducted. Due to logistical challenges five interviews were conducted face-to-face and two via telephone over a three-month period (July-September 2018).

All face-to-face interviews were conducted at each SME work location in a quiet, appendix private room, away from distraction, to ensure confidentiality and freedom to speak candidly. Locations included University campuses, a HEMS unit, and a hospital. The two telephone interviews were arranged so that the SME was away from distraction/work and able to discuss in detail NTS associated with managing an OHCA. All face-to-face interviews were audio recorded using an encrypted device and additional field notes taken, however, telephone interviews could not be recorded due to technology issues, so detailed field notes were taken. These notes were emailed to the two SME and checked for accuracy before analysis.

5.4.2 Interview Procedure

An interview schedule was developed based on previous BMS work by Rutherford (2015). This enabled a set of predetermined questions to be used, developed from the results of research phase one questionnaire and research phase two focus groups (see Appendix H). This ensured that following an explanation of the research phase and overall study, the first question asked was aimed at allowing the SME to recall a challenging OHCA where several NTS were observed.

Known as a critical incident interview technique (Flanagan, 1954), Mitchell (2011) successfully used this method in the development of a BMS for scrub nurses' non-technical skills, as it can be difficult for SME to verbalise their experiences and knowledge. Mellanby (2015) also used a similar technique critical decision method, when interviewing for the development of a BMS for junior doctors. Based on work by Klein et al. (1989) this method uses a series of flexible probing questions to allow for a flow of dialogue, with typical interviews lasting approximately one hour.

The combination of these methods were used as they allowed for pre-determined questions to be employed, intended to allow the SME to expand on their answers and the interviewer to check their understanding to help guide the interview. The use of a semi-structured interview also provided the opportunity for the conversation to flow, reducing the rigidity of the interview, allowing SME to relate their own knowledge and experience of NTS when managing an OHCA to validate the previous research phase findings.

5.4.3 Data Analysis

All interviews were transcribed using a denaturalised approach, as it was felt that the content rather than the speech representation was more important for this stage of analysis. This allowed for a clean, textual description yet ensured a complete transcription (Oliver et al., 2005). Template analysis, using a procedural method suggested by Brooks et al. (2015) was also used as it allowed for thematic analysis using hierarchical coding based on a set of *a priori* themes generated from the scoping review and research phase one (see Appendix I).

Each interview transcript was read thoroughly to enable familiarity with the text before starting thematic analysis, with coding performed using the coding template and NVivo software (QSR International Pty Ltd, 2018). Although the themes of barriers to effective NTS and negative culture were identified in the previous research phases, they were not included in the coding template, as they were not considered as NTS. For the purposes of this design phase, the term category will be used in data analysis, rather than the term theme, as each *a priori* theme refers to the NTS category.

Initial coding included individual interview transcript analysis, with levels of frequency, extensiveness, and specificity identified to form a hierarchy of non-technical skill categories. Phrases from each category were reviewed and any relationships between categories identified. To ensure cross-validation, textual data were discussed with the director of studies and the relationship between each NTS category and phrases associated with OHCA management reviewed. This allowed for the removal or combination of NTS categories and an updated

NTS coding template (see Appendix J) to be produced before axial coding was performed. This ensured that only the specific NTS for managing an OHCA were identified and coded against the template, providing further validation of the specific categories needed to inform the BMS design.

5.5 Semi-structured Interview Results

Seven semi-structured interviews of subject matter experts were completed, with the sample consisting of more males (n=5) than females (n=2), and all interviewees were aged 30-49 years. Three subject matter experts were HEMS doctors, the others were critical care/advanced paramedics. All interviewees had extensive clinical experience, including significant exposure rates of OHCA and training in crew resource management. Six of the SME were involved in paramedic education across three different educational institutions and included the teaching and assessment of advanced life support and resuscitation for paramedics and critical care paramedics. Interview lengths ranged from 23 minutes to 51 minutes with a mean time of 36 mins. The total interview time was four hours and 13 minutes.

5.5.1 Initial Coding

Using *a priori* NTS coding template, data were deductively coded into each of the seven NTS categories, identified from the previous scoping review (see chapter two) and research phases (see chapter four); communication; leadership; teamwork; decision-making; situation assessment; team coordination; task management) by identifying meaningful and frequent phrases (see glossary for definitions). The number of phrases ranged from the highest team coordination (n=77) to the lowest decision-making (n=22). It should be noted that there were no comments relating to decision-making by SME 5 or for leadership by SME 7. This stage provided initial coding with a summary of the main results provided after table 5.3, which displays the number of individual and total phrases identified during the interviews.

Table 5.3 Subject matter expert individual and total number of phrases

	Non-technical skills and number of phrases							
	Team Coordination	*Teamwork*	*Communication*	*Leadership*	*Task Management*	*Situation Awareness*	*Situation Assessment*	*Decision-Making*
SME 1	12	10	6	7	6	1	1	4
SME 2	10	13	5	12	3	5	1	4
SME 3	14	13	6	10	8	6	8	8
SME 4	12	7	7	2	2	2	4	2
SME 5	17	5	9	5	6	5	2	0
SME 6	10	7	8	5	5	5	3	1
SME 7	2	1	3	0	4	2	1	3
Total Phrases	**77**	**56**	**44**	**41**	**34**	**26**	**20**	**22**

5.5.1.1 Leadership and Teamwork

Leadership and teamwork both had reasonably high frequencies of comments but there was significant overlap with team coordination, with specific comments and a noted importance placed on the need for adaptability and flexibility of a team. Although leadership was considered as an important element of OHCA management, it was recognised that the unfamiliarity, varied size, arrival times, and mixed clinical competencies of OHCA teams resulted in difficulty in assigning a dedicated leader. Smaller teams resulted in difficulty for a dedicated leader to remain 'hands off' with comments emphasising the importance of good followership to reduce cognitive load and increase bandwidth. Although focus group participants considered teamwork as an important aspect of managing an OHCA, all SME identified followership as a specific component of teamworking. Comments identified that paramedics were poor at leading and that all team members needed to support each other, appropriately challenging decisions, and behaviour where possible, drawing attention to effective communication and coordination. Comments coded as team coordination indicated that good people management rather than task management was important and there was a need for a cohesive team committed to a shared aim. Similar to the focus groups comments, leadership was considered as an individual category, necessary to provide coordination. Nevertheless, practical aspects of an OHCA such as managing the patient, bystander and other paramedics were noted in negative comments, including poor leadership and the limited experience of many paramedics. The frequency of comments resulted in the NTS category of in team coordination, suggesting that this was a more appropriate NTS category.

5.5.1.2 Decision-making and Task Management

Both decision-making and task management had limited extensiveness and specificity of phrases, with elements of each NTS identified in comments relating to communication, team coordination, leadership, and situation assessment. Comments suggested that decision-making is limited to a paramedic's explicit knowledge and application of clinical algorithms, with the recognition that most paramedics' limited exposure to an OHCA reduced their tacit knowledge, with judgement and decision-making relying on clinical algorithms. Similar to the focus group results, SME agreed that in general student and qualified paramedics lack confidence, focus on familiar clinical tasks such as CPR, and often leave decisions to others perceived as more experienced. This includes decision-making around when to stop resuscitation or best extrication methods (Brandling et al., 2017). Although decision-making was noted to influence planning, SME considered this as reactive more than proactive with the perception that many paramedics experience task focus, and overload limiting their ability to think ahead or manage resources effectively.

Comments about task management suggested that this was more applicable as an element of team coordination, combining the application of procedural and equipment knowledge to prioritise clinical interventions and people management to support and organise others. It appeared that tasks were dependent on the clinical algorithm and could be limited by the number of clinicians on scene. As an individual NTS category, it was considered that task management could be merged into team coordination offering a more accurate representation of the questionnaire and focus group results.

5.5.1.3 Situation Awareness and Situation Assessment

At this stage situation awareness was identified rather than situation assessment as found in the focus groups, and had a reasonable frequency of phrases (n=26), with specific comments relating to Endsley's (1995) three stages: gathering information; processing and understanding the information; anticipation, identified in each transcript. However, there were 13 negative comments about situation awareness, including the suggestion that paramedics ''crews don't necessarily understand what situation awareness is and then lack it'' (SME 2). Comments were like those in the focus groups, with attention concentrated on the use of clinical algorithms to guide decisions and planning, and a limited exposure to an OHCA influencing a paramedic's ability to adapt to a time critical patient. Comments suggested that cognitive overload and associated increased levels of stress resulted in difficulty in making sense of the scene, supporting the interpretation, that analysis of a patient's condition is limited to confirming a cardiac arrest, focusing on immediate clinical skills such as chest compressions. Comments expanded on those from the focus groups, providing a deeper understanding of what appears to be difficulties with situation awareness and assessment. This led to the interpretation that situation assessment, rather than situation awareness, was perceived as a more important NTS. Defined as 'the process of understanding the needs and conditions of a scene and team to inform decisions and plan…making sense of the scene, uses knowledge and understanding of clinical algorithm to inform decisions', this definition was interpreted from comments that emphasised a focus on making sense of the scene with limited information collected very little anticipation and the use of clinical algorithms to aid decision-making. Although considered as the first part of situation awareness, the importance placed on paramedic's perception of an OHCA was interpreted as "a complex process of perception and pattern matching greatly limited by working-memory and attentional capacity" (Sarter & Woods, 1991, pp. 50) therefore the term situation assessment was included for review in axial coding, rather than situation awareness.

5.5.1.4 Communication

Communication had a similar frequency of comments to leadership (n=44), with extensive comments and a perception that it was an important category. Phrases reflected verbal and non-verbal communication methods, reflecting issues such as noise, unfamiliar teams, and task focus highlighting a need for effective communication. Again, comments were similar to focus groups, with a similar number of phrases and noted comments about the use of closed loop methods and consideration of timing, validating communication as an individual NTS category. More detail and discussion on this category will be provided in the axial coding section.

5.5.2 Review of Initial Coding

Following the initial coding and categorisation, results were reviewed and discussed with the director of studies to inform axial coding. Task management was integrated into team coordination due to its overlap, low levels of specificity and limited extensiveness, and consideration that observable behaviour was more applicable to team coordination. The category of decision-making was retained after review, despite specific comments referring to decision-making linked to algorithm knowledge there was a perception of it being an outcome of situation assessment and the observation that not all decisions are based on clinical knowledge. The importance of identifying options, problem solving and re-evaluating the scene emphasised the importance of decision-making and validated comments previously identified in the focus groups. Based on the results of the initial coding an updated axial coding template was designed for use when coding the complete data set.

5.5.3 Axial Coding

Axial coding was used to draw connections between the NTS categories identified by SME and provide context to validate previous categories identified from the focus groups. Final individual categories, including supporting example phrases are provided next.

5.5.3.1 Team coordination

Team coordination represented the adaptability needed for OHCA teams, reflecting unfamiliar ad hoc teams and a connection between leadership and followership. It incorporated elements of leadership, followership, and teamworking, including coordination and support of others combined with task allocation and working together towards a shared aim. When leadership and teamworking were considered in the context of an OHCA and the range of associated barriers to effective team performance including egotistical behaviour, limited OHCA exposure and different clinical competencies, their inclusion as separate NTS categories was felt to inaccurately represent paramedic practice. The relationships between leadership, followership and teamworking were recognised, and team coordination was considered to provide an accurate representation of practice, reflecting the unpredictability of OHCA management. Therefore, team coordination was considered as an important and specific category able to recognise a range of behaviours, regardless of if a paramedic is leading or not, common practice in paramedic management of an OHCA (Dagnell, 2020: Brandling et al., 2016). The category of team coordination was identified across all semi-structured interviews and was considered as a validated specific NTS category for paramedic managed OHCA, supported by example phrases presented below.

> *''Commitment to participation, how well do you commit to the team task, goal, how well do you accept the team leader, a lot of people want it to be them, part of followership''* (SME 1)

> *''a good coordinator manages the whole team, fatigue, stress tasks, planning time checks''* (SME 2)

> *''committed to team goal, recognition of effectiveness, understand roles and followership then if all commit to team goal the more effective team''* (SME 3)

> *''an ad hoc unfamiliar team need coordination''* (SME 4)

> *''have to be able to adapt, manage people, be flexible in people management rather than task management''* (SME 4)

> *''everyone needs to function as one CPR delivery unit''* (SME 5)

''change the terminology but a clear conductor, like an orchestra, the conductor may not be able to play all the instruments, but they can read the music and coordinate everyone'' (SME 5)

''A clear team coordination, clear verbalisation of what I'm doing and what I'm planning on doing next'' (SME 6)

''roles change, adaptability would be a good quality. Being able to manage people, be flexible, people management rather than task management'' (SME 7)

5.5.3.2 Situation Assessment

As an individual NTS category, situation assessment was considered in the context of an OHCA. The connections between situation assessment and decision-making were clear with decisions based on initial clinical observations and restricted to clinical algorithm guidance. It was strongly suggested by participants in both the focus groups and semi-structured interviews that there is limited processing of information gathered from an OHCA due to insufficient exposure rates, while the ability to plan and anticipate was hindered by cognitive overload and task focus. There appears to be a focus on the patient observations rather than considerations of the environment, patient history or others on scene. As an accurate representation of a paramedic managed OHCA, situation assessment was confirmed as a more applicable term, focusing on the processes such as sense making and analysis of the situation, rather than a state of knowledge. As decision-making relies on good situation assessment, its inclusion as a specific NTS category was validated, supported by example phrases.

''Lack of planning, limited thinking about physical move of patient, often only 30seconds ahead, reactive rather than proactive'' (SME 1)

''crews don't necessarily understand what situation awareness is and then lack it'' (SME 2)

''Paras tend to see individual tasks, objectives rather than planning ahead, lack of anticipation…poor situation awareness'' (SME 3)

''lack of perception, processing and projection'' (SME 3)

''Reading the scene, what's in front of you, recognising very ill patient, change of mind-set, stress response. Manage stress and fatigue levels, emotional intelligence'' (SME 4)

''The airway person should be thinking two minutes ahead, chest five minutes, and other person next ten minutes. Rather than four people living in the here and now'' (SME 5)

''people get focused on starting CPR and then get stuck on that, they drop the bags down and don't really think about what they need to do as they go on'' (SME 6)

''There isn't much planning, just whether to shock or give drugs, it's more clinically based, like clinical interventions and tasks. Not many people think ahead such as moving the patient or calling for other resources'' (SME 7)

5.5.3.3 Communication

Communication overlapped all other NTS categories as expected. However, the importance and specificity of comments emphasised its need to be included as an individual category. When considered in the context of an OHCA the need for effective verbal and non-verbal communication methods as observable behaviours was clear. Subject matter expert comments supported the textual data from the focus groups with the recognition that terminology must be adapted when gathering or sharing information with laypersons or other emergency service personnel. The connection of good communication and a high performing team included the recognition of task overload, consideration of timing and sharing of essential information only (Petrosoniak et al., 2020). The environmental ergonomics of an OHCA, such as noise, location, position of the patient and equipment also influenced the need for effective communication. Again, as a specific NTS to managing an OHCA its inclusion was validated by the SME textual data with example phrase below, demonstrating its importance as an observable behaviour.

> *''If you are constantly updating team, such as multiple handovers or updates, interventions stop, they don't happen''* (SME 1)

> *''Early goal, communication and shared understanding is important''* (SME 2)

> *''Also need unexpected things to communicated back…issues, feedback loop, make leader aware of problems. Allows for rethink, adaptability''* (SME 3)

> *''Someone may think there's a better way of doing something or something is a priority…how this is communicated can make or break a team. Verbal and non-verbal comms, tone and volume can alter but not rude. The way someone speaks is important''* (SME 4)

''recognition of tiredness…important for CPR. Task overload, focus, emotional upset due to case. Can inhibit to perform, so need to communicate'' (SME 4)

''Expands communication to emergency ops centre and crew starts with a mini-brief, second crew aware, second crew on scene so roles will be IV, drugs and taking over CPR'' (SME 5)

''Communication needs to be closed loop, no jargon, something that everyone understands, adapt verbal comms to team, may include others, so lower to common denominator'' (SME 6)

''comms needs to be inclusive, to be shared mind-set and aim'' (SME 7)

5.5.3.4 Decision-making

Decision-making appeared to be rule based, incorporating elements of tacit knowledge of OHCAs, but focused on explicit knowledge of clinical and professional procedures and equipment in addition to information gathered from the scene. Comments emphasised that decisions were made in accordance with clinical algorithms and professional guidelines, with options such as the appropriateness of resuscitation and cardiac rhythm assessment used to inform decisions. Decision-making appeared to be more relevant to ad hoc team and logistical difficulties, previously identified as barriers to effective team performance. The recognition of problems and subsequent management, such as unfamiliar teams, varied numbers of clinicians and clinical ability, location, position, and movement of the patient were considered as important aspects of decision-making. The need for identifying and considering options, prioritising tasks, re-evaluating the scene, team and patient condition, problem solving and calling for additional help appeared to reflect actual practice, and was considered as an important non-technical skill, associated with managing an OHCA. The textual data from this research phase validated this category as a specific NTS, linking other categories to form a set of behavioural marker domains. Example phrases for this category are provided below.

> *''difference in levels of knowledge and understanding of roles, clinical algorithm and aim''* (SME 1)
>
> *''Knowledge is a must, important. Includes algorithms and what to prioritise''* (SME 2)
>
> *''Paramedics are used to working in pairs and making decisions about their patient without others''* (SME 3)
>
> *''lack of familiarisation with kit, need to be equipment aware/knowledge, offload and reduce cognitive load''* (SME 3)
>
> *''case mix that paramedics are exposed to now – more primary care, chronic illness, sudden change for out-of-hospital cardiac arrest, different case, time critical. Change in mind-set needed''* (SME 4)
>
> *''From a clinical view, knowledge…could be demonstrated as an observable skill, very important''* (SME 4)
>
> *''Good knowledge and familiarity of clinical algorithm, and equipment helps with confidence and frees up bandwidth to work together and increase situation awareness''* (SME 5)
>
> *''Can be a lack of understanding of guidelines and some will want to continue CPR even if futile''* (SME 5)

''I think decision-making isn't really that difficult, you follow the algorithm, most of the decision making is more about ROLE or moving the patient'' (SME 6)

''out-of-hospital cardiac arrest checklists are too long, poorly designed or missing, need a level of knowledge and understanding of clinical algorithm, from start to finish'' (SME 7)

The final NTS categories identified and validated from the axial coding include team coordination, situation assessment, communication, and decision-making, all considered as observable and distinguishable behaviours, specific to paramedic managed OHCA.

5.6 Discussion

Overall, the four NTS categories identified from the SME data provide context and a greater understanding. Although task management, teamwork and leadership appear to be common non-technical skills in other behavioural marker systems (Dietz et al., 2014a), they were considered as too restrictive as individual non-technical skills when managing an OHCA. However, elements of each skill could be incorporated into other categories, including team coordination, decision-making and situation assessment, enabling improved observable behaviours.

As identified in the research phase two focus groups, the category of leadership did not appear to reflect the complexity of an OHCA, and it was not considered as comprehensive as team coordination. The limited team numbers, adaptability of roles and varying clinical abilities of staff (Lim et al., 2020) limit the effectiveness of leadership as a specific NTS. This is unlike other areas of in-hospital practice, where teams work in more controlled environments. As an example, emergency departments receive a pre-alert from an ambulance trust that a critically unwell patient is en route. This allows for time for a briefing, with roles allocated, including a team leader before a patient arrives (Gabr, 2019).

Although the term situation awareness was clearly considered as an important aspect of OHCA management, when comments were reviewed its contextual meaning was felt to be an inaccurate representation. Described as 'knowing what is going on around us' (Flin et al., 2015, pp. 17), comments did not support the simplicity of this statement suggesting that there is limited understanding and prediction, and a focus on the processes used to achieve knowledge, rather than a state of knowledge. This may be a result of using clinical algorithms to guide decisions and plans, explaining comments that suggest a lack of anticipation. Comments from other categories suggest that aims are not shared, possibly due to poor communication or as a result of unfamiliar ad hoc teams with no clear leader. However, when comments and categories were connected the combination of task focus, reliance on clinical algorithms and limited experience suggested a need to focus on situation assessment rather than awareness is an individual NTS specific to managing an OHCA.

Although communication is not included as an individual NTS in other healthcare behavioural marker systems (Flowerdew et al., 2012; Rutherford, 2015; Holly et al., 2017) its perception as a significant and separate NTS category was clearly indicated and validated by SME comments and axial coding. The varied environments and unfamiliarity of paramedic teams results in the necessity for effective verbal and non-verbal communication, with the use of non-clinical language an important aspect that reflects the public nature of an OHCA (Mainds & Jones, 2018). Despite comments relating to communication noted in other NTS categories, its importance as an individual NTS is emphasised by the need to adapt and overcome barriers to effective teamwork previously identified in the previous research phases.

The results of the semi-structured interviews serve to validate a set of NTS that when considered together produce an output, the care and treatment of a patient in cardiac arrest. This final IPO model (see figure 5.1) is characterised by the individual NTS and their links with each other. Without situation assessment, decision-making and teamwork cannot occur, whereas communication serves to transfer information within the team, leading to a coordinated attempt at resuscitation. As the aim is to design a BMS that can reliably evaluate the non-technical skills of paramedics managing an out-of-hospital cardiac arrest, the NTS needed to be connected, specific to an OHCA and able to differentiate between good and poor behaviour. As a system, the NTS validated here serve to provide a whole that is more than the sum of the individual parts.

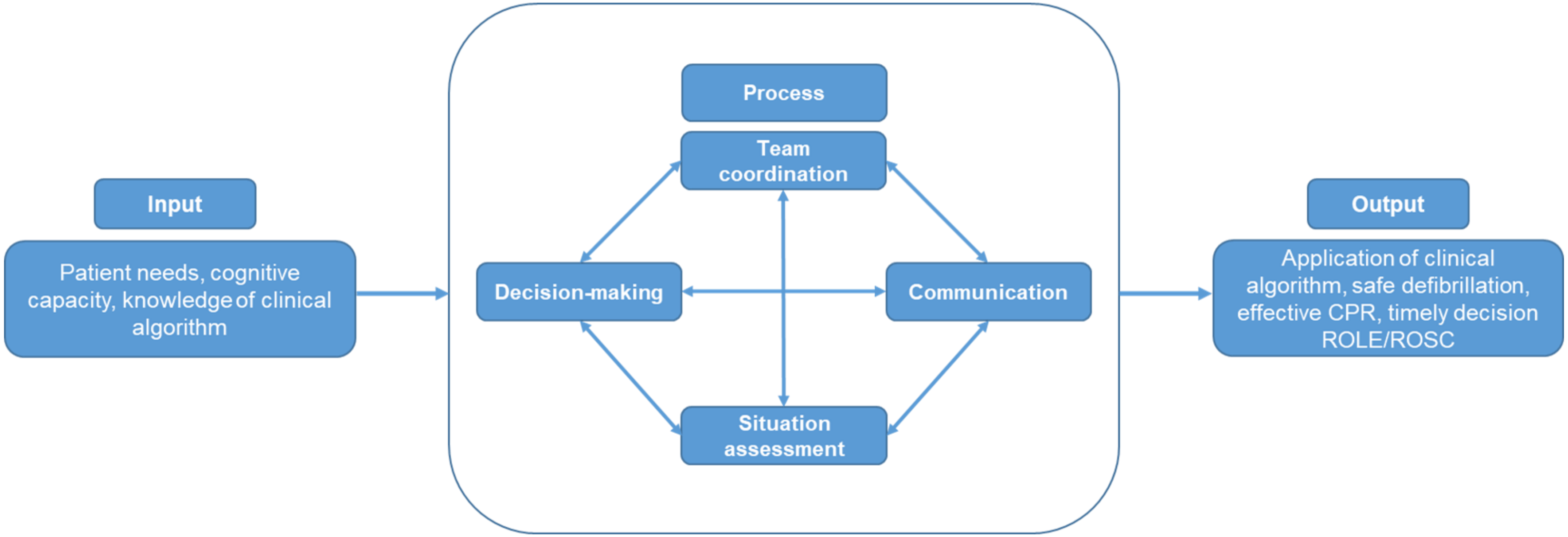

Figure 5.1 Final Input-Process-Output model

5.6.1 Limitations

A potential limitation is the use of SME, but the variety of backgrounds, association with different clinical and educational institutions, and consideration as true experts due to their areas of practice, experience, and knowledge, reduced this risk. It is recognised that there was a risk of bias from the subject matter experts and interpretation of the data, but the interview schedule and coding templates provided structure and when combined with the data analysis methods, the risk was reduced.

5.7 Summary

The aim of this part of the design phase was to validate the NTS considered specific to a paramedic managed OHCA, identified in the previous research phase to inform the taxonomy for the paramedic managed OHCA BMS. It is noted that only four specific, individual NTS categories have been identified, with definitions presented in table 5.4, necessitating an additional narrative literature review of comparable BMS in the triangulation part to supplement data integration.

Table 5.4 Included NTS and definitions

NTS domain	*Definition*
Situation Assessment	Information gathering from the scene, patients, bystanders, other clinicians, making sense of the scene, uses knowledge and understanding of clinical algorithm to inform decisions
Team Coordination	Coordination and integration of a team, tasks, patient care, adaptability, and flexibility of roles to achieve a shared goal, shared responsibility, application of clinical knowledge to aid patient care, and management of tasks
Decision-making	Reaching a judgement when dealing with evolving, complex situations and incorporation of clinical algorithms, uses algorithm to aid decision making
Communication	The sharing and delivery of information within teams, the public and onward medical care, shares information, uses effective verbal and non-verbal methods, considers timing

The final design of a complete taxonomy, including elements, exemplar behaviours and performance ratings will be identified from data integration in the next part of this design phase, triangulation.

5.8 Triangulation

5.8.1 Introduction and Aim

Having validated the NTS, this section details the data triangulation methods and rationale used to integrate the results of the questionnaire, focus groups and semi-structured interviews with a narrative literature review of comparable published behavioural marker systems. The aim of this phase was to triangulate data to produce a taxonomy of NTS consisting of categories, elements, behavioural markers, and a performance rating scale for the prototype BMS. This method allowed for the cross-verification of data, increasing the trustworthiness of the research findings (Knafl & Breitmayer, 1991; Thurmond, 2004). Figure 5.2 framework diagram provides a visualisation of the integrated data and expected output.

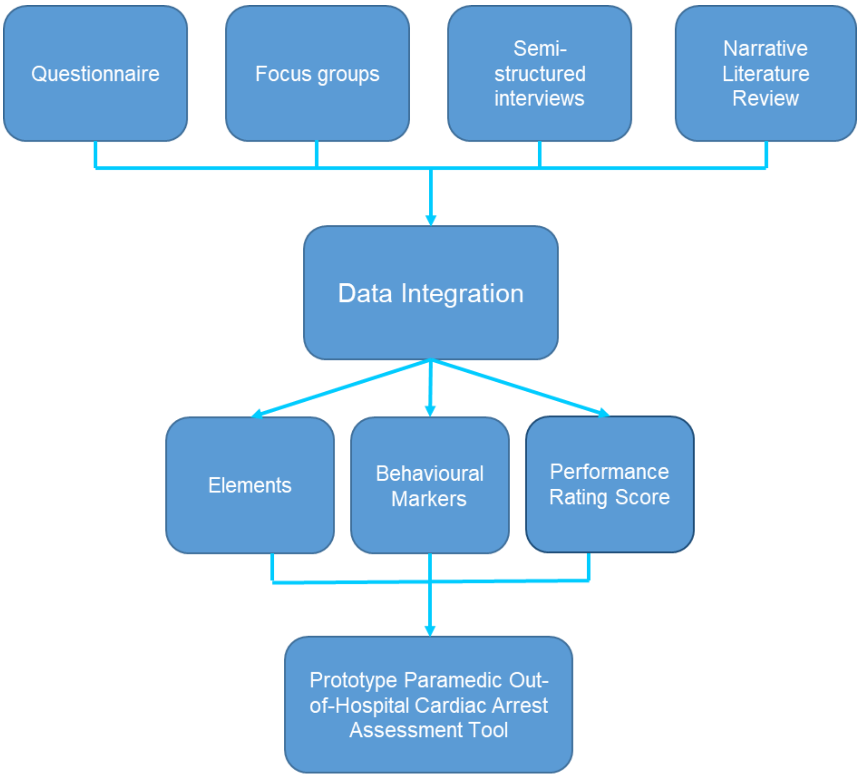

Figure 5.2 Data integration flow chart

5.8.2 Design Context

As a new BMS, consideration to the design was necessary to ensure the prototype resulted in a usable assessment tool, with clear contextual information. Although the aim of this project was to develop a reliable, valid, and usable BMS to assess the NTS used by paramedics when managing an OHCA, consideration to the inclusion of second- and third-year student paramedics as observees was made. Although not qualified paramedics, the shared competencies, similarities in clinical skill sets and active participation in clinical practical placements meant that student paramedics shared the identified NTS specific to the management of an OHCA. As the use of a BMS in a real-life OHCA was not considered feasible or ethical due to the sensitive subject and impracticalities of using an observational feedback tool in actual practice, its use is best suited to a controlled simulated environment. Based on previous work by Fletcher et al. (2003), and Mellanby (2015) design and contextual considerations included:

- Use in a realistic/natural simulated environment
- Focus on the NTS specific to a paramedic managed OHCA
- Design of an OHCA scenario to ensure a range of behaviours/NTS could be observed
- Observation of an individual to reflect the change in roles as the scenario evolves, rather than the whole team
- Complements clinical skills and management of an OHCA, reflecting national resuscitation standards and clinical algorithms
- Rating scale that allows for differentiation between behaviours and overall performance of the individual

- Hierarchical structure of NTS categories, elements, and behavioural markers for ease of use and versatility
- Rating scale fits on one page including a range of described behaviours
- Raters must be trained to aid understanding of BMS aim and use
- Use of simple and familiar language for raters and observee (student paramedics, qualified paramedics, HEMS doctors, paramedic lecturers)
- Easy to use, reduces rater workload allowing for focus on observation
- Feedback must be easy to understand to help improve individual understanding of own performance and NTS used within an OHCA team
- Use by peer-to-peer and tutor-to-student as formative feedback tool

These design and contextual considerations provide a structure to support the psychometric criteria, presented in section 6.1, needed for the evaluation phase. They also offer information on the intended use of the final BMS as part of educational programmes and continuing professional development (CPD) sessions, allowing for peer-to-peer and tutor-to-student formative feedback. The main purpose is to optimise formative feedback for individual student/qualified paramedics when managing a simulated OHCA, with the intention to enhance their understanding and use of NTS as a method to improve individual performance when working as part of an OHCA team. If used in combination with direct training in NTS, there is potential to reduce the risk of errors that can occur through poor communication and a lack of situation assessment, while improving an understanding of the barriers associated with managing an OHCA such as low levels of confidence, as an OHCA remains an infrequent case for UK ambulance clinicians. This supports the additional aim of this part of the study, the development of a BMS that can provide feedback to reinforce safe practice and effective team performance.

5.8.3 Narrative Literature Review

To aid triangulation, a narrative literature review was performed to identify contemporary, comparable healthcare BMS to assist in the classification of associated elements, behavioural markers, and performance rating scales for each of the previously validated NTS categories.

The healthcare databases AMED - The Allied and Complementary Medicine Database; CINAHL complete - Cumulative Index to Nursing and Allied Health Literature and MEDLINE - Medical Literature Analysis and Retrieval System Online were used as they provide a wide range of relevant peer reviewed literature, with material relevant to prehospital and out-of-hospital practice areas. Search terms included healthcare behavioural marker systems OR behavioural markers OR observable behaviour OR non-technical skills AND emergency care to ensure a broad but targeted search. Filters were applied; published date 2010-2018 to reflect the dates of the ongoing study (see figure 3.2), English language, and journal articles. A total of 3334 articles were identified and screened for relevance. Articles were considered for inclusion if they included a taxonomy of NTS, included prehospital/emergency clinicians or were relevant to cardiac arrest management. Articles were excluded if they only included one non-technical skill or the sample was based on a hospital based non-emergency team. Figure 5.3 presents the Prisma flow chart of results, including reasons for exclusion.

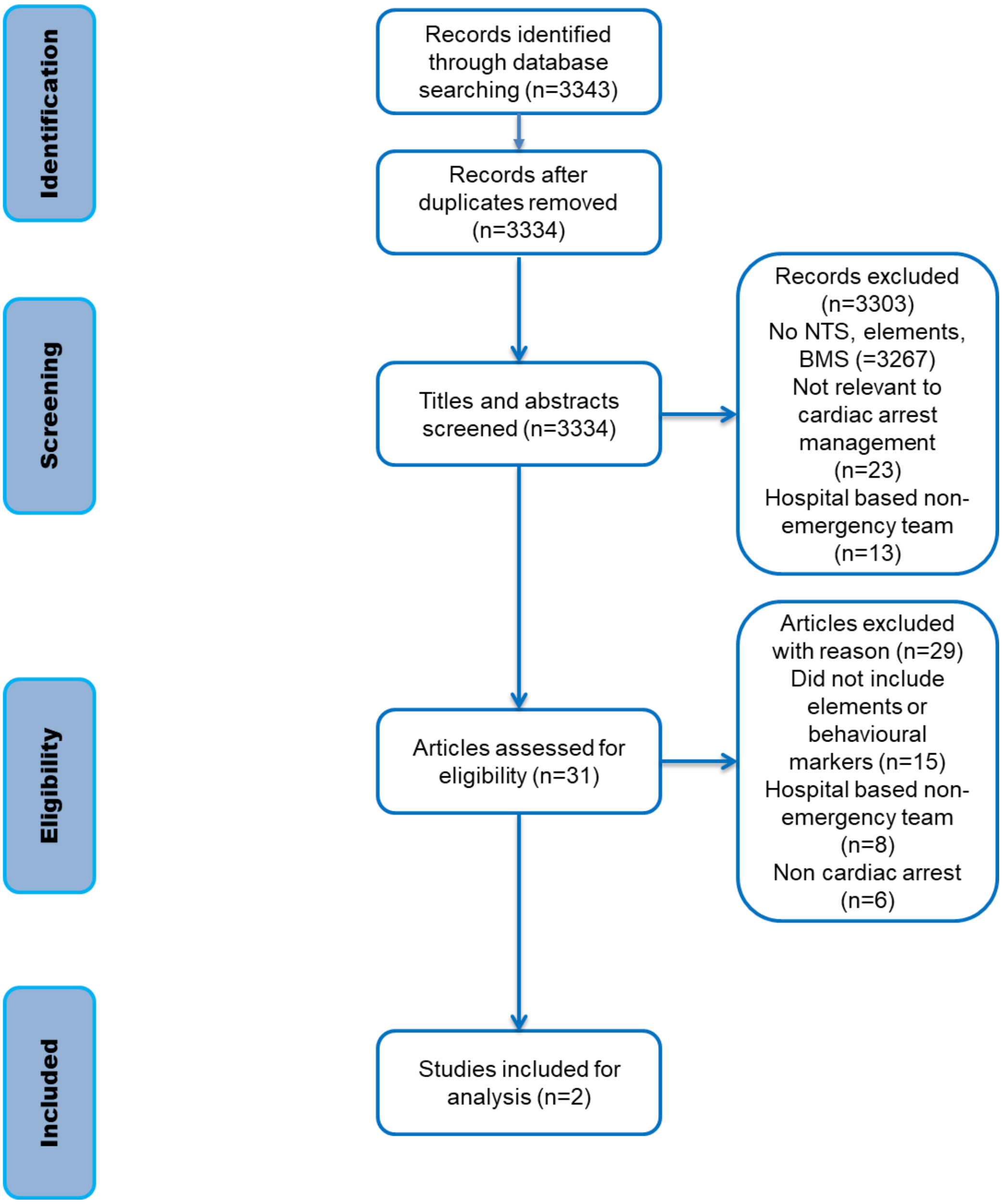

Figure 5.3 Flow chart of rapid review article selection in accordance with PRISMA guidelines

Only two articles met the inclusion criteria; Myers et al. (2016) Non-technical skills evaluation in the critical care air ambulance environment: introduction of an adapted rating instrument - an observational study (AeroNOTS), and Holly et al. (2017) Development of a behaviour rating system for rural/remote prehospital settings (IMCBRS). Both detailed the development of a BMS that focused on prehospital/emergency clinicians, including cardiac arrest management, and included categories, elements, behavioural markers, and rating scales. The inclusion of only two articles highlights a gap in the literature, but also suggests that the search criteria was perhaps too tight. However, comments from the focus groups and semi-structured interviews indicated that an OHCA is unique. Despite some similarities to in-hospital cardiac arrest teams, such as ad hoc team formation and communication difficulties, identified from the literature in chapter two, the same model does not transfer easily. As suggested in chapter one (table 1.1 and figure 1.3), specific to an OHCA there is ‘’little time for briefing, numbers are limited to three or four paramedics for each cardiac arrest scenario and 360-degree access is not always possible’’ (Cormack et al., 2020a, pp. 29). Therefore, it was considered important to only include BMS with comparable environments and practice.

5.9 Triangulation Methods

5.9.1 Methodological Considerations and Process

Data triangulation was performed to reduce the risk of any weaknesses and bias stemming for using a single method, resulting in a comprehensive view of all data collected and analysed. It also served to reduce any influence that the position of the lead researcher had as a qualified HEMS critical care paramedic, educator, and part-time PhD student. By integrating different data sources and methods it was felt that the supervisory team could review the direction of the study, ensuring any identified bias was then recognised and accounted for, further strengthening the outcomes.

Data triangulation was performed using source (questionnaire, focus groups, semi structured interviews, narrative literature review), time (May 2017 – Dec 2018) and use of different data collection and analysis methods (questionnaire, focus groups, semi-structured interviews, narrative literature review). It is recognised that triangulation can be limited by the quality of the data set and the combination of data alone may not reduce any inaccuracies. To reduce this risk, data collection was varied; a range of participant data was collected over a year, ensuring the data collected included a range of OHCA exposure rates, operational and educational experiences including different types of OHCA, team size and make up as well as different locations. The same researcher led the study throughout the three research phrases to ensure consistency in the aim and a clear understanding of the methods used.

Although data integration is common in mixed methods studies, protocols for triangulation are limited (O'Cathain et al., 2010). To provide a robust approach a triangulation protocol based on the work of Farmer et al. (2006) was used as it provided a clear structure to integrate all data, resulting in a complete objective interpretation of the results (Flick, 2007). The protocol consisted of six steps:

Step one

- Sort data from each research phase and identified existing relevant BMS into elements (sub-components of each NTS category), behavioural markers (clearly defined observable behaviour) and performance rating scales

- Determine areas of overlap or divergence

Step two

- Convergence of elements, behavioural markers and performance rating scales based on the specificity and prominence relevant to each non-technical skill category
- Research team identifies levels of agreement for each element, behavioural marker, and performance rating scale – partial agreement, agreement, dissonance

Step three

- Convergence assessment to compare and discuss any key differences and findings of research team discussions for elements, behavioural markers, and performance rating scales

Step four

- Completeness assessment of prototype taxonomy to compare each section to produce a cohesive set of findings, including name of BMS

Step five

- Subject matter expert to review and compare identified elements, behavioural markers, and performance rating scale to review and clarify prototype taxonomy and name

Step six

- Feedback of prototype taxonomy to research team and subject matter experts for final review and clarification

5.9.2 Elements Steps 1-3

Step one consisted of the lead researcher sorting the elements and behavioural markers from the two BMS articles and three research phases' textual data for each NTS category. Step two involved the research team reviewing and discussing the level of convergence for each element and behavioural marker. Each element and associated behavioural marker were considered for relevance, specificity, and prominence to a paramedic managed OHCA, with consideration given to the previously identified barriers to effective team performance. This assisted with identifying the most relevant elements and behavioural markers for the prototype BMS. Table 5.5 provides a summary of sorted elements and table 5.6 (see pages 168 - 173) displays the included elements and their associated behavioural markers. Each table provides a level of agreement and designated sources, denoted with a X. Areas of silence are shaded grey, while green highlighted text indicates those elements and behavioural markers considered for inclusion in step four. Elements were included if four or more sources were denoted, as this was considered as full or near full agreement. Behavioural markers were included if there were three or more sources represented, as the lower number of sources signified the specificity of behaviours. These tables are followed by a narrative of steps two and three before an explanation of the performance rating scale and is presented.

*Table 5.5 Summary of sorted elements and level of agreement (*category, **questionnaire) green highlighted text indicates elements and behavioural markers considered for inclusion in step four*

*NTS Cats**	*Elements*	*Question***	*Focus Groups*	*Semi-Structured Interviews*	*AeroNOTS*	*IMCBRS*	*Level of convergence*
Team coordination	Delegation of roles and tasks	X	X	X		X	Partial agreement
	Managing workloads			X		X	Partial agreement
	Identifying and utilising resources		X	X	X	X	Partial agreement
	Motivates and supports others	X	X	X	X		Partial agreement
	Assessing capabilities				X	X	Partial agreement
	Coordinates team	X	X	X	X	X	Agreement
	Maintains standards		X	X	X		Partial agreement
	Cooperation/followership		X	X		X	Partial agreement
	Asking others for help when I am overwhelmed by a task/tasks	X		X		X	Partial agreement
	Authority & Assertiveness/ Provides clear instruction		X	X	X		Partial agreement
Communication	Exchanging/ sharing information	X	X	X	X	X	Agreement
	Active listening, considers timing	X	X	X		X	Partial agreement
	Encourages others to voice their opinions					X	No agreement
	Uses effective verbal/non-verbal communication methods	X	X	X		X	Partial agreement
	Selecting & Communicating Options			X			No agreement
	Clearly communicating information about the chosen course of action			X		X	Partial agreement

Table 5.5 continued…

*NTS Cats**	*Elements*	*Question***	*Focus Groups*	*Semi-Structured Interviews*	*AeroNOTS*	*IMCBRS*	*Level of convergence*
Situation Assessment	Gathering information	X	X	X	X	X	Agreement
	Recognises and understands information		X	X	X		Partial agreement
	Anticipation and planning		X	X	X		Partial agreement
	Uses algorithm to inform decisions and planning	X	X	X	X		Partial agreement
	Interprets information/makes sense of the scene	X	X	X		X	Partial agreement
	Updating the team		X	X			Partial agreement
Decision-making	Balancing risks and selecting options				X		No agreement
	Generating/considers options			X	X		Partial agreement
	Reviewing/Re-evaluates options		X	X	X	X	Partial agreement
	Identifies options and prioritises tasks guided by algorithm	X	X	X	X	X	Agreement
	Selects and manages options	X	X	X	X		Partial agreement

After reviewing the sorted elements, one element per NTS category reached full agreement across all sources, three elements were not agreed with, and no dissonance was observed. It was noted that there was some overlap, and the specificity and prominence of the data was then reviewed. The wording of elements was important, as the BMS needed to be usable, including consideration to rater workload and to ensure each element was specific to managing an OHCA. Having presented a range of elements in table 5.5, each NTS and the elements highlighted green are considered next.

5.9.2.1 Team coordination

Only ‘coordinate’s team’ reached full agreement and was considered to include an overlap of elements: ‘assessing capabilities’, ‘managing workloads’, and ‘cooperation/followership’. However, it reflected the previously identified frequent changing of roles as different clinicians arrive on scene, with leadership and followership considered as fluid, therefore allowing for flexibility when observing a simulated OHCA scenario.

All other elements reached partial agreement, but it was recognised that ‘identifying and utilising resources’, ‘delegation of roles and tasks’, and ‘motivates and supports others’ almost reached full agreement. As team formation had previously been identified as a barrier to effective team performance, it was considered in relation to how the elements could be applied to a paramedic managed OHCA. The element of ‘delegation of roles and tasks’ was judged to be an accurate and more observable behaviour than ‘identifying and utilising resources’ and it was felt to reflect the varying size of teams, with formation dependent on timing and availability of clinicians.

The element of ‘motivates and supports others’ was agreed as an important sub-category of team coordination and was identified in all data sources except the IMCBRS (Holly et al., 2017). As experience and exposure to an OHCA varies, it was an important aspect of team coordination, providing an observable social skill that could be demonstrated by a range of clinicians.

5.9.2.2 Communication

Although ‘exchanging/sharing information’ reached full agreement, two other elements stood out, ‘active listening, considers timing’, and ‘uses effective verbal/non-verbal communication methods’. It was noted that the two BMS identified from the literature review did not include communication as a separate NTS category, but the IMCBRS (Holly et al., 2017) combined it with teamwork. This may explain why there were two elements that had no agreement, as communication was not an individual category. As the questionnaire, focus groups and semi-structured interviews all identified communication as an important NTS, the elements and their associated behavioural markers had to reflect the nature of an OHCA, including location, noise, unfamiliar ad hoc teams, and variance of people on scene. Considered as an important aspect of gathering and sharing information to aid decisions and reflecting agreement in all sources, 'exchanging/sharing information’ was included for its specificity to managing an OHCA. The sharing of information was considered essential for team coordination and task completion, whereas clear communication of information about a shared aim and course of action critical to effective patient care. Noted in specific comments from research phase two focus groups, and identified in four sources, there was a clear emphasis on the importance of ‘active listening and considers timing/others'. As an element, it was felt to reflect task focus and workload with consideration to those less experienced or lacking confidence in clinical skills. Although the element of 'encourages others to voice their opinions' was included in the IMCBRS (Holly et al., 2017), other sources did not appear to consider this as an important element. As numbers of paramedics can be limited at an OHCA, importance was placed on when to exchange/share information, and therefore this element was considered important and included. Again, the nature of an OHCA informed the inclusion of 'uses effective verbal/non-verbal communication methods'. As an OHCA can occur in a variety of locations, including public places, the importance of this element, and its associated behavioural markers, was considered as a critical aspect of decision-making, and professional behaviour. It incorporated closed-loop communication to ensure tasks and information were understood, reducing the risk of assumption, missed clinical tasks and therefore error. The use of suitable and appropriate language emphasised the inclusion of relatives and other clinicians in decision-making, reflecting a patient centred approach to care (Douma et al., 2021).

5.9.2.3 Situation Assessment

None of the published BMS included situation assessment, and only AeroNOTS (Myers et al., 2016) included situation awareness as a NTS category. The IMCRBS (Holly et al., 2017) included gathering information as a NTS category, often identified as the first element of situation awareness (Rutherford, 2015; Flowerdew et al., 2012). However, research phase one and the semi-structured interviews validated situation assessment as a preferred NTS, specific to the paramedic managed OHCA. Consequently, elements needed to reflect scene assessment and ‘gathering information’, with its agreement identified in all sources, was clearly recognised as an essential component with cross over identified in both published BMS. Without gathering information from the patient, scene, bystanders, clinical observations, or other team members, it would be difficult to identify an OHCA and start resuscitation.

To process this information there is a need to link it to tacit and explicit knowledge, resulting in ‘interprets information/makes sense of the scene’ considered as an intrinsic element. AeroNOTS (Myers et al., 2016) incorporated Endsley’s (1995) model of situation awareness as elements. However, the IMCRBS (Holly et al., 2017) identified gathering information as a category with elements of risk assessment and safety, reviewing decisions and trying alternative approaches, supported by behavioural markers that reflected the prehospital environment. However, when all components of each element and behavioural markers were considered, interpreting the scene, and making sense of it, was considered a critical feature of situation assessment. This interpretation also acknowledges a paramedic's range of experience and exposure rates to an OHCA and their influence on tacit and explicit knowledge. It could also be easily observed as altering the physical environment and patient movement are key aspects of managing an OHCA.

The third element considered was ‘uses algorithm to inform decisions and planning’, identified in all but the IMCBRS (Holly et al., 2017). Incorporating anticipation and planning, this element and associated behavioural markers reflected the use and reliance of clinical algorithms to make clinical decisions and plans. It was felt that the physical use of an algorithm could be observed, with planning incorporating the recognition of time on scene, verbalisation of patient movement options and additional resources needed reflecting the focus on clinical algorithms used by paramedics.

5.9.2.4 Decision-making

Decision-making is clearly considered as an important NTS, often dependent on the situation and experience of team members (Flin et al., 2015) but compared to the other categories there were less elements identified. Only full agreement was observed in ‘identifies options and prioritises tasks guided by algorithm’. The ‘guided by algorithm’ was an important addition, as a pattern identified in all research phases, it emphasised aspects of naturalistic decision-making. Although an OHCA is perhaps not considered as a hazardous industry, the time critical nature of a patient's condition, inadequate patient information, changing clinical condition of the patient and unfamiliar and inexperienced teams appear to affect decision-making. Identified from the textual data of all three-research phases, clinical algorithms are used to inform the order of clinical tasks, ensuring that best practice is followed. Where a paramedic has limited experience and/or limited exposure to an OHCA, rule-based decision-making may reflect an increased reliance on clinical algorithms and memory aids. Research phase three results ascertained a tendency to use clinical algorithms as a method to cognitively offload, utilising the less experienced member of the team to guide task management and inform decisions, rather than recognition-primed decision-making. As an element of decision-making, each element and behavioural marker needed to reflect actual practice, and the observed use of algorithms reflected how decisions appear to be identified and prioritised in addition to situation assessment.

It was clear that each element needed to be complementary, not only in the associated category but across all others. The elements of ‘selects and manages options’ and ‘reviewing/re-evaluating options’ were considered as they reached agreement in four sources. As decision-making is cyclic, the next practical step from identifying options would be to select an option/task and then to review it. Emphasised in the focus groups, a varying level of knowledge and understanding of clinical tasks and equipment, linked to lower levels of confidence, appeared to influence who did what. Therefore, the element of ‘selects and manages options’ was considered an important part of decision-making as it would allow consideration to who is best to perform the task, any logistical problems associated with patient movement, all informed by the patient’s condition. This naturally led to the need to review decisions when managing an OHCA, as it is unpredictable and time sensitive (Ong et al., 2018), with changes occurring to the patient’s condition, environment, team size and make up. Reviewing the elements identified in all sources, the need to review and re-evaluate decisions and tasks reflects the changing in roles, highlighted in the questionnaire and focus group data, and was felt to represent a combination of all the textual data reviewed.

5.9.3 Behavioural Markers Steps 1-3

Once elements were identified, the associated behavioural markers and their application to a paramedic managed OHCA were discussed with the supervisory team. It was agreed that each behavioural maker needed to be observable, clearly defined, appropriate and indicative of performance (Klampfer et al., 2001). They also needed to reflect the varied numbers of clinicians, varied timing of arrival, levels of experience/exposure and clinical ability on scene to ensure that examples of good and poor behaviour could also be identified. Each behaviour marker from the two BMS were reviewed and considered against the category comments from the textual data of the three research phases, previously identified in step one (sorting). Comments from each of the research phases were considered if they had high levels of specificity, perception, extensiveness, and were applicable to each element. Table 5.6 displays the associated behavioural markers that were identified, and their level of convergence. An X denotes the associated source and green highlighted text signifies those behavioural markers identified across three or more sources and therefore considered as full or near full agreement and suitable for inclusion in step four, completeness assessment.

*Table 5.6 Summary of behavioural markers and level of agreement (*category, **questionnaire, *** focus groups, **** semi-structured interviews) green highlighted text indicates behavioural markers considered for inclusion in step four*

*NTS Cat**	*Element*	*Behavioural Marker*	*Q***	*FG****	*SSI*****	*Aero-NOTS*	*IMCBRS*	*Level of Convergence*
Team coordination	Coordinating team - Assessing capabilities	Assess priorities of the situation		X	X	X	X	Partial Agreement
		Assess potential capabilities/ resources of others and decide on their roles				X	X	Partial agreement
		Working together with others to carry out tasks, for both physical and cognitive activities, understanding the roles and responsibilities of different team members			X	X		Partial agreement
		Proactive in team coordination, considers teams experience, abilities, needs and workload		X	X	X	X	Partial Agreement
		Identifies team aim based in initial patient presentation		X			X	Partial agreement
		Assertive, manages disputes/ problems and disruptions when needed	X	X	X			Partial agreement
		Takes responsibility for own actions and others	X				X	Partial agreement

Table 5.6 continued…

*NTS Cat**	*Element*	*Behavioural Marker*	*Q***	*FG****	*SSI*****	*Aero-NOTS*	*IMCBRS*	*Level of Convergence*
Team coordination	Delegation of roles and tasks	Establishing the necessary, and available, requirements for task completion (e.g., People, expertise, equipment, time)				X		No agreement
		Establishes skill level early and allocates/accepts roles effectively; clinical, logistics, family management	X		X	X		Partial agreement
		Allocates tasks and monitors workload of others		X	X	X	X	Partial Agreement
		Flexible can adapt between roles as more clinicians arrive on scene	X	X	X			Partial agreement
	Motivation and support of team	Provides motivation and support for the team	X	X	X		X	Partial agreement
		Appears friendly and approachable		X			X	Partial agreement
		Providing physical, cognitive, or emotional help to their members of the team		X		X		Partial agreement
		Supports others, guides, and directs, recognises tiredness, task focus, overload, and underload		X	X			Partial agreement
		Adaptable, responsive to clinical and team changes	X	X	X			Partial agreement

Table 5.6 continued…

*NTS Cat**	*Element*	*Behavioural Marker*	*Q***	*FG****	*SSI*****	*Aero-NOTS*	*IMCBRS*	*Level of Convergence*
Communication	Exchanging/ sharing information	Shares/provides information about chosen course of action	X	X	X	X	X	Agreement
		Considers risks of various options and discusses this with the team			X	X		Partial agreement
		Relays and shares information relevant to different levels of clinical ability, lay persons, other professional organisations				X		No agreement
		Ask for information/feedback from all team members			X		X	Partial agreement
		Confirms that instructions/requests have been received/understood		X	X		X	Partial agreement
		Shares mental model to ensure common understanding		X	X		X	Partial agreement
	Uses effective verbal/non-verbal communication methods	Uses specific accurate language when giving information or instructions			X	X	X	Partial Agreement
		Adapts language, tone, and/or volume to suit	X	X	X		X	Partial agreement
		Aware of body language, looks for focused attention, impaired dexterity, signs of frustration or tiredness			X		X	Partial agreement
	Active listening, considers timing and others	Listens, acknowledges receipt of information, and clarifies when necessary		X	X		X	Partial agreement
		Asks relevant questions, does not verbally overload others		X	X			Partial agreement
		Checks on members who are less vocal					X	No agreement

Table 5.6 continued…

*NTS Cat**	*Element*	*Behavioural Marker*	*Q***	*FG****	*SSI*****	*Aero-NOTS*	*IMCBRS*	*Level of Convergence*
Situation Assessment	Gathering information	Actively surveys the environment, specifically collecting data about the situation by monitoring all available people, scene, data sources and cues			X	X		Partial agreement
		Observing the scene (stop and look, note time and other information)					X	No agreement
		Frequently scans environment; verbalises and acts on hazards/surroundings	X	X	X			Partial agreement
	Interprets information/ makes sense of the scene	Alters physical environment – asks for team input and help to move most appropriate choice to ensure best access for team; patient, furniture, equipment etc.	X	X	X			Partial agreement
		Recognises need for additional resources/specialist help – HEMS, HART, FIRE, POLICE			X			No agreement
	Uses algorithm to inform decisions and planning	Asking 'what if' questions and thinking about potential outcomes and consequences of action				X		No agreement
		Reviews algorithm/guidelines/ checklists to cross-check information and plans ahead	X	X	X			Partial agreement
		Aware of time on scene, considers egress/additional resources needed	X	X	X		X	Partial agreement

Table 5.6 continued…

*NTS Cat**	*Element*	*Behavioural Marker*	*Q***	*FG****	*SSI*****	*Aero-NOTS*	*IMCBRS*	*Level of Convergence*
Decision-making	Identifies options and prioritises tasks guided by algorithm	Scheduling tasks, activities, issues, information channels, etc. – according to important (e.g., due to time, seriousness)	X		X	X		Partial agreement
		Supporting safety and quality by reviewing accepted principles of patient movement, clinical algorithms or guidelines and checklists	X	X	X			Partial agreement
		Generating alternative possibilities or course of action to be considered in making a decision or problem solving		X	X	X		Partial agreement
	Selects and manages options	Assessing hazards to weigh up the threats or benefits of a situation, considering the advantages and disadvantages of different action; choosing a solution or course of action based on these processes			X	X		Partial agreement
		Provides clear and supported working and differential diagnosis		X	X			Partial agreement
		Considers and selects extrication devices and methods based on position and location of patient, and number of resources on scene	X	X	X			Partial agreement

Table 5.6 continued…

*NTS Cat**	*Element*	*Behavioural Marker*	*Q***	*FG****	*SSI*****	*Aero-NOTS*	*IMCBRS*	*Level of Convergence*
Decision-making	Reviewing options	Continually reviewing the suitability of options identified, assessed, and selected; and re-assessing the situation following implementation of a given action				X		No agreement
		Ask others for a second opinion regarding the decision			X		X	Partial agreement
		Discuss alternative suggestions			X		X	Partial agreement
		Involves team members in the decision-making process		X	X		X	Partial agreement

Only full agreement was reached for 'shares/provides information about chosen course of action' in the element of exchanging/sharing information. Seven behavioural markers reached no agreement, and in general, there was a lower level of agreement for all, which may reflect some overlap, and previous identification of the NTS categories. Nonetheless, there was a need to include behavioural markers that were specific and suitable. Those that were identified in three or more sources were considered, and their relevance and appropriateness had to be applicable to a paramedic managed OHCA. Yet, distinct relevant behavioural markers were identifiable for each element and category that were considered as key factors including the management of a patient in what can be a complex and varied environment. They also reflected an unfamiliar ad hoc team, varying in size and experience, all of which appear to influence the change in roles.

The specific behavioural markers highlighted green were included for review in step four as this allowed for a completeness assessment in conjunction with exemplar behaviours and a performance rating scale. This would ensure a review of all the whole taxonomy to provide a cohesive set of findings.

5.9.4 Performance Rating Scale Steps 1-3

The next consideration was the inclusion of a performance rating scale. Although it is recognised that a checklist design can be used to identify if a behaviour was demonstrated, a performance rating scale was preferred as it allowed the level and frequency of behaviour to be documented (Flin et al., 2015). Rating scores from the two BMS were sorted and reviewed before completion of step three, convergence assessment. The IMCRBS rating system used by Holly et al. (2012)

included ratings ‘demonstrated, not demonstrated, not clear and N/A’ but lacked detail on how these were developed and used. There rating scale in the AeroNOTS rating tool (Myers et al., 2016), used a five-point scale, with supporting descriptors and was considered for adaptation as it was clear and considered easy to understand. However, one example was not considered satisfactory, and examples from the behavioural markers workshop report Klampfer et al. (2001) were included to provide a balanced view.

Rating scores from NOTECHS (O’Connor et al., 2002) and the University of Texas Behavioural Markers Rating Scale (LOSA) (Helmreich et al., 1999b) were reviewed and discussed for their applicability for paramedic practice. Although each rating score was slightly different in its presentation and number, after reviewing each scale a combination of the AeroNOTS (Myers et al., 2016) and NOTECHS (O’Connor et al., 2002) scales appeared to offer a clear range of behaviours that could be observed, ranging from very poor to excellent. A five-point scale was considered as a suitable method for scoring paramedics, as it allowed for differentiated levels of performance based on a range of behaviour that relate to social, cognitive, and personal skills. It also allowed for category and summative scores, providing a three-dimensional aspect that rated a whole performance rather than specific levels of skills (Dietz, 2014b). Table 5.7 displays each rating option and descriptor.

Table 5.7 Prototype rating options and descriptors

Rating option	*Descriptor*
Excellent (exceptional)	Exceptional performance. Observed behaviour is consistent, effective, safe and could be an example for others
Good (strong)	Good performance. Observed behaviour is frequently of high standard, effective and safe but could improve in some categories
Acceptable (adequate)	Satisfactory performance. Observed behaviour does not endanger patient or others, adequate and safe but could improve in all categories
Poor (concerning)	Concerning performance. Observed behaviour potentially compromises safety of patients and others. Ineffective at times, needs significant improvement across all categories
Unacceptable (unsafe)	Unsafe performance. Observed behaviour does not meet ALS standards, patients and others endangered. Ineffective throughout: additional training required

The rating options reflect varying levels of observed performance, with the descriptors detailing example behaviour to enable raters to distinguish between each option.

A not observed option was not included as paramedics perform a variety of roles and tasks during an OHCA reflecting the evolving and unscheduled nature of an OHCA, with teams adapting as other clinicians arrive with different competencies. Therefore, it was expected that a range of performance would be identified for all categories included in the prototype tool, and a rating for the overall performance could be distinguished.

5.10 Step four - Completeness Assessment

A completeness assessment was performed to compare the categories, elements, behavioural markers, and performance rating scale as a complete set of findings. The lead researcher considered textual comments that related to poor and good behaviours about the management of an OHCA, previously identified from the questionnaire, focus groups and subject matter expert semi-structured interviews, and supervisors to ensure specific and applicable behavioural markers were included. The performance rating scale was also considered, as it needed to measure observed performance, serving as a method to prioritise training needs. Exemplar behaviours identified from the textual data in the previous research and design phases were reviewed by the research team and included if considered as an observable action, relevant to each non-technical skill category and element, and had to be quantifiable when compared against the performance rating scale. Good and poor example behaviours considered by the research team are presented below.

5.10.1 Team Coordination

Examples of good behaviour

- *Assesses priorities of the situation, ensures safety for all involved including the need for early chest compressions and defibrillation*
- *Confirms patient condition and takes control of scene in a calm manner, establishes skill levels and roles needed for effective advanced life support*
- *Shares own understanding of patient presentation to ensure team is aware of shared aim*
- *Recognises or offers to help others if tired/task overloaded/under-loaded/stressed*

- *Adapts between leader and follower easily and without problem or confrontations as more clinicians arrive on scene*
- *Accepts role/tasks/direction generally without question*

Examples of poor behaviour

- *Not proactive in team coordination, does not consider priorities or safety aspects of scene/patient care*
- *Performs own tasks at inappropriate times without consideration to patient needs or condition*
- *Does not identify shared aim or consider patient needs*
- *Does not recognise or offer to help others if tired/task overloaded/under-loaded/stressed*
- *Does not adapt or accept alternative tasks/roles as other clinicians arrive*
- *Does not accept role/tasks/direction, questions, and challenges throughout*

5.10.2 Communication

Examples of good behaviour

- *Frequently shares information and clarifies when requested*
- *Communication is appropriate and effective, can adapt language/volume/tone to relay and share information*
- *Recognises different levels of clinical ability, lay persons, other professional organisations*
- *Communication is calm, precise, directed, timely and clear, discusses options with team*
- *Asks relevant questions, aware of concentration for clinical interventions, does not verbally overload others*
- *Actively listens, confirms, and follows instructions dependent on role*
- *Aware of own and others body language, looks for focused attention, impaired dexterity, signs of frustration or tiredness*

Examples of poor behaviour

- *Does not share or exchange Information, even when requested*
- *Does not readily communicate, does not adapt tone, volume, or language, does not consider other's capabilities or understanding*
- *Communication is not calm, precise, directed, timely or clear, does not respond to others*
- *Asks irrelevant questions, unaware of concentration for clinical interventions, can verbally overload others*
- *Does not confirm receipt of tasks/role, rarely follows instructions*
- *Demonstrates abrupt/rude/dismissive behaviour*
- *Adopts defensive stance, folds arms, does not consider those with lower levels of confidence, dismissive or other's*

5.10.3 Situation Assessment

Examples of good behaviour

- *Can be seen actively surveying the scene, not focused on patient, considers location and position of patient, others on scene, and environment*
- *Continues to gather information throughout cardiac arrest, uses this information to make sense of patient condition*
- *Alters physical environment – asks for team input and help to move patient/furniture/equipment, to provide best access for team to perform safe and effective resuscitation*
- *Recognises need for and calls for additional resources/specialist help – HEMS, HART, FIRE, POLICE, requests early and updates control room*
- *Uses algorithm/guidelines/checklist to cross-check information to aid decision-making and planning relative to time on scene*

Examples of poor behaviour

- *Does not survey the scene, focuses on patient environment, does not recognise hazards/surroundings, or ask others about scene*
- *Does not gather information from team, relatives, or bystanders, does not try to make sense of scene*
- *Makes no effort to alter physical layout of scene, starts resuscitation without moving anything, does not consider best access for safe and effective resuscitation*
- *Does not recognise need or call for additional resources, focused on their own tasks, does not update control room*
- *Does not cross-check information or use algorithm/guidelines/checklist for decisions or plans, is not aware of time scene*

5.10.4 Decision-making

Examples of good behaviour

- *Uses and has good knowledge and understanding of algorithms to identify options, uses this to prioritise clinical tasks and guide decisions*
- *Considers cause of OHCA, including reversible causes, possibility of recognition of life extinct (ROLE) or return of spontaneous circulation (ROSC)*
- *Can be seen to plan and prepare for clinical interventions, considers alternative options*
- *Recognises egress routes and selects safe and appropriate extrication methods, based on location, patient size, condition, number of resources available*
- *Discusses/contributes to alternative clinical and extrication options, involved in suggestions to help review risks and tasks*
- *Reviews situation throughout entirety of OHCA, open to other’s views, alters decisions if appropriate/beneficial*

Examples of poor behaviour

- *Does not display safe or acceptable knowledge of BLS/ALS algorithms, deviates from clinical algorithm*
- *Makes no reference to clinical algorithm, does not consider cause of OHCA, reversible causes or outcome of OHCA*
- *Does not plan or prepare for clinical tasks or movement of patient*
- *Does not discuss/contribute to decisions, review, or consider alternatives or risks*
- *Is not active in reviewing the situation, does not alter own decisions or role, can be disruptive*
- *Is dismissive of other's suggestions/observations*

The example behaviours above provided a description for good and poor behaviour and were included in the prototype BMS to aid consistent feedback and a 'higher level of granularity' (Thomas, 2018, pp. 105). As a BMS needs to be easy to use, ensuring that observation is possible and accounting for rater workload each behavioural marker was reviewed individually and as a set for similarity, relevance to good and poor behaviour, ease of observation, and relevance to patient care, safety, and national resuscitation standards (Resuscitation Council UK, 2021b). Based on this review the following behavioural markers were included and are presented in table 5.8 prototype taxonomy including the NTS category and definition, element, behavioural marker, and rationale for their inclusion.

Table 5.8 Prototype taxonomy with supporting rationale

NTS Category and Definition	*Element*	*Behavioural Marker*	*Rationale*
Team coordination The coordination and integration of a team, tasks, patient care, adaptability, and flexibility of roles to achieve a shared goal, shared responsibility, application of clinical knowledge to aid patient care, and management of tasks	Coordinating team - Assessing capabilities	Assess priorities of the situation	Ensures safety for all, including early chest compressions and defibrillation as per evidence-based practice, aims to improve survivability
		Proactive in team coordination, considers teams experience, abilities, needs and workload and reviews	Essential to controlling the scene, ensuring calmness, identified urgency of tasks, reflecting time critical nature of the patient's condition
		Identifies team aim based on patient presentation	Ensures all are working towards same goal, allows for review as patient condition or team dynamics change
	Delegation of roles and tasks	Establishes skill level early and allocates/ accepts roles effectively; clinical, logistics, family management	Allows for the identification of other resources, the allocation and adaptation of those best suited to tasks, in relation to patient condition and team abilities
		Allocates tasks and monitors workload of others	Ensures support where needed, and that tasks are completed in timely fashion
		Flexible can adapt between roles as more clinicians arrive on scene	Reflects reality of OHCA and ad hoc team formation
	Motivation and support of team	Supports others, guides, and directs, recognises tiredness, task focus, overload, and underload	Reflects ad hoc unfamiliar team including varied levels of experience/exposure and ensures support for team
		Adaptable, responsive to clinical and team changes	Reflects ad hoc unfamiliar team, allows for observation of calm, responsible behaviour in a range of conditions and team formation/size

Table 5.8 continued…

NTS Category and Definition	*Element*	*Behavioural Marker*	*Rationale*
Communication The sharing and delivery of information within teams, to the public, and onward medical care using verbal and non-verbal methods with consideration to timing	Exchanging/ sharing information	Shares/provides information about chosen course of action	Essential for communicating patient condition throughout OHCA
		Confirms that instructions/requests have been received/understood	Use of closed loop communication to reduce risk of missed tasks, ensures a shared understanding of team aim, reflects ad hoc team
	Uses effective verbal/non-verbal communication methods	Uses specific accurate language when giving information or instructions	Reduced risk of misunderstanding, supports professional identify
		Adapts language, tone, and/or volume to suit	Reflects different scenes, locations, noise, people on scene, or watching, considers public nature of case
		Aware of body language, looks for focused attention, impaired dexterity, signs of frustration or tiredness	Recognition of emotional intelligence, considers others on scene, reflects public and emotive nature of OHCA
	Active listening, considers timing and others	Checks on members who are less vocal	Makes consideration of those who are concentrating, possess low level of confidence, enhances teamwork
Situation Assessment The process of understanding the needs and conditions of a scene and team to inform decisions and plan. Information gathering from the scene, patients, bystanders, other clinicians, making sense of the scene, uses knowledge and understanding of clinical algorithm to inform decision	Gathering information	Actively surveys the environment throughout, specifically collecting data about the situation by monitoring all available people, scene, documentation, and cues	Ensures considers whole scene, not just focused on patient, important for safety, legal and ethical implications, such as end of life care, do not resuscitate orders, clues to cause of OHCA and informs decisions and plans
	Interprets information/ makes sense of the scene	Alters physical environment – asks for team input and help to move the most appropriate choice to ensure best access for team; patient, furniture, equipment etc.	Important to ensure safe and effective resuscitation, including time sensitive and potentially harmful interventions such as use of needles and defibrillation

Table 5.8 continued…

NTS Category and Definition	*Element*	*Behavioural Marker*	*Rationale*
Situation Assessment (continued…)	Interprets information/ makes sense of the scene	Recognises need for additional resources/specialist help – HEMS, HART, FIRE, POLICE	Reflects patient and team needs. Important for patient care and consideration of movement
	Uses algorithm to inform decisions and planning	Reviews algorithm/guidelines/checklists to cross-check information and plans	Ensures structured and safe decisions that influence appropriate clinical interventions throughout
Decision-Making The process of making choices to reach a judgement when dealing with evolving, complex situations, by identifying decisions, gathering information, and assessing alternative options	Identifies options and prioritises tasks guided by algorithm	Scheduling tasks, activities, issues, information channels, etc. – according to importance (e.g., due to time, seriousness)	Reflects evolving team, time sensitive clinical interventions, and consideration to movement of patient from scene to definitive care
		Generating alternative possibilities or course of action to be considered in deciding or problem solving	Important in the consideration of causes of the OHCA, reversible causes, need for additional support from clinical desk, doctors, or critical care paramedics
	Selects and manages options	Considers and selects extrication devices and methods based on position and location of patient, and number of resources on scene	Specific to an OHCA, need to consider the patient, team, others on scene, location, safety aspects, policy, and procedures for safe manual handling
		Provides clear and supported working and differential diagnosis	Consideration needed for rationale if recognition of life extinct or decision if pulse is returned, has legal and ethical implications, consideration of wider context
	Reviewing options	Discuss alternative suggestions	Ensures safety and best practice for patient care
		Involves team members in the decision-making process	Reduces risk of task focus/overload and poor decision making, acts as a cross-checking mechanism

Following completion of the prototype taxonomy, a name was needed that reflected the persons observed and its use. The name ‘Paramedic Out-of-Hospital Cardiac Arrest Assessment Tool’ (POHCAAT) was considered appropriate and would be reviewed, with the draft prototype in step five, a review by subject matter experts.

5.11 Step five – Researcher Comparison

To compare the findings, clarify interpretations and ensure validation of the previous triangulation steps, step five consisted of a review by six SME. Previous participants from the design phase semi-structured interviews were contacted in addition to the lead author and researcher of a previous healthcare BMS. Chosen for their expertise, knowledge and understanding of OHCA management, use of NTS and previous use of BMS, eight SME were emailed a copy of the draft prototype POHCAAT, with supporting information of the proposed use and planned evaluations. Conducted over a 2-month period (October-November 2018) email was used as a communication method due to the varied locations and work commitments of all SME. It allowed for group discussion, albeit via email but also documentation of opinion. All were asked for their opinion on the proposed use, if they considered the categories, elements, and behavioural markers explicit, transparent, accurate and able to provide observations of behaviours in an OHCA. They were also asked to rate the NTS categories in order of hierarchy, preference to the rating scale and if the name was suitable.

Six SME replied, three were Helicopter Emergency Medical Service (HEMS) critical care paramedics (SME 1, SME 2, and SME 3), one HEMS emergency department consultant doctor (SME 4), one patient safety lead for a large ambulance trust (SME 5) and the sixth the lead author and researcher of a healthcare BMS (SME 6).

Based on email correspondence, all six SME agreed on the name, stating that it was clear, and evident to when it should be used. Feedback on the categories was similar with all agreeing that they were what they expected to be included; as they reflected team behaviour in a paramedic managed OHCA.

Although the categories and their order were agreed on, with SME 6 highlighting the inclusion of communication as a separate NTS. They suggested that communication is not always included as an individual category in other healthcare BMS, primarily as it is '*interwoven in other categories'*, often used as a method for demonstrating the occurrence of other behaviour. It was discussed that communication was considered as 'the glue that holds the system together' and when viewed in the IPO models (see figures 4.10 and 5.1) it was felt that its inclusion as a separate NTS category was justified. The SME acknowledged this and agreed that its inclusion as an individual category was necessary, as it is an important and specific NTS for a paramedic managed OHCA. Other SMEs did not comment specifically on communication as an individual category but did note that some elements appeared to overlap between team coordination, situation assessment, and decision-making. In team coordination, the allocation of tasks and roles was felt to be similar to the establishment of skills levels and that this element also included the allocation of roles. However, it was noted that there was a need to establish abilities before allocating tasks or roles, but the POHCAAT needed to reflect this more clearly.

The use of algorithms was noted as an element in both situation assessment and decision-making. It was suggested that these overlaps could result in difficulty in distinguishing behaviours for each category and that when used with the rating scale, observation could be subjective (SME 2 and 4). It was also recognised that some behaviours would be observable across each category, with the suggestion that the performance rating scale could be used to weight the elements (SME 4). Yet SME 3 felt that it was '*straightforward to use with little/no ambiguity*'.

This led onto one-to-one discussions between the lead researcher and SME via email that suggested that although the elements for each category were appropriate, there was the possibility of an observee falling in-between the rating scales depending on the observed behaviour. It was suggested that a paramedic could display a range of behaviour, performing well in situation assessment but poorly in team coordination (SME 1 and 2). However, the lead researcher suggested that if a paramedic demonstrated varied behaviour, particularly as more resources arrived, raters could circle or highlight the most applicable behavioural markers and use these as a basis to provide a score for each category, and then combine these to provide an overall score. This resulted in more discussion on which score would be considered as acceptable, with the majority of SME agreeing that if each category was scored as 3 – acceptable, this would total 12, considered as overall acceptable behaviour. It was suggested that if a paramedic was considered as acceptable in three out the four categories that this should also be considered as acceptable behaviour, as this would result in most categories reaching individual and an overall score that was considered as acceptable. However, after reviewing scoring combinations, it was agreed that any total score of ≤10 would be considered as less than adequate behaviour and that if a score was ≥11 then the breakdown of individual category scores should be taken into consideration. If more categories were rated as unacceptable or poor, then this would need to be highlighted in the feedback, regardless of the summative score. It was anticipated that student or qualified paramedics demonstrating a behaviour that was observed as unacceptable or poor would be unlikely to then be rated as excellent in a different category. However, as a prototype BMS, the performance rating scale was considered appropriate, and the evaluation would provide feedback to how well this performed. It was noted that the performance rating scale used a five-point scale and that this would enable an overall score to distinguish between behaviours if there was an exemplar behaviour included for each score.

5.12 Step six – Researcher Feedback

A draft prototype POHCAAT was updated to include examples of behaviours for each category and element, and an associated score. It was recirculated to all SMEs and in general, the feedback received on the design was that it was now too dense and would result in too high a workload for raters, reducing the time for observation. All the SMEs requested that a simplified version was needed and would be best used in simulated OHCA scenario as they were unsure how the POHCAAT could be used in a real OHCA, based on ethical and professional considerations. Based on this, the prototype was redrafted with a simplified design including example behaviours and is presented in figure 5.4 below.

Paramedic Out-of-Hospital Cardiac Arrest Assessment Tool (POHCAAT)

Name of student/paramedic being observed…………………………Assessor Name………………………………Date…………..

Rating option	***Descriptor***
Excellent (exceptional)	Exceptional performance. Observed behaviour is consistent, effective, safe and could be an example for others
Good (strong)	Good performance. Observed behaviour is frequently of high standard, effective and safe but could improve in some categories
Acceptable (adequate)	Satisfactory performance. Observed behaviour does not endanger patient or others, adequate and safe but could improve in all categories
Poor (concerning)	Concerning performance. Observed behaviour potentially compromises safety of patient and others. Ineffective at times, needs significant improvement across all categories
Unacceptable (unsafe)	Unsafe performance. Observed behaviour does not meet ALS standards, patient and others endangered. Ineffective throughout: additional training required

Your score should reflect the one observed student/paramedic's behaviour throughout the simulated OHCA. Please provide a score for each category and a final summative score. The highest score possible is 20, the lowest 4, an acceptable score is ≥11.
Example behaviours can be found on page 3.

NTS Category	***Element***	***Behavioural Marker***	***Score***
Team Coordination Total score……	Coordinates team	Proactive in team coordination, considers teams experience, abilities, needs and workload and reviews Flexible can adapt between roles as more clinicians arrive on scene	
	Motivates and supports others	Supports others, guides, and directs, recognises tiredness, task focus, overload, and underload	
	Delegates roles and tasks	Establishes skill level early and allocates/accepts roles effectively; clinical, logistics, family management	
Communication Total score……	Exchanging/sharing information	Shares/provides information about chosen course of action clearly and simply	
	Actively listens, considers timing and others	Listens, acknowledges receipt of information, and clarifies, when necessary, recognises task focus	
	Uses effective verbal/non-verbal communication methods	Adapts language, tone, and/or volume to suit, recognises body language	
Situation Assessment Total score……	Gathers information	Scans scene; verbalises and acts on hazards/surroundings with team and others	
	Interprets information/makes sense of the scene	Alters physical environment to ensure best access for team; patient, furniture, equipment, calls for additional resources	
	Uses algorithm to inform decisions and planning	Reviews algorithm/guidelines/checklists to cross-check information and plans	
Decision-making Total score……	Identifies options and prioritises tasks guided by algorithm	Uses observations and algorithm knowledge to prioritise clinical interventions, identifies course of action to aid decision/problem solving	
	Selects and manages options	Considers algorithm based on working and differential diagnosis. Considers patient options based on people, equipment, scene, and timing	
	Reviewing/Re-evaluates options	Reviews risks and prioritises tasks with other in response to patient condition	
Feedback			Summative score

NTS Category	***Element***	***Example of good behaviour***	***Example of poor behaviour***
Team Coordination	Coordinates team	Assesses priorities of the situation, ensures safety for all involved including the need for early chest compressions and defibrillation Confirms patient condition and takes control of scene in a calm manner, establishes skill levels and roles needed for effective advanced life support	Not proactive in team coordination, does not consider priorities or safety aspects of scene/patient care Performs own tasks at inappropriate times without consideration to patient needs or condition
	Motivates and supports others	Supports others, recognises tiredness, task focus, guides and directs when needed, leads with no support required	Does not recognise or offer to help others if tired/task overloaded/under-loaded/stressed
	Delegates roles and tasks	Establishes skill level and allocates roles, accepts role/tasks/direction generally without question	Does not adapt or accept alternative tasks/roles as other clinicians arrive Does not accept role/tasks/direction, questions, and challenges throughout
Communication	Exchanging/sharing information	Frequently shares information and clarifies when requested	Does not share or exchange Information, even when requested
	Actively listens, considers timing and others	Actively listens, confirms, and follows instructions dependent on role, considers timing of communication	Asks irrelevant questions, unaware of concentration for clinical interventions, can verbally overload others
	Uses effective verbal/non-verbal communication methods	Communication is calm, precise, directed, timely and clear, discusses options with team Aware of own and others body language, looks for focused attention, impaired dexterity, signs of frustration or tiredness	Communication is not calm, precise, directed, timely or clear, does not respond to others Demonstrates abrupt/rude/dismissive behaviour

NTS Category	***Element***	***Example of good behaviour***	***Example of poor behaviour***
Situation Assessment	Gathers information	Scans scene, and continues throughout cardiac arrest, not focused on patient, considers location and position of patient, others on scene, and environment	Does not survey the scene, focuses on patient environment, does not recognise hazards/surroundings, or ask others about patient
	Interprets information/makes sense of the scene	Alters physical environment – asks for team input and help to move patient/furniture/equipment, to provide best access for team to perform safe and effective resuscitation. Calls for help early	Makes no effort to alter physical layout of scene, starts resuscitation without moving anything, does not consider best access for safe and effective resuscitation. Does not call for help
	Uses algorithm to inform decisions and planning	Uses algorithm/guidelines/checklist to cross-check information to aid decision-making and planning relative to time on scene	Does not cross-check information or use algorithm/guidelines/checklist for decisions or plans, is not aware of time scene
Decision-making	Identifies options and prioritises tasks guided by algorithm	Uses and has good knowledge and understanding of algorithms, applies these to the patient to prioritise clinical tasks and guide decisions	Makes no reference to clinical algorithm, does not display acceptable knowledge of BLS/ALS algorithms, deviates from clinical algorithm
	Selects and manages options	Considers cause of OHCA, can be seen to plan and prepare for patient interventions/care and movement	Does not consider cause of OHCA, reversible causes or patient presentation, very limited planning of interventions
	Reviewing/Re-evaluates options	Reviews situation throughout entirety of OHCA, open to other's views, alters decisions if appropriate/beneficial	Is not active in reviewing the situation, does not discuss/contribute to decisions, review, or consider alternatives

Figure 5.4 Prototype POHCAAT

Feedback for this draft prototype included that the changes appeared to be appropriate and provided an improved scoring method, with SME 2 stating that the layout was '*very easy to read, the descriptor and rating options are well worded and very easy to understand*' and SME 3 commenting that '*it hits all points of an OHCA that aren't clinical*'. It was considered by all SME that the evaluation phase would need to include sufficient training to allow raters to fully understand and become familiar with the content before using it. Comments about training included that it would need to emphasise that the POHCAAT is aimed at observing one person per simulated scenario as this would reflect the '*potential that the role of leader can be tossed around the team depending upon what each of the team members are doing at that particular time*' (SME 3).

In general, feedback was positive and that the POHCAAT was ready for evaluation, with SME 1 commenting that the final draft prototype included categories that were '*good to see these were the ones you might expect*', while SME 4 stated that '*It would be good to pilot the tool and see the results*'.

Overall, feedback from the SME provided an agreement that the taxonomy included categories, elements, and behavioural descriptors that they associated with a paramedic managed OHCA. It was agreed that they could understand how each category, element, and behavioural marker related to each other, with a final comment from SME 3 of '*I think this is a tool that needs to be implemented within our role. This is the part of the OHCA that isn't focused on in any way as crews are far too concentrated on the clinical aspect*' highlighting the need for the POHCAAT. The overall opinion was that the draft prototype provided an appropriate method to rate the observed behaviours of paramedics when managing an OHCA and that evaluation would identify if any further changes were needed.

5.13 Conclusion

The aim of this chapter was to produce a NTS taxonomy for a prototype BMS. The findings of the chapter indicate that an OHCA is unique and required the identification of specific NTS before a BMS could be designed. Although there are similarities between some of the NTS categories and elements with other healthcare BMS, the unscheduled and unpredictable nature of an OHCA and varied team structures and formation result in specific NTS categories, elements, and behavioural markers. These reflect the changing of roles as the team evolves, the varying levels of behaviour that reflect clinicians general experience including communication methods, ability to gather information and understand the scene, all of which are influenced by the limited exposure rate of an OHCA and therefore were essential to inform the design of the prototype POHCAAT.

The research and design phases have identified a range of data that has resulted in four NTS categories, associated elements, behavioural markers, exemplar behavioural and performance ratings. The next chapter will detail the preliminary and final evaluation phases, in which the POHCAAT was assessed for its validity, reliability and usability.

Chapter 6 - Evaluation Phase

6.1 Introduction and Aim

The previous chapter detailed the development of the prototype Paramedic Out-of-Hospital Cardiac Arrest Assessment Tool (POHCAAT). Acknowledged across a range of healthcare BMS (Fletcher, 2006; Mitchell, 2011; Rutherford, 2015; Mellanby, 2015) it is recommended that they must be evaluated in a contextual setting to ensure they are reliable and valid. The purpose of this chapter is to provide a detailed explanation of the methods, results, and discussion from the preliminary and final evaluation phases.

The aim of the preliminary evaluation of the prototype POHCAAT was to assess how well it performed and to identify areas for improvement. A secondary aim was to ensure that the POHCAAT could provide feedback to reinforce safe practice and effective team performance. Flin et al. (2015) and Thomas (2018) have identified key areas to establish if a BMS works and these are listed as a set of objectives for this phase:

- Reliability - to evaluate the overall consistency of the results. Divided into the reliability of assessment results, internal consistency of the categories and elements, the degree of agreement between raters and the ability to reproduce measurements
- Validity - to assess the accuracy of the measurements, divided into content, construct and face validity
- Sensitivity - to assess the level of detection of different behaviour
- Usability and structure – to evaluate if the POHCAAT is practical, measures the key non-technical skills (NTS) relevant to an Out-of-Hospital Cardiac Arrest (OHCA) and is understandable

6.2 Ethical Considerations

Ethical approval for the preliminary and final evaluations were received from the University ethics committee (P89152 see Appendix K; P94169 see Appendix J).

6.3 Preliminary Evaluation Methods

6.3.1 Rater Sample

Snowball sampling was used to recruit raters, as this enabled a wide reach of suitable participants within a short timeframe (Parker et al., 2019). Subject matter experts, based on their previous involvement in research phases and understanding of NTS, were contacted, and asked to participate. Inclusion criteria included substantial experience of managing an OHCA, as well as working as an operational prehospital clinician (qualified paramedic, HEMS critical care paramedic/doctor, experienced university paramedic lecturer), education/training in NTS, with previous experience of using a BMS considered as beneficial but not essential. They were asked to share the study information with those they considered as appropriate for undertaking the role of a rater. All interested participants were asked to contact the lead researcher with details about their clinical role, experience of an OHCA, and training, understanding, knowledge and experience in NTS, to ensure they were suitable to undertake the role of a rater.

A total of 35 advanced paramedics and prehospital doctors expressed an interest, with 25 volunteering to undertake an online training package (see Appendix M) as an introduction to the POHCAAT and the training and testing workshop (see Appendix N). Both the online training package and workshop are discussed more in section 6.3.3. Upon completion of the online training package a total of 17 SME (Helicopter Emergency Medical Service (HEMS) critical care paramedics (n=7), HEMS doctors (n=2), advanced paramedics (n=4) and senior lecturers in paramedic science (n=4)) were available to attend a face-to-face training and testing workshop and act as raters in the preliminary evaluation of the prototype POHCAAT (see table 6.1). Despite being considered as novice raters due to their limited use of BMS, the mix of HEMS and non-HEMS clinicians ensured that the POHCAAT was evaluated by a cross section of suitably experienced prehospital clinicians, allowing for a full evaluation (Streiner et al., 2015).

Table 6.1 Preliminary evaluation rater information

Rater	*Previous Participation*	*Experience*
1. Emergency Medicine Consultant HEMS Critical care doctor	SME - Semi-structured interviews and research comparison	UG/PG paramedic teaching, OHCA management, CRM/NTS, 15yrs+ operational experience
2. Emergency Medicine Consultant HEMS Critical Care Doctor	SME - Semi-structured interviews	UG/PG paramedic teaching, OHCA management, CRM/NTS, 15yrs+ operational experience
3. Critical Care Paramedic HEMS	SME – Focus group	UG/PG paramedic teaching, OHCA management, CRM/NTS, 20yrs+ operational experience
4. Critical Care Paramedic HEMS	SME - Semi-structured interviews and research comparison	UG/PG paramedic teaching, OHCA management, CRM/NTS, 15yrs+ operational experience
5. Critical Care Paramedic HEMS	SME - Semi-structured interviews and research comparison	UG/PG and ambulance trust paramedic teaching, OHCA management, CRM/NTS, 20yrs+ operational experience
6. Critical Care Paramedic HEMS	No previous participation	UG paramedic teaching, OHCA management, CRM/NTS, 20yrs+ operational experience
7. Critical Care Paramedic HEMS	No previous participation	UG paramedic teaching, OHCA management, CRM/NTS, 20yrs+ operational experience
8. Critical Care Paramedic HEMS	No previous participation	Ambulance trust paramedic teaching, OHCA management, CRM/NTS, 15yrs+ operational experience
9. Critical Care Paramedic HEMS	No previous participation	Ambulance trust paramedic teaching, OHCA management, CRM/NTS, 10yrs+ operational experience

Table 6.1 Continued…

Rater	*Previous Participation*	*Experience*
10. Advanced Paramedic	No previous participation	Ambulance trust paramedic teaching, OHCA management, NTS education, 25yrs+ operational experience
11. Advanced Paramedic	Questionnaire and focus group	Clinical mentor and supervisor, OHCA management, NTS education, 10yrs operational experience
12. Advanced Paramedic	Questionnaire	Clinical mentor and supervisor, OHCA management, NTS education, 10yrs operational experience
13. Advanced Paramedic	No previous participation	Clinical mentor and supervisor, OHCA management, NTS education, 10yrs operational experience
14. Paramedic science lecturer	Questionnaire	UG paramedic teaching, OHCA management, NTS education, 10yrs operational experience
15. Paramedic science lecturer	No previous participation	UG paramedic teaching, OHCA management, NTS education, 15yrs operational experience
16. Paramedic science lecturer	No previous participation	UG paramedic teaching, OHCA management, NTS education, 10yrs operational experience
17. Paramedic science lecturer	No previous participation	UG paramedic teaching, OHCA management, NTS education, 15yrs operational experience

In addition, two SME who had previously participated in the semi-structured interviews and researcher comparison phases, were identified and attended a meeting prior to the training workshop. Both these SME were invited due to their substantial experience of over 25 years working in healthcare including HEMS clinical roles, education in crew resource management (CRM) and NTS, previous use of BMS as part of their current roles, and experience in the training and assessment of an OHCA. The purpose of this meeting was to provide an agreed score for each category and overall score based on their observations of the recorded films and discussion with the lead researcher. This also provided an opportunity to calibrate both raters and to confirm that each film demonstrated a range of behaviours to assist with the sensitivity analysis.

6.3.2 Films

Ethical approval included a stipulation that the films used were of existing recordings of student-led simulated OHCA scenarios as part of a current teaching programme. This consideration helped with the positionality of the lead researcher, as they were a paramedic science lecturer and there was potential for influence on participation, possibly seen as a benefit to students' academic study. To reduce this, all films used in the preliminary evaluation were selected from previously recorded OHCA simulated assessments and chosen for their range of NTS behaviours demonstrated. Like the research phase (refer to chapter four) all student paramedics participating as ambulance crews in these films were contacted for consent and were informed that the use of the films had no bearing on their academic study and that they could withdraw their consent at any time. Emphasis was always placed on the researcher's role as a PhD student to further reduce any risk of influence that their place as a lecturer had on student participants.

Although the films used for the preliminary evaluation were of student paramedic simulated OHCA scenarios as part of their existing clinical ALS training, all student paramedics involved were nearing the end of their degree. This resulted in experience of managing several real-life OHCA, a possession of in-depth knowledge and understanding of clinical algorithms due to continual assessments, as well as training in teamwork as part of a clinical decision-making module. This training included a range of practical group scenarios, consisting of OHCA, trauma, and road traffic collision management in conjunction with the fire service, followed by a day of debriefing, used to highlight where teamwork could be improved. Based on the level and observation of behaviours, two films were identified as training films, allowing raters to observe and discuss their scores as a group, to ensure familiarity with the POHCAAT and identify any inaccuracies. The other five films were used as test films, where each rater observed and scored each film individually, without discussion. Example images for the training and test films are presented in figures 6.1, an OHCA scenario in a simulated residential setting with multiple ambulance clinicians (preliminary test film one) and figure 6.2 (test film five) a typical objective structured clinical examination of a simulated OHCA scenario. Each film plot, timing, level of behaviour demonstrated and number of paramedics on scene is detailed in table 6.2 and includes category and overall agreed scores.

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Figure 6.1 Test film one still (Authors personal collection, 2019)

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Figure 6.2 Test film five still (Authors personal collection, 2019)

Table 6.2 Preliminary evaluation film detail; length, plot and NTS illustrated per film

Film	*Time*	*Plot*	*NTS illustrated*
Training film 1	15m 32s	Male 55-year-old, chest pain - OHCA, shockable heart rhythm. Patient 360° access. One crew; one paramedic and one emergency medical technician (EMT). Observee demonstrates poor information gathering and planning leaves crewmate doing cardio-pulmonary resuscitation (CPR), limited ALS algorithm knowledge. Reluctant to engage with crewmate.	Overall score 9 – poor behaviour Poor team coordination 2 Acceptable communication 3 Poor situation assessment 2 Poor decision-making 2
Training film 2	11m 58s	Male 55-year-old collapsed at home, chest pain - OHCA, shockable heart rhythm. Patient 360° access. Two crews: one paramedic and one EMT, 2x EMT's. Observee calm but limited communication, good planning. Coordinates and supports others.	Overall score 12 – acceptable behaviour Acceptable team coordination 3 Acceptable communication 3 Acceptable situation assessment 3 Acceptable decision-making 3
Test film 1	14m	Male 45-year-old, small bedsit, limited space. Collapse - OHCA, shockable heart rhythm. Five clinicians: one student paramedic, two paramedics, two EMT's. Observee is first on scene adapts between leader and follower. Managed well initially but becomes task focused and overwhelmed with the number of clinicians.	Overall score 11 – acceptable behaviour Acceptable team coordination 3 Acceptable communication 3 Poor situation assessment 2 Acceptable decision-making 3
Test film 2	12m 59s	Male 32-year-old, residential address, 360° access, collapse, cause of OHCA low blood sugar, occluded airway. Non-shockable heart rhythm. One crew: paramedic and EMT. Observee first on scene was calm, delegated tasks, good knowledge of clinical tasks. Clear planning throughout.	Overall score 15 – good behaviour Good team coordination 4 Good communication 4 Acceptable situation assessment 3 Good decision-making 4

Table 6.2 continued…

Film	*Time*	*Plot*	*NTS illustrated*
Test film 3	15m 45s	Male 55-year-old, 360° access, collapse, OHCA, Shockable heart rhythm. Two crews: two paramedics and two EMT's. Second crew problematic, disregard observee. Patients partner in attendance. Lead observee copes well, manages other crew, delegates tasks, stands back and reviews.	Overall score 12 – acceptable behaviour Acceptable team coordination 3 Acceptable communication 3 Acceptable situation assessment 3 Acceptable decision-making 3
Test film 4	18m 30s	Male 60-year-old, in the rear of the shop, very tight space. Chest pain – OHCA, shockable heart rhythm. Observee is one of a crew of three, two paramedics, one EMT. Very limited situation assessment fails to manage the scene or coordinate crew and relies on others. Becomes overloaded and poor algorithm knowledge. Struggles throughout.	Overall score 9 – poor behaviour Poor team coordination 2 Acceptable communication 3 Poor situation assessment 2 Poor decision-making 2
Test film 5	10m 54s	Male 20-year-old, collapsed in public park, overdose - OHCA, non- shockable heart rhythm. Difficult bystander on scene. Heart rhythm changes throughout. Once crew: one paramedic and one EMT. Observee is calm, leads throughout, confident, good team coordination and knowledge of ALS algorithm. Timely and structured. Manage scenario well.	Overall score 16 – good behaviour Good team coordination 4 Good communication 4 Good situation assessment 4 Good decision-making 4

6.3.3 Preliminary Training and Testing Workshop

An online information package was created and sent to all participants who were considered suitable to undertake the training and testing workshop (see Appendix M). It included a PowerPoint presentation that detailed the development and design of the prototype POCHAAT, with information specific to NTS and BMS use. It also included the aim and objectives of the preliminary evaluation and information on the face-to-face workshop

For this phase of the evaluation, a workshop schedule was created to detail the objectives of the preliminary evaluation, equipment required, and timeline of the workshop (see Appendix N). The day included an overview of the workshop, a presentation detailing the purpose and aim of the POHCAAT, information on BMS, NTS in the OHCA, how to use the POHCAAT, rater bias, evaluation methods, and an explanation of the films for observation. Following this a training and testing phase was undertaken, finishing with a discussion and completion of a survey, consisting of 12-closed and two open questions to enable feedback (see Appendix O). The preliminary training and evaluation workshop was held at the researcher's university and ran from 0900-1830hrs on two separate dates in July 2019 to accommodate all raters. It is recognised that a minimum of 2-5 consecutive days is required for training (Flin et al., 2015) however, time was very limited, and it was considered that as the SME had a good level of prior experience of the subject and NTS one longer day of training would be sufficient.

Based on feedback from the research comparison section of the previous triangulation phase, before watching the films, all raters were reminded that behaviour was considered as poor if the overall score was ≤10, acceptable between 11 and 12 and good ≥13. Details of the rating scale and discussion around the choice of a five-point scale can be found in section 5.9.4 (pages 177-179). Raters were informed that if an observee fell between two scales, they should review each element and behaviour, and reflect the category and overall score to the behaviour demonstrated the most. This was included to support all raters had a clear understanding of a secondary aim of the POHCAAT: to provide feedback to ensure safe practice and effective team performance.

Following the initial training presentation, the two training films were watched as a group, and individual raters asked to evaluate the NTS behaviour of the identified observee per film using the prototype POHCAAT. During and following each training film, the use, observations, and scores were discussed to verify that raters understood and were comfortable using the POHCAAT. Following observation of the training films, the preliminary evaluation was performed using the five test films, with each rater individually evaluating the identified observee in each scenario. Individual raters were instructed not to discuss their observations or scores to reduce group influence and increase the validity of the data.

Upon completion of the preliminary evaluation, all raters were asked to complete an anonymised questionnaire consisting of 12 closed and two open questions. The aim of this was to collect rater information and evaluate the design, face validity, acceptability, and usability.

6.3.4 Data Analysis

To evaluate the prototype POHCAAT a range of statistical analyses were performed to ensure accurate and reliable scores and feedback for the person being observed (Barchard, 2012). These included measurements of internal consistency, sensitivity, inter-rater reliability, intra-class correlation coefficient, accuracy, and validity. Each statistical method of analysis is detailed separately, including scales for the identification of acceptable measurements before the results are presented in the following section.

6.3.4.1 Internal Consistency

As an observational assessment tool, the POHCAAT must provide consistent measurements, with reproducible element and category scores when used by different raters. To evaluate the reliability of the elements and categories, internal consistency was measured using Cronbach's α. It has been suggested that the use of Cronbach's α alone is not sufficient, so it was used in combination with other statistical measures such as construct validity to assess reliability (Agbo, 2010). It has also been used previously to assess the internal consistency of other BMS (Rutherford, 2015; Fletcher, 2006) as it enables the identification of a consistent measurement of individual elements, exemplar behaviours and categories. Using George and Mallery's (2003, pp. 231) guide, an acceptable value was considered between $0.8 > \alpha \geq 0.7$ (see table 6.3). Below this and the level of consistency is considered as poor and $\alpha \geq 0.9$ would suggest item duplication (DeVellis, 2012).

Table 6.3 Ranges of Cronbach Alpha adapted from George and Mallery (2003)

Cronbach α	*Internal Consistency*
α ≥ 0.9	Excellent
0.9 > α ≥ 0.8	Good
0.8 > α ≥ 0.7	Acceptable
0.7 > α ≥ 0.6	Questionable
0.6 > α ≥ 0.5	Poor
0.5 > α	Unacceptable

6.3.4.2 Sensitivity

To evaluate the sensitivity of the prototype POHCAAT a Wilcoxon signed-rank paired test was performed to evaluate its ability to differentiate between a range of behaviours when used by a range of raters. Films that demonstrated different levels of behaviour were paired:

- film four – poor (overall score 9) and film five – good (overall score 16)
- film three – acceptable (overall score 12) and film four – poor (overall score 9)
- film two – good (overall score 15) and film three acceptable (overall score 12)

This statistical analysis provided a measurement to examine if the null hypotheses; 'there is no significant difference between rating scores for different observed behaviours when assessed using the POHCAAT' could be rejected (Hankins, 2008).

6.3.4.3 Inter-Rater reliability and absolute agreement

An objective for this preliminary evaluation was to determine if the POHCAAT would enable raters to consistently measure observed behaviours. To assess the consistency and level of agreement in raters observed scores, intra-class correlation coefficient (ICC), 2-way random effects model, consistency and absolute agreement, single measures for each category and element were used. As this was a preliminary evaluation of the prototype POHCAAT a small sample size was acceptable however, this could result in a high level of variability. Therefore, a sample size of 20% to 30% higher than the minimum sample size was chosen to reduce rater variability. Based on the observations of five films, a minimum sample size of four raters was required to achieve the statistical significance for an alpha-value set at p = <0.05 and with the minimum power of at ≥80% (Bujang & Baharum, 2017). This would enable the detection of the acceptable levels of reliability and rejection of the null hypothesis that raters do not agree on individual film category and element scores.

Four random raters were chosen using an online list randomiser (Ultimatesolver, 2020), rater 7, rater 14, rater 16 and rater 17. Intra-class correlation coefficient estimates, with a 95% confidence interval (CI), were calculated using SPSS statistical package version 25 (IBM, 2017). Inter-rater reliability measurements were interpreted using Koo and Mae's (2016) levels of reliability (table 6.4). Based on recommendations from the Wilkinson and Task Force on Statistical Inference (1999), acceptable measurements were based on the lower bound of the confidence interval and the minimal value of reliability, suggested as 0.70 for a research tool.

Table 6.4 Levels of reliability adapted from Koo and Mae (2016)

ICC values	*Level of reliability*
<0.5	Poor reliability
0.5 – 0.75	Moderate reliability
0.75 - 0.9	Good reliability
>0.90	Excellent reliability

For level of agreement, Kappa was reported and interpreted using Landis and Koch, (1977), presented in table 6.5. An acceptable level of agreement was considered as >0.60 as this would represent a minimum of 36-63% of reliable data (McHugh, 2012).

Table 6.5 Landis and Koch, (1977) interpretation of levels of agreement

Kappa	***Interpretation***	***% Of Data that are reliable***
< 0	Poor agreement	0%
0.0 – 0.20	Slight agreement	0-4%
0.21 – 0.40	Fair agreement	4-15%
0.41 – 0.60	Moderate agreement	16-35%
0.61 – 0.80	Substantial agreement	36-63%
0.81 – 1.00	Almost perfect agreement	64-100%

In line with previous studies (Rutherford, 2015; Yule et al., 2008) within group correlation was also measured to assess inter-rater agreement (r_{wg}), and completed for group category, element, and overall film scores using the Lindell et al. (1999) formula to calculate r_{wg}. Although LeBreton and Senter (2008) suggest a value of 0.70 is acceptable for newly developed measures, such as the POHCAAT, a r_{wg} of ≥0.80 was considered high enough to establish inter-rater agreement, as there were 17 raters providing ratings for five films, based on a five-point scale (Newman & Sin, 2020).

As a guide to measure the r_{wg} inter-rater agreement results, LeBreton and Senter (2008, pp. 836) revised standards for interpreting interrater agreement estimates were used and are detailed in table 6.6.

Table 6.6 LeBreton and Senter (2008) Revised Standards for Interpreting Interrater agreement (IRA) estimates

6.3.4.4 Accuracy

To assess the level of accuracy of the prototype POHCAAT, the expert agreed rater scores were used as a standard measurement. A null hypothesis was formed; raters experience and training in NTS does not influence the accuracy of observed performance ratings. As all HEMS raters had substantial experience of crew resource management training, including NTS, raters were grouped into HEMS and non-HEMS for analysis. To assess the levels of accuracy, the strength of relationship for HEMS and non-HEMS raters was measured against the expert agreed rater scores for each film using Spearman's rank-order correlation as the measurements were from an ordinal scale. A p value <0.05 was considered as statistically significant. Results were assessed using the recommended strengths of Spearman's rank order correlation according to Dancey and Reidy (2004).

Table 6.7 Strengths of relationships for Spearman's rho adapted from Dancey and Reidy (2004)

Strength of Relationship	*Level of relationship*
0.01 – 0.19	none
0.20 – 0.29	weak
0.30 – 0.39	moderate
0.40 – 0.69	strong
≥ 0.70	very strong

To evaluate the level of absolute agreement and therefore accuracy between individual rater scores categories and elements and expert agreed raters scores ICC, two-way mixed effects model, single-measures, absolute agreement was used as an acceptable alternative to weighted kappa. This decision was based on recommendations by Streiner et al. (2015) as the scale was ordinal. To assess the strength of agreement, the Landis and Koch (1977) standards were used (see table 6.5).

6.3.4.5 Construct Validity

As there was no previous comparable standard for comparison, criterion validity was not possible, construct validity was evaluated (Cronbach & Meehl, 1955). Exploratory factor analysis (EFA) was performed to measure the interrelationship between the elements and categories (Yong & Pearce, 2013). Although the sample size for the preliminary evaluation was reasonably small, the data set for each film was considered acceptable due to the ''complex dynamics of a factor analysis' (Henson & Roberts, 2006, pp. 402). It is suggested that 5-10 cases per variable provide a minimum sample size. Each of the five films displayed a range of observable behaviours for the four NTS categories, each sub-divided into three elements, totalling 60 variables. Analysis was performed using varimax and rotations. A Kaiser-Meier-Olin (KMO) test was included to determine the sampling adequacy, and Bartlett's test measured correlation. Kaiser suggests that a KMO value should be close to one, but 0.70 is considered as a good value (Kaiser, 1974). Eigenvalues were calculated to identify the levels of variance and scree plots reviewed to confirm the cut-off point of one. High correlation, set at >0.80 (Berry & Feldman, 1985), would suggest multicollinearity and therefore a risk of wide confidence interval and less reliability of the effect of the individual elements in each film scenario. This would lead to elements being reconsidered and removed if this was found. To aid the understanding of results KMO values were used as displayed below.

Table 6.8 Interpretation of KMO values taken from Kaiser (1974)

KMO value	*Interpretation*
< 0.5	Factor analysis not a good idea
0.5 – 0.7	Mediocre
0.7 – 0.8	Good
0.8 – 0.9	Great
> 0.9	Superb

6.3.4.6 Validity

Where reliability tests the consistency of scores and how reproducible the measure of behaviour is, validity is the evaluation of a tool to identify if it measures what it is supposed to measure (Hecker & Violato, 2009). The statistical test results were used in combination with raters responses to the post training and testing workshop questionnaire, and used to evaluate the content, usability, application, and discrimination of the prototype POHCAAT.

To establish content validity following the training and testing workshop all raters completed a 14-question survey (see Appendix O). Questions evaluated raters opinions of the ease of use, content, confidence in use and representability of the tool and were answered using a five-point Likert scale (strongly disagree 1 to strongly agree 5). Data were evaluated for levels of agreement and presented as mean and standard deviation. The results were compared with the results from inter-rater agreement, Spearman's rank-order correlation and measures of absolute agreement using ICC, 2-way mixed effects model, single measures as this provided an in-depth analysis of the tool.

Two open questions provided textual data, analysed using a thematic approach to code, categorise and identify central themes, and processed using NVivo software (QSR International Pty Ltd, 2018).

6.4 Preliminary Evaluation Results

A total of 17 raters participated in the preliminary evaluation. The majority of raters were male (n=12), with just over half stating that they had previous experience of CRM/NTS (n=10). There were slightly more participants with HEMS experience (n=9) and six had previously been involved with one of the research phases.

Rater overall scores were not dissimilar when compared against each other and the agreed expert rater scores (table 6.9). However, it appeared that rater 13 tended to score more highly than others (figure 6.3).

Table 6.9 Comparison of overall film scores

Film	*Expert agreed overall score*	*Median rater overall score*
Film 1	Acceptable behaviour score 11	Poor behaviour score 10
Film 2	Good behaviour score 15	Good behaviour score13
Film 3	Acceptable behaviour score 12	Acceptable behaviour 12
Film 4	Poor behaviour score 9	Poor behaviour score 10
Film 5	Good behaviour score 16	Good behaviour score 13

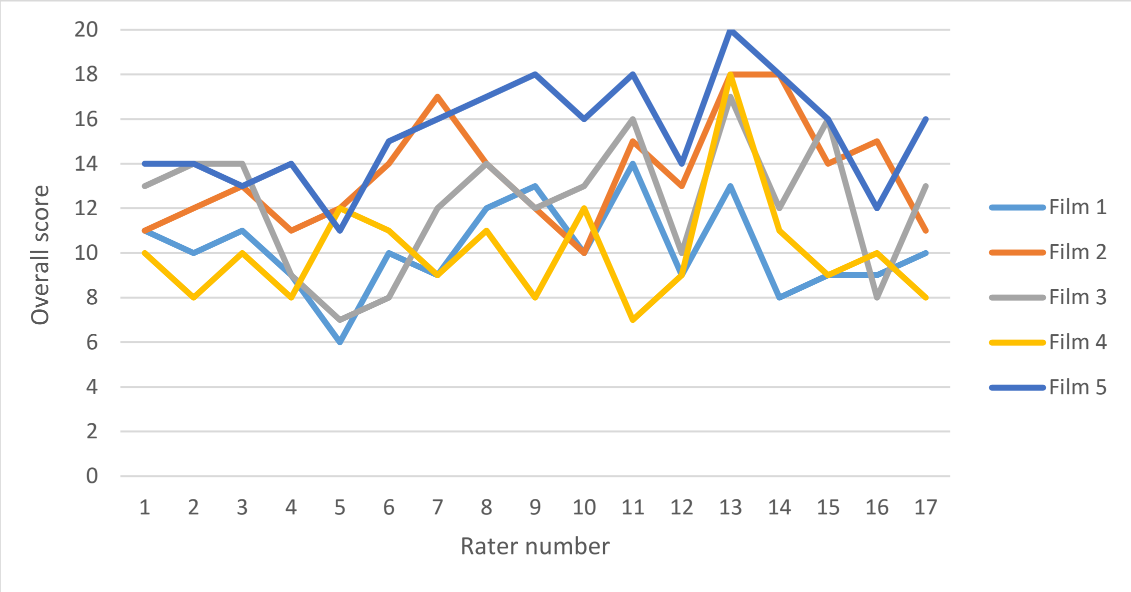


Figure 6.3 Line graph of overall film scores for individual raters films 1-5

6.4.1 Internal Consistency

Cronbach α result are presented in table 6.10 and show each film average and individual element results for the prototype POHCAAT. Measurements <0.7 and ≥0.9 are highlighted grey.

*Table 6.10 Internal consistency Cronbach α measurements for the preliminary evaluation of the prototype POHCAAT (*communication)*

Film	*Team Coordination elements*	*Comm* elements*	*Situation Assessment elements*	*Decision-making elements*	*Average for film*
1	0.85	0.85	0.78	0.94	0.85
2	0.91	0.94	0.81	0.93	0.89
3	0.96	0.97	0.89	0.89	0.92
4	0.94	0.93	0.93	0.93	0.93
5	0.93	0.95	0.86	0.91	0.91
Average for category	0.91	0.92	0.85	0.92	

When assessed against the George and Mallery (2003) ranges for internal consistency, the prototype POHCAAT appears to have a good to excellent level of internal consistency. However, there may be some item duplication as there are several results of ≥0.90, yet the averages for each film suggest this may be minimal as results are marginally over 0.90.

6.4.2 Sensitivity

A Wilcoxon signed-rank paired test was performed to assess raters ability to distinguish different behaviours. Films were paired where they demonstrated a difference in poor, acceptable and good behaviour. A value of $p<0.05$ was considered as statistically significant. The mean and standard deviation for each element and overall category score were calculated.

Table 6.11 Wilcoxon signed-ranks test mean score and SD for films 4 and 5

	Film 4 (poor)	***Film 5 (good)***		
	Mean (SD)	*Mean (SD)*	*Difference in means*	*p value*
Overall score	10.05 (2.53)	15.41 (2.37)	5.36	<.001
Team Coordination	2.23 (0.43)	4.05 (0.74)	1.82	<.001
Communication	2.64 (0.78)	3.88 (0.78)	1.24	0.03
Situation Assessment	2.35 (0.78)	3.58 (0.61)	1.23	<.001
Decision-making	2.64 (0.60)	3.70 (0.68)	1.06	0.01

Data indicates there is a statistically significant difference between poor and good behaviour. Based on these results the null hypothesis ‘there is no significant difference between rating scores for good and poor behaviour identified by using the POHCAAT’ can be rejected.

Table 6.12 Wilcoxon signed-ranks test mean score and SD for films 2 and 3

	Film 2 (good)	***Film 3 (Acceptable)***		
	Mean (SD)	*Mean (SD)*	*Difference in means*	*p value*
Overall score	13.52 (2.45)	12.23 (2.96)	1.29	0.19
Team Coordination	3.47 (1.00)	2.70 (0.91)	0.77	0.03
Communication	3.58 (0.71)	3.11 (1.05)	0.47	0.05
Situation Assessment	2.88 (0.69)	3.17 (0.80)	0.29	0.21
Decision-making	3.64 (0.70)	3.17 (0.63)	0.47	0.04

The results indicate that the null hypothesis cannot be rejected for a differentiation between good and acceptable behaviour.

Table 6.13 Wilcoxon signed-ranks test mean score and SD for films 3 and 4

	Film 3 (Acceptable)	***Film 4 (Poor)***		
	Mean (SD)	*Mean (SD)*	*Difference in means*	*p value*
Overall score	12.23 (2.96)	10.05 (2.53)	2.18	0.03
Team Coordination	2.70 (0.91)	2.23 (0.43)	0.47	0.12
Communication	3.11 (1.05)	2.64 (0.78)	0.47	0.11
Situation Assessment	3.17 (0.80)	2.35 (0.78)	0.82	0.01
Decision-making	3.17 (0.63)	2.64 (0.60)	0.53	0.01

There is an indication that the results for acceptable vs poor behaviour scores are statistically significant except team coordination and communication. Overall, raters appear to be able to distinguish between poor and good behaviour.

6.4.3 Inter-Rater Reliability

Measurements for each film category and element for randomly selected raters 7, 14, 16 and 17 were assessed based on single measurement (k=4), consistency, 2-way random effects model. A 95% confidence interval was used to estimate the interval of ICC (Koo & Mae, 2016). Table 6.14 presents the results with values <0.70 highlighted grey.

Table 6.14 Four random raters inter-rater reliability results

Categories and elements consistency	***ICC (CI 95%)***
Team Coordination category score	0.70 (0.54-0.84)
Coordinating team - Assessing capabilities	0.73 (0.46-0.91)
Delegation of roles and tasks	0.63 (0.34-0.87)
Motivation and support of team	0.79 (0.56-0.93)
Communication category score	0.60 (0.42-0.77)
Exchanging/sharing information	0.63 (0.33-0.87)
Uses effective verbal/non-verbal communication	0.58 (0.27-0.85)
Active listening, considers timing and others	0.61 (0.31-0.86)
Situation Assessment Category score	0.53 (0.35-0.70)
Gathering information	0.57 (0.25-0.84)
Interprets information/makes sense of the scene	0.50 (0.18-0.80)
Uses algorithm to inform decisions and planning	0.54 (0.23-0.83)
Decision-making category score	0.65 (0.49-0.75)
Identifies options and prioritises tasks guided by algorithm	0.76 (0.51-0.92)
Selects and manages options	0.46 (0.14-0.78)
Reviewing options	0.74 (0.48-0.91)

Although the ICC estimates are considered as predominantly moderate to good, the confidence intervals are wide, and it is uncertain where the true effect lies. The lower bound of the confidence interval in all categories and elements is lower than the minimal value of reliability when measured against the 0.70 for a research tool (Streiner et al., 2015). The selects and manages options element demonstrated a poor reliability between the four random raters. Overall, it appears there is an acceptable level of inter-rater reliability for the prototype POHCAAT.

6.4.4 Inter-Rater Agreement

Levels of inter-rater agreement (IRA) for randomly selected raters 7, 14, 16 and 17 was also calculated. Each category and element measurements for films 1–5 were measured using ICC, single measurement (k=4), absolute agreement, 2-way random-effects model. Table 6.15 presents the results with levels of agreement <0.60 highlighted grey.

Table 6.15 Results of inter-rater agreement films 1-5 category and element scores

Categories and elements absolute agreement	***ICC (CI 95%)***
Team Coordination category score	0.67 (0.49-0.82)
Coordinating team - Assessing capabilities	0.65 (0.34-0.88)
Delegation of roles and tasks	0.58 (0.27-0.84)
Motivation and support of team	0.78 (0.55-0.93)
Communication category score	0.58 (0.39-0.76)
Exchanging/sharing information	0.63 (0.34-0.87)
Uses effective verbal/non-verbal communication	0.56 (0.26-0.83)
Active listening, considers timing and others	0.58 (0.28-0.84)
Situation Assessment Category score	0.44 (0.22-0.64)
Gathering information	0.43 (0.12-0.78)
Interprets information/makes sense of the scene	0.43 (0.13–0.76)
Uses algorithm to inform decisions and planning	0.49 (0.19-0.80)
Decision-making category score	0.64 (0.47-0.78)
Identifies options and prioritises tasks guided by algorithm	0.74 (0.49-0.91)
Selects and manages options	0.46 (0.15-0.79)
Reviewing options	0.71 (0.44-0.90)

Based on the results presented in table above, despite wide confidence intervals, it appears the levels of agreement are acceptable. When assessed against Landis and Koch’s (1977) levels of agreement, there is a moderate to substantial level of agreement between raters for each category and element. This suggests that between 16 and 63% of the data is reliable and reflects the small random sample used.

6.4.5 Within Group Agreement

Within-group agreement was completed for all rater measurements of category, element, and overall film scores. Inter-rater agreement average measurements for each film category and elements assessed with r_{wg} are presented in table 6.16 with measurements below <0.80 highlighted grey.

Table 6.16 Inter-rater agreement for all films assessed with r_{wg}

	Film 1	***Film 2***	***Film 3***	***Film 4***	***Film 5***	***Average r_{wg}***
Team coordination	0.84	0.86	0.79	0.96	0.88	0.86
Coordinating team - Assessing capabilities	0.80	0.75	0.79	0.95	0.88	0.83
Delegation of roles and tasks	0.86	0.79	0.79	0.94	0.85	0.84
Motivation and support of team	0.86	0.75	0.79	0.91	0.86	0.83
Communication	0.95	0.90	0.73	0.94	0.86	0.87
Exchanging/sharing information	0.89	0.89	0.72	0.94	0.86	0.86
Uses effective verbal/non-verbal communication	0.93	0.89	0.74	0.94	0.84	0.87
Active listening, considers timing and others	0.89	0.89	0.72	0.94	0.86	0.86
Situation Assessment	0.93	0.86	0.88	0.89	0.94	0.90
Gathering information	0.93	0.80	0.88	0.90	0.94	0.88
Interprets information/makes sense of the scene	0.94	0.80	0.95	0.86	0.94	0.89
Uses algorithm to inform decisions and planning	0.94	0.89	0.91	0.94	0.90	0.91
Decision-making	0.88	0.95	0.93	0.94	0.94	0.92
Identifies options and prioritises tasks guided by algorithm	0.91	0.91	0.97	0.89	0.93	0.92
Selects and manages options	0.86	0.89	0.97	0.94	0.93	0.92
Reviewing options	0.91	0.96	0.97	0.94	0.94	0.94
Average r_{wg} for film	0.89	0.85	0.84	0.92	0.89	

Using LeBreton and Senter (2008) standards for IRR r_{wg} measurements varied between rwg average agreement levels of ≥0.70 (strong agreement) and 1.0 (very strong agreement). Film two had less average agreement for all team coordination elements and film three had less average agreement for team coordination and communication elements. However, no film had an average IRA r_{wg} of ≤0.70. There is an indication that the prototype POHCAAT has a strong level of average agreement for each film category and element when within group agreement was assessed.

6.4.6 Accuracy

Although reliability and consistency are important, accuracy must also be evaluated. It was hypothesised that the HEMS raters would have a stronger relationship with the expert rater scores, as both sets of raters have more experience of CRM/NTS when compared to non-HEMS raters.

A Spearman's rank correlation was performed to assess the relationship between HEMS raters (n=9), non-HEMS raters (n=8) and expert raters (n=2) agreed scores for categories and elements. Table 6.17 presents mean film category and overall scores for HEMS and non-HEMS raters vs expert rater agreed measurements, analysed with Spearman r_s with values <0.05 highlighted grey.

Table 6.17 HEMS and non-HEMS groups assessed against expert rater agreed scores for all films category and overall scores

Category and element measures	*HEMS r_s and p value*	*Non-HEMS r_s and p value*
Team coordination	0.89 *p* = 0.41	0.47 *p* = 0.45
Communication	0.91 *p* = 0.02	0.61 *p* = 0.26
Situation assessment	0.89 *p* = 0.04	0.67 *p* = 0.21
Decision-making	0.97 *p* = 0.005	0.94 *p* = 0.01
Overall	0.91 *p* = 0.02	0.61 *p* = 0.26

Using the Dancey and Reidy (2004) recommended strengths of Spearman's rank order correlation there is a very strong (≥ 0.70), positive relationship between HEMS raters and the expert agreed scores that was considered statistically significant. The non-HEMS measurements ranged from strong (0.40–0.69) to very strong (≥0.70) with only decision-making considered statistically significant.

The level of absolute agreement between individual raters and the expert agreed rater scores for all film categories and elements was also assessed using the weighted Kappa alternative, ICC two-way mixed, absolute agreement, single rater measurements (Streiner et al., 2015). Table 6.18 shows the results assessed against Landis and Koch (1977) interpretation of kappa (see table 6.4). Scores k<0.4 (slight to fair) are highlighted grey and k>0.6 (substantial) are highlighted yellow.

Table 6.18 Accuracy of individual rater scores compared to expert rater agreed scores

Rater	*Categories*	*Elements*
1	0.49	0.18
2	0.68	0.18
3	0.57	0.18
4	0.52	0.14
5	0.02	0.11
6	0.27	0.14
7	0.64	0.33
8	0.76	0.20
9	0.53	0.14
10	0.43	0.12
11	0.78	0.27
12	0.60	0.27
13	0.21	0.11
14	0.56	0.27
15	0.65	0.29
16	0.30	0.20
17	0.71	0.23
Average	0.51	0.19
SD	0.80	0.82

The results show that the average kappa values for categories was moderate agreement (κ=0.51), but elements were slight agreement (κ=0.19). The SD is also reasonably high but is less than 1 SD. Those raters with higher levels of absolute agreement were predominately raters with HEMS experience.

6.4.7 Construct Validity

Table 6.19 shows the results of the exploratory factor analysis, performed with Varimax rotation and Kaiser normalisation. The Kaplan-Meier-Olkin (KMO), Bartlett's test of Sphericity, eigenvalues, and cumulative variation are included.

Table 6.19 Exploratory factor analysis results for preliminary test films 1-5

Film	*KMO*	*Bartlett's test*	*Number of eigenvalues >1*	*Actual eigenvalues if >1*	*Cumulative % variation with one, two, three or four factors*			
1	0.46	<0.001	4	4.3, 2.6, 1.7, 1.3	35.8	58.0	72.2	83.3
2	0.51	<0.001	2	4.4, 2.7	49.0	68.2	-	-
3	0.63	<0.001	3	7.0, 1.4, 1.2	58.6	70.5	81.1	-
4	0.56	<0.001	2	7.1, 1.5	59.9	73.0	-	-
5	0.63	<0.001	3	7.0, 1.4, 1.2	58.6	70.5	81.1	-

As the KMO is mediocre for films 2-5 and <.50 for film one, factor analysis is not advised. Despite this, the statistical significance of the Bartlett's test of Sphericity results suggests there is a correlation between the elements and categories for each film. All films had more than two eigenvalues demonstrating there is variance for elements in each category.

6.4.8 Validity

Content validity results from the post training and evaluation workshop survey are presented in table 6.20, including the questions, raters level of agreement, mean score and standard deviation.

Table 6.20 Post training and testing workshop questionnaire descriptive statistical results

Question	*Strongly Disagree n (%)*	*Disagree n (%)*	*Neither n (%)*	*Agree n (%)*	*Strongly Agree n (%)*	*Mean (SD)*
1.The POHCAAT was easy to use	0	0	0	14 (82.4)	3 (17.6)	4.18 (0.39)
2. The domains were well suited to an OHCA	0	0	1 (5.9)	12 (70.6)	4 (23.5)	4.18 (0.52)
3. It was easy to associate the observed behaviour and the POHCAAT domains	0	1 (5.9)	2 (11.8)	13 (76.5)	1 (5.9)	3.82 (0.63)
4. The POHCAAT was useful for structuring observations of the videos	0	0	2 (11.8)	7 (41.2)	8 (47.1)	4.35 (0.70)
5. It was easy to differentiate observed behaviours	0	0	7 (41.2)	9 (52.9)	1 (5.9)	3.65 (0.60)
6. The descriptions of the domains were clear	0	1 (5.9)	0	12 (70.6)	4 (23.5)	4.12 (0.69)
7. The descriptions of the ratings were clear	0	0	0	10 (58.8)	7 (41.2)	4.41 (0.50)
8. The wording for each domain was meaningful	0	1 (5.9)	3 (17.6)	8 (47.1)	5 (29.4)	4.00 (0.86)
9. The information on the POHCAAT was adequate	0	0	1 (5.9)	12 (70.6)	4 (23.5)	4.18 (0.52)
10. You feel confident in using the POHCAAT	0	0	4 (23.5)	10 (58.8)	3 (17.6)	3.94 (0.65)
11. The POHCAAT accurately scores non-technical skills behaviour	0	0	3 (17.6)	10 (58.8)	4 (23.5)	4.06 (0.65)
12. The POHCAAT can be used to assess student paramedics non-technical skills in the OHCA	0	0	1 (5.9)	11 (64.7)	5 (29.4)	4.24 (0.56)

The descriptive data suggests a positive response to using the prototype POHCAAT. On average, nine out of the twelve questions were agreed with, and there was a general agreement that it can be used to measure specific NTS for managing an OHCA and that it was easy to use.

When the text was analysed, despite limited responses, three themes were identified: simulation design, observation of behaviours, and usability. The codes simulation (*n*=7), briefing (*n*=2) and application of content (*n*=6) formed the categories of simulation and behaviour, and related to the simple nature of the simulated scenarios that relied on instructor input. This appeared to result in a 'stuttered' approach by crews at times, resulting in some difficulty in applying the example behaviours. Example comments included:

> *'The fact that it was "sim" seemed to heavily interfere - comms with you rather than the rest of the'* PN2
>
> *'It may work better with a more formal brief around the rules of engagement'* PN2
>
> *'Different environments/filming and intervention by the researcher/lecturer in situ can all lead to altered perception of NTS by the observer'* PN7
>
> '*Harder to apply to scenarios that were in more of an osce format*' PN5

Observation of behaviours was formed from the categories and content formed from the code's observation (*n*=3), scoring (*n*=3), accuracy (*n*=2) and use (*n*=3). Comments suggested the example behaviours and their application to a simulated scenario could be difficult to distinguish at times.

> *'The examples given within the tool are quite specific and it is often difficult to align them to the observed behaviour'* PN8

'Some elements may be underrated…There are several indicators of not listening/being rude but few addressing failure to lead' PN16

'I found to be divided in some of the assessments and therefore hard to definitively categorise some students in a specific domain' PN17

The final theme of usability was identified from the categories use and content, combining the codes of application of content (*n*=6), design (*n*=5) scoring (*n*=3), and use (*n*=3) suggesting improvements for the overall design but also complementing its aim.

'Descriptors within each domain were a little too wordy and at times the participants in the films could 'meet part of the criteria within a sentence but not all of it' PN3

'The assessment tool works well but is a bit wordy' PN5

'This is a well designed and constructed tool, well done' PN8

'I thought the tool was an excellent way of consistently assessing the effectiveness of non-technical skills within a student scenario' (PN9)

'I wanted to give half scores' PN17

When all the data were reviewed and compared to assess the content and face validity, it appears to be representative of the aim and suitable to use when assessing the observed non-technical skills of paramedics managing an OHCA. Based on the descriptive statistics it appears that raters found the prototype POHCAAT reasonably easy to use, that it can be applied to a simulated OHCA scenario to assess NTS specific to managing an OHCA and that a range of behaviours can be reasonably distinguished.

6.5 Preliminary Evaluation Discussion

As an original behavioural marker system, designed specifically to assess the NTS of paramedics managing an OHCA, it appears the prototype POHCAAT is moderately reliable. It can distinguish between good and poor behaviour and has good content and face validity (see tables 6.11 and 6.12). As a newly established BMS this was welcomed (O'Neill, 2017) and when compared against other similar healthcare behavioural markers (Flowerdew et al., 2012; Myers et al., 2016; Holly et al., 2017), the results appear to be similar.

There was an indication of element duplication and although the factor analysis was not recommended, there appeared to be an association between categories and elements (see table 6.19). These results may be explained by the unpredictable nature of an OHCA, with roles changing as different clinicians arrive, the varied environment resulting in different patient needs and tasks being performed, reflecting a range of NTS and elements demonstrated. It was apparent from the textual data in chapters four and five that there are barriers to effective team performance, such as unfamiliar teams, resulting in poor communication and leadership. The low rates of exposure to an OHCA also appear to influence confidence, perhaps reducing the ability to lead, while the focus on clinical algorithms to guide decisions appears to limit a full assessment of the scene. These factors influenced the taxonomy and content of the POHCAAT as raters needed to be able to observe a range of behaviour often linked to a change in roles and may explain some duplication.

When compared to other healthcare BMS (Rutherford, 2015; Myers et al., 2016; Holly et al., 2017), similarities were noted in difficulties associated with rater recruitment, and difficulty in creating a realistic simulated scenario. As recognised by Rutherford (2015) there is little information on recommended sample sizes from comparable BMS. Identifying raters with sufficient experience and knowledge of NTS and OHCA managed proved difficult and this is noticeable in the small sample size and difference in accuracy results. Despite the inclusion of raters from HEMS areas, all trained and experienced in NTS/CRM all raters were considered as novice raters. This may explain the inter-rater reliability and agreement results that although considered acceptable, the wide confidence intervals result in some uncertainty. However, within group correlation results were better than expected with no film averaging an IRA r_{wg} of <0.70, suggesting that individual raters held shared perceptions, regardless of their backgrounds and experiences (see table 6.16).

Despite rater training, it could be suggested that there was an element of halo and horns bias (Talamas et al., 2016) as positive and negative behaviours could influence other elements and categories. There appeared to be a central tendency for some raters, often scoring elements and categories at the midpoint of the measurement scale. It is noted that other BMS use alternative scales and the use of a five-point scale can risk raters opting for the middle score of acceptable. However, like other validated BMS designed for similar setting and observes, the AeroNOTS (Myers et al., 2016) and Medi-StuNTS BMS (Hamilton et al., 2019; Phillips et al., 2021) both used a five-point scale with positive results. As the POHCAAT is designed to assess a range of student and qualified paramedics, with varying levels of experience and OHCA exposure rates the middle score, considered as acceptable, was felt to offer a sensible option as feedback is formative, designed to highlight areas for improvement. Yet the use of a five-point scale may explain some of the variances in elements and overlap but based on all analyses it does appear that although the categories are relevant and appropriate to an OHCA, the elements need reviewing and updating. This should help with reducing potential bias for future raters, but this can never be truly eliminated.

Although statistical results were acceptable, similar to the IMCBRS BMS (Holly et al., 2017), raters commented that the format of the scenarios, using an objective structured clinical examination (OSCE) often used for clinical assessments, created a false environment, interfering with their observation of behaviours. The lack of realism appeared to influence raters observations more than expected and indicated that further evaluation and future use would be best performed using a realistic, yet simple structured OHCA scenario rather than use in an OSCE. This may explain the variance in some raters scores. For further evaluations of the POHCAAT the use of semi-scripted scenarios, detailed brief for all involved and realistic scene with different arrival times of crews may be beneficial. However, once validated as an observational assessment tool, scenarios should not rely on scripted behaviours as the aim was to provide structured formative feedback for student and qualified paramedics, with the aim of improving their understanding and use of NTS when managing a simulated OHCA.

There were logistical issues including identifying a suitable training space, dates for the workshop and arranging travel arrangements, which influenced the delivery of the training and testing workshop resulting in it being shorter than

Klampfer et al. (2001) advise. An initial online training package was used and on reflection, this may be a useful method for future training as it could help to overcome logistical issues. Considering current global events, such as COVID and climate change, it is plausible to consider the use of a complete online training workshop for future training and testing, which may increase the number of raters and allow for refresher training.

It is recognised that improvements in the scenario and simulation design are required, as are modifications to the design and content. Comments about usability suggested that it could be 'less wordy' and have clearer breakdowns of the example behaviour, but the majority of raters agreed (n=16) that the categories were well suited to the paramedic management of an OHCA. It does appear that confidence in using the POHCAAT was limited, but as a preliminary evaluation over a short timeframe, this was not unexpected. This does stress the need for a detailed training workshop and information, as well as more practice films to help establish confidence and usability as it is designed to be used by trained raters, including peer-to-peers and tutor-to-student paramedics to assess an individual working as part of a team during a simulated OHCA scenario.

6.6 Summary of Preliminary Evaluation

Overall, it appears the prototype POHCAAT is suitable for use, but improvements are necessary and include a simpler design so as not to overload raters to allow them time and space to observe (Beaubien et al., 2004). However, the main area for improvement appears to be the use of realistic simulations, with crew arrival and numbers that reflect actual practice. The next section presents the final evaluation phase and provides details of the modifications made, methods, results, and discussion.

6.7 Final Evaluation

6.7.1 Introduction

Following the results of the preliminary evaluation phase, modifications were made to the prototype Paramedic Out-of-Hospital Cardiac Arrest Assessment Tool (POHCAAT). Changes were based on the statistical results and textual comments, as there appeared to be a duplication of elements and a need to improve usability. Minor changes to elements and behavioural markers were made to make them more specific, and the design of the POHCAAT was simplified. This included the use of colours to separate levels of behaviour, a reduction in the amount of text, the addition of clearer information on use, and scoring boxes for each category. Overlap between elements was considered, with all elements of decision-making updated to balance team coordination and situation assessment, aiming to reduce duplication. Elements were written to be more specific to a paramedic managed OHCA based on rater comments. The modifications to the elements are presented in table 6.21, including rationale for each change.

*Table 6.21 Changes to POHCAAT elements (*category)*

*NTS Cat**	*Prototype POHCAAT v1 Elements*	*Prototype POHCAAT v2 Elements*	*Rationale*
Team coordination	Coordinates team	Coordinates scene – leads or follows	Rater feedback, clearer identification of leader/follower role. Reflects change of roles
	Motivates and supports others	Supports others	Rater feedback, motivation was considered unclear, can observe supportive actions
	Delegates roles and tasks	Delegates roles and tasks	No change
Communication	Exchanging/sharing information	Shares information	Reflects giving and receiving of thoughts, ideas, information with team
	Actively listens, considers timing and others	Considers timing of communication	Rater feedback, difficult to observe active listening, timing more important
	Uses effective verbal/non-verbal communication methods	Uses effective verbal and non-verbal methods	No change
Situation assessment	Gathers information	Gathers information	No change
	Interprets information/ makes sense of the scene	Uses information to make sense of the scene	Rater feedback, difficult to observe interpretation of scene
	Uses algorithm to inform decisions and planning	Uses algorithm to inform decisions and planning	No change
Decision-making	Identifies options and prioritises tasks guided by algorithm	Prioritises decisions and tasks based on patient and resources	Duplication of situation assessment, rater feedback difficult to observe identifying options
	Selects and manages options	Safe decisions based on patient condition/scene	Rater feedback, safety not included before, is critical to team and patient care
	Reviewing/re-evaluates options	Reviewing/re-evaluates options	No change

As the elements were changed, the behavioural markers were also updated to reflect the changes. Rater feedback emphasised that the previous version was ‘too wordy’ and that ‘paramedics could meet part of the criteria within a sentence’. As the POHCAAT v2 needed to be easy to use, maximising observation time, and able distinguish a range of behaviours not just good and poor, behavioural markers were revised to be more specific to a paramedic managed OHCA with a the POHCAAT v2 presented in figure 6.4.

Paramedic Out-of-Hospital Cardiac Arrest Assessment Tool - POHCAAT

This is an observational feedback tool designed to provide comments on Non-Technical Skills (NTS) exhibited by students when practicing OHCA management. There are four NTS categories (situational assessment, team coordination, task management/algorithm adherence, communication), each category scores 1 – 5 based on behaviour you observe. Pick **one** student to watch and underline/circle/mark the category description you see. Based on your observations, give an individual score for each category (out of 5) and then add each category score for an overall mark. You can use the tool to structure your feedback based on the descriptions and overall mark given. You can mix the scores for each category based on what you see. The highest overall mark possible is 20, the lowest 4, and an acceptable score 11-12. E.g. if you scored situational assessment good 4, team coordination good 4, knowledge and procedure excellent 5 and communication good 4 that would total 17/20.

Scoring option	**Descriptor**
5 – Excellent	**Exceptional** performance. Observed behaviour is **consistent**, effective, safe and could be an example for others
4 – Good	**Good** performance. Observed behaviour is **frequently** of high standard, effective and safe but could improve in some categories
3 – Acceptable	**Satisfactory** performance. Observed behaviour does not endanger patient or others, **adequate and safe** but could improve in all categories.
2 – Poor	**Concerning** performance. Observed behaviour potentially **compromises safety** of patient and others. Ineffective at times, needs significant improvement across all categories.
1 – Unacceptable	**Unsafe** performance. Observed behaviour does not meet ALS standards, patient and others endangered. **Ineffective throughout**; retraining required.

FEEDBACK for:

OVERALL MARK: (made up of 4 scores Situation Assessment, Team Coordination, Task Management, knowledge/procedures and Communication);

Figure 6.4 POHCAAT v2 (page 1)

Category	Unacceptable (1)	Poor (2)	Acceptable (3)	Good (4)	Excellent (5)
Situational Assessment Gathers information Uses information to make sense of the scene Uses algorithm to inform decisions and planning	**Never** scans scene or moves things, does not get info. Focus on one thing, needs help/prompts. Does not request help.	**Limited** scanning of scene, misses things. Moves some things. Gathers some info, needs prompts. Requests help late.	**Mostly** scans scene, gets some info, understands what is needed. Moves some things. Requests help early, plans as goes along.	**Often** scans scene, gathers and processes info. Good understanding, alters scene as needed, shares plan and updates team, EOC.	**Always** scanning scene, gathers, processes info, alters scene. Clear understanding. Plans ahead early, requests specialist help, updates team, EOC, relatives.
Team Coordination Coordinates scene – leads or follows Supports others Delegates roles and tasks	**Never** coordinates team, does not help others. Does own tasks without team. Does not delegate or accept help. Inconsiderate. No team aim.	**Limited** in coordinating team, lacks confidence, needs leading, focuses on own task, helps others if requested. Team aim unclear/late.	**Mostly** coordinate's team, follows others more. Does own tasks, supports others. Team aim clear but late. Confident but needs support, offers advice.	**Often** coordinates team. Adapts between lead and follower. Considerate, clear team aim, does own tasks appropriately helps/supports others.	**Always** coordinating, considerate leader. Stays hands off, clear team aim. Helps/supports others, manages scene. Feeds back team. Flexible.
Decision-making Prioritises decisions and tasks based on patient and resources Safe decisions based on patient condition/scene Reviewing/re-evaluates options	**Never** adheres to BLS/ALS algorithm. Very poor CPR, not aware of time, cycles, shocks, tasks. Unsafe defib. Overloaded, disruptive, no problem solving, Does not prioritise tasks.	**Limited** adherence to BLS/ALS. Poor CPR, loses track of cycles, shocks, defib not always safe. Gets overloaded and task focused. Poor problem solving and team input. Limited task awareness.	**Mostly** adheres to BLS/ALS algorithm. Mostly keeps track of CPR, cycles, safe defib. Can get overloaded, and task focused. Stepwise approach to tasks, helps with problems.	**Often** adheres to BLS/ALS algorithm. Keeps track of CPR cycles/shocks, good timing and safe defib. Minimal task focus, manages ABC, delegates, problems solves, prioritises most tasks.	**Always** adheres to BLS/ALS algorithm, ensures CPR, depth/ rate, timing, number of cycles/ shocks, safe defib. Does not get task focused. Manages ABC, delegates, problem solves, prioritises tasks.
Communication Shares information Uses effective verbal and non-verbal methods Considers timing	**Never** shares info. Does not listen. Poor verbal/non-verbal language, abrupt, rude, poor timing, disruptive. Not calm, dismissive. Does not clarify info.	**Limited** sharing of info. Limited listening, abrupt, poor timing with questions. Not always calm. Can ignore others. Does not direct comms or clarify.	**Mostly** shares info. Calm, listens, can miss things, questions poorly timed. Quiet but adapts verbal/non-verbal comms to effect. Clarifies info when needed.	**Often** shares info. Calm, clear and good timing. Active listener, directs comms, clarifies info. Adaptable in verbal/non-verbal comms.	**Always** shares info. Precise, calm, timely, clear, eye contact. Active listener, directs and confirms comms. Adapts verbal/non-verbal comms. Open to others.

Figure 6.4 continued…POHCAAT v2 (page 2)

The films previously used were advanced life support simulations and this was a key area identified for improvement, resulting in the use of a realistic simulated environment and changes to the scenarios and teams made. A BMS is not static and so the aim of this phase was to evaluate the prototype POHCAAT v2 to see if the changes improved the reliability, validity, sensitivity, and usability. This research phase will provide information on the methods used for data collection and analysis, followed by the results, which will then be discussed.

6.8 Final Evaluation Methods

6.8.1 Simulated Scenario Design and Setting

Six scenarios were designed, all based in the same bedroom in the university simulation building. A similar plot was used as the mannequin limited the age and sex of the patient. However, the bedroom enabled a realistic scene as it was furnished with a double bed, bedside tables, wardrobe, chest of draws and a small table and chair (see figure 6.5).

Figure 6.5 Bedroom in simulation house used for final evaluation phase scenario (Authors personal collection, 2019)

This limited the available space, mimicking real life, and included props such as replica medication and personal effects. Different cardiac rhythms were displayed on the cardiac monitor for each scenario, and the timings of arrival, numbers and clinical skill levels of crews were varied to reflect the ad hoc formation of teams. All crews consisted of three to four final year student paramedics, all with experience of OHCA to reflect a typical ambulance response to an OHCA (see chapter one). Students were assigned to one of six crews and briefed with a loose script for each scenario. One student per crew was identified as this individual for raters to observe and instructed on the level of behaviour to illustrate. The rest of the crew were also briefed on how to react to this student to ensure clear behaviours for each category were visible. This was to ensure the sensitivity of the POHCAAT v2 was tested and not the raters.

Each scenario was performed twice, one week apart with the same six simulated scenarios, location, and student paramedic crews, to provide a test-retest evaluation. Table 6.22 details each scenario plot, instructions, NTS illustrated, including category and overall rating.

Table 6.22 Final evaluation simulated scenario information; plot, instructions and NTS illustrated per film

Scenario	*Plot*	*Instructions*	*NTS illustrated*
1	Male 30's, chest pain, collapse. Cardiac arrest on arrival, presenting rhythm - pulseless ventricular tachycardia, reverts to ventricular fibrillation (both shockable rhythms). Patient positioned on floor in-between bed and wall. Solo paramedic responder arrives first, followed by crew - paramedic and emergency medical technician 2 mins later. Recognition of life extinct.	Solo paramedic identified for observation and assessment. Fails to coordinate team, fails to share information, does not gather information, fails to adhere to algorithm, no planning. Panicky, unsettled, quiet, disorganised, obstructive, and easily overloaded, abrupt.	Unacceptable behaviour Expert agreed overall rating – 4 Team coordination - 1 Communication – 1 Situation Assessment - 1 Decision-making -1
2	Male 60's, chest pain, collapse. Cardiac arrest on arrival, presenting rhythm - pulseless electrical activity throughout (non-shockable rhythm). Patient positioned on bed. Two crews - paramedic and emergency medical technician arrive first, followed by paramedic and student paramedic 3 mins later. Recognition of life extinct.	First paramedic from the crew identified for observation and assessment. Limited team coordination. Quiet behaviour, reluctant to lead, unsure of clinical algorithms, task focused, limited communication, minimal planning, overloaded but polite.	Poor behaviour Expert agreed overall rating – 8 Team coordination - 2 Communication – 2 Situation Assessment - 2 Decision-making - 2
3	Male 70's, chest pain, collapse. Cardiac arrest on arrival - presenting rhythm, asystole throughout (non-shockable rhythm). Patient positioned on floor at end of bed. Two crews - paramedic and emergency medical technician arrive first, followed by two emergency medical technicians 5 mins later. Recognition of life extinct.	Paramedic identified for observation and assessment. Mostly coordinates team, quiet but confident. Shares information but is quiet, prefers to follow, scans the scene and makes sense of it. Some task allocation and prioritisation. Makes safe decisions and plans, uses clinical algorithm but needs prompts.	Acceptable behaviour Expert agreed overall rating – 11 Team coordination - 3 Communication – 3 Situation Assessment - 3 Decision-making – 2

Table 6.22 continued…

Scenario	*Plot*	*Instructions*	*NTS illustrated*
4	Male 50's, chest pain, collapse. Cardiac arrest on arrival - presenting rhythm, ventricular fibrillation (shockable rhythm), reverts to pulseless electrical activity (non-shockable rhythm). Patient positioned on floor in-between bed and wall. Crew of three paramedic, emergency medical technician and student paramedic arrive first, followed by solo paramedic 5 mins later. Recognition of life extinct.	Paramedic identified for observation and assessment. Mostly coordinates the team, does own tasks, and uses closed loop communication. Requests help early, safe decisions and plans based on ALS algorithm. Can get task focused, reviews most decisions. Fairly confident and structured but quiet.	<u>Acceptable behaviour</u> Expert agreed overall rating – 12 Team coordination - 3 Communication – 3 Situation Assessment - 3 Decision-making – 3
5	Male 50's, chest pain, collapse. Cardiac arrest on arrival - presenting rhythm, asystole (non-shockable rhythm), reverts to ventricular fibrillation (shockable rhythm). Patient positioned on floor in-between bed and wall. First crew two paramedics followed by two paramedics 5 mins later. Results in move patient to hospital.	Paramedic identified for observation and assessment. Remains hands off and coordinates the team throughout. Adapts and support others, uses checklist, closed loop communication, recognises body language, shares decisions, plan, reviews often, adheres to time and algorithm.	<u>Excellent behaviour</u> Expert agreed overall rating – 18 Team coordination - 5 Communication – 5 Situation Assessment - 4 Decision-making – 4
6	Male 40's, chest pain, collapse. Cardiac arrest on arrival, presenting rhythm, ventricular fibrillation throughout (shockable rhythm). Patient positioned on bed. Solo paramedic responder followed by crew of paramedic and emergency medical technician 2 mins later. Results in move patient to hospital.	Paramedic identified for observation and assessment. Not hands off but effectively coordinates. Supports others, calm, directs communication, requests help early, prioritises tasks and plans ahead, adheres to algorithm, minimal task focus, reviews throughout, considers alternatives.	<u>Good behaviour</u> Expert agreed overall rating – 14 Team coordination - 3 Communication – 4 Situation Assessment - 3 Decision-making – 4

The simulated advanced life support scenarios were part of existing live formative ALS practice that was conducted over a two-week period in November 2019. Two separate evaluation days were completed, one week apart to allow for a test-retest. Each day consisted of the same students performing the same 30-minute scenarios, each lasting a maximum of 25-minutes, and 5-minutes for a short debrief (see table 6.22). The use of the existing training weeks allowed for the use of a range of final year student paramedics, university simulation house, and equipment to be combined with a timely evaluation of the POHCAAT v2.

Raters were invited to the two days and due to the limited space in the simulation house, scenarios were viewed in a separate classroom via a live stream. This provided separation between the student paramedics and raters and was possible as covert cameras enabled a live stream. Paramedic teaching staff were in a separate control room and controlled the cardiac monitor. This allowed student paramedics to behave in a more natural way, and utilised multiple simulated scenarios, resulting in a live evaluation of the POHCAAT v2. The two separate days of evaluation used the same raters, student paramedics, setting and scenarios to ensure no significant differences for the test-retest. Following the final evaluation day, student paramedics were debriefed and those observed asked to complete a nine-question paper survey to evaluate their experience of feedback when raters used the POHCAAT v2 (see Appendix P). Each rater was interviewed using a semi-structured approach to enquire about the representativeness and suitability of the POHCAAT v2. An interview schedule was created (see Appendix Q) and all interviews were audio recorded to enable analysis.

6.8.2 Participants

All raters who participated in the preliminary evaluation were invited to return and participate in the final evaluation phase. Of the 17 previous raters, six were able to attend two separate dates for the final test-retest phase. Three raters were HEMS critical care paramedics, two were university lecturer paramedics and one an operational paramedic, all with significant operational experience and exposure to OHCA management. Two additional raters (SME involved in the design phase) were included and acted as expert raters. They also participated in the final evaluation phase, in addition to the six other raters, totalling eight raters. Upon completion of the test-retest phase, the two additional raters provided benchmark ratings after discussion with the lead researcher to aid statistical analysis. Table 6.23 shows the raters position and previous participation in the study.

Table 6.23 Final evaluation rater information

Rater	*Previous Participation*	*Experience*
1. Paramedic science lecturer	Preliminary evaluation	UG paramedic teaching, OHCA management, NTS education, 10+yrs operational experience
2. Paramedic science lecturer	Questionnaire and preliminary evaluation	UG paramedic teaching, OHCA management, NTS education, 10yrs operational experience
3. Paramedic science lecturer/Critical Care Paramedic HEMS	Focus group and preliminary evaluation	UG/PG paramedic teaching, OHCA management, CRM/NTS, 20yrs+ operational experience
4. Critical Care Paramedic HEMS	Preliminary evaluation	UG paramedic teaching, OHCA management, CRM/NTS, 20yrs+ operational experience
5. Critical Care Paramedic HEMS	Preliminary evaluation	Ambulance trust paramedic teaching, OHCA management, CRM/NTS, 15yrs+ operational experience
6. Advanced Paramedic	Preliminary evaluation	Ambulance trust paramedic teaching, OHCA management, NTS education, 25yrs+ operational experience
7. Critical Care Paramedic HEMS	SME Semi-structured interviews and researcher comparison	Prehospital emergency care, OHCA, CRM/NTS, 25yrs+ operational experience
8. Critical Care Doctor HEMS/Consultant Anaesthetist	SME Semi-structured interviews	Prehospital medicine, OHCA, CRM, resuscitation, human factors and NTS education, previous use of BMS. 25yrs+ operational/clinical experience

Due to logistical and timing difficulties, a two-hour online refresher training session using the Zoom application was used. This provided an efficient method to review the POHCAAT v2 and included an updated training and guidance on how to use it.

Twenty-two final year student paramedics preparing for their final advanced life support examinations were used as 'actors' in the simulated scenarios, but only six were identified for rater observation. All student paramedics who agreed to participate in the final evaluation phase attended a one-hour session on the purpose and use of the POHCAAT v2, delivered as part of their clinical decision-making module one week prior to the evaluation.

6.8.3 Data Analysis

The same data analyses methods used for the preliminary evaluation (see page 195) were used as these provided measurements of internal consistency, sensitivity, inter-rater reliability and absolute agreement, and intra-class correlation coefficients (ICC). It was important to test the longitudinal consistency, and a test-retest correlation method was considered as an acceptable method to evaluate the stability of the POHCAAT v2 when used by the same rater on two separate occasions (Hankins, 2008; Berchtold, 2016). Based on Bujang and Baharum (2017) guide for ICC sample size, eight raters viewing four simulations on two separate occasions, one week apart would have an 80% power to detect an ICC of 0.7-0.9.

The two expert raters provided an agreed rating for each simulation to evaluate accuracy. The agreed ratings for each simulated scenario are listed:

- scenario one/seven – unacceptable
- scenario two/eight – poor
- scenario three/nine – acceptable
- scenario four/ten – acceptable
- scenario five/eleven - excellent
- scenario six/twelve – good

As each analytical method has previously been explained in detail in the preliminary evaluation phase, the statistical tests are listed below followed by an explanation of the analysis for the semi-structured interviews. All results are presented and discussed following this section.

- Internal Consistency – measured with Cronbach α with acceptable values based on George and Mallery (2003) standards
- Sensitivity – measured with Wilcoxon signed-rank paired test. A value of $p<.05$ was considered statistically significant
- Inter-Rater Reliability – evaluated with intra class correlation coefficient (ICC), 2-way random effects model, consistency, single measures. Measured against Koo and Mae (2016) levels of reliability
- Inter-Rater Agreement – reported using Kappa, 2-way random-effects model, absolute agreement, single measures. Measured against Landis and Koch (1977) levels of agreement and group correlation measured against LeBreton and Senter (2008) Revised Standards for Interpreting Interrater agreement (IRA) estimates
- Test-retest – evaluated with intra class correlation coefficient (ICC), 2-way mixed effects model, absolute agreement, single measures (Koo & Mae, 2016). Measured against Landis and Koch (1977) interpretation of levels of agreement. Presented as Bland-Altman Plot (Giavarina, 2015).

- Accuracy – evaluated using the weighted Kappa alternative, ICC two-way mixed, absolute agreement, single rater measurements (Streiner et al., 2015). Assessed against Landis and Koch (1977) interpretation of kappa
- Validity – content and face, with descriptive statistics used to measure the levels of agreement for survey answers (mean and SD)

The content and face validity were measured using thematic analysis of the semi-structured interviews, with the same approach used as in research phase two (Strauss & Corbin, 1998). Each recorded interview was transcribed, read through to increase familiarity, and coded using NVivo 12 software (QSR International Pty Ltd, 2018). Once codes were identified, they were grouped into categories and the frequency, extensiveness and specificity analysed for their relevance to the acceptability and usability of the POHCAAT v2. The results were reviewed with the expert raters and supervision team for comparison and themes used to report these, with example quotes and a narrative format.

Following feedback from each simulation, student paramedic participants completed a survey (see Appendix P) to evaluate their opinions of the feedback received. Eight closed questions were answered using a five-point Likert scale and one open question was included to provide contextual comments. These answers were thematically analysed, using the same approach as research phase one (chapter four, section 4.7), due to the similarity in design. Scale data were analysed with descriptive statistics and presented as mean (SD) and a narrative format with supporting example quotes was used to report the textual data.

6.9 Final Evaluation Results

Eight raters observed and provided ratings for 12 simulated OHCA scenarios. There were five males and three females, with ages ranging from 21-49 years. All were experienced in the paramedic management of an OHCA, teaching and assessing simulated OHCA and had previous experience of using the POHCAAT in the preliminary evaluation stage (see table 6.23). The overall scenario ratings for each rater are presented in figure 6.6.

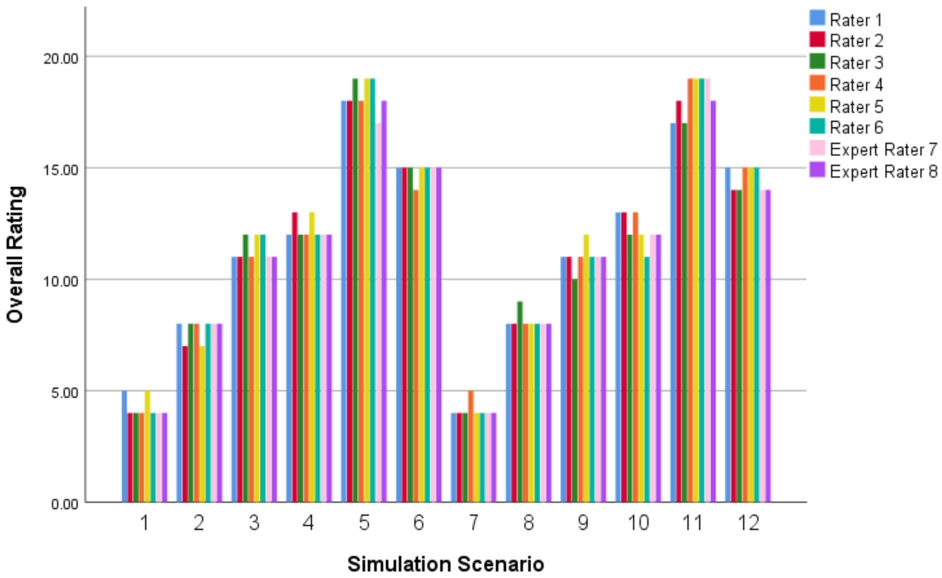


Figure 6.6 Final evaluation individual rater overall scenario ratings

Although there are some slight discrepancies between raters, there appears to be a general agreement for each scenario.

6.9.1 Internal Consistency

Table 6.24 shows Cronbach's α results for the POHCAAT v2, with individual elements and average scores for each film presented. Measurements <0.7 and ≥0.9 highlighted grey.

*Table 6.24 Final evaluation Cronbach α for scenario elements and averages (*communication)*

Scenario	*Team coordination elements*	*Comm* elements*	*Situation Assessment elements*	*Decision-making elements*	*Average for scenario*
1	0.88	0.70	0.79	0.72	0.77
2	0.63	0.70	0.79	0.85	0.74
3	0.70	0.64	0.70	0.82	0.71
4	0.80	0.73	0.84	0.76	0.78
5	0.61	0.80	0.74	0.78	0.73
6	0.64	0.89	0.70	0.92	0.78
7	0.81	0.76	0.90	0.78	0.81
8	0.65	0.87	0.81	0.81	0.78
9	0.70	0.60	0.82	0.86	0.74
10	0.82	0.75	0.85	0.75	0.79
11	0.65	0.87	0.75	0.75	0.75
12	0.65	0.87	0.73	0.90	0.78
Average for category	0.71	0.76	0.78	0.80	

When measured against George and Mallery's (2003) ranges for internal consistency some elements appear to be questionable as they fall <0.70, however there appears to be less duplication than the preliminary results and all averages are within an acceptable to excellent range of internal consistency.

6.9.2 Sensitivity

Sensitivity was measured using a Wilcoxon signed-rank paired test. A value of $p<.05$ was considered statistically significant and the mean and standard deviation for each element and overall category score were calculated for a combination of all scenarios (see Appendix R). All scenario pairings were found to be statistically significant, except the pairing of scenarios four and six, and scenario five and six, presented in tables 6.25 - 6.26, with values not considered statistically significant highlighted grey.

Table 6.25 Final evaluation Wilcoxon signed-ranks test mean score and SD for scenarios four and six

	Scenario 4 (acceptable)	***Scenario 6 (good)***		
	Mean (SD)	Mean (SD)	Difference in means	*p* value
Overall rating	12.2 (0.48)	14.8 (0.37)	2.60	.015
Team Coordination	2.85 (0.37)	3.85 (0.37)	1.00	.020
Communication	3.00 (0.00)	3.14 (0.37)	0.14	.317
Situation Assessment	3.14 (0.37)	4.00 (0.00)	0.86	.014
Decision-making	3.28 (0.48)	3.85 (0.37)	0.57	.102

Table 6.26 Final evaluation Wilcoxon signed-ranks test mean score and SD for scenarios five and six

	Scenario 5 (excellent)	***Scenario 6 (good)***		
	Mean (SD)	Mean (SD)	Difference in means	*p* value
Overall rating	18.2 (0.75)	14.8 (0.37)	3.40	.016
Team Coordination	4.85 (0.37)	3.85 (0.37)	1.00	.008
Communication	4.57 (0.53)	3.14 (0.37)	1.43	.015
Situation Assessment	4.28 (0.48)	4.00 (0.00)	0.28	.157
Decision-making	4.57 (0.53)	3.85 (0.37)	0.72	.059

Apart from communication, and decision-making in paired scenarios four (acceptable) and six (good), and situation assessment in paired scenarios five (excellent) and six (good) the means for each scenario indicated clear differences between unacceptable and excellent behaviour, with standard deviations below 1SD.

6.9.3 Inter-Rater Reliability and Absolute Agreement

Each category and individual elements were evaluated using two random raters (one and five) ratings for all 12 scenarios, as this would give ≥80.0% power to detect an ICC of between 0.6-0.9 at a 5% level of significance (Bujang & Baharum, 2017).

Measurements were calculated using intra-class correlation coefficient, single measurement (k=2), consistency and absolute agreement, 2-way random effects model. A 95% confidence interval was used to estimate the interval of ICC. Results are presented in table 6.27, with <0.75 highlighted grey when measured against Koo and Mae (2016) levels of reliability.

Table 6.27 Final Evaluation Inter-rater reliability consistency ICC for raters one and five

Categories and elements consistency	***ICC (CI 95%)***
Team Coordination category score	0.84 (0.74-0.90)
Coordinates scene – leads or follows	0.81 (0.61-0.91)
Delegates roles/tasks	0.77 (0.54-0.89)
Supports others	0.87 (0.73-0.94)
Communication category score	0.83 (0.76-0.89)
Shares information	0.85 (0.70-0.96)
Considers timing of communication	0.77 (0.54-0.89)
Uses effective verbal and non-verbal methods	0.86 (0.71-0.94)
Situation Assessment Category score	0.69 (0.55-0.79)
Gathers information	0.72 (0.46-0.87)
Uses information to make sense of the scene	0.79 (0.58-0.90)
Uses algorithm to inform decisions and planning	0.54 (0.20-0.77)
Decision-making category score	0.77 (0.66-0.85)
Prioritises decisions and tasks based on patient and resources	0.72 (0.46-0.87)
Safe decisions based on patient condition/scene	0.77 (0.53-0.89)
Reviewing/re-evaluates options	0.85 (0.68-0.93)

Overall, there appears to be a good reliability between two random raters for all scenarios. Situation assessment was noted to be moderately reliable, with other categories demonstrating a good reliability. Only the elements ‘Gathers information’, ‘Uses algorithm to inform decisions and planning’ and ‘Prioritises decisions and tasks based on patient and resources’ were moderately reliable. Confidence intervals were reasonably narrow with some noted to be wider than others but overall, there was an improvement (moderate to good reliability) in comparison to the preliminary results.

Absolute agreement was also evaluated and interpreted using Landis and Koch, (1977) levels of agreement, with measures >0.60 considered as acceptable. Those <0.60 are highlighted grey in table 6.28.

Table 6.28 Final Evaluation Inter-rater reliability absolute agreement ICC for raters one and five

Categories and elements consistency	**ICC (CI 95%)**
Team Coordination category score	0.84 (0.74-0.90)
Coordinates scene – leads or follows	0.80 (0.59-0.90)
Delegates roles/tasks	0.78 (0.57-0.90)
Supports others	0.88 (0.74-0.94)
Communication category score	0.83 (0.73-0.89)
Shares information	0.86 (0.70-0.93)
Considers timing of communication	0.77 (0.54-0.89)
Uses effective verbal and non-verbal methods	0.87 (0.72-0.94)
Situation Assessment Category score	0.69 (0.55-0.79)
Gathers information	0.73 (0.47-0.87)
Uses information to make sense of the scene	0.80 (0.60-0.91)
Uses algorithm to inform decisions and planning	0.56 (0.20-0.78)
Decision-making category score	0.73 (0.52-0.84)
Prioritises decisions and tasks based on patient and resources	0.64 (0.22-0.84)
Safe decisions based on patient condition/scene	0.71 (0.33-0.87)
Reviewing/re-evaluates options	0.85 (0.68-0.93)

The results identify that apart from the element ‘Uses algorithm to inform decisions and planning’ there is an overall substantial level of agreement. Confidence intervals are narrower than the preliminary results, except the element ‘Prioritises decisions and tasks based on patient and resources’.

6.9.4 Within Group Agreement

Like the preliminary evaluation, within-group agreement was calculated for category, element, and overall score. All categories and elements had r_{wg} averages between 0.95-0.99, with no simulated scenarios averaging $r_{wg}<0.8$. This indicates there is a very strong level of agreement (see Appendix S).

6.9.5 Test-Retest Reliability

A test-retest was performed with an interval of seven days. All raters who participated in the first day of simulated scenarios returned one-week later and observed the same simulated scenarios again (see section 6.8.1 and table 6.22 for simulated scenario details). Figure 6.7 displays the Bland Altman Plot, with the lower and upper levels of agreement relatively narrow, and a low bias measurement, indicating consistency in the results.

Figure 6.7 Final evaluation Bland Altman Plot of test-retest means and difference in overall scores

The mean difference for each overall simulated scenario score ranged from the lower level of agreement of -1.35 to the upper level of agreement of 1.77. Bias was measured at 0.20, and SD 0.79.

A two-way mixed effects model was also performed to calculate the intraclass correlation coefficient, absolute agreement, single measures for each pair of simulated scenario overall scores, with results presented in Appendix T. When interpreted with Landis and Koch, (1977) level of agreement is an almost perfect level of agreement, suggesting that 64-100% of the data is reliable. Both analyses support the stability of the POHCAAT v2 between eight raters observing the same simulated OHCA scenarios one-week apart.

6.9.6 Accuracy

Absolute agreement between individual raters and the expert agreed ratings for all scenario categories and elements was assessed with results presented below.

Table 6.29 Final evaluation Accuracy of individual rater scores compared to expert rater agreed scores

Rater	*Categories*	*Elements*
1	0.90	0.80
2	0.95	0.83
3	0.90	0.87
4	0.91	0.80
5	0.93	0.86
6	0.94	0.86
Average	0.92	0.83
SD	0.02	0.03

It appears the average kappa values for categories (κ=0.92) and elements (κ=0.83) is almost perfect, with a low standard deviation.

6.9.7 Validity

All eight raters were interviewed using guidance questions (see Appendix Q), and four themes identified. Overall, raters found the POHCAAT v2 was relevant and suitable for evaluating the NTS of student paramedics managing a simulated OHCA. Comments included suggestions for improvements but overall, it was easy to use, the design suited the task, and it was applicable and would have a positive influence on practice.

6.9.7.1 Theme 1 - Design

Raters commented that the design of the POHCAAT v2 was usable, with the content reflecting practice. Raters found that the categories, elements, descriptors, and ratings were clear and suited to the task. They were also able to associate the observed behaviours with the categories, elements, descriptors, and ratings. Some improvements were suggested but these will be presented in theme three - improvements. Codes, categories and the resulting theme are presented in figure 6.8, with supporting comments after.

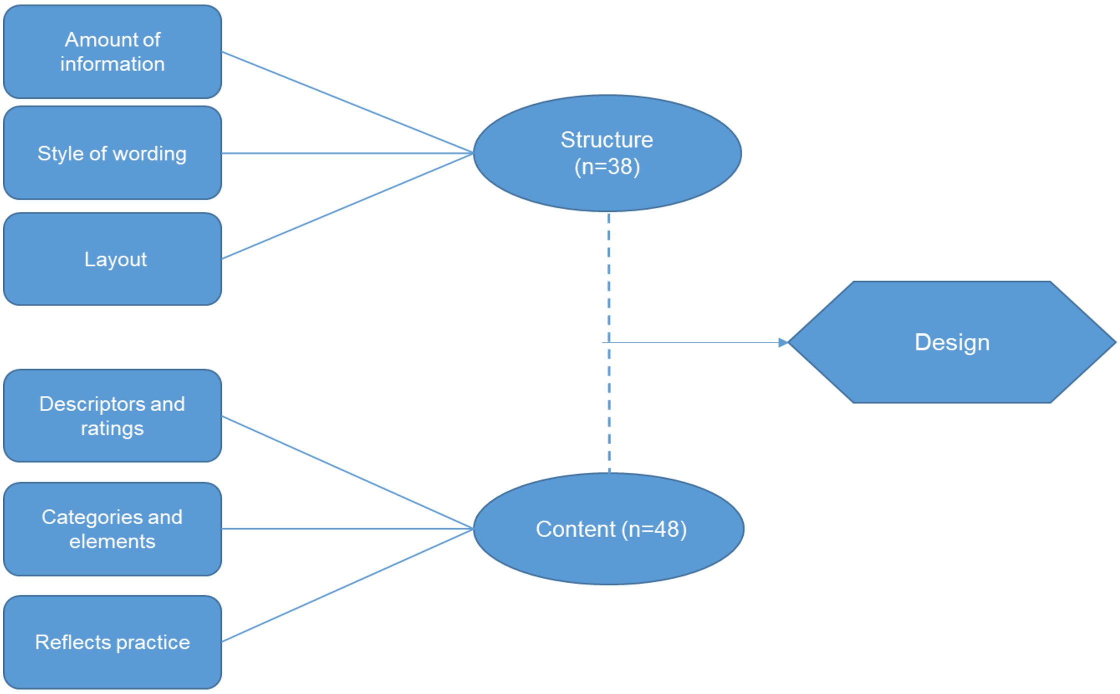


Figure 6.8 Design codes-to-themes model

Example comments for design:

> *''I know communication is interwoven in all the other categories, and some may think it shouldn't be separated but I think it's a really important aspect of managing an out-of-hospital cardiac arrest''* (R1)
>
> *''the number of elements and categories are good; they cover all aspects of team behaviour during an out-of-hospital cardiac arrest''* (R2)
>
> *''the descriptors relate well to the behaviour observed''* (R3)
>
> *''Excellent layout, very easy to read. The descriptor and rating options are very well worded and very easy to understand''* (R4)

''This is the part of an out-of-hospital cardiac arrest that isn't focused on in any way as crews are far too concentrated on the clinical aspect, good to see it designed'' (R4)

''clear descriptors, easy to see different levels of behaviour'' (R6)

''I've used other observational tools and i like the rating categories as I think students and paramedics will understand them'' (R7)

''Colours help when focusing on observation'' (R8)

''I like all the elements and categories, match what happens in an out-of-hospital cardiac arrest'' (R8)

6.9.7.2 Theme 2 - Usability

Overall, raters found the POHCAAT v2 easy to use, although some raters had initial reservations about separating behaviours and use in actual practice. Raters believed the category domains, elements, performance rating, and descriptors were recognisable and suited to the paramedic management of an OHCA. Raters generally found that they could distinguish between behaviours, commenting that the categories, elements, and descriptors providing flexibility. The design assisted with structuring feedback and comments suggested that students and paramedics would be able to understand the rating system. Codes, categories and the resulting theme are presented in figure 6.9, with supporting comments after.

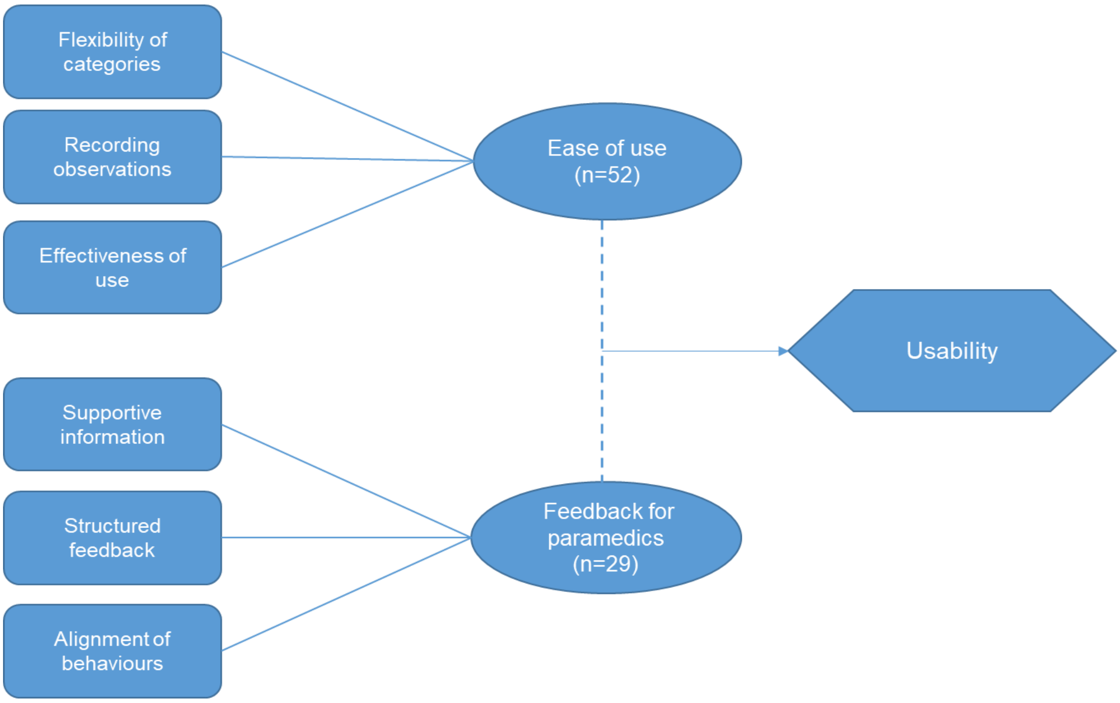


Figure 6.9 Usability codes-to-themes model

Example comments for reservations for usability:

> *"I did think that it looks very complex, for use in sim it would work but I'm not sure this format would work in practice"* (R5)
>
> *"I wondered at how to score someone who falls between two different rating levels as someone could display all these behaviours in a single simulation. But the ratings and descriptions help"* (R5)
>
> *"I was concerned that observable behaviour might not be able to be measured but I can see throughout the development of this that it is clear and easy to use"* (R7)
>
> *"It's clearer that it's aimed at just observing and assessing one person, i don't think it would work for more than one, it would be too difficult"* (R7)
>
> *"I thought it would just be for a team leader but watching the simulations I can see how you can adapt the tool to the change in roles"* (R8)

Positive comments on the usability of the POHCAAT v2:

''I think anyone not familiar with behavioural markers will need training to become familiar but overall, the POHCAAT seems pretty clear and easy to use'' (R1)

''I like that you can see them using the available resources to optimise the outcome, or not sometimes, depending on their experience and behaviour'' (R2)

''In general, I think it's a great tool. I think it's straightforward with little/no ambiguity'' (R3)

''Excellent layout, very easy to read. The descriptor and rating options are very well worded and very easy to understand'' (R4)

''If aimed at just being used 'on the fly' during a simulated resus, i think it's good and can provide good feedback'' (R5)

''The team coordination category allows person being observed to change from leader to follower and vice versa, reflects team adaption'' (R6)

''Reflects different environments and crews, easy to use for different levels of behaviour'' (R6)

''I like that there are clear levels of behaviour and ratings associated with them, helps with feedback'' (R7)

''A great tool to support feedback and team improvement'' (R8)

''I like all the elements and categories, match what happens in an out-of-hospital cardiac arrest'' (R8)

6.9.7.3 Theme 3 - Application to Practice

Raters provided positive comments for the application of the POHCAAT v2 and its potential influence on real-life practice. Comments suggested that it could improve individual performance as part of an OHCA team, with potential to positively influence team performance. Raters felt it worked well in a realistic simulated scenario, but further testing would be needed if it was to be used in operational practice areas, such as ambulance trusts. Codes, categories and the resulting theme are displayed in figure 6.10, with supporting comments after.

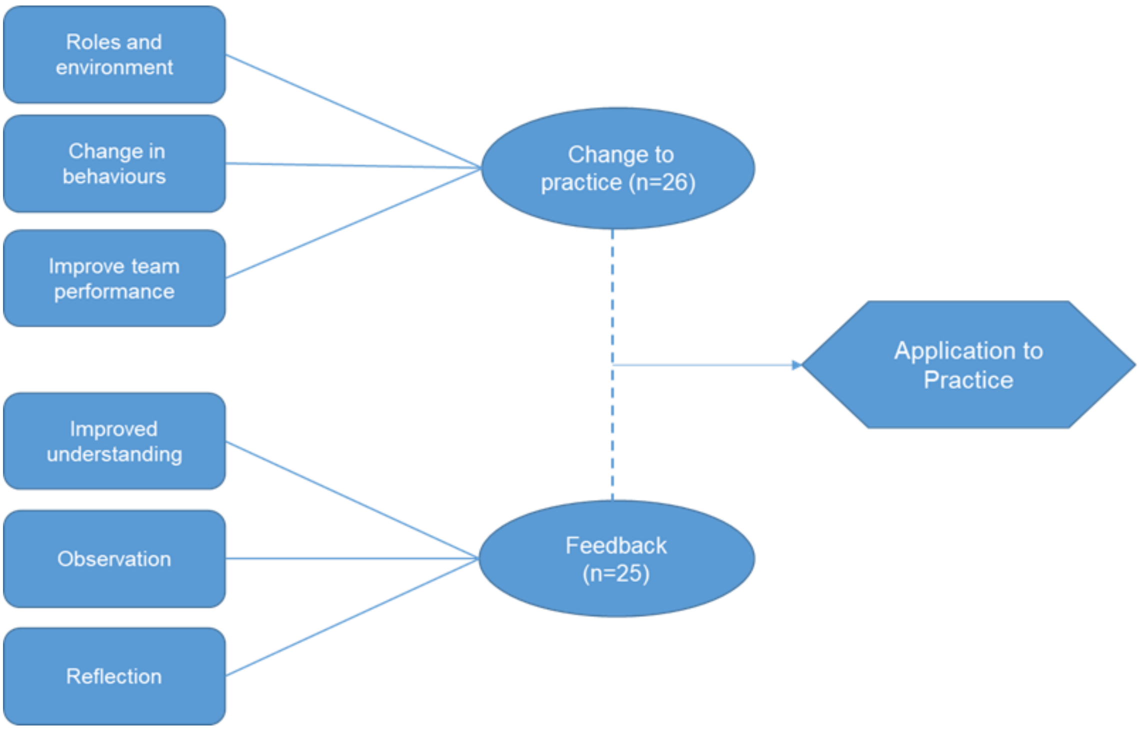


Figure 6.10 Application to practice codes-to-themes model

Example comments for reservations for application to practice:

''I like that you have tested the POHCAAT using realistic simulations, i think the next step will be to try and use it in practice but I'm not sure how you would do this'' (R1)

''Allows someone to better understand roles, clinical competence/abilities, the situation is important, good to be able to observe and rate these for feedback, so the student or para can improve'' (R2)

''An out-of-hospital cardiac arrest can be a complex environment, depending on the patient and location, lots of contributing factors that affect comms, teamwork, process failure. Integration of team is needed to work, and I think the POHCAAT can help to identify this'' (R2)

''It will help with debriefing, allows for structure and clear areas for improvement'' (R3)

''By encouraging this type of tool to be used I would expect a better outcome for the patients as the teams will be working more effectively and efficiently'' (R4)

''It identified how that person worked within the team, it's good it doesn't just focus on leading'' (R5)

''Very easy to understand and would be useful for peer review'' (R6)

''Team coordination category allows person being observed to change from leader to follower and vice versa, reflects team adaption'' (R6)

‘’I don't think there is ever just one true leader at an out-of-hospital cardiac arrest, due to the fluid nature of the role another person can take the role at certain times. I think the POHCAAT reflects this’’ (R7)

‘’I think the POHCAAT will work in practice, it’s certainly applicable to practice’’ (R8)

‘’A great tool to support feedback and team improvement’’ (R8)

6.9.7.4 Theme 4 - Improvements for the POHCAAT v2

Comments included a suggestion of a simplified version if using in a practice area, such as an ambulance hub. Although the aim of the POHCAAT is to be used in a simulated environment and not actual practice, this would potentially encourage use for paramedic peer-to-peer and paramedic mentor-to-student assessment use while on operational shifts. Other comments included concerns that if the student/qualified paramedic observed did not lead, this may be unfair, as it was perceived that to score an excellent rating the observee would need to lead throughout the scenario. Yet, the POHCAAT v2 was designed to reflect role changes as more clinicians arrive. This includes clinical interventions that are dependent on paramedic clinical competencies and a positive contribution to all four NTS can still be achieved regardless of leading or following. Despite some concerns, it appears the improvements made have resulted in improved usability with potential for testing in operational areas, including ambulance trusts and as part of CPD activities, not just as part of undergraduate paramedic programmes.

Codes, categories and the resulting theme are included in figure 6.11, with supporting comments after.

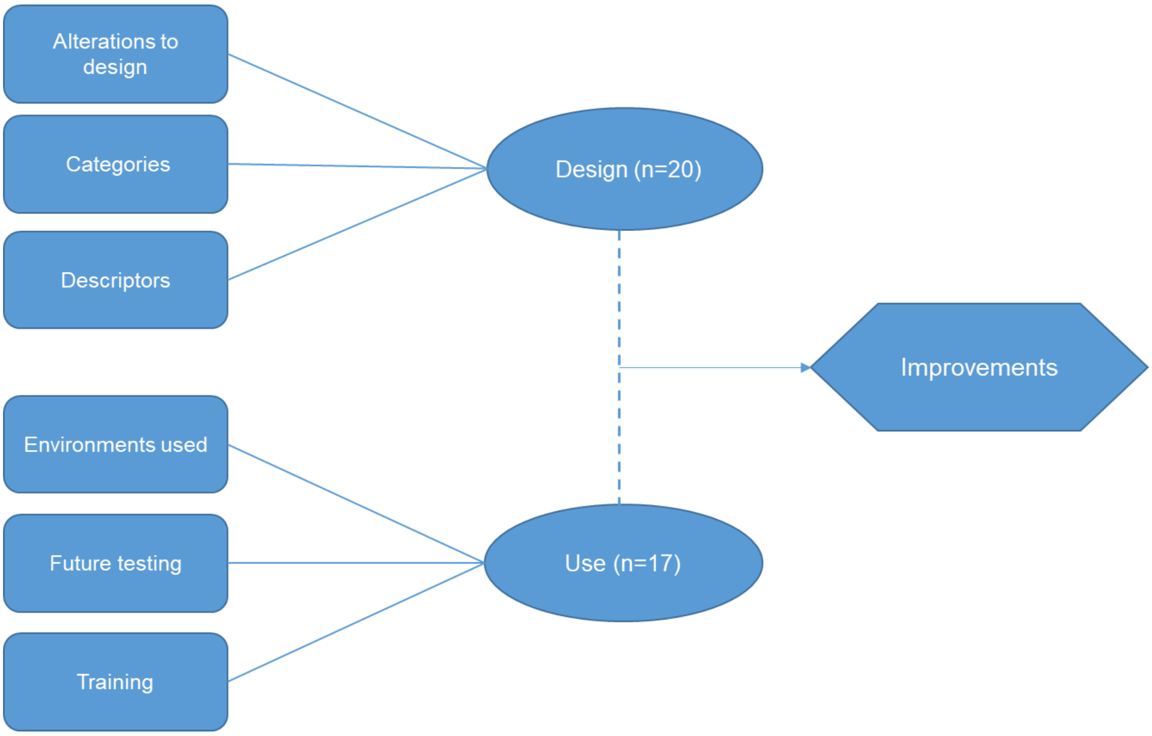


Figure 6.11 Improvements codes-to-themes model

Example comments for reservations for improvements:

> *''A simplified presentation may help, so it is easy to use when watching a resuscitation and giving feedback''* (R1)

> *''The team coordination descriptor, consider a reword just to make it clearer''* (R2)

> *''Could move the columns round so they flow better….SA, then decision-making, then communication etc.''* (R4)

> *''I did think that it looked very complex, for use in sim it would work but I'm not sure this format would work in practice''* (R5)

''Ratings are useful, but may be very subjectively scored'' (R5)

''Sometimes difficult to watch and write down info at the same time'' (R6)

''It was clear although it can be a little wordy'' (R7)

''I did wonder in the preliminary test at who the tool was aimed at, i think it works really well for students, but it needs to be tested with more experienced paramedics'' (R7)

''I wonder if it would be harder to score excellent if you didn't lead'' (R8)

6.9.8 Student Paramedic Actor Survey

The six students who were observed as individuals during the simulated scenario days for the final evaluation completed an eight-question survey (see Appendix P). This was designed to assess their experiences of being observed and the feedback provided when the eight raters used the POHCAAT. Descriptive statistics of the post simulation feedback student survey are presented in table 6.30, including levels of agreement, mean score and standard deviation for each question.

Table 6.30 Final evaluation post simulation student paramedic actor survey descriptive statistical results

Question	*Strongly Disagree n (%)*	*Disagree n (%)*	*Neither n (%)*	*Agree n (%)*	*Strongly Agree n (%)*	*Mean (SD)*
1. The POHCAAT v2 provided me with useful feedback	0 (0%)	0 (0%)	0 (0%)	4 (66%)	2 (33%)	4.66 (0.51)
2. The feedback is easy to understand	0 (0%)	0 (0%)	0 (0%)	3 (50%)	3 (50%)	4.50 (0.54)
3. The amount of feedback is adequate	0 (0%)	0 (0%)	0 (0%)	3 (50%)	3 (50%)	4.50 (0.54)
4. The feedback will help me improve my non-technical skills in an OHCA	0 (0%)	0 (0%)	0 (0%)	4 (66%)	2 (33%)	4.66 (0.51)
5. The non-technical skill categories and elements made sense	0 (0%)	0 (0%)	1 (16%)	2 (33%)	3 (50%)	4.33 (0.81)
6. The descriptions of the behaviours were easy to understand	0 (0%)	0 (0%)	1 (16%)	2 (33%)	3 (50%)	4.33 (0.81)
7. The POHCAAT v2 accurately scores non-technical skills behaviour	0 (0%)	0 (0%)	0 (0%)	2 (33%)	4 (66%)	4.66 (0.51)
8. The POHCAAT v2 can be used to assess student and paramedic non-technical skills in the OHCA	0 (0%)	0 (0%)	0 (0%)	2 (33%)	4 (66%)	4.66 (0.51)

The results above indicate that there was a good level of agreement for all questions, with only one student answering neither for questions five and six. It appears student paramedics found the feedback, content, and design of the POHCAAT v2 useful, easy to understand and that it accurately assessed their levels of behaviour. Comments from the open question support and help to understand the results:

> *''very useful to give pointers to work on. Clearly reveals what needs improvement''* (PN1)

> *''I like that it's not just a pass/fail, it really shows what's good and not so good, allows you to improve''* (PN1)

> *"it provides beneficial feedback which certainly helps show how you can improve''* (PN2)

> *"I like how it covers things you don't always think about, like moving equipment''* (PN2)

> *"I think it will give similar feedback from multiple assessors on the same student because of the scoring structure''* (PN3)

> *''It helps you move forward, it's constructive, I could easily discuss with my mentor''* (PN3)

> *''Easy to understand the behaviours, they reflect how you work as a team''* (PN4)

> *''It allows for feedback based on how the team changes, reflects how different people work''* (PN4)

“Better than a checklist for what you did, like an algorithm or OSCE checklist, it was more detailed’’ (PN5)

’’The feedback improved my confidence as it was constructive and clear to see where I was good and bad’’ (PN5)

“Having the POHCAAT to look at was really useful, it helped with the feedback’’ (PN6)

Student paramedics appear to have had a positive experience and identified that the POHCAAT v2 provided in-depth and constructive feedback, not just based on their clinical abilities.

6.10 Final Evaluation Discussion

The results indicate that the design, reliability, and validity of the POHCAAT v2 have improved when compared to the preliminary evaluation results. Greater levels of internal consistency, rater accuracy and reliability were identified, with a comparison between the preliminary and final evaluation results shown in table 6.31.

Table 6.31 Comparison of preliminary and final evaluation results

Statistical Analysis	*Preliminary Evaluation Results*	*Final Evaluation Results*
Internal Consistency Cronbach α	Good – excellent 0.85-0.93 (Duplication present)	Acceptable – excellent 0.60-0.92 (Less duplication present)
Sensitivity Wilcoxon signed-rank paired test	Can distinguish between poor and good behaviour	Can distinguish full range of behaviours unacceptable – excellent
Inter-rater reliability ICC single measurement, consistency, 2-way random effects model	Overall acceptable (0.44-0.79) Wide CI	Moderate – good reliability (0.54-0.87) Narrow CI
Inter-rater agreement ICC, single measurement, absolute agreement, 2-way random-effects model	Overall acceptable level of agreement (0.43-0.78) Wide CI	Substantial level of agreement (0.56-0.88) Narrow CI
Within-group agreement	Strong level of average agreement Average r_{wg} for films 0.84-0.92	Very strong level of agreement Average r_{wg} for films 0.95-0.99
Accuracy Spearman's rank-order correlation	Moderate agreement for NTS categories (κ=0.51) Slight agreement for elements (κ=0.19)	Almost perfect agreement for NTS categories (κ=0.92) Almost perfect agreement for NTS categories(κ=0.83)
Exploratory factor analysis Kaiser-Meier-Olin (KMO) test	KMO 0.46 for film one KMO 0.51-0.63 for films 2-5 Factor analysis is not advised	Not performed
Test-retest	Not performed	Almost perfect level of agreement

Despite the preliminary evaluation completing four months prior, the use of eight raters from the same sample appeared to result in a good level of retention when using the POHCAAT v2. The use of online training has been shown to improve knowledge retention and results (Olivet et al., 2016) and the combination of an initial face-to-face workshop followed by a short online refresher session appears to have benefited the raters, as reliability and validity were both improved. This may reflect an increased familiarity, while the realistic simulations and improved design appear to have made it easier to use. For future use and continuing evaluations, a mix of face-to-face workshops, supported by multiple online refresher sessions would be beneficial.

Comments suggested that paramedics might be rated poorly if they did not lead, however it was important that the POHCAAT v2 could reflect the changing of roles identified in comments from the questionnaire and focus groups in chapter four. Although there appeared to be reservations in observing a range of behaviours, comments suggested the ratings and descriptors helped in recognising the change in roles and behaviour. These comments support the category of team coordination and are reinforced by comments that the POHCAAT v2 was easy to use and met the needs of the task, reflected in the sensitivity results (see Appendix R). These results may be explained by the change to the simulated scenarios using a more directed approach, use of a loose script and more realistic environment. Although simulation has some limitations, Hunziker et al. (2011) suggests that high-fidelity simulation recreates a realistic environment, reducing bias and standardising the situation.

This change in the simulation environment and use of live streaming appears to have resulted in the students reacting in a more natural way. With no direction in the simulation provided, their behaviours were easier to observe, and are reflected in the statistical results. Despite the general improvement, results for distinguishing between acceptable, good, and excellent behaviours for communication, application of knowledge and situation assessment were slightly less than the other categories. However, this may be due to some of the simulations being repeated one-week apart and an aspect of rater drift and temporal representation (Bakeman & Quera, 2011) with students performing slightly differently. This was a risk of using live-streamed simulations, as exact behaviour could not be replicated despite using the same students, scenarios, and scripts. However, this allowed for an accurate representation of how the POHCAAT v2 could be used in future.

The inter-rater reliability, agreement and within group agreement results were more consistent, with higher levels of agreement, and narrower confidence intervals (see tables 6.27-6.29 and 6.31). This could be explained by using the same raters as the preliminary evaluation, as they were more familiar with the POHCAAT v2 despite the modifications. There may be an aspect of rater drift, as the group had worked and trained together before, possibly exemplifying greater reliability (Girard & Cohn, 2016). The results may also be a consequence of clearer observed behaviours and improved simulated performances from the student paramedics, however situation assessment was only moderately reliable, an improvement from the preliminary evaluation but still a reflection of possible difficulties in observing cognitive behaviour (Hunter et al., 2020).

The test-retest was better than expected, and this may have been due to the relatively short time frame of four months between the preliminary and final evaluation stages, suggesting the refresher training was beneficial and raters retained an understanding of using the POHCAAT. Despite raters previous participation in the preliminary evaluation, and being considered as experienced qualified paramedics, they were still considered as novice raters as use of a BMS was restricted to this study. It does appear that a test-retest evaluation is not commonly included in other healthcare behavioural marker systems and comparison is limited. The Oxford NOTECHS system (Mishra et al., 2009) and the ANTS-AP (Rutherford, 2015), both performed test-retest with differing results, these results indicate the POHCAAT v2 is stable.

Content validity and face validity suggested that the POHCAAT v2 was both suitable and representative of the aim; to design and test a behavioural marker system for paramedic NTS when managing an OHCA. This is supported by comments on usability and application to practice themes highlighting the ability to provide detailed feedback, reflecting team changes and the real-life management of an OHCA. One rater suggested that for use with qualified paramedics or in a practice environment such as an operational ambulance hub, additional testing would be needed, and this is planned as post-doctoral research.

Comments also noted the complexity of an OHCA, supporting the need for a separate communication category due to its importance and how the POHCAAT v2 could improve individual and team performance. This may assist a more team-oriented approach as paramedic exposure to an OHCA is recognised as low, and linked to patient survival (Dyson et al., 2016). The number of paramedics responding to an OHCA is also dependent on effective NTS as increased numbers have been identified to benefit time to advanced life support (Tsai et al., 2020) with smaller teams more prone to errors (Bayley et al., 2008).

Student data also supported the aim of the POHCAAT v2, to develop a reliable, valid, and usable BMS to assess the NTS used by paramedics when managing OHCA. The information provided by the observed students of their experience of feedback from raters using the POHCAAT v2 indicated that they felt it provided useful, understandable, sensible, and constructive feedback and worked well as a learning tool. Comments further supported its application to practice as students felt it did not just concentrate on clinical ability, often the focus of ALS scenarios, and would be beneficial for use as part of peer review. Students also highlighted the use of category and overall ratings, rather than a pass/fail method as it allowed them to identify specific areas of NTS for improvement and felt that this may improve their confidence.

6.10.1 Limitations

Although there have been improvements in the reliability, validity and the overall use, there are limitations. Both evaluations included a small sample size and the experience of raters may have affected their use of the POHCAAT. Those less experienced may have had to rely on the descriptors, limiting observation, but as presented in table 6.23, all raters had a good range of experience including managing an OHCA, NTS, CRM, and paramedic assessments. While the use of three senior lecturer paramedics from the same university as the student paramedic actors may have resulted in some preconceptions of students and different interpretations of social interactions. However, the data indicates that raters were consistent in their ratings, with almost perfect agreement between novice and expert ratings, therefore these limitations may have been minimised.

Although a refresher training session was provided, this was affected due to time and availability constraints with rater comments highlighting the need for additional training. However, comments also included that the design made the POHCAAT v2 easy to use and it is envisioned that an initial one-day workshop supported by regular maintenance and refresher training will help to improve raters use and competence (Sullivan et al., 2019).

6.11 Conclusion

The aim of this chapter was to evaluate the prototype POHCAAT. The results indicate that additional training, use of improved simulations, alterations to the design and content have enhanced the usability and identified a positive application to practice. It appears the POHCAAT v2 is representative and suitable for providing an observational assessment of paramedic NTS when managing an OHCA. Notwithstanding the limitations, the final evaluation has provided additional analyses and it is recognised that future research studies using larger sample sizes, could be incorporated into undergraduate and postgraduate paramedic programmes to aid further evaluation. The next chapter provides a discussion of the context of the POHCAAT in relation to other BMS and its application to practice.

Chapter 7 - Discussion

7.1 Introduction

This chapter moves on to discuss the interpretation of the key findings within the framework of study, placing it in the wider context of other BMS and its application to paramedic practice. It expands on the previous discussion sections, presenting four significant findings: contextual results, barriers to NTS and negative culture, the specific NTS categories, and the evaluative results of the POHCAAT. It provides an explanation of the general limitations, suggestions for further research, before concluding with a summary of the implications for practice

7.2 Contextual Results

When the POHCAAT was considered within the concept of the chain of survival (see figure 1.2), a key finding was the importance placed on identifying specific NTS for the management of an OHCA. It has been recommended that the use of evidence based clinical algorithms coupled with continuing education and training can assist with team structure and the ability to work effectively (Brandling et al, 2017). Both the Resuscitation Council (UK) guidelines (2021b), and UK Ambulance Service Clinical Practice Guidelines (Joint Royal Colleges Ambulance Liaison Committee and Association of Ambulance Chief Executives, 2016, 2019) advocate the teaching of and use of NTS for OHCA management with little change since the introduction of NTS in the 2010/15 ALS guidelines (Soar et al., 2010). However, when this was explored, there was little rationale or reference material presented to support the NTS included in the guidance.

The scoping review confirmed that there is a paucity of relevant literature, resulting in a need to identify specific NTS for a paramedic managed OHCA, as this was needed to provide a taxonomy to develop a BMS.

Inference had to be drawn from previous studies conducted for in-hospital cardiac arrest teams, as many of the out-of-hospital studies focused on technical skills. Studies by von Wyl et al. (2009) and Riem et al. (2013) identified a correlation between clinical skills, knowledge of procedures and equipment, and NTS, but fell short of identifying specific NTS or a reliable assessment method. Petrosoniak et al. (2020) who recognised that when knowledge is poor, teamwork and decision-making can be affected, creating a safety threat to patient care, support this. The results in Chapter four established that an OHCA is unpredictable, can occur in a variety of locations, differing environments and is often responded to by unfamiliar teams, with limited exposure rates to an OHCA. This emphasised the difference between an OHCA and hospital based cardiac arrest teams, and that an adapted BMS would not be sufficient to assess the NTS used by paramedics. Chapter one and two identified a clear gap for the identification of specific NTS and the need for a BMS to provide a reliable assessment method for paramedics.

As a new BMS, there was a need to establish reliability, validity, and sensitivity, before considering its implications for practice. In the context of other healthcare BMS, especially those for use in an out-of-hospital setting (Myers et al., 2016; Holly et al., 2017) the evaluation results appeared to be comparable. Although all raters were considered as novices due their limited use of BMS, similar to those raters used in other healthcare BMS, it appeared the POHCAAT could provide reliable and accurate scores. Although testing was conducted using simulated scenarios, even when the environment was less realistic, the POHCAAT was still moderately reliable. As such, it is suggested that a simulated environment can provide a realistic scenario, emphasising the potential for the use of the POHCAAT in an education and training setting, such as undergraduate paramedic programmes (see section 5.8.2 for context). This chapter now turns to a discussion of the key results identified when developing the POHCAAT.

7.3 Barriers to Non-Technical Skills and Negative culture

Although the scoping review identified difficulties associated with cardiac arrest management in general, there was limited information or studies that related to a paramedic managed OHCA. Directly linked to the behaviours of paramedics, a significant finding of this study was that there are several barriers to the effective use of NTS. As the POHCAAT needed to reliably assess the NTS of paramedics managing an OHCA, barriers to its use needed to be considered. This ensured that not only specific NTS were included but it also provided an in-depth understanding of how these barriers influence team performance and how it can be improved.

The results from this study reflect those identified by Miller (2015), including low confidence levels when working in teams, ineffective leadership, and poor communication. Although details were limited, there was a recognition that teams are inconsistent, with a lack of a clear leader, and higher levels of confidence when performing practised clinical skills.

The results of this study expand on this, providing an in-depth explanation, and a greater understanding of these issues. This includes the identification of the theme of negative culture, which appears to stem from perceptions of egotistical behaviour and low confidence levels that were associated with limited experience and OHCA exposure. Although both themes are not strictly considered as NTS but perhaps relate more to the ability to cope with a range of behaviours, the identification signified the importance of producing a taxonomy that accounted for these difficulties.

In relation to the context of an OHCA, the unscheduled and unpredictable nature increases the challenges of working as an effective team. A typical ambulance response includes an unfamiliar ad hoc team, varied in size and with staggered arrival times, resulting in structural problems. Although the questionnaire data indicated that a leader is required, there were several barriers to effecting this. A key finding was the influence that team formation and structure has on the ability to work as an effective team. The varied response times result in a difficulty in allocating a leader and subsequent coordination of a team. Paramedics are used to working in teams of two (Dagnell, 2020), and comments from the theme of negative culture included that some paramedics try to lead the arrest yet are perceived by the rest of the team to have an authoritarian style, resulting in personality clashes and poor teamwork. Comments indicated that there was an assumption that the first paramedic on scene was the leader and that this resulted in ineffective leadership due to subsequent task overload, as the paramedic leading was responsible for performing a range of clinical interventions.

This lack of leadership and difficulties associated with unfamiliar ad hoc teams appeared to negatively influence the use of NTS and team performance. Although similar issues were identified from the literature about in hospital-based cardiac arrest teams (Andersen et al., 2010), the unpredictable nature of an OHCA accentuates these barriers. The nuances of an OHCA, such as the limited space, noisy environments, and the sometimes-public nature appears to heighten teamwork and communication difficulties.

The textual data provided an explanation to why there were perceived difficulties with leadership and communication. A significant finding was the low exposure rates of an OHCA and different training routes that result in a difference in knowledge of clinical algorithms and equipment. There was the indication that this was associated with low levels of confidence, task overload and difficulty in challenging others. Perhaps an expected finding was that those participants who expressed lower levels of confidence indicated a preference to follow rather than lead. However, there were noted comments about poor leadership styles and egotistical behaviour from all participants. This suggests that there may be a lack of leadership training within the ambulance trust for those paramedics working on an operational ambulance, rather than in a specialist role such as Hazardous Area Response Teams or HEMS (National Ambulance Resilience Unit, n.d.; BMJ, 2010). The implications of this add weight to the inclusion of the POHCAAT in paramedic training and education, as leadership training alone may not be beneficial for all personality types.

Confidence levels and the aspects of negative culture such as trust, personality and tacit knowledge can be further explained by the relatively low operational ambulance paramedic retention rates (National Audit Office, 2017). When coupled with low OHCA rates (McClelland et al., 2016; Dyson et al., 2016), the Dunning-Kruger effect (Dunning, 2011) may provide some explanation. It was suggested that some paramedics who were perceived as more experienced, demonstrated an overestimation in their knowledge and competence. Participants insinuated that qualified paramedics, typically those with rank, were overconfident displayed egotistical traits, resulting in poor leadership, communication, and teamwork. This highlighted the differences in team dynamics, supporting the need to account for leadership and followership, resulting in a key finding of the NTS category of team coordination.

Difficulties within OHCA teams were not entirely unexpected, as previous literature has identified similar problems, although not in such detail (Clarke et al., 2014; Miller, 2015). The complexities of working in an unfamiliar, ad hoc team, in different settings with varied patient presentations explained and supported the need for specific NTS that incorporated the key issues of leadership, followership, communication, and teamwork. The emergent themes of barriers to NTS and negative culture emphasised the need for a BMS that could provide structured feedback for student and qualified paramedics when practising a simulated OHCA, to improve their ability when working in unfamiliar ad hoc teams, regardless of their role or experience.

7.4 Non-Technical Skill Specific to an Out-of-Hospital Cardiac Arrest

Having explained the influence of barriers to effective NTS associated with managing an OHCA, this section discusses how the four specific NTS categories of team coordination, communication, situation assessment, and decision-making, were identified. Their inclusion as a taxonomy initially stems from the results of the scoping review. Although it has been ascertained that an OHCA is different to an in-hospital cardiac arrest, previous studies have highlighted similar difficulties with communication and leadership (Andersen et al., 2010; Hunziker et al., 2011; Fernandez Castelao et al., 2015). Despite the literature indicating that a team leader is both needed and beneficial in cardiac arrest management (Tschan et al., 2006; von Wyl et al., 2009; Andersen et al., 2010; Fernandez Castelao et al., 2013; Lowe et al., 2016), the allocation of a leader is difficult in an OHCA, with less experienced paramedics preferring to take on the role of a follower. These results add meaning to the preference to the category of team coordination, as it combined elements of leadership such as task delegation and support with followership and teamwork. As a NTS category, it incorporated the identified role changes as result of the evolving team and provided a method to assess paramedics whether leading or following as a result of being less confident or less experienced.

Although teamwork was not included as a specific NTS, it is intrinsically linked with team coordination as this accounts for structure and performance (Ji & Yan, 2020). The challenges identified by Miller (2015) included ineffective teamwork and this can be explained by the suggestion that paramedics can become overloaded, resulting in cognitive freeze and difficulty in actively listening, resulting in a breakdown in effective teamwork (Gabr, 2019). Comments from the semi-structured interviews of SME (see chapter five, section 5.5) signified that when paramedics attended an OHCA, they placed a focus on clinical tasks, indicating that paramedics are reactive rather than responsive, limiting task and role delegation.

It appears paramedics attempt to perform clinical interventions and manage the OHCA simultaneously, which can be explained by the unfamiliarity of teams and limited team numbers. This can be linked to cognitive processing, with clinical interventions and leadership resulting in parallel stimuli, increasing the level and complexity of workload (McClelland et al., 1986). With multiple tasks resulting in a high workload, team performance can be related to the difficulty experienced by paramedics when performing a task. The resulting effort required to complete a clinical intervention is dependent on the capability of the paramedic and context of the OHCA (Cain, 2007; Diaz-Vilela et al., 2015). Reflected in focus group comments, the low levels of confidence, and limited knowledge of algorithms and equipment influenced a paramedic's ability to work effectively.

As teams are often unfamiliar and formed on an ad hoc basis there was a clear indication that roles, tasks, and decisions are assumed, which was more noticeable in larger teams. Yet an interesting note was that where teams were familiar, regardless of size, team coordination and performance were considered as better. This could be explained by the fact that familiar teams possess increased levels of trust, communication, and coordination (Maynard et al., 2019).

It was interpreted that paramedics value familiarity, not only with each other but also with procedures and equipment. This has been understood to reduce error often contributed to by assumption (O'Daniel & Rosenstein, 2008). A key example of error that can be associated with task assumption is that of paramedic intubation. This clinical skill consists of inserting a tube into a patient's airway to aid ventilation but has been associated with harm such as 'unrecognised esophageal intubation, lengthy pauses in chest compressions, and overventilation' (Benger et al., 2018, pp.788). Comments in this study emphasised that responding to an OHCA is uncommon, resulting in high levels of concentration for clinical tasks, with the ''assumption that everyone knows what is going on'' (see table 4.6). As OHCA exposure rates remain low, team formation and size is varied, and with many teams unfamiliar, there is an emphasis on educational and training needs to improve the use of NTS when managing an OHCA. This accentuates the finding that there is a need for a specific BMS to assess NTS, as although clinical skills are assessed within paramedic education programmes there is a limited focus on the cognitive and social aspects (Bennett et al., 2020).

An interesting result was the identification of situation assessment as a specific NTS. Described as the result of task focus, overload and a lack of leadership, participants identified that tasks and roles within an OHCA are often assumed. This suggests that paramedics do not achieve a state of 'knowing what is going on around us' (Flin et al., 2015, pp. 17) and there was a need to focus on situation assessment.

Previously discussed in chapters four and five, it was apparent that paramedics focus on the patient and the application of clinical algorithms with limited understanding and anticipation, which is interpreted as poor situation awareness. This focus identified a need to concentrate on the processes needed to achieve an appropriate state of situation awareness.

Although many other healthcare BMS include situation awareness as an individual NTS category (Fletcher et al., 2003; Yule et al., 2008; Flowerdew et al., 2012; Mitchell et al., 2012; Myers et al., 2016) the inclusion of situation assessment in the POHCAAT, can be further explained by the work of Hunter et al. (2021). They concluded that student paramedics lacked situation awareness, and although their simulated scenarios did not include an OHCA, some of their results were comparable to those identified in the textual data from this study. Themes from Hunter et al. (2021) included an organised approach, tunnel vision, stress, and urgency. These findings reflected the difficulties of low exposure rates and limited experience associated with managing an OHCA identified in this study.

It was recognised that the use of student paramedics as participants in the questionnaire and focus groups might have resulted in comments that were informed by a limited understanding of situation awareness. However, when comments were compared during analysis between the research and design phases, qualified paramedics and subject matter experts provided similar comments, suggesting that it is the low exposure rates and unpredictable nature of an OHCA that appears to influence the ability to be situationally aware. This emphasised the need to focus the processes rather than a state of awareness.

When compared to other healthcare BMS (Fletcher et al., 2003; Yule et al., 2006; Holly et al., 2017), the other NTS categories are comparable. Despite the recognition that decisions are influenced by clinical algorithms, comments suggested that decision-making varies and is influenced by knowledge. As an OHCA requires a team approach to achieve safe and effective resuscitation, the inclusion of decision-making aimed to ensure that all options are considered by the team, and not based on an individual's interpretation of the clinical algorithm.

Although communication is not commonly included as an individual NTS category in other healthcare BMS, its inclusion in the POHCAAT was based on the need for effective and adaptable communication methods. As an OHCA is emotive, often involving relatives, bystanders, and other emergency services (Mion et al., 2021) there was a need to assess and provide feedback on effective communication. The level of importance applied to it as an individual and specific NTS was emphasised by the frequent and specific comments provided by each participant. The included NTS were not intended to be evaluated as individual NTS but must be considered as a complete set that aim to improve team performance in a paramedic managed OHCA.

Apart from the BMS designed by Myers et al. (2016) and Holly et al. (2017), all other healthcare BMS are designed for teams working in a controlled environment, with increased clinical support and larger teams. The textual data in this study highlighted the difficulties associated with managing an OHCA, with limited support available, and teams dependent on the availability of other clinicians (Fisher, 2020). As a BMS aims to enhance safety, team performance, and therefore patient care and outcomes, the POHCAAT needed to include observable NTS that complement technical skills (Higham et al., 2019).

As a complete study, it has provided data to support the inclusion of the specific NTS and their associated elements, resulting in a prototype BMS. Having discussed the NTS included in the POHCAAT, the next part of this section will discuss the evaluation stages.

7.5 Evaluation of the POHCAAT

As previously explained, a BMS needs to provide an accurate and reliable assessment of NTS to identify areas of strength and weakness, to improve individual and therefore team performance. As chapter six has already provided a discussion of the evaluation stages, this section presents the notable results in comparison to other BMS.

Noted as a limitation in the development of the ANTS-AP (Rutherford, 2015), the use of two separate evaluation stages allowed an opportunity for calibration, necessary as novice raters were used. Although the preliminary results were acceptable, feedback provided clear areas for improvement. A key issue of the preliminary evaluation was the use of existing films of student paramedic advanced life support objective structured clinical examinations. This resulted in difficulty in observing a range of behaviours, with students relying on the assessor for information. The lack of a realistic simulated scenario also influenced students' performance and behaviours, resulting in a somewhat staged response. This partially explains why raters appeared to have difficulty in differentiating between similar levels of behaviour. This can be further explained as although raters were experiences clinicians, they were considered as novice raters, and the challenges of providing a workshop for training resulted in limited training time. Due to work and personal commitments, although the raters were provided with a day of training, this was shorter than recommended (Klampfer et al., 2001). It also had to incorporate the evaluation of five films, shortening the training period. Yet, with an aim to incorporate the POHCAAT into student paramedic education programmes, rater training for teaching staff could be delivered over a longer period, with observation built into taught sessions, expanding the number of simulated OHCA scenarios, and assisting with rater calibration.

The relatively small number of raters and films were also a concern; however, the results were promising. Despite less raters and observed films used when compared to other BMS (Rutherford, 2015; Myers et al., 2016; Holly et al., 2017), the inclusion of a secondary, final evaluation stage allowed for modifications to be made. Although logistically challenging, perhaps the most important change was the use of live, realistic simulated OHCA scenarios. In removing the assessor from the simulation, this improved the student’s reactions and subsequent observable behaviours. As the POHCAAT was designed to evaluate student and qualified paramedics NTS when managing a simulated OHCA, its design needed to ensure raters could distinguish between a range of naturally occurring behaviours. Although students were briefed, this was limited, and the students identified for rater observation were chosen for their known strengths and weaknesses in OHCA management.

This removed the reliance on a specific briefing and allowed students to act more naturally. The use of a final evaluation stage provided improved results and appeared to outweigh the limitations such as the small rater sample, limited training, and limited experience of some raters. The final results were pleasing, as it appears the POHCAAT, when used in a simulated environment, with varied raters, can reliably evaluate the non-technical skills of paramedics managing an out-of-hospital cardiac arrest. These recognised difficulties inform the future use of the POHCAAT, primarily designed for a simulated environment as an observational feedback tool, it's use in a realistic but not necessarily high-fidelity scenario, with a mix of online and face-to-face training is possible and use as a learning tool for student paramedics and as part of CPD for qualified paramedics is plausible.

In relation to other healthcare BMS, the statistical results are comparable and encouraging. However, like any new BMS there are practical implications, and it is unknown if its use could improve patient outcome. It is recognised that the sample sizes and number of observed simulations was less than other BMS (Fletcher et al., 2003; Yule et al., 2006; Rutherford, 2015). There was a reliance on the use of HEMS doctors and paramedics to act as raters and despite the expansion of this speciality (Royal College of Surgeons of Edinburgh, 2021), the availability of participants was limited. However, it is noted that not all BMS developed for healthcare include an evaluation stage (Mellanby, 2015) and as a prototype BMS, further analysis is recommended to explore its practical value.

The use of increased sample sizes and inclusion in undergraduate and apprentice paramedic programmes may provide further data on its application to practice.

7.6 Limitations

Like all areas of research, limitations were noted in this study, in particular the specificity of the subject. The need to identify NTS to develop the POHCAAT resulted in a large-scale study, primarily undertaken by the lead researcher on a part time basis, with time constraints. As specific limitations have been discussed in the previous chapters this section will focus on the key limitations of the specificity of participants, the small numbers of raters and difficulty in identifying suitable observation material.

As a newly developed BMS in an under researched area, the prototype was developed using a range of student and qualified paramedics and this may have resulted in bias due to the position of the lead researcher, as some participants were students and other colleagues. Although effort was made to reduce the risk of the researcher's positionality, the fact remains that participants in all phases could have influenced the direction of the research and potentially the outcomes. However, the use of raters from other HEMS and education institutions, and the removal of the raters and the lead researcher from the simulated environments provided distance, with good results.

It is probable that it was not possible to capture a complete range of experiences and it was evident that education on NTS is limited, which possibly influenced the results. Low exposure rates to an OHCA have been recognised and it is unknown if the passage of time impaired participants ability to accurately recall events (Mechera-Ostrovsky & Gluth, 2018). Challenges in recruiting adequate sample sizes may be explained by the continuing need to develop a culture of research in prehospital practice (Pocock et al., 2016). Recruiting adequate numbers of raters was hindered by entry requirements, such as formal training in NTS, human factors or crew resource management (Flin et al., 2015). This limited the available pool of suitable raters as only HEMS units provide regular accredited training in elements of human factors. Although human factors is gaining momentum within healthcare, it appears to be poorly interpreted by some paramedics, with a focus on NTS rather than the organisational socio-technical system (Clinical Human Factors Group, n.d.). This lack of understanding may have resulted in bias and difficulty in observation. However, the raters used had a range of experiences and backgrounds, and despite all considered as novice raters, due their very limited previous use of BMS, the evaluation indicated that the POHCAAT was usable and produced reliable and consistent results.

As part of the ethical approval process, the stipulation of using existing recorded objective structured clinical observations (OSCE) of paramedic managed OHCA scenarios clearly hindered raters ability to observe behaviours. Although the preliminary evaluation statistical results were reasonable, the qualitative aspect of this phase identified a ‘stuttered approach’ in each film as a result of the participants relying on a member of the teaching team for direction, common with an OSCE. This was considered as problematic, as observing each NTS was difficult. However, this identification was only highlighted due to the study design. This indicated that the use of realistic simulated scenarios was essential to the final evaluation to provide a safe, controlled, and standardised environment in which to assess NTS (Hunziker et al., 2011).

Despite the use of realistic simulated OHCA scenarios and improvements to the design of the POHCAAT, a key limitation of the final evaluation was still the use of simulated scenarios. The preliminary evaluation resulted in difficulties observing a range of behaviours with 'actors' not behaving as they would in a real-life OHCA. In an attempt to make the final evaluation as realistic as possible, the use of manikins and a simulated bedroom still restricted the scenarios and perhaps did not recreate the same levels of stress or emotion when compared to an actual OHCA. The use of the simulation house resulted in one environment, and it is recognised that different situations, mannequin types and locations may evoke different behaviours. However, the POHCAAT performed well when used in a realistic simulated environment and is supported by the suggestion that 'teamwork studies conducted in simulation settings generalise to real life settings in acute care' (Schmutz et al., 2019, pp 13).

Despite these promising results, questions remain. As the POHCAAT was evaluated in a simulated setting over a short period, it is unknown if its use in simulated education environments or a real-life OHCA would have an influence on clinical outcomes, such as ROSC rates. However, it would be logistically and ethically difficult, as well as inappropriate, to evaluate in an actual real-life OHCA. Although the use of body worn cameras by paramedics is increasing (College of Paramedics, 2021) and recordings have been considered as a method to enhance feedback for OHCA teams (Lowe et al., 2017), challenges include the sensitive nature of an OHCA, data protection issues including consent and anonymity, as well as access to confidential material.

It was felt that evaluating the POHCAAT in a real-life OHCA would have been inappropriate and beyond the capacity of this study. However, the findings support that the POHCAAT is a reliable, valid, and usable BMS for assessing paramedic's NTS when managing a simulated OHCA, which has the benefit of being used across a range of education institutions and ambulance trust training centres as part of initial and ongoing learning for paramedics.

7.7 Recommendations for Research and Education

A key strength of this study was the overall design, with a mix of data collected, analysed, and then integrated to produce a reliable, valid, and usable BMS. Moving forward, although this study has produced a BMS that can be used by student and qualified paramedics in a simulated environment, further research that considers the variables of rater experience, training, and simulated environments, will need to be undertaken. The use of the POCHAAT can be divided into two areas: research and education.

7.7.1 Research

Recommendations for research include the further exploration and evaluation of the POHCAAT as part of undergraduate paramedic and ambulance trust training programmes. This would allow for a larger sample of differentiated participants (UG full time student paramedics and ambulance trust employees – AAPs and qualified paramedics) and a greater variety of raters (educators and ambulance training officers) that would provide a comparison between student and qualified paramedics. Designed as an observational feedback tool, specific to a simulated paramedic managed OHCA, this research would expand the use of the POHCAAT into ambulance trusts as a training and learning tool that can be used in initial Associate Ambulance Practitioner (AAP) training and as part of ongoing CPD training.

It is recognised that this would be logistically challenging and require assent from higher education institutions, and ambulance trusts. However, the use of the POHCAAT within an operational ambulance hub as part of CPD training, would allow the ability to review ambulance OHCA data, pre and post POHCAAT implementation to understand if its use has an influence on paramedic managed OHCA and patient data, including incidences of ROSC and time on scene/transport to hospital. The use of a cohort study design is potentially applicable, as this could incorporate a pre and post training and assessment phases to provide a clear delineation for OHCA clinical data analysis. As an area of further research, the aim would be to evaluate the POHCAAT on a larger scale as part of university education paramedic programmes and as part of ambulance trust CPD training. An additional outcome includes the analysis of ambulance OHCA data to explore if there is any difference in ROSC rates and to examine qualified paramedics experiences of managing an OHCA following training using the POHCAAT.

7.7.2 Education

From an educational view, there are two strands: rater training and use of the POHCAAT as a learning/assessment tool. It is suggested that the further development of initial and ongoing rater training and education is needed, as not all raters would have the same level of operational experience or exposure rates of an OHCA as those who participated in this study. Despite the design and use of a face-to-face rater workshop within this study, in the context of an ambulance trust and CPD training, there may be limitations to the practical application of training, as participation would rely on operational staff undertaking training when not on shift, to ensure sufficient training is achieved.

However, the combination of a face-to-face workshop and online refresher training used for rater training in chapter six, demonstrated knowledge retention and a good level of usability, and this could be a viable method for the delivery of initial and ongoing training of raters on a larger scale. It is acknowledged that the lead researcher delivered the rater training for this study and this would not be a viable option for wider rater training. Therefore, the development of an educational package, including a handbook for novice raters with limited operational experience would need input from previous participants to enhance the current training workshop and online package, ensuring it could be used and delivered by those less experienced and familiar with the POHCAAT than the lead researcher.

The use of the POHCAAT as an assessment/learning tool is perhaps more straightforward. As the lead researcher is employed as a university senior lecturer in paramedic science, its inclusion into the current undergraduate paramedic programme is supported. The inclusion of the POHCAAT into lectures as an example of NTS used within a practice area has already been completed. Its use as a formative feedback tool as part of ALS assessments is planned when the new academic year starts, as it is envisioned that this will enhance student paramedics' use and understanding of NTS when managing a simulated OHCA. As the lead researcher has presented the development of the POHCAAT in the UK and North America throughout the study, there is also interest from other education institutions to incorporate the POCHAAT into existing paramedic programmes, emphasising the need for an easy to use and clear rater-training package.

As presented in the design context (see section 5.8.2) an intended use of the POHCAAT is as a peer-to-peer method to provide formative feedback for student paramedics. It is planned to train final year BSc student paramedics as raters to support other students as they practice OHCA in a simulated scenario. This would strengthen the knowledge and understanding of students acting as raters and provide an opportunity for them to demonstrate their ability to mentor and assess others as they transition to qualified, HCPC registered paramedics.

7.8 Implications and Recommendations for Practice

Raters confirmed that the POHCAAT is applicable to paramedic practice (see section 6.9.7.3) as its use in simulated environments reflected the NTS specific to a real-life paramedic managed OHCA. The results of this study present a new reliable, valid, and usable BMS, with a realistic potential for it to inform the management of a paramedic managed OHCA as part of ongoing paramedic education programmes and CPD requirements. It has the capacity to be incorporated into university paramedic programmes as part of ALS education, training, and assessment, with student participants indicating that they found it was a useful feedback method in addition to their clinical skills training. Recommendations for use include the addition of the POHCAAT into the next Resuscitation Council (UK) education guidelines and the UK Ambulance Service Clinical Practice Guidelines, with the aim to increase the use and understanding of paramedic NTS, specific to an OHCA, thus strengthening the fourth part of the chain of survival, the delivery of effective ALS. This is especially relevant as current resuscitation guidelines and paramedic curriculum guidance all advocate the use of NTS in an OHCA but focus on dated in-hospital literature, and do not include the identification of specific OHCA NTS. As a learning and assessment tool for student paramedics it is recommended the POHCAAT should be integrated into undergraduate university paramedic programmes, forming part of both formative and summative assessments for modules that already teach leadership, decision-making and ALS.

Although it is unknown if the POHCAAT can influence actual paramedic managed OHCA or patient outcomes, these could be evaluated in the form of ROSC rates, reduced on scene times with appropriate transportation of patients to hospital, and a review of associated adverse OHCA incidents from ambulance trusts that adopt the POHCAAT. Based on the results of this study it appears the POHCAAT has the potential to improve individuals' understanding and use of NTS specific to an OHCA, and have a positive influence on a paramedic managed OHCA.

7.9 Summary

This chapter has offered a response to the final objective of this study: provide recommendations for the use of a paramedic OHCA BMS. It is recommended that the POHCAAT should be used as part of the training and education of student and qualified paramedics, firstly in a university setting incorporated into undergraduate paramedic programmes. This would result in a natural progression to this study, providing an evaluation of the POHCAAT on a larger scale, which would address some of the limitations previously identified. Initially included as part of ALS teaching, the POHCAAT would help to provide a holistic understanding of how to effectively manage an OHCA. A further recommendation is a greater focus on the use of the POHCAAT in the context of an operational ambulance setting, with its inclusion in ambulance trust training programmes and CPD sessions that use simulated OHCA scenarios to teach and assess ALS. This has the potential to produce interesting findings that account for a wider range of experiences and would help to establish a greater degree of accuracy on team performance.

To conclude this chapter, it has presented a discussion of the key findings and how they relate to the literature, other BMS and the context of paramedic managed OHCA. Although the barriers to the use of NTS and challenges of managing an OHCA were expected, the level of detail and significant influence that an unfamiliar ad hoc team has on team performance was unanticipated. As staff retention rates and OHCA exposure rates remain low, the identified barriers strengthen the need for a suitable training and assessment method. In summary, the identification of a specific NTS taxonomy has informed the development of a reliable BMS, capable of assessing paramedic management of an OHCA in simulated setting. The next chapter provides a final summary of the entire study, including recommendations for further research and changes to practice.

Chapter 8 - Conclusion

The research presented in this thesis has investigated and established the importance of effective non-technical skills (NTS) and their use by paramedics when managing an out-of-hospital cardiac arrest (OHCA). The rationale for this study was based on the limited associated literature and national resuscitation guidance that advises the use of NTS in an OHCA to enhance patient safety and effective management. However, until this study the NTS specific to a paramedic managed OHCA were unclear, and no method of assessment or feedback for student or qualified paramedics existed. The scoping review confirmed a gap in the research and resulted in the question 'Can a behavioural marker system reliably evaluate the non-technical skills of paramedics managing an out-of-hospital cardiac arrest?'. This final chapter presents a conclusion to the study and consists of a summary of the findings associated with the research aim and objectives before presenting the contribution to research.

8.1 Summary of Findings Associated with the Research Aim

Within the chain of survival, importance has been rightly placed on the early recognition of an OHCA, and bystander CPR. However, the effective delivery of advanced life support (ALS) is critical to strengthening the complete chain. Chapter one established that ALS is not always effective and that a poorly performing team can affect the fourth link in the chain of survival. Critical to patient care and outcomes it was clear that this link needed strengthening. After reviewing other areas of healthcare, including anaesthetics and emergency medicine, it was identified that a BMS provides teams with an effective system to enhance safety and achieve high levels of performance. The identification of limited supporting literature and barriers critical to effective NTS emphasised the challenges faced by paramedics when managing an OHCA. This reinforced the need to develop a BMS specific to a paramedic managed OHCA.

The aim of this study was to develop a reliable, valid, and usable BMS to assess the NTS used by paramedics when managing OHCA. Supported by four objectives (see section 1.1), it has sought to answer the research question, by identifying and validating four specific NTS, before evaluating the prototype BMS. This has resulted in an in-depth understanding of the challenges faced by paramedics when managing an OHCA and the design of a BMS applicable to use in a simulated environment by both student and qualified paramedics.

This study has confirmed that the unpredictability of an OHCA, low levels of exposure and varied experience of paramedics result in challenges when managing an OHCA. It has established in chapter one (see section 1.4) that training and education in NTS for paramedics is limited, as well as identifying that not all paramedics have the same level of knowledge or understanding of clinical algorithms and equipment. As the study progressed, greater emphasis was placed on the gap in the knowledge base of paramedics.

Based on the statistical results and textual data the research question can be answered. The results reveal that the POHCAAT is not only reliable and valid, but it is also suitable to assess both student and qualified paramedics NTS when managing a simulated OHCA. Although it is recognised that the POHCAAT has only been tested in a simulated environment, the textual data indicates that its use and design is highly applicable to practice. The NTS categories reflect the fluid nature of an OHCA, and it has provided an appropriate system to assess NTS to deliver feedback on individual NTS. It is hoped that the use of the POHCAAT can improve team integration and performance, when used as an assessment and learning tool with the potential to influence patient outcomes, such as increased ROSC rates.

8.2 Final Conclusion and Contribution to Research

This study has contributed to an area of research previously considered as deficient. It has resulted in the development of an original, structured, reliable, valid, and usable BMS specific to assessing a simulated paramedic managed OHCA. The issue of improving team performance when managing an OHCA is an intriguing one, and this study has achieved a greater understanding of specific NTS, the associated challenges of managing an OHCA and the design of the POHCAAT, which has the potential to positively influence patient care and even outcomes that can be explored with further research.

Reference List

Ågård, A., Herlitz, J., Castrén, M., Jonsson, L., & Sandman, L. (2012). Guidance for ambulance personnel on decisions and situations related to out-of-hospital CPR. *Resuscitation, 83*(1), 27-31.

Agbo, A. A. (2010). Cronbach's Alpha: Review of Limitations and Associated Recommendations. *Journal of Psychology in Africa, 20*(2), 233-239. https://doi:10.1080/14330237.2010.10820371

Allen, I. E, & Seaman, C. A. (2007). Likert Scales and Data Analyses. *Quality Progress, 40*(7), 64–65.

American Heart Association. (2021). *Out-of-hospital Chain of Survival.* https://cpr.heart.org/en/resources/cpr-facts-and-stats/out-of-hospital-chain-of-survival

Andersen, P. O., Jensen, M. K., Lippert, A., & Østergaard, D. (2010). Identifying non-technical skills and barriers for improvement of teamwork in cardiac arrest teams. *Resuscitation, 81*(6), 695–702. https://doi.org/10.1016/j.resuscitation.2010.01.024

Anderson, N. E., Gott, M., & Slark, J. (2018). Grey areas: New Zealand ambulance personnel's experiences of challenging resuscitation decision-making. *International Emergency Nursing, 39*, 62–67. https://doi.org/10.1016/j.ienj.2017.08.002

Arksey, H., & O'Malley, L. (2005). Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology, 8*(1), 19-32. https://doi:10.1080/1364557032000119616

Armitage, A. (2007, September 5-8). *Mutual Research Designs: Redefining Mixed Methods Research Design* [Paper presentation]. British Educational Research Association Annual Conference, Institute of Education, University of London. http://www.leeds.ac.uk/educol/documents/167799.htm

Bakeman, R., & Quera, V. (2011). *Sequential analysis and observational methods for the behavioural sciences*. Cambridge University Press.

Barchard, K. A. (2012). Internal Consistency Reliability. In N. J. Salkind (Ed.) *Encyclopaedia of Research Design*. (pp. 616-619). Sage Publications, Inc.

Barrett, J., Gifford, C., Morey, J., Risser, D. & Salisbury, M. (2001). Enhancing patient safety through teamwork training. *Journal of Healthcare Risk Management, 21*(4), 61-69. https://doi.org/10.1002/jhrm.5600210410

Baumann, N. (2016). How to use the medical subject headings (MeSH). *International Journal of Clinical Practice, 70*(2), 171-174. https://doi.org/10.1111/ijcp.12767

Bayley, R., Weinger, M., Meador, S., & Slovis, C. (2008). Impact of Ambulance Crew Configuration on Simulated Cardiac Arrest Resuscitation. *Prehospital Emergency Care, 12*(1), 62-68. https://doi.org/10.1080/10903120701708011

Beaubien, M., Baker, D. and Salvaggio, A. (2004) Improving the construct validity of line operational simulation ratings: Lessons learned from the assessment center. *International Journal of Aviation Psychology, 14*(1), 1-17.

Benger, J. R., Kirby, K., Black, S., Brett, S. J., Clout, M., Lazaroo, M. J., Nolan, J. P., Reeves, B. C., Robinson, M., Scott, L. J., Smartt, H., South, A., Stokes, E. A., Taylor, J., Thomas, M., Voss, S., Wordsworth, S., & Rogers, C. A. (2018). Effect of a Strategy of a Supraglottic Airway Device vs Tracheal Intubation During Out-of-Hospital Cardiac Arrest on Functional Outcome: The AIRWAYS-2 Randomized Clinical Trial. *JAMA, 320*(8), 779–791. https://doi.org/10.1001/jama.2018.11597

Bennett, R., Mehmed, N., & Williams, B. (2020). Non-technical skills in paramedicine: A scoping review. *Nursing and Health Sciences, 23*(1), 40-52.

Berchtold, A. (2016). Test–retest: Agreement or reliability?. *Methodological Innovations, 9*, 1-7. https://doi:10.1177/2059799116672875

Bergman, M. M. (1998). A Theoretical Note on the Differences Between Attitudes, Opinions, and Values. *Swiss Political Science Review, 4*(2): 81-93.

Berry, W. D., & Feldman, S. (1985). *Multiple regression in practice*. Sage Publications, Inc. https://www.doi.org/10.4135/9781412985208

BMJ. (2010). *HEMS helicopter crew course*. https://doi.org/10.1136/bmj.c3559

Brandling, J., Kirby, K., Black, S., Voss, S., & Benger, J. (2016). Paramedic Resuscitation Decision-Making in Out of Hospital Cardiac Arrest: An Exploratory Study. *Emergency Medicine Journal, 33*(9), e11.3-e12.

Brandling, J., Kirby, K., Black, S., Voss, S., & Benger, J. (2017). Emergency medical service provider decision-making in out of hospital cardiac arrest: an exploratory study. *BMC emergency medicine, 17*(1), 24. https://doi.org/10.1186/s12873-017-0136-3

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101.

British Heart Foundation. (n.d.). *Watch: What's the difference between a heart attack and a cardiac arrest?.* https://www.bhf.org.uk/informationsupport/heart-matters-magazine/medical/heart-attack-and-cardiac-arrest

Brooks, J., McCluskey, S., Turley, E., & King, N. (2015). The Utility of Template Analysis in Qualitative Psychology Research. *Qualitative research in psychology, 12*(2), 202–222. https://doi.org/10.1080/14780887.2014.955224

Bryman, A. (2006). Integrating quantitative and qualitative research: how is it done? *Qualitative Research, 6*(1), 97–113.

Bujang, M., A., & Baharum, N. (2017). A simplified guide to determination of sample size requirements for estimating the value of intraclass correlation coefficient: A review. *Archives of Orofacial Sciences, 12*(1), 1-11.

Cain, B. (2007). *A Review of the Mental Workload Literature*. Defence Research and Development Canada Toronto. https://apps.dtic.mil/sti/pdfs/ADA474193.pdf

Catchpole, K. R., de Leval, M. R., McEwan, A., Pigott, N., Elliott, M. J., McQuillan, A., MacDonald, C., & Goldman, A. J. (2007). Patient handover from surgery to intensive care: using Formula 1 pit-stop and aviation models to improve safety and quality. *Paediatric anaesthesia, 17*(5), 470–478. https://doi.org/10.1111/j.1460-9592.2006.02239.x

Catchpole, K., Sellers, R., Goldman, A., McCulloch, P., & Hignett, S. (2010). Patient handovers within the hospital: translating knowledge from motor racing to healthcare. *Quality & safety in health care, 19*(4), 318–322. https://doi.org/10.1136/qshc.2009.026542

Chiu, C. J. (2014). *Development and Validation of Performance Assessment Tools for Interprofessional Communication and Teamwork (PACT)* (Unpublished doctoral thesis]. University of Washington.

Chyung, S.Y., Roberts, K., Swanson, I., & Hankinson, A. (2017). Evidence-Based Survey Design: The Use of a Midpoint on the Likert Scale. *Performance Improvement, 56*(10), 15-23.

Clarke, S., Lyon, R. M., Short, S., Crookston, C., & Clegg, G. R. (2014). A specialist, second-tier response to out-of-hospital cardiac arrest: setting up TOPCAT2. *Emergency Medicine Journal, 31*(5), 405–407. https://doi.org/10.1136/emermed-2012-202232

Clinical Human Factors Group. (n.d.). *What are clinical human factors?.* https://chfg.org/what-are-clinical-human-factors/

College of Paramedics. (2019a). *Become a Paramedic.* https://www.collegeofparamedics.co.uk/COP/Become_a_Paramedic/COP/BecomeAParamedic/Become_a_Paramedic.aspx?hkey=f10838de-b67f-44a0-83b7-8140d8cdba83

College of Paramedics. (2019b). *Paramedic Curriculum Guidance. 5th Edition.* https://collegeofparamedics.co.uk/COP/ProfessionalDevelopment/Paramedic_Curriculum_Guidance.aspx

College of Paramedics. (2020). *Paramedic Career Framework 2020.* https://www.collegeofparamedics.co.uk/COP/Professional_development/interactive_career_framework/COP/ProfessionalDevelopment/Interactive_Career_Framework.aspx?hkey=5058228a-13ef-4d38-a7b0-255e6263c9f7

College of Paramedics. (2021). *Body Worn Cameras.* https://www.collegeofparamedics.co.uk/COP/Blog_Content/Body_Worn_Cameras.aspx

Colquitt, J., Walker, A., & Haney, N. (2017). *The In-hospital Implementation of the Pit Crew Resuscitation Model.* https://citizencpr.org/wp-content/uploads/2018/01/The-In-Hospital-Implementation-of-the-Pit-Crew-Resuscitation-Model.pdf

Cooper, S., Cant, R., Porter, J., Sellick, K., Somers, G., Kinsman, L., & Nestel, D. (2010b). Rating medical emergency teamwork performance: development of the Team Emergency Assessment Measure (TEAM). *Resuscitation, 81*(4), 446–452. https://doi.org/10.1016/j.resuscitation.2009.11.027

Cooper, S., Porter, J., & Endacott, R. (2010a). Mixed methods research: a design for emergency care research?. *Emergency Medicine Journal, 28*(8), 682-685.

Cooper, S., Cant, R., Connell, C., Sims, L., Porter, J. E., Symmons, M., Nestel, D., & Liaw, S. Y. (2016). Measuring teamwork performance: Validity testing of the

Team Emergency Assessment Measure (TEAM) with clinical resuscitation teams. *Resuscitation*, *101*, 97–101. https://doi.org/10.1016/j.resuscitation.2016.01.026

Cormack, S., Scott, S., & Stedmon, A. (2020a). Pitstops for paramedics. The Ergonomist, 576, 28-30.

Cormack, S., Scott, S., & Stedmon, A. (2020b). Non-technical skills in out-of-hospital cardiac arrest management: A scoping review. *Australasian Journal of Paramedicine, 17*. https://doi.org/10.33151/ajp.17.744

Coventry University. (2021). *Coventry University Simulation*. https://covunisim.coventry.domains/facilities/

Creswell, J. W. (2014). *Research Design* (4th ed.). Sage Publications, Inc.

Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research* (2nd ed.). Sage Publications, Inc.

Cronbach, L. J., & Meehl, P. E. (1955). Construct validity in psychological tests. *Psychological bulletin, 52*(4), 281–302. https://doi.org/10.1037/h0040957

Cummins, R. O. (1993). Emergency medical services and sudden cardiac arrest: the "chain of survival" concept. *Annual review of public health, 14*, 313–333. https://doi.org/10.1146/annurev.pu.14.050193.001525

Dagnell, A. (2020). Teamwork and leadership in out-of-hospital cardiac arrest – do these non-technical skills require attention?. *Australasian Journal of Paramedicine, 17*. https://doi.org/10.33151/ajp.17.748

Dancey, C. & Reidy, J. (2004). *Statistics without Maths for Psychology: using SPSS for Windows*. Prentice Hall.

Data Protection Act 1998, c.29, https://www.legislation.gov.uk/ukpga/1998/29/contents

Data Protection Act 2018, c.12. https://www.legislation.gov.uk/ukpga/2018/12/contents/enacted

Deakin, C., Brown, S., Jewkes, F., Lockey D., Lyon, R., Moore, F., Perkins, G. D., & Whitbread, M. (2015). *Prehospital Resuscitation.* https://www.resus.org.uk/resuscitation-guidelines/prehospital-resuscitation/

DeJonckheere, M., & Vaugh, L. M. (2019). Semistructured interviewing in primary care research: a balance of relationship and rigour. *Family Medicine and Community Health, 7,* e000057. https://doi:10.1136/fmch-2018-000057

National Quality Board. (2012*). Department of Health Human Factors Reference Group Interim Report, 1 March 2012.* http://www.england.nhs.uk/ourwork/pa rt-rel/nqb/ag-min/

DeVellis, R., F. (2012). *Scale Development: Theory and Applications* (3rd ed.). Sage Publications, Inc.

Diaz-Vilea. L. F., Rodriguez, N. D., Isla-Diaz. R., Diaz-Cabera. D., Hernandez-Fernaud. E., & Rosales-Sanchez. C. (2015). Relationships between Contextual and Task Performance and Interrater Agreement: Are there Any?. *PLOS one, 10*(10), 1-13.

Dietz, A. S., Pronovost, P. J., Benson, K. N., Mendez-Tellez, P. A., Dwyer, C., Wyskiel, R., & Rosen, M. A. (2014a). A systematic review of behavioural marker systems in healthcare: what do we know about their attributes, validity and application?.

BMJ quality and safety, 23(12), 1031–1039. https://doi.org/10.1136/bmjqs-2013-002457

Dietz, A. (2014b). *The Development and Testing of a Measurement System to Assess Intensive Care Unit Team Performance*. [Doctoral dissertation, University of Central Florida]. https://stars.library.ucf.edu/etd/4780

Douma, M. J., Ali, S., Bone, A., Dainty, K. N., Dennett, L., Smith, K. E., Frazer, K., & Kroll, T. (2021). The Needs of Families During Cardiac Arrest Care: A Survivor- and Family-led Scoping Review Protocol. *Journal of Emergency Nursing, 47*(5), 778-788.

Dunning, D. (2011). Chapter five - The Dunning–Kruger Effect: On Being Ignorant of One's Own Ignorance. In M. P. Zanna, P. Devine, J. M. Olson & A. Plant (Ed.) *Advances in Experimental Social Psychology* (pp. 247-296). Academic Press.

Dyson, K., Bray, J., Smith, K., Bernard, S., Straney, L., & Finn, J. (2015). Paramedic exposure to out-of-hospital cardiac arrest is rare and declining in Victoria, Australia. *Resuscitation, 89*, 93–98. https://doi.org/10.1016/j.resuscitation.2015.01.023

Dyson, K., Bray, J. E., Smith, K., Bernard, S., Straney, L. & Finn, J. (2016). Paramedic Exposure to Out-of-Hospital Cardiac Arrest Resuscitation Is Associated With Patient Survival. *Circulation: Cardiovascular Quality and Outcomes, 9*(2), 154-160.

Dwyer, S. C., & Buckle, J. L. (2009). The Space Between: On Being an Insider-Outsider in Qualitative Research. *International Journal of Qualitative Methods*, 54–63. https://doi.org/10.1177/160940690900800105

Eisenberg, M., Lippert, F.K., Shin, S. D., Bobrow, B., Castren, M., Moore, F., Ong, M., Rea, T., Steen, P. A., & Walker, T. (2015). *Improving Survival from Out-of-Hospital Cardiac Arrest: A Call to Establish a Global Resuscitation Alliance.* https://foundation915.files.wordpress.com/2016/07/a-call-to-establish-a-global-resuscitation-alliance-2016.pdf

Elfil, M. & Negida, A. (2017). Sampling methods in Clinical Research; an Educational Review. *Emergency 5*(1), e52.

Endsley, M. R. (1995). Toward a Theory of Situation Awareness in Dynamic Systems. *Human Factors, 37*(1), 32–64. https://doi.org/10.1518/001872095779049543

Engel, N., Patey, R. E., Ross, S., & Wisely, L. (2008). Non-technical skills. *Student BMJ, 16*, 454-455. https://doi.org/10.1136/sbmj.0812454

Farmer, T., Robinson, K., Elliott, S. J., & Elyes, J. (2006). Developing and Implementing a Triangulation Protocol for Qualitative Health Research. *Qualitative Health Research, 16*(3), 377–394. https://doi.org/10.1177/1049732305285708

Feilzer, M. Y. (2010). Doing Mixed Methods Research Pragmatically: Implications for the Rediscovery of Pragmatism as a Research Paradigm. *Journal of Mixed Methods Research, 4*(1), 6-16.

Fernandez Castelao, E., Boos, M., Ringer, C., Eich, C., & Russo, S. G. (2015). Effect of CRM team leader training on team performance and leadership behavior in simulated cardiac arrest scenarios: a prospective, randomized, controlled study. *BMC medical education*, *15*, 116. https://doi.org/10.1186/s12909-015-0389-z

Fernandez Castelao, E., Russo, S. G., Riethmüller, M., & Boos, M. (2013). Effects of team coordination during cardiopulmonary resuscitation: a systematic review of the literature. *Journal of critical care, 28*(4), 504–521. https://doi.org/10.1016/j.jcrc.2013.01.005

Fisher, R, M. (2020). Improving post-resuscitation care after out-of-hospital cardiac arrest. *Journal of Paramedic Practice 12*(1), 14-21.

Flanagan, J. C. (1954). The critical incident technique. *Psychological Bulletin, 51*(4), 327.

Fletcher, G. (2006). *Development of a Behavioural Marker System for Anaesthetists' Non-Technical Skills* [Doctoral thesis, University of Aberdeen]. EThOS. https://ethos.bl.uk/OrderDetails.do?uin=uk.bl.ethos.439988

Fletcher, G., Flin, R., McGeorge, P., Glavin, R., Maran, N., & Patey, R. (2003). Anaesthetists' non-technical skills (ANTS): Evaluation of a behavioural marker system. *British Journal of Anaesthesia, 90*(5), 580-588.

Flick, U. (2007). Concepts of triangulation. In U. Flick (Ed), *Managing quality in qualitative research* (pp. 38-54). Sage Publications, Ltd. https://www.doi.org/10.4135/9781849209441

Flin, R., & Maran, N. (2004). Identifying and training non-technical skills for teams in acute medicine. *British Medical Journal Quality & Safety, 13,* i80-i84.

Flin, R., & Martin, L. (2001). Behavioral markers for crew resource management: A review of current practice. *The International Journal of Aviation Psychology, 11*(1), 95–118. https://doi.org/10.1207/S15327108IJAP1101_6

Flin, R., O'Connor, P., & Crichton, M. (2015). *Safety at the Sharp End: A Guide to Non-Technical Skills*. CRC Press.

Flin, R., Patey, R., Glavin, R., & Maran, N. (2010). Anaesthetists' non-technical skills. *British Journal of Anaesthesia, 105*(1), 38–44.

Flin, R., Youngson, G. G., & Yule. (2016). *Enhancing Surgical Performance.* CRC Press.

Flowerdew, L., Brown, R., Vincent, C., & Woloshynowych, M. (2012). Development and validation of a tool to assess emergency physicians' nontechnical skills. *Annals of emergency medicine, 59*(5), 376–385.e4. https://doi.org/10.1016/j.annemergmed.2011.11.022

Freytag, J., Stroben, F., Hautz, W.E., Schauber, S. K., & Kämmer. (2019). Rating the quality of teamwork—a comparison of novice and expert ratings using the Team Emergency Assessment Measure (TEAM) in simulated emergencies. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine, 27*(12). https://doi.org/10.1186/s13049-019-0591-9

Friesen, P., Brown, L. H., Cabanas, J., Hinchey, P., & Remick, K. (2018). *The Pit Crew Model and Pediatric Cardiac Arrest.* EMS World. https://www.hmpgloballearningnetwork.com/site/emsworld/article/219579/pit-crew-model-and-pediatric-cardiac-arrest

Gaba, D. M., Howard, S. K., Flanagan, B., Smith, B. E., Fish, K. J., & Botney, R. (1998). Assessment of clinical performance during simulated crises using both technical and behavioral ratings. *Anesthesiology, 89*(1), 8–18. https://doi.org/10.1097/00000542-199807000-00005

Gabr, A, K. (2019). The importance of nontechnical skills in leading cardiopulmonary resuscitation teams. *The Journal of Royal College of Physicians Edinburgh, 49*(2), 112-116. https://doi.org/10.4997/JRCPE.2019.205

George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference.* https://wps.ablongman.com/wps/media/objects/385/394732/george4answers.pdf

Giavarina D. (2015). Understanding Bland Altman analysis. *Biochemia Medica, 25*(2), 141–151. https://doi.org/10.11613/BM.2015.015

Givati, A., Markham, C., & Street, K. (2018). The bargaining of professionalism in emergency care practice: NHS paramedics and higher education. Advances in health sciences education: theory and practice, 23(2), 353–369. https://doi.org/10.1007/s10459-017-9802-1

Gibbs, G. (2018). *Analyzing qualitative data* (2nd ed.). Sage Publications, Ltd. https://www.doi.org/10.4135/9781526441867

Girard, J. M., & Cohn, J. F. (2016). A Primer on Observational Measurement. *Assessment, 23*(4), 404-413. https://doi:10.1177/1073191116635807

Gold, L. S., & Eisenberg, M. S. (2009). The Effect of Paramedic Experience on Survival from Cardiac Arrest. *Prehospital Emergency Care, 13*(3), 341-344. https://doi:10.1080/10903120902935389

Goldkuhl, G. (2012). Pragmatism vs interpretivism in qualitative information systems research. *European Journal of Information Systems, 21*(2), 135-146.

Gonzales, L., Oyler, B. K., Hayes, J. L., Escott, M. E., Cabanas, J. G., Hinchey, P. R., & Brown, L. H. (2019). Out-of-hospital cardiac arrest outcomes with "pit crew" resuscitation and scripted initiation of mechanical CPR. *The American Journal of Emergency Medicine, 37*(5), 913–920. https://doi.org/10.1016/j.ajem.2018.08.031

Grabowski B. (2016). "P < 0.05" Might Not Mean What You Think: American Statistical Association Clarifies P Values. Journal of the National Cancer Institute, 108(8), djw194. https://doi.org/10.1093/jnci/djw194

Grandjean, E. (1980). *Fitting the task to the man*. Taylor & Francis.

Greene, J. (2007). *Mixed Methods in Social Inquiry*. Jossey-Bass.

Guest, G., Namey, E., & McKenna, K. (2017). How Many Focus Groups Are Enough? Building an Evidence Base for Nonprobability Sample Sizes. *Field Methods, 29*(1), 3–22. https://doi.org/10.1177/1525822X16639015

Hall, B., & Howard, K. (2008). A Synergistic Approach: Conducting Mixed Methods Research With Typological and Systemic Design Considerations. *Journal of Mixed Methods Research, 2*(3), 248–269. https://doi.org/10.1177/1558689808314622

Hamilton, A. L., Kerins, J., MacCrossan, M. A., & Tallentire, V. R. (2019). Medical Students' Non-Technical Skills (Medi-StuNTS): preliminary work developing a behavioural marker system for the non-technical skills of medical students in acute care. *BMJ Simulation & Technology Enhanced Learning, 5*(3), 130. http://dx.doi.org/10.1136/bmjstel-2018-000310

Hankins, M. (2008). How discriminating are discriminative instruments?. *Health and quality of life outcomes, 6*(36), 1-5. https://doi.org/10.1186/1477-7525-6-36

Harari, Y., Riemer, R., Jaffe, E., Wacht, O., & Bitan, Y. (2020). Paramedic equipment bags: How their position during out-of-hospital cardiopulmonary resuscitation (CPR) affect paramedic ergonomics and performance. *Applied Ergonomics, 82*(102977). https://doi.org/10.1016/j.apergo.2019.102977

Härgestam, M., Lindkvist, M., Brulin, C., Jacobsson, M., & Hultin, M. (2013). Communication in interdisciplinary teams: exploring closed-loop communication during in situ trauma team training. *BMJ Open 3*(10), 1-8.

Health and Care Professions Council. (2014). *Standards of Proficiency – Paramedics*. https://www.hcpc-uk.org/resources/standards/standards-of-proficiency-paramedics/

Health and Care Professions Council. (2016). *Standards of conduct, performance and ethics*. https://www.hcpc-uk.org/standards/standards-of-conduct-performance-and-ethics/

Health and Care Professions Council. (2018). *Standards of education and training.* https://www.hcpc-uk.org/standards/standards-relevant-to-education-and-training/set/

Health and Care Professions Council. (2021). *Registrant snapshot - 1 May 2021*. Retrieved November 30, 2021, from https://www.hcpc-uk.org/about-us/insights-and-data/the-register/registrant-snapshot-may-2021/

Hecker, K., & Violato, C. (2009). Validity, reliability, and defensibility of assessments in veterinary education. *Journal of Veterinary Medical Education, 36*(3), 271–275. https://doi.org/10.3138/jvme.36.3.271

Helmreich, R. L., Merritt, A. C., & Wilhelm, J. A. (1999a). The Evolution of Crew Resource Management Training in Commercial Aviation. *International Journal of Aviation Psychology, 9*(1), 19-32.

Helmreich, R.L. & Merritt, A. C. (2000). Safety and error management: The role of crew resource management. *Aviation resource management, 1*,107-119.

Helmreich, R.L., Klinect, J.R, & Wilhelm, J. A. (1999b, May 3-6). *Models of threat, error, and CRM in flight operations*. [Paper Presentation]. In: Proceedings of the Tenth International Symposium on Aviation Psychology. Columbus, Ohio.

Henson, R. K., & Roberts, J. K. (2006). Use of Exploratory Factor Analysis in Published Research: Common Errors and Some Comment on Improved Practice. *Educational and Psychological Measurement, 66*(3), 393–416. https://doi.org/10.1177/0013164405282485

Higham, H., Greig, P. R., Rutherford, J., Vincent, L., Young, D., & Vincent, C. (2019). Observer-based tools for non-technical skills assessment in simulated and real clinical environments in healthcare: a systematic review. *BMJ Quality & Safety, 28*(8), 672–686. https://doi.org/10.1136/bmjqs-2018-008565

Hinski, S., Cooke, N. J., McNeese, N., Sen, A., & Patel, B. (2016). A Human Factors Approach to Building High-Performance Multi- Professional Cardiac Arrest Teams: Developing a Code Blue Team Performance Metric. *Proceedings of the International Symposium on Human Factors and Ergonomics in Health Care, 5*(1), 68–71. https://doi.org/10.1177/2327857916051006

Holly, D., Swanson, V., Cachia, P., Beasant, B., & Laird, C. (2017). Development of a behaviour rating system for rural/remote pre-hospital settings. *Applied Ergonomics, 58*, 405-413. https://doi.org/10.1016/j.apergo.2016.08.002

Hopkins, C. L., Burk, C., Moser, S., Meersman, J., Baldwin, C., & Youngquist, S. T. (2016). Implementation of Pit Crew Approach and Cardiopulmonary Resuscitation Metrics for Out-of-Hospital Cardiac Arrest Improves Patient Survival and Neurological Outcome. *Journal of the American Heart Association, 5*(1), e002892. https://doi.org/10.1161/JAHA.115.002892 https://bmcmededuc.biomedcentral.com/articles/10.1186/s12909-019-1609-8#Tab5

Hunter, J., Porter, M., & Williams, B. (2020). Towards a theoretical framework for situational awareness in paramedicine. *Safety Science, 122*(104528). https://doi.org/10.1016/j.ssci.2019.104528

Hunter, J., Porter, M., Phillips, A., Evans-Brave, M., & Williams, B. (2021). Do paramedic students have situational awareness during high-fidelity simulation? A mixed-methods pilot study. *International emergency nursing, 56*, 100983. https://doi.org/10.1016/j.ienj.2021.100983

Hunziker, S., Johansson, A. C., Tschan, F., Semmer, N. K., Rock, L., Howell, M. D., & Marsch, S. (2011). Teamwork and leadership in cardiopulmonary resuscitation. *Journal of the American College of Cardiology, 57*(24), 2381–2388. https://doi.org/10.1016/j.jacc.2011.03.017

Hunziker, S., Tschan, F., Semmer, N. K., Howell, M. D., & Marsch, S. (2010). Human factors in resuscitation: Lessons learned from simulator studies. *Journal of Emergencies, Trauma, and Shock, 3*(4), 389–394. https://doi.org/10.4103/0974-2700.70764

IBM Corp. (2017). *IBM SPSS Statistics for Windows,* (Version 25.0) [Computer software]. https://www.ibm.com/uk-en/products/spss-statistics

Information Commissioner's Office. (n.d.). *Guide to the UK General Data Protection Regulation (UK GDPR).* https://ico.org.uk/for-organisations/guide-to-data-protection/guide-to-the-general-data-protection-regulation-gdpr/

Institute of Medicine. (2015). *Strategies to Improve Cardiac Arrest Survival: A Time to Act.* https://doi.org/10.17226/21723

International Ergonomics Association. (2020). *Human Factors/Ergonomics definition*. https://iea.cc/

Jacobs, I. G., Finn, J. C., Jelinek, G. A., Oxer, H. F., & Thompson, P. L. (2011). Effect of adrenaline on survival in out-of-hospital cardiac arrest: A randomised double-blind placebo-controlled trial. *Resuscitation, 82*(9), 1138–1143. https://doi.org/10.1016/j.resuscitation.2011.06.029

Jager, J., Putnick, D. L., & Bornstein, M. H. (2017). II. More than Just Convenient: The Scientific Merits of Homogenous Convenience Samples. *Monographs of the Society for Research in Child Development, 82*(2), 13–30. https://doi.org/10.1111/mono.12296

Jamshed, S. (2014). Qualitative research method-interviewing and observation. *Journal of Basic and Clinical Pharmacy, 5*(4), 87–88. https://doi.org/10.4103/0976-0105.141942

Jentzer, J. C., Clements, C. M., Wright, R. S., White, R. D., & Jaffe, A. S. (2016). Improving Survival From Cardiac Arrest: A Review of Contemporary Practice and Challenges. *Annals of emergency medicine, 68*(6), 678–689. https://doi.org/10.1016/j.annemergmed.2016.05.022

Ji, H., & Yan, J. (2020). How Team Structure Can Enhance Performance: Team Longevity's Moderating Effect and Team Coordination's Mediating Effect. *Frontiers in Psychology, 11,* 1873. https://doi.org/10.3389/fpsyg.2020.01873

Johnson, B., Runyon, M., Weekes, A., & Pearson, D. (2018). Team-focused Cardiopulmonary Resuscitation: Prehospital Principles Adapted for Emergency Department Cardiac Arrest Resuscitation. *The Journal of Emergency Medicine, 54*(1), 54–63. https://doi.org/10.1016/j.jemermed.2017.08.065

Johnson, R., & Onwuegbuzie, A. J. (2004). Mixed Methods Research: A Research Paradigm Whose Time Has Come by. *Educational Researcher, 33*(7), 14–26.

Joint Royal Colleges Ambulance Liaison Committee, Association of Ambulance Chief Executives (2006). *JRCALC Clinical Guidelines 2006*. Class Professional Publishing.

Joint Royal Colleges Ambulance Liaison Committee, Association of Ambulance Chief Executives (2016). *JRCALC Clinical Guidelines 2016*. Class Professional Publishing.

Joint Royal Colleges Ambulance Liaison Committee, Association of Ambulance Chief Executives (2019). *JRCALC Clinical Guidelines 2019*. Class Professional Publishing.

Joint Royal Colleges Ambulance Liaison Committee. (2021). *History & Previous Editions*. https://www.jrcalc.org.uk/about/previous-editions/

Jones, T.L., Baxter M. A. J. & Khanduja, V. (2013). A quick guide to survey research. *Annals of Royal College Surgeons England 95*(1), 5–7.

Kaiser, H. F. (1974). An index of factorial simplicity. *Psychometrika, 39*(1), 31–36. https://doi.org/10.1007/BF02291575

Kaushik, K., & Walsh, C. A. (2019). Pragmatism as a Research Paradigm and Its Implications for Social Work Research. *Social Science 8*(9), 255-272.

Kelle, U. (2006). Combining qualitative and quantitative methods in research practice: Purposes and advantages. *Qualitative Research in Psychology, 3*(4), 293-311.

Kitto, S. C., Chesters, J., & Grbich, C., (2008). Quality in qualitative research. *Medical Journal of Australia, 188*(4), 243-246.

Klampfer, B., Flin, R., Helmreich, R. L., Häusler, R., Sexton, B., Fletcher, G., Field, P., Staender, S., Lauche, K., Dieckmann, P., & Amacher, A. (2001). *Enhancing Performance in High Risk Environments: Recommendations for the use of Behavioural Markers*. http://www.raes-hfg.com/reports/notechs-swiss.pdf

Klein, G. A., Calderwood, R., & MacGregor, D. (1989). Critical decision method for eliciting knowledge. *IEEE Transactions on Systems, Man, & Cybernetics, 19*(3), 462–472. https://doi.org/10.1109/21.31053

Knafl, K. & Breitmayer, B. (1991). Triangulation in qualitative research: issues of conceptual clarity and purpose. In Morse, J. M. (Ed.) *Qualitative nursing research: A contemporary dialogue* (pp. 226-239). Sage Publications, Inc.

Koo, T. K., & Li, M. Y. (2016). A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. *Journal of chiropractic medicine, 15*(2), 155–163. https://doi.org/10.1016/j.jcm.2016.02.012

Krage, R., Zwaan, L., Tjon Soei Len, L., Kolenbrander, M. W., van Groeningen, D., Loer, S. A., Wagner, C., & Schober, P. (2017). Relationship between non-technical skills and technical performance during cardiopulmonary resuscitation: does stress have an influence?. *Emergency Medicine Journal, 34*(11), 728–733. https://doi.org/10.1136/emermed-2016-205754

Krueger, R. A. (1994). *Focus groups: A practical guide for applied research* (2nd ed.). Sage Publications, Inc.

Krueger, R. A., & Casey, M. A. (2009). *Focus Groups: A Practical Guide for Applied Research* (4th ed.). Sage Publications, Inc.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*, 159-174.

Langdalen, H., Abrahamsen, E. B., Sollid, S., Sørskår, L., & Abrahamsen, H. B. (2018). A comparative study on the frequency of simulation-based training and assessment of non-technical skills in the Norwegian ground ambulance services and helicopter emergency medical services. *BMC health services research, 18*(1), 509. https://doi.org/10.1186/s12913-018-3325-1

Larmore, S. (2011) Subject matter Expert: Working Toward Ensuring The Value In A Project Organization [Unpublished master's thesis]. University of Pennsylvania.

LeBreton, J. M., & Senter, J. L. (2008). Answers to 20 questions about interrater reliability and interrater agreement. *Organizational Research Methods, 11*,815-852. https://doi:10.1177/1094428106296642

Leggat, S.G. (2007). Effective healthcare teams require effective team members: defining teamwork competencies. *BMC Health Services Research 7*(17). https://doi.org/10.1186/1472-6963-7-17

Lim, S. L., Smith, K., Dyson, K., Chan, S. P., Earnest, A., Nair, R., Bernard, S., Leong, B. S., Arulanandam, S., Ng, Y. Y., & Ong, M. (2020). Incidence and Outcomes of Out-of-Hospital Cardiac Arrest in Singapore and Victoria: A Collaborative Study. *Journal of the American Heart Association, 9*(21), e015981. https://doi.org/10.1161/JAHA.119.015981

Lincoln, Y. & Guba, E. (1985). *Naturalistic Inquiry*. Sage Publications, Inc.

Lindell, M. K., & Brandt, C. J. (1999). Assessing interrater agreement on the job relevance of a test: A comparison of CVI, T, rWG(J)}, and r*WG(J)} indexes. *Journal of Applied Psychology, 84*(4), 640–647. https://doi.org/10.1037/0021-9010.84.4.640

Lindner, T. W., Søreide, E., Nilsen, O. B., Torunn, M. W., & Lossius, H. M. (2011). Good outcome in every fourth resuscitation attempt is achievable--an Utstein template report from the Stavanger region. *Resuscitation, 82*(12), 1508–1513. https://doi.org/10.1016/j.resuscitation.2011.06.016

Lowe, D. J., Dewar, A., Lloyd, A., Edgar, S., & Clegg, G. R. (2017). Optimising clinical performance during resuscitation using video evaluation. *Postgraduate Medical Journal, 93*(1102), 449–453. https://doi.org/10.1136/postgradmedj-2016-134357

Mainds, M. D., & Jones, C, (2018). Breaking bad news and managing family during an out-of-hospital cardiac arrest. *Journal of Paramedic Practice, 10*(7), e2041-9457. https://doi.org/10.12968/jpar.2018.10.7.292

Malec, J. F., Brown, A. W., Leibson, C. L., Flaada, J. T., Mandrekar, J. N., Diehl, N. N., & Perkins, P. K. (2007). The mayo classification system for traumatic brain injury severity. *Journal of neurotrauma, 24*(9), 1417–1424. https://doi.org/10.1089/neu.2006.0245

Manser T. (2009). Teamwork and patient safety in dynamic domains of healthcare: a review of the literature. *Acta anaesthesiologica Scandinavica, 53*(2), 143–151. https://doi.org/10.1111/j.1399-6576.2008.01717.x

Marsch, S. C., Müller, C., Marquardt, K., Conrad, G., Tschan, F., & Hunziker, P. R. (2004). Human factors affect the quality of cardiopulmonary resuscitation in simulated cardiac arrests. *Resuscitation, 60*(1), 51–56. https://doi.org/10.1016/j.resuscitation.2003.08.004

Matheson, R. (2019). Human factors in student paramedic practice. *Journal of Paramedic Practice 11*(1), 15-20. https://doi.org/10.12968/jpar.2019.11.1.15

Maurin Söderholm, H., Andersson, H., Andersson Hagiwara, M., Backlund, P., Bergman, J., Lundberg, L., & Sjöqvist, B. A. (2019). Research challenges in prehospital care: the need for a simulation-based prehospital research laboratory. *Advances in simulation, 4*(3). https://doi.org/10.1186/s41077-019-0090-0

Maykut, P., Morehouse, R. (1994). *Beginning qualitative researchers: A philosophical and practical guide.* Falmer.

Maynard, M. T., Mathieu, J. E., Gilson, L. L., R. Sanchez, D., & Dean, M. D. (2019). Do I Really Know You and Does It Matter? Unpacking the Relationship Between Familiarity and Information Elaboration in Global Virtual Teams. *Group & Organization Management, 44*(1), 3–37. https://doi.org/10.1177/1059601118785842

McCambridge, J., Kypri, K., & Elbourne, D. (2014). Research participation effects: a skeleton in the methodological cupboard. *Journal of clinical epidemiology, 67*(8), 845–849. https://doi.org/10.1016/j.jclinepi.2014.03.002

McClelland, G., Younger, P., Haworth, D., Gospel, A., & Aiken-Fell, P. (2016). A service evaluation of a dedicated pre-hospital cardiac arrest response unit in the North East of England. *British Paramedic Journal, 1*(2), 35-41.

McClelland, J. L., Rumelhart, D. E., & Hinton, G. E. (1986). The appeal of parallel distributed processing. In D. A. Balota & E. J. Marsh (Ed.) *Cognitive Psychology: Key Readings* (pp. 75-99). Psychology Press.

McHugh M. L. (2012). Interrater reliability: the kappa statistic. *Biochemia medica, 22*(3), 276–282.

McManamny, T., Sheen, J., Boyd, L., & Jennings, P. A. (2015). Mixed methods and its application in prehospital research a systematic review. *Journal of Mixed Methods Research, 9*(3), 214–231.

Mechera-Ostrovsky, T., & Gluth, S. (2018). Memory Beliefs Drive the Memory Bias on Value-based Decisions. *Scientific Reports, 8*, 10592. https://doi.org/10.1038/s41598-018-28728-9

Mellanby, E. A. (2015). *Development of a behavioural marker system for the non-technical skills of junior doctors in acute care* [Doctoral thesis, University of Edinburgh]. EThOS. https://ethos.bl.uk/OrderDetails.do?uin=uk.bl.ethos.726507

Miller, J. (2015). Better together? Ambulance staff views of human factors in resuscitation. *Emergency Medical Journal, 32*(6), P006.

Mion, M., Case, R., Smith, K., Lilja, G., Nordström, E. B., Swindell, P., Nikolopoulou, E., Davis, J., Farrell, K., Gudde, E., Karamasis, G. V., Davies, J. R., Toff, W. D., Abella, B. S., & Keeble, T. R. (2021). Follow-up care after out-of-hospital cardiac arrest: A pilot study of survivors and families' experiences and recommendations. *Resuscitation Plus, 7*, 100154. https://doi.org/10.1016/j.resplu.2021.100154

Mishra, A., Catchpole, K., & McCulloch, P. (2009). The Oxford NOTECHS System: reliability and validity of a tool for measuring teamwork behaviour in the operating theatre. *Quality & safety in health care, 18*(2), 104–108. https://doi.org/10.1136/qshc.2007.024760

Mishra, A., Catchpole, K., Dale, T., & McCulloch, P. (2008). The influence of non-technical performance on technical outcome in laparoscopic cholecystectomy. *Surgical endoscopy, 22*(1), 68–73. https://doi.org/10.1007/s00464-007-9346-1

Mitchell, L, (2011). *Development of a behavioural rating system for scrub nurses' non-technical skills* [Doctoral thesis, University of Aberdeen]. EThOS. https://ethos.bl.uk/OrderDetails.do?uin=uk.bl.ethos.542646

Mitchell, L., Flin, R., Yule, S., Mitchell, J., Coutts, K., & Youngson, G. (2012). Evaluation of the scrub practitioners' list of intraoperative non-technical skills system. *International Journal of Nursing Studies, 49*(2), 201-211.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS medicine, 6*(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097

Morgan, D. L (2007). Paradigms Lost and Pragmatism Regained. *Journal of Mixed Methods Research 1*(1), 48-76.

Morgan, D. L. (1997). *Focus Groups as Qualitative Research* (2nd Ed.). Sage Publications, Inc.

Munn, Z., Peters, M. D. J., Stern, C., Tufanaru, C., McArthur, A., & Aromataris, E. (2018). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology, 18*(143), 2-7.

Myat, A., Song, K. J., & Rea, T. (2018). Out-of-hospital cardiac arrest: current concepts. *Lancet, 391*(10124), 970–979. https://doi.org/10.1016/S0140-6736(18)30472-0

Myers, J. A., Powell, D. M., Psirides, A., Hathaway, K., Aldington, S., & Haney, M. F. (2016). Non-technical skills evaluation in the critical care air ambulance environment: introduction of an adapted rating instrument--an observational study. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine, 24*, 24. https://doi.org/10.1186/s13049-016-0216-5

National Ambulance Resilience Unit. (n.d.). H*azardous Area Response Teams (HART).* https://naru.org.uk/what-we-do/hart/

National Audit Office. (2017). *NHS Ambulance Services*. https://www.nao.org.uk/wp-content/uploads/2017/01/NHS-Ambulance-Services.pdf

Newman, D. A., & Sin, H., P. (2020). Within-Group Agreement (rWG): Two Theoretical Parameters and their Estimators. *Organizational Research Methods, 23*(1), 30–64. https://doi.org/10.1177/1094428118809504

Noble, D. (1993). A model to support development of situation assessment aids. In G. A. Klein, J. Orasanu, R. Calderwood, & C. E. Zsambok (Eds.) *Decision making in action: Models and methods* (pp. 287–305). Ablex.

Norris, E.M., & Lockey, A. S. (2012). Human factors in resuscitation teaching. *Resuscitation, 83*(4), 423-427.

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic Analysis: Striving to Meet the Trustworthiness Criteria*. International Journal of Qualitative Methods, 16*, 1-13. https://doi.org/10.1177/1609406917733847

O'Connor, P., Hörmann, H.-J., Flin, R., Lodge, M., Goeters, K.M., & the JARTEL group. (2002). Developing a method for evaluating CRM skills: A European perspective. *International Journal of Aviation Psychology, 12*(3), 263-286.

O'Daniel, M., & Rosenstein, A. H. (2008). Professional Communication and Team Collaboration. In R. G. Hughes (Ed.) *Patient Safety and Quality: An Evidence-Based Handbook for Nurses* (pp.271-284). Agency for Healthcare Research and Quality.

O'Neill, T. A. (2017). An Overview of Interrater Agreement on Likert Scales for Researchers and Practitioners. *Frontiers in Psychology, 8*(777). https://doi:10.3389/fpsyg.2017.00777

O'Cathain, A., Murphy, E., & Nicholl, J. (2010). Three techniques for integrating data in mixed methods studies. *BMJ (Clinical research ed.), 341*, c4587. https://doi.org/10.1136/bmj.c4587

Ochieng, N. T., Wilson, K., Derrick, C. J., & Mukherjee, N. (2018). The use of focus group discussion methodology: Insights from two decades of application in conservation. *Methods in Ecology and Evolution, 9*(1), 20–32. https://doi.org/10.1111/2041-210X.12860

Oliver, D. G., Serovich, J. M., & Mason, T. L. (2005). Constraints and opportunities with interview transcription: Towards reflection in qualitative research. *Social Forces, 84*(2), 1273–1289.

Olivet, J., Zerger, S. R., Greene, N., Kenney, R. R. & Herman, D. B. (2016) Online Versus Face-to-Face Training of Critical Time Intervention: A Matching Cluster Randomized Trial. *American Journal of Distance Education, 30*(4), 237-249. https://doi:10.1080/08923647.2016.1232107

Ong, M., Perkins, G. D., & Cariou, A. (2018). Out-of-hospital cardiac arrest: prehospital management. *Lancet, 391*(10124), 980–988. https://doi.org/10.1016/S0140-6736(18)30316-7

Onwuegbuzie, A. J., Dickinson, W. B., Leech, N. L., & Zoran, A. G. (2009). A Qualitative Framework for Collecting and Analyzing Data in Focus Group Research. *International Journal of Qualitative Methods, 8*(3), 1–21. https://doi.org/10.1177/160940690900800301

Onwuegbuzie, A.J., & Johnson, R. B. (2006). The validity issue in mixed research. *Research in the Schools, 13*(1), 48-63.

Ormerod, R. (2006). The History and Ideas of Pragmatism. *Journal of Operational Research Society, 57*(8), 892-909.

Out of Hospital Cardiac Arrest Outcomes Project Team. (2019). *Out of Hospital Cardiac Arrest Outcomes Epidemiology report 2018: English Ambulance Services.* https://warwick.ac.uk/fac/sci/med/research/ctu/trials/ohcao/publications/epidemiologyreports/ohcao_epidemiology_report_2018_published.pdf

Panesar, S. S., Ignatowicz, A. M., & Donaldson, L. J. (2014). Errors in the management of cardiac arrests: an observational study of patient safety incidents in England. *Resuscitation, 85*(12), 1759–1763.

Pap, R., Lockwood, C., Stephenson, M., & Simpson, P. (2018). Indicators to measure prehospital care quality: a scoping review. *JBI database of systematic reviews and implementation reports, 16*(11), 2192–2223. https://doi.org/10.11124/JBISRIR-2017-003742

Parker, C., Scott, S., & Geddes, A. (2019). Snowball Sampling. In P. Atkinson, S. Delamont, A. Cernat, J.W. Sakshaug, & R.A. Williams (Eds.), *Sage Research Methods Foundations*. https://www.doi.org/10.4135/9781526421036831710

Parker, P., & Tritter, J. (2006). Focus group method and methodology: current practice and recent debate. *International Journal of Research and Method in Education, 29*(1), 23-37. https://doi.org/10.1080/01406720500537304

Patterson, P. D., Weaver, M., Landsittel, D. P., Krackhardt, D., Hostler, D., Vena, J. E., Hughes, A., Salas, E., & Yealy, D. M. (2016). Prehospital care: Teammate familiarity and risk of injury in emergency medical services. *Emergency Medicine Journal, 33*(4), 280-285.

Patterson, P.D., Weaver, M.D., Weaver, S.J., Rosen, M.A., Todorova, G., Weingart, L.R., Krackhardt, D., Lave, J.R., Arnold, R.M., Yealy, D.M., & Salas, E. (2012). Measuring teamwork and conflict among emergency medical technician personnel. *Prehospital Emergency Care, 16*(1), 98–108.

Pemberton, K. E., Franklin, R. C., & Watt, K. (2019). Strategies to improve out-of-hospital cardiac arrest outcomes in the pre-hospital environment – Part B: non-pharmaceutical strategies. *Australasian Journal of Paramedicine, 16*. https://doi.org/10.33151/ajp.16.753

Perkins, G. D., Lockey, A. S., de Belder, M. A., Moore, F., Weissberg, P., Gray, H., & Community Resuscitation Group (2016). National initiatives to improve outcomes from out-of-hospital cardiac arrest in England. *Emergency Medicine Journal, 33*(7), 448–451. https://doi.org/10.1136/emermed-2015-204847

Perona, M., Rahman, M. A., & O'Meara, P. (2019). Paramedic judgement, decision-making and cognitive processing: a review of the literature. *Australasian Journal of Paramedicine, 16*. https://doi.org/10.33151/ajp.16.586

Peters, M. D., Godfrey, C. M., Khalil, H., McInerney, P., Parker, D., & Soares, C. B. (2015). Guidance for conducting systematic scoping reviews. *International Journal of Evidence-based Healthcare, 13*(3), 141–146. https://doi.org/10.1097/XEB.0000000000000050

Petrosoniak, A., Fan, M., Hicks, C. M., White, K., McGowan, M., Campbell, D., & Trbovich, P. (2021). Trauma Resuscitation Using in situ Simulation Team Training (TRUST) study: latent safety threat evaluation using framework analysis and video review. *BMJ Quality & Safety, 30*(9), 739–746. https://doi.org/10.1136/bmjqs-2020-011363

Petter, J., & Armitage, E. (2013). Raising educational standards for the paramedic profession. *Journal of Paramedic Practice, 4*(4), 241-242. https://doi.org/10.12968/jpar.2012.4.4.241

Pham, M. T., Rajić, A., Greig, J. D., Sargeant, J. M., Papadopoulos, A., & McEwen, S. A. (2014). A scoping review of scoping reviews: advancing the approach and enhancing the consistency. *Research synthesis methods, 5*(4), 371–385. https://doi.org/10.1002/jrsm.1123

Phillippi, J. & Lauderdale, J. (2018). A Guide to Field Notes for Qualitative Research: Context and Conversation. *Qualitative Health Research, 28*(3), 381–388. https://doi.org/10.1177/1049732317697102

Phillips, E. C., Smith, S. E., Clarke, B., Hamilton, A. L., Kerins, J., Hofer, J., & Tallentire, V. R. (2021). Validity of the medi-StuNTS behavioural marker system: Assessing the non-technical skills of medical students during immersive simulation. *BMJ Simulation & Technology Enhanced Learning, 7*(1), 3-10. http://dx.doi.org/10.1136/bmjstel-2019-000506

Pilbery, R., Teare, M. D., & Lawton, D. (2019). Do RATs save lives? A service evaluation of an out-of-hospital cardiac arrest team in an English ambulance service. *British Paramedic Journal, 3*(4), 32–39. https://doi.org/10.29045/14784726.2019.03.3.4.32

Pocock, H., Deakin, C. D., Quinn, T., Perkins, G. D., Horton, J., & Gates, S. (2016). Human factors in prehospital research: lessons from the PARAMEDIC trial. *Emergency Medicine Journal, 33*(8), 562–568. https://doi.org/10.1136/emermed-2015-204916

Power, D., Henn, D., O'Driscoll, P., Power, T., McAdoo, J., Hynes, H., & Cusack, S. (2013a). An evaluation of high-fidelity simulation training for paramedics in Ireland. *International Paramedic Practice, 2*(1), 11–8.

Power, D., Henn, P., Hick, D., & McAdoo, J. (2013b). An evaluation of high-fidelity simulation using a human patient simulator in a new Diploma in Military Medical Care. *Journal of Military and Veterans' Health, 21*(4), 4-10.

QSR International Pty Ltd. (2018). *NVivo qualitative data analysis software; Version 12*.

Rajagopal, S., Booth, S. J., Brown, T. P., Ji, C., Hawkes, C., Siriwardena, A. N., Kirby, K., Black, S., Spaight, R., Gunson, I., Brace-McDonnell, S. J., Perkins, G. D., & OHCAO collaborators. (2017). Data quality and 30-day survival for out-of-hospital cardiac arrest in the UK out-of-hospital cardiac arrest registry: a data linkage study. *British Medical Journal open, 7*(11), e017784. https://doi.org/10.1136/bmjopen-2017-017784

Ratan, S. K., Anand, T., & Ratan, J. (2019). Formulation of Research Question – Stepwise Approach. *Journal of Indian Association of Pediatric Surgeons, 24*(1), 15-20.

Rattray, J. & Jones, M. C. (2007). Essential elements of questionnaire design and development. *Journal of Clinical Nursing, 16*(2), 234-243.

Reader, T., Flin, R., Lauche, K., & Cuthbertson, B. H. (2006). Non-technical skills in the intensive care unit. *British Journal of Anaesthesia, 96*(5):551–559.

Reeves, S., Kitto, S., & Masiello, I. (2013). Crew resource management: how well does it translate to an interprofessional healthcare context?. *Journal of Interprofessional Care, 27*(3), 207–209. https://doi.org/10.3109/13561820.2012.748722

Repo, J.P., Rosqvist, E., Lauritsalo, S., & Paloneva, J. (2019). Translatability and validation of non-technical skills scale for trauma (T-NOTECHS) for assessing simulated multi-professional trauma team resuscitations. *BMC Medical Education, 19*(40). https://doi.org/10.1186/s12909-019-1474-5

Resuscitation Council (UK). (2021a). *Adult Advanced Life Support Algorithm 2021*. https://www.resus.org.uk/sites/default/files/2021-04/Adult%20Advanced%20Life%20Support%20Algorithm%202021.pdf

Resuscitation Council (UK). (2021b). *Education Guidelines.* https://www.resus.org.uk/library/2021-resuscitation-guidelines/education-guidelines

Resuscitation Council (UK). (2021c). *e-ALS (Advanced Life Support) Course.* https://www.resus.org.uk/training-courses/adult-life-support/e-als-advanced-life-support

Riem, N., Boet, S., Bould, M. D., Tavares, W., & Naik, V. N. (2012). Do technical skills correlate with non-technical skills in crisis resource management: a simulation study. *British Journal of Anaesthesia, 109*(5), 723-728.

Royal College of Surgeons of Edinburgh. (2021). *Faculty Accreditation Pre-hospital Emergency Medicine (PHEM).* https://fphc.rcsed.ac.uk/examinations/faculty-accreditation

Rutherford, J. (2015). *Development of a behavioural rating system for the non-technical skills used by anaesthetic nurses and operating department practitioners* [Doctoral thesis, University of Aberdeen]. EThOS. https://ethos.bl.uk/OrderDetails.do?uin=uk.bl.ethos.655667

Sackett, D. L., & Wennberg, J. E. (1997). Choosing the best research design for each question. *British Medical Journal, 315*(7123), 1636.

Salas, E., Sims, D. E., & Burke, C. S. (2005). Is there a “Big Five” in Teamwork? *Small Group Research, 36*(5), 555–599. https://doi.org/10.1177/1046496405277134

Saldana, J. (2016). *The Coding Manual for Qualitative Researchers*. Sage Publications, Ltd.

Sarter, N. B., & Woods, D. D. (1991). Situation Awareness: A Critical But Ill-Defined Phenomenon. *International Journal of Aviation Psychology 1*(1). https://doi.org/10.1207/s15327108ijap0101_4

Saumure, K. & Given, L. M. (2008). Rigour in Qualitative Research Methods. In L. M. Given (Ed.) *The SAGE Encyclopedia of Qualitative Research Methods* (pp. 796). Sage Publications, Inc.

Schmutz, J. & Manser, T. (2013). Do team processes really have an effect on clinical performance? A systematic literature review. *British Journal of Anaesthesia, 110*(4), 529–544.

Schoonenboom, J., & Johnson, R, B. (2017). How to Construct a Mixed Methods Research Design. *Kolner Zeitschrift Fur Soziologie Und Sozialpsychologie, 69*(suppl 2), 107-131.

Seager, L., Smith, D. W., Patel, A., Brunt, H., & Brennan, P. A. (2013). Applying aviation factors to oral and maxillofacial surgery--the human element. *The British journal of oral & maxillofacial surgery, 51*(1), 8–13.

Sedlár, M. (2020). Cognitive skills of emergency medical services crew members: a literature review. *BMC Emergency Medicine, 20*(44). https://doi.org/10.1186/s12873-020-00330-1

Shields, A., & Flin, R. (2013). Paramedics' non-technical skills: a literature review. *Emergency Medicine Journal, 30*(5), 350–354. https://doi.org/10.1136/emermed-2012-201422

Shorrock, S. (2020). *Proxies for Work-as-Done: 1. Work-as-Imagined. Humanistic Systems.* https://humanisticsystems.com/?s=work+as+imagined

Singer, S., & Couper, M. P. (2017). Some Methodological Uses of Responses to Open Questions and Other Verbatim Comments in Quantitative Surveys. *Methods, data, analyses, 11*(2), 115-134.

Sinha, P. K. (2008). *Management Control Systems a managerial emphasis*. Excel books.

Smith, J. H. (1987). Elton Mayo and the Hidden Hawthorne. *Work, Employment and Society, 1*(1), 107–120. https://doi.org/10.1177/0950017087001001007

Smith, M. W., Bentley, M. A., Fernandez, A. R., Gibson, G., Schweikhart, S. B., & Woods, D. D. (2013). Performance of experienced versus less experienced paramedics in managing challenging scenarios: a cognitive task analysis study. *Annals of Emergency Medicine, 62*(4), 367–379. https://doi.org/10.1016/j.annemergmed.2013.04.026

Soar, J., Mancini, M. E., Bhanji, F., Billi, J. E., Dennett, J., Finn, J., Ma, M. H., Perkins, G. D., Rodgers, D. L., Hazinski, M. F., Jacobs, I., Morley, P. T., & Education, Implementation, and Teams Chapter Collaborators (2010). Part 12: Education, implementation, and teams: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Resuscitation, 81* Suppl 1(1), e288–e330. https://doi.org/10.1016/j.resuscitation.2010.08.030

Soar, J., Deakin, C. D., Nolan, J. P., Perkins, G. D., Yeung, J., Couper, K., Hall, M., Thorne, C., Price, S., Lockey, A., Wyllie, J., & Hampshire, S. (2021). *Adult advanced life support Guidelines. Resuscitation Council UK.* https://www.resus.org.uk/library/2021-resuscitation-guidelines/adult-advanced-life-support-guidelines

Strauss, A., & Corbin, J. (1998). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. Sage Publications, Inc.

Streiner, D. L., Norman, G. R., & Cairney, J. (2015). *Health measurement scales: A practical guide to their development and use* (5th ed.). Oxford University Press.

Sullivan, A., Elshenawy, S., Ades, A., & Sawyer, T. (2019). Acquiring and Maintaining Technical Skills Using Simulation: Initial, Maintenance, Booster, and Refresher Training. *Cureus, 11*(9), e5729. https://doi.org/10.7759/cureus.5729

Summers, A. & Willis, S. (2013). Human factors within paramedic practice: the forgotten paradigm. *Journal of Paramedic Practice 2*(9), 424-428. https://doi.org/10.12968/jpar.2010.2.9.78627

Talamas, S. N., Mavor, K. I., & Perrett, D. I. (2016) Blinded by Beauty: Attractiveness Bias and Accurate Perceptions of Academic Performance. *PLoS One. 11*(2), e0148284. https://doi:10.1371/journal.pone.0148284

Tashakkori, A., & Creswell, J.W. (2007). Editorial: exploring the nature of research questions in mixed methods research. *Journal of Mixed Methods Research, 1*(3), 207–211.

Tashakkori, A., & Teddlie, C. (1998). *Mixed methodology: Combining qualitative and quantitative approaches*. Sage Publications, Inc.

Tavares, W., Boet, S., Theriault, R., Mallette, T., & Eva, K. W. (2013). Global rating scale for the assessment of paramedic clinical competence. *Prehospital emergency care: official journal of the National Association of EMS Physicians and the National Association of State EMS Directors, 17*(1), 57–67. https://doi.org/10.3109/10903127.2012.702194

Teddlie, C., & Tashakkori, A. (2009). *Foundations of Mixed Methods Research: Integrating Quantitative and Qualitative Approaches in the Social and Behavioral Sciences.* Sage Publications, Inc.

The National Confidential Enquiry into Patient Outcome and Death. (2021). Time Matters. *A review of the quality of care provided to patients aged 16 years and over who were admitted to hospital following an out-of hospital cardiac arrest*. https://www.ncepod.org.uk/2021ohca.html

Thomas, D.R. (2003). A general inductive approach for qualitative data analysis. *The American Journal of Evaluation, 27*(2), 237-246.

Thomas, E. J., Sexton, J. B., & Helmreich, R. L. (2004). Translating teamwork behaviours from aviation to healthcare: development of behavioural markers for neonatal resuscitation. *Quality & safety in health care, 13*(Suppl 1), i57–i64. https://doi.org/10.1136/qhc.13.suppl_1.i57

Thomas, M. J. W. (2018). *Training and Assessing Non-Technical Skills A Practical Guide*. CRC Press.

Thurmond, V. A. (2004). The Point of Triangulation*. Journal of Nursing Scholarship, 33*(3), 253-258.

Tiah, L., Kajino, K., Alsakaf, O., Bautista, D. C., Ong, M. E., Lie, D., Naroo, G. Y., Doctor, N. E., Chia, M. Y., & Gan, H. N. (2014). Does pre-hospital endotracheal intubation improve survival in adults with non-traumatic out-of-hospital cardiac arrest? A systematic review. *The Western Journal of Emergency Medicine, 15*(7), 749–757. https://doi.org/10.5811/westjem.2014.9.20291.

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K., Colquhoun, H., Kastner, M., Levac, D., Ng, C., Sharpe, J. P., Wilson, K., Kenny, M., Warren, R., Wilson, C., Stelfox, H. T., & Straus, S. E. (2016). A scoping review on the conduct and reporting of scoping reviews. *BMC Medical Research Methodology, 16*, 15. https://doi.org/10.1186/s12874-016-0116-4

Tsai, B. M., Sun, J-T., Hsieh, M-J., Lin, Y-Y., Kao, T-C., Chen, L-W., Huei-Ming Ma, M. & Wen-Chu, C. (2020). Optimal paramedic numbers in resuscitation of patients with out-of-hospital cardiac arrest: A randomized controlled study in a simulation setting. *PLoS ONE 15*(7), e0235315. https://doi.org/10.1371/journal.pone.0235315

Tschan, F., Semmer, N. K., Gautschi, D., Hunziker, P., Spychiger, M., & Marsch, S. U. (2006). Leading to Recovery: Group Performance and Coordinative Activities in Medical Emergency Driven. *Human Performance 19*(3), 277-304.

Ultimatesolver. (2020). *Random Generator - Random Order.* https://www.ultimatesolver.com/en/random-order#random_generator

University of Huddersfield. (2021). *Paramedic Science BSc(Hons)*. https://courses.hud.ac.uk/full-time/undergraduate/paramedic-science-bsc-hons

University of Wolverhampton. (2020). *New £4.8m health education facilities opened.* https://www.wlv.ac.uk/news-and-events/latest-news/2020/january-2020/new-48m-health-education-facilities-opened.php

Viereck, S., Møller, T. P., Rothman, J. P., Folke, F., & Lippert, F. K. (2017). Recognition of out-of-hospital cardiac arrest during emergency calls - a systematic review of observational studies. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine, 25*(1), 9. https://doi.org/10.1186/s13049-017-0350-8 von Vopelius-Feldt, J., Powell, J., Morris, R., & Benger, J. (2016). Prehospital critical care for out-of-hospital cardiac arrest: An observational study examining survival and a stakeholder-focused cost analysis. *BMC Emergency Medicine, 16*(1), 47. https://doi.org/10.1186/s12873-016-0109-y

von Wyl, T., Zuercher, M., Amsler, F., Walter, B., & Ummenhofer, W. (2009). Technical and non-technical skills can be reliably assessed during paramedic simulation training. *Acta anaesthesiologica Scandinavica, 53*(1), 121–127. https://doi.org/10.1111/j.1399-6576.2008.01797.x

Walker, S., Brett, S., McKay, A., Lambden, S., Vincent, C., & Sevdalis, N. (2011). Observational Skill-based Clinical Assessment tool for Resuscitation (OSCAR): development and validation. *Resuscitation, 82*(7), 835–844. https://doi.org/10.1016/j.resuscitation.2011.03.009

Weaver, S. J., Dy, S. M., and Rosen, M. (2014). Team-training in healthcare: a narrative synthesis of the literature. *BMJ Quality & Safety, 23*(5), 359-372.

Weiss, N., Ross, E., Cooley, C., Polk, J., Velasquez, C., Harper, S., Walrath, B., Redman, T., Mapp, J., & Wampler, D. (2018). Does Experience Matter? Paramedic Cardiac Resuscitation Experience Effect on Out-of-Hospital Cardiac Arrest Outcomes. *Prehospital emergency care: official journal of the National Association of EMS Physicians and the National Association of State EMS Directors, 22*(3), 332–337. https://doi.org/10.1080/10903127.2017.1392665

Whitmore, D., & Furber, R. (2006). The Need for a Professional Body for UK Paramedics. *Journal of Emergency Primary Health Care 4*(1). http://dx.doi.org/10.33151/ajp.4.1.354

Wilkinson, L., & the Task Force on Statistical Inference. (1999). Statistical methods in psychology journals: Guidelines and explanations. *American Psychologist, 54*(8). 594-604.

Wisborg, T., Brattebø, G., Brinchmann-Hansen, A., & Hansen, K. S. (2009). Mannequin or standardized patient: participants' assessment of two training modalities in trauma team simulation. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine, 17*(59), 1-4. https://doi.org/10.1186/1757-7241-17-59

Wisdom, J., & Creswell, J.W. (2013). *Mixed methods: integrating quantitative and qualitative data collection and analysis while studying patient-centered medical home models. Agency for Healthcare Research and Quality.* https://pcmh.ahrq.gov/page/mixed-methods-integrating-quantitative-and-qualitative-data-collection-and-analysis-while

Wisdom, J.P., Cavaleri, M.C., Onwuegbuzie, A.T., & Green, C. A. (2011). Methodological reporting in qualitative, quantitative, and mixed methods health services research articles. *Health Service Research, 47*(2), 721–745.

Wright, K. B. (2005). Researching Internet-Based Populations: Advantages and Disadvantages of Online Survey Research, Online Questionnaire Authoring Software Packages, and Web Survey Services*. Journal of Computer-Mediated Communication, 10*(3). https://doi.org/10.1111/j.1083-6101.2005.tb00259.x

Wright, M. C., Phillips-Bute, B. G., Petrusa, E. R., Griffin, K. L., Hobbs, G. W., & Taekman, J. M. (2009). Assessing teamwork in medical education and practice: relating behavioural teamwork ratings and clinical performance. *Medical teacher, 31*(1), 30–38. https://doi.org/10.1080/01421590802070853

Yong, A. G. & Pearce, S. (2013). A Beginner's Guide to Factor Analysis: Focusing on Exploratory Factor Analysis. *Tutorials in Quantitative Methods for Psychology, 9*(2), 79-94.

Young, M. S., Lenné, M. G., & Stedmon, A. W. (2017). Prologue. In: M.S. Young & M. G. Lenné (Eds), *Simulators for transportation human factors: research and practice* (pp.3-18). CRC Press.

Yule, S., Flin, R., Maran, N., Rowley, D., Youngson, G., & Paterson-Brown, S. (2008). Surgeons' non-technical skills in the operating room: Reliability testing of the NOTSS behavior rating system. *World Journal of Surgery, 32*(4), 548-556.

Yule, S., Flin, R., Paterson-Brown, S., Maran, N., & Rowley, D. (2006). Development of a rating system for surgeons' non-technical skills. *Medical education, 40*(11), 1098–1104. https://doi.org/10.1111/j.1365-2929.2006.02610.x

Appendices

Appendix A. Copy of Cormack, S., Scott, S., & Stedmon, A. (2020a). Pitstops for paramedics. The Ergonomist and statements of permission

Appendix B. Copy of Cormack, S., Scott, S., & Stedmon, A. (2020b). Non-technical skills in out-of-hospital cardiac arrest management: A scoping review. Australasian Journal of Paramedicine and statements of permission

Appendix C. Copy of Questionnaire ethics certificate P48036

Appendix D. Copy of P65504 Focus group ethics certificate

Appendix E. Focus group question guide

Appendix F. Copy of P72923 Subject matter expert semi-structured interview ethics certificate

Appendix G. Copy of P75774 Subject matter expert researcher comparison step ethics certificate

Appendix H. Interview schedule for subject matter expert semi-structured interviews

Appendix I. Template analysis for initial coding

Appendix J. Updated template analysis for axial coding

Appendix K. Copy of P89152 preliminary POHCAAT evaluation ethics certificate

Appendix L. Copy of final evaluation POHCAAT evaluation ethics certificate

Appendix M. Online information package for POHCAAT evaluation

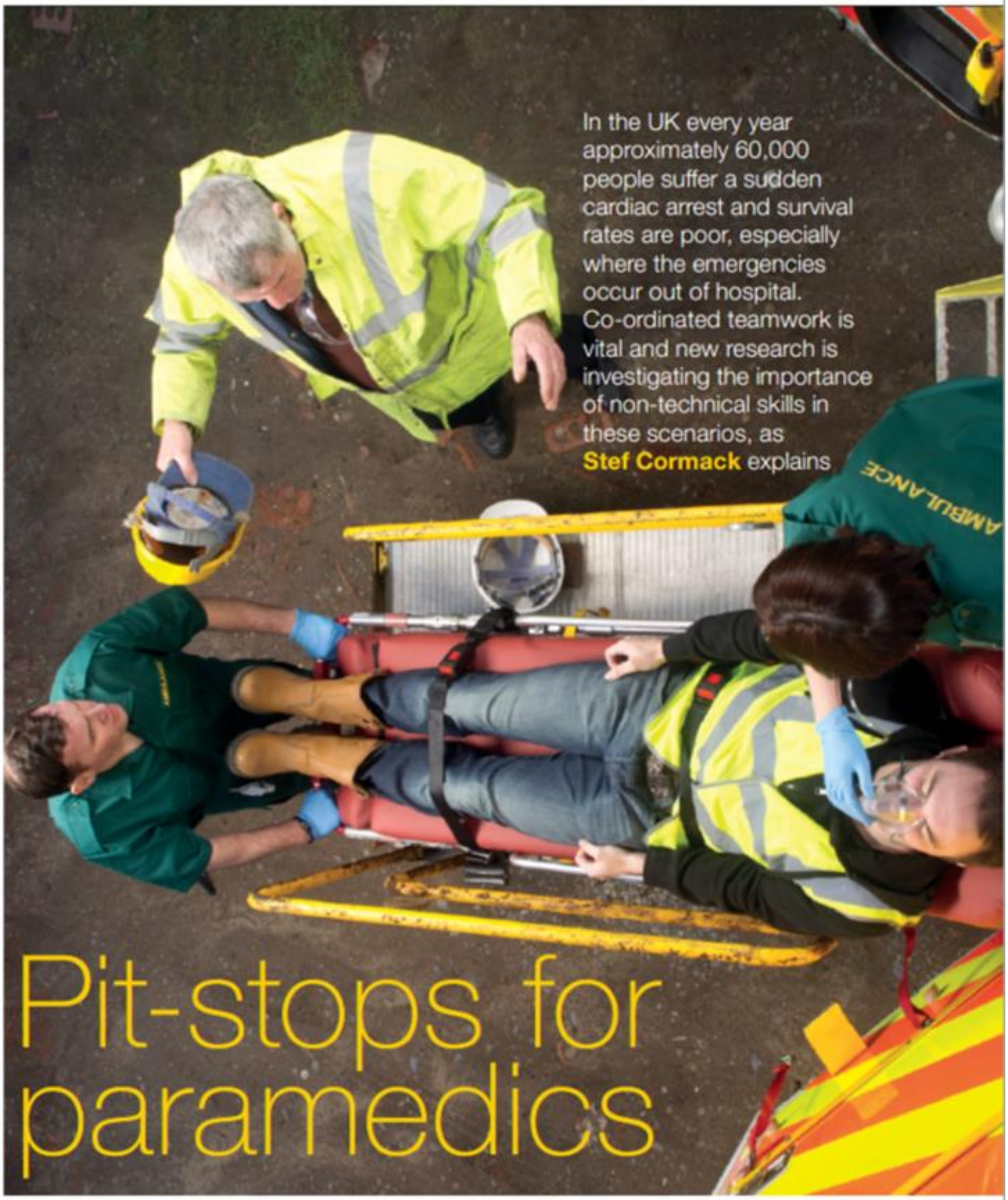
Appendix A. Copy of Cormack, S., Scott, S., & Stedmon, A. (2020a). Pitstops for paramedics. The Ergonomist, 576, 28-30 (including statements of permission from journal and co-authors)

Statement from the other authors confirming your contribution to the publication: ‘I have no objections to Stef referencing and including our co-authored paper on which she led and completed the drafts and final version of 'Pitstops for paramedics’ within her thesis’ – Dr Steve Scott

‘I have no objections to Stef including 'Pitstops for paramedics’ within her thesis, on which I co-authored. Stef was the main contributor, conceived the idea and completed the draft and final versions of the publication’ – Prof Alex Stedmon

Statement of permission from the Ergonomist (via email): ‘Please take this as permission to include a copy of your article: Cormack, S., Scott, S., & Stedmon, A. (2020). Pitstops for paramedics. The Ergonomist, 576, 28-30, in your thesis.

Tina Worthy. Chief Operating Officer | Chartered Institute of Ergonomics & Human Factors



In the UK every year approximately 60,000 people suffer a sudden cardiac arrest and survival rates are poor, especially where the emergencies occur out of hospital. Co-ordinated teamwork is vital and new research is investigating the importance of non-technical skills in these scenarios, as **Stef Cormack** explains

Pit-stops for paramedics

Sudden cardiac arrest refers to the unexpected cessation of cardiac activity with hemodynamic collapse, typically due to sustained cardiac arrhythmias. This is when the heart stops beating and the circulation of blood around the body is interrupted. This can have life-threatening and life-limiting consequences if not treated quickly, so it's vital that the patient receives immediate medical attention.

Despite increased public awareness surrounding sudden cardiac arrests, including the teaching of Cardiopulmonary Resuscitation (CPR) and increased access to public accessible defibrillators, survival rates from sudden cardiac arrests, especially when they occur outside of a hospital, are extremely low. In the UK, typically only 8% of victims survive longer than one month.

Of those first on the scene when attending a sudden cardiac arrest, paramedics are routinely taught how to perform CPR and trained in advanced life support skills such as maintaining airways, gaining intravenous access and administering life-saving drugs.

The pit stop paradigm

Within wider medical practice, for example in operating theatres and Accident & Emergency departments, the 'pit stop paradigm' has gained traction for managing a variety of procedures. This was adopted from motor racing Formula 1 teams where each team member has a dedicated role. Through specialised training it's possible that such teams can accomplish complex tasks extremely efficiently and quickly, and there have been some positive applications to in-hospital procedures.

In these situations, the pit stop paradigm typically advocates that each medical team member has a predefined role, that there are a minimum of six to eight clinicians attending a patient, a dedicated leader, 360-degree access to the patient, and a standardised layout of equipment. If this was an F1 pit stop then there would be dedicated team members for each wheel, refuelling, attending to the driver, and an overall management of the process. However, the same paradigm does not migrate to out of hospital procedures so readily, as there is little time for briefing, numbers are limited to three or four paramedics for each cardiac arrest scenario and 360-degree access is not always possible.

In some cases, there has been resistance to the pit stop paradigm; medicine is not the same as F1, after all. The human body, with all its complexities, requires a more sensitive and user-centred approach to patient care than is needed to refuel a car or change a tyre in just a few seconds. When medical procedures are transferred outside the hospital the pit stop paradigm can be even less relevant. Sudden cardiac arrests most often occur outside of a hospital setting, sometimes in a public place but more usually in the patient's own home. Such arrests typically occur in a bathroom or bedroom and even gaining access to the patient can be a major issue. There may not be enough room to physically get more than one or two people around the patient.

A designated 'hands-off' team leader can improve team performance

Even trying to perform chest compressions on a patient can be a major challenge in their home. For example, compressions can't be carried out on a standard bed mattress as it doesn't provide a firm surface and moving the patient onto the floor might be impossible. There may also be relatives present (if at home) or bystanders (if in a public space) and all these factors result in a complex and varied environment, with multiple distractions and where all round access to the patient is rarely possible.

Another key issue is how ad-hoc teams coordinate their activities. In addition to clinical skills, national pre-hospital resuscitation guidance advocates the use of Non-Technical Skills (NTS) such as leadership, communications and situation assessment, to ensure effective team performance but roles can be difficult to determine quickly in ad-hoc teams.

Improving team performance

Literature from in-hospital cardiac arrest teams has identified that a designated 'hands-off' team leader, that is, someone who is not involved with any clinical interventions including CPR, and the use of closed loop communication, can improve team performance. Regular team training focusing on a range of NTS can also increase an awareness of task focus, cognitive load and scene assessment.

While these advantages are apparent in hospital settings, there are critical differences out of hospital such as the operational environment and differences in the number of clinicians attending (some of which may be more or less familiar with procedures than others). Paramedics might rarely attend more than six to eight sudden cardiac arrests per year and so potential skill fade is an important issue and can impact team performance. Therefore, the identification of specific NTS for paramedics working as an ad-hoc team is critical.

With these issues in mind, it was established that an observational behavioural marker system was required to assess and provide feedback for paramedics. As part of this, work, it's been necessary to identify specific NTS attributes and descriptors relevant to sudden cardiac arrest scenarios for paramedics that could be developed into an operational tool.

A new behavioural tool

The Paramedic Out-of-Hospital Cardiac Arrest Tool (POHCAT) is intended to be used as an observational assessment method using simulated scenarios. It has been developed to provide paramedics with feedback on specific NTS skills when working as part of an ad-hoc team managing a sudden cardiac arrest. Divided into positive and undesirable descriptors, it →

Two NHS ambulance service paramedics on bicycles

allows an assessor to identify relevant NTS and give feedback to help improve the team's performance.

In order to develop the POHCAT tool, an initial literature review was conducted that identified a range of existing behavioural markers, ranging from those for anaesthetists to maritime/navy deck officers. Although some general medical NTS were identified, specific paramedic NTS needed to be developed that were sensitive and relevant to out of hospital activities. Informed by existing healthcare behavioural marker systems and data gathered from student paramedics, subject matter experts and current literature, essential NTS relevant to a sudden cardiac arrest were identified.

The sudden cardiac arrest behavioural marker system consists of four NTS domains: situation assessment, team coordination, knowledge of procedure/task management, and communication. Examples of observable behaviour were developed along with a 5-point assessment rating system (from unsafe to excellent). This allows assessors to score the observed behaviours of individual student paramedics and provide additional feedback. The POHCAT tool can be used to observe one paramedic whilst also being adapted to take in additional roles as more paramedics arrive.

The NTS categories and ratings have been designed to help improve individual NTS and overall team performance for paramedics. The behavioural marker system allows for the evaluation of training and education, identifying areas of strength and weakness, which can then be improved with further consolidatory learning and practice. Using observational approaches allows the paramedic to learn and rehearse in a naturalistic setting, for example, in a simulated public space or even in an ambulance.

Sudden cardiac arrests can occur in complex and varied environments with multiple distractions

Exploring paramedic NTS

Pioneering research is being conducted at Coventry University where a mixed methods approach has explored student paramedics' understanding and experiences of NTS in a sudden cardiac arrest. A reasonable understanding of NTS was demonstrated, but there were several barriers identified. These included hierarchical problems, communication, leadership and situation awareness issues.

Despite paramedics possessing similar clinical skillsets (regardless of rank or role) students often found they struggled with challenging qualified paramedics who had more experience, stronger personalities or a higher rank. Hierarchical problems included paramedics dismissing student suggestions despite student paramedics often possessing more up-to-date knowledge of procedures as a result of continual assessment. Students also considered that paramedics perceived that they lacked experience and exposure to sudden cardiac arrests and therefore were not competent.

Student paramedics also felt that although a leader is needed in a sudden cardiac arrest, they considered team coordination was more important than leadership. They disliked the term 'leadership' as they felt it equated to an autocratic, egotistical leader who wanted to perform clinical skills, rather than remain hands-off. Student paramedics were clear about their own roles and had a clear mindset and mental model of what should happen in a sudden cardiac arrest, but in reality, they found it difficult to assimilate in the team as some paramedics lacked knowledge in clinical skills and resuscitation algorithms often resulting in poor teamwork.

These issues impact on overall situation assessment. Many students explained that they fixated on the patient and clinical algorithms, missing basic information, often becoming task focused as they had to concentrate more on their role in the sudden cardiac arrest. However, when students were part of a more familiar and smaller team, they found it easier to speak up, received more support when performing clinical skills reducing task overload and there was a greater use of closed-loop communication.

Early work with the POHCAT tool has demonstrated there are benefits of training and assessment of an ad-hoc team's NTS in sudden cardiac arrest scenarios. As yet, NTS are not routinely taught or incorporated into UK university paramedic programmes and so this remains a challenge in terms of developing a culture where NTS are given as much importance as clinical skills, and practitioners are aware of how important this concept can be on ad-hoc team performance. ●

This research is being led by **Stef Cormack** from the Faculty of Health and Life Sciences with support from **Dr Steve Scott** of the Faculty of Engineering, Environment and Computing, both at Coventry University, and **Professor Alex Stedmon** who runs Open Road Simulation Ltd and Science Witness Ltd.

Further reading

Catchpole K et al. Patient handovers within the hospital: translating knowledge from motor racing to healthcare. *BMJ Quality and Safety* 2010 Aug;19(4):318-2

Hopkins C L et al. Implementation of Pit Crew Approach and Cardiopulmonary Resuscitation Metrics for Out-of-Hospital Cardiac Arrest Improves Patient Survival and Neurological Outcome. *J Am Heart Assoc* 2016 Jan, 5(1). Available from https://doi.org/10.1161/JAHA.115.002695

Andersen P O et al. Identifying non-technical skills and barriers for improvement of teamwork in cardiac arrest teams. *Resuscitation* 2010; 81:695–2.

Hunziker S et al. Teamwork and Leadership in Cardiopulmonary Resuscitation. *J Am Coll Cardiol* 2011; 57:2381–8.

Appendix B. Copy of Cormack, S., Scott, S., & Stedmon, A. (2020b). Non-technical skills in out-of-hospital cardiac arrest management: A scoping review. Australasian Journal of Paramedicine, 17 (including statements of permission from journal and co-authors)

Statement from the other authors confirming your contribution to the publication:

'I have no objections to Stef including our co-authored paper, which she conceived the original idea and completed drafts and final version of 'Non-technical skills in out-of-hospital cardiac arrest management: A scoping review' within her thesis' – Dr Steve Scott

'I have no objections to Stef including a copy of our co-authored publication 'Non-technical skills in out-of-hospital cardiac arrest management: A scoping review' within her thesis. Stef conceived the idea, completed the draft and final versions of the publication and submitted to the Australasian Journal of Paramedicine' – Prof Alex Stedmon

Statement of permission from the Editor in Chief Australasian Journal of Paramedicine:

Australasian Journal of Paramedicine

6 April 2022

To whom it may concern,

I am writing to provide permission for Stefanie Cormack to include the article 'Non-technical skills in out-of-hospital cardiac arrest management: A scoping review' as an appendix in her thesis. This article was published in the Australasian Journal of Paramedicine on 13 May 2020 https://doi.org/10.33151/ajp.17.744

Sincerely,

Associate Professor Paul Simpson
Interim Editor in Chief
Australasian Journal of Paramedicine

Australasian Journal of Paramedicine

Review

Non-technical skills in out-of-hospital cardiac arrest management: A scoping review

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Abstract

Introduction
Current United Kingdom resuscitation guidance advocates the use of non-technical skills (NTS) such as teamwork, decision-making and communication for ad-hoc teams managing an out-of-hospital cardiac arrest (OHCA). It is unknown which NTS are advantageous or commonly used, or if there is supporting literature. This scoping review sought to establish a literature base and identify key NTS relevant to ad-hoc teams managing an OHCA.

Methods
Arksey and O'Malley's five-stage framework was used to perform a scoping review to identify relevant literature from the medical domain. Thematic analyses were used to identify relevant NTS in relation to OHCA management.

Results
A total of 12 articles were identified and selected for detailed analysis. The articles represented a range of study designs, with most commenting on observed simulated practice from in-hospital practice. There was a paucity of literature for NTS associated with ad-hoc OHCA teams. Three common NTS were identified: leadership, teamwork and communication, with improved team performance associated with a hands-off team leader. Barriers were also identified and included low confidence in communicating and hierarchical difficulties in resuscitation teams.

Conclusion
We believe this scoping review provides the first comprehensive review of its kind and identifies important knowledge gaps, NTS themes and recommendations for paramedic-led OHCA teams. Three NTS from in-hospital cardiac arrest management can be related to OHCA management, but further research is needed to identify specific NTS for ad-hoc teams managing an OHCA.

Keywords:
non-technical skills; teamwork; leadership; communication; out-of-hospital cardiac arrest; ad-hoc teams

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Introduction

In the United Kingdom the ambulance service responds to approximately 30,000 out-of-hospital cardiac arrest (OHCA) cases per year (1). Despite improvements in the chain of survival (2), long-term survival rates in the UK remain extremely low at approximately 8–9% in comparison to European data, which reports survival rates as high as 43% (3,4). Higher survival rates appear to be associated with changes to European Resuscitation Council guidelines (5), increased numbers of publicly accessible defibrillators and the promotion of cardiopulmonary resuscitation (CPR) teaching to the public (6-9). Despite these changes, there is discussion about the effectiveness of advanced life support (ALS) delivered by paramedics. Research suggests that long-term survival rates are not always improved by ALS (10-12). Further evidence suggests that paramedic performance is linked to ALS delivery (13,14), with good OHCA management requiring the coordination of a number of clinical (intravenous access, airway management, drug administration) and non-clinical skills (team coordination, trust, shared mental model) (15). However, due to the complexity of an OHCA, its unpredictable environment and ad-hoc formation of paramedic teams (16), it is argued that there is a correlation between a poorly performing team and higher error rates. These include miscommunication, poor ALS algorithm adherence and CPR quality, highlighting the importance of team coordination and effective clinical skills (17,18). Individual paramedic performance also appears to be affected by a lack of OHCA exposure, with associated clinical skill fade and task overload (19-21). Such factors can contribute to poor non-technical skills (NTS), described as social and cognitive skills that enhance team performance (22).

Developed as part of human factors theory, the education and training of NTS has been adapted and used in areas such as surgery, trauma and anaesthetics (23-25). In relation to OHCA management, the UK Resuscitation Council guidelines advocate the use of NTS and a team approach to the delivery of ALS to achieve the best chance of survival (26). In relation to general paramedic practice, NTS have been identified as an important factor and include elements such as situation awareness (information gathering, processing and planning); decision making (reaching a judgement when dealing with evolving, complex situations); communication (sharing and delivery of information within teams, to the public and onward medical care); teamwork (effective working together towards a shared goal); and leadership (coordinating, motivating and supporting others) (27).

For ad-hoc OHCA teams to work effectively, the use of NTS are regarded as vital to successful teamwork; yet it is unclear which NTS are relevant or if their use is common in an OHCA. A scoping review was conducted to investigate the current evidence base for NTS associated with ad-hoc teams managing an OHCA, and to determine which NTS are most commonly used in ad-hoc resuscitation teams.

Methods

In order to explore NTS use in an OHCA scenario, an initial literature search of Google Scholar and MEDLINE using broad, simple search terms (paramedic, non-technical skills, out-of-hospital cardiac arrest) was performed. Only three articles directly related to NTS and OHCA were identified (27-29). In general, the literature identified did not focus explicitly on NTS in an OHCA, and this highlighted a need to explore the concept in more depth. This stage of the process provided the basis for identifying relevant search criteria that are described below.

Scoping reviews provide a useful means of clarifying concepts and specific research questions (30). Previous research has taken a similar approach in developing insights into OHCA from a wider perspective when the immediate literature was not available (31). Conducting a scoping review allows for a systematic search process to identify any gaps so that recommendations can be made for future practice (32). In order to take a structured approach to investigate NTS and the management of an OHCA, the review utilised Arksey and O'Malley's five-point framework for data interrogation and analysis incorporating the identification of research questions; identification of relevant sources/studies; selection of relevant literature; charting of data; and collation and analysis of the literature (33).

Identifying a research question
As this review aimed to identify a wide range of literature relevant to NTS and OHCA management, based on the initial literature search results a research question was formed: Which NTS are associated with ad-hoc teams in the management of a cardiac arrest?

Identifying relevant studies
Search terms were generated using MeSH on Demand. This technique analysed text from the literature identified from the initial search to produce relevant medical subject headings (34). The MeSH terms included: ambulance, communication, crew resource management, emergency medical services, human factors, leadership, non-technical skills, out-of-hospital cardiac arrest, pre-hospital, paramedic, resuscitation, soft skills and team resource management. Five online medical databases were searched: MEDLINE, AMED, CINAHL, PsycINFO and PsycARTICLES. In addition, ScienceDirect was also reviewed as it provided a broad range of scientific and technical research relevant to healthcare. Reference lists from articles found in the initial search were used to expand the search process.

Study selection
The inclusion and exclusion criteria are shown in Table 1.

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Rationale
Types of studies	Publication date 2000 to present
	Studies from any geographical location
	English language
Types of participants	Adults (>18 years)
Context	NTS in cardiac arrest management; real world or simulated exercises
Publication type	Full text of published journal articles, conference proceedings
Exclusion criteria	
Types of studies	Before 2000
Types of participants	Less than 18 years of age
Context	Literature that did not include NTS and cardiac arrest management
Publication type	Non-peer reviewed literature

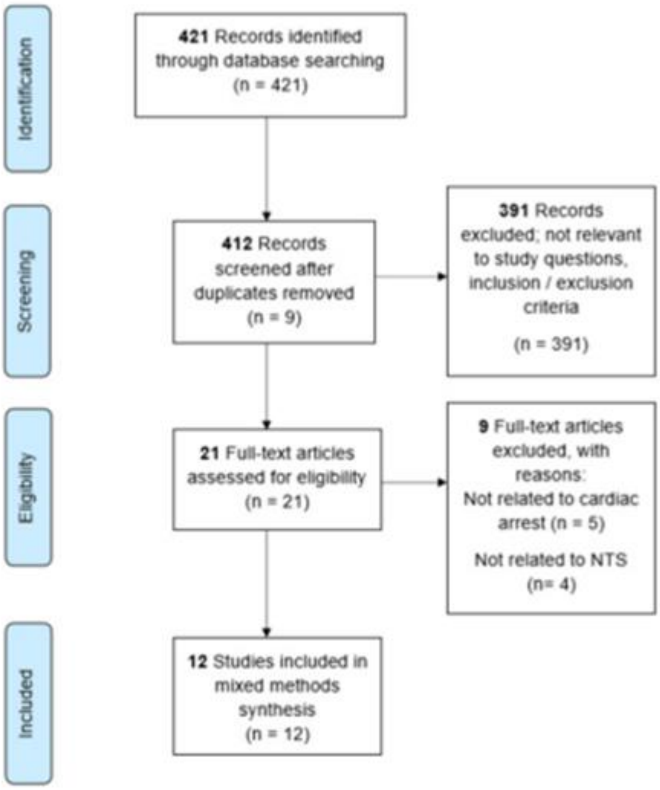

Figure 1. Flow chart of article selection in accordance with Prisma guidelines

This process provided the basis for identifying 421 potentially relevant sources. Following the removal of duplicate articles (n=9) the titles and abstracts were screened by the lead author for eligibility. A total of 391articles were rejected due to a lack of relevance to the subject. The remaining 21 articles were reviewed by all authors and 12 articles were agreed on for inclusion. The selection process is presented in Figure 1 .

Charting the articles

Each article included from the search was summarised, including author, year and place of publication, study aim, overview of research method, study highlights and limitations. Common NTS associated with cardiac arrest management were identified in each article using thematic analysis, demonstrating a pattern of potentially relevant NTS for OHCA management (Table 2).

Table 2 highlights the three key NTS associated with cardiac arrest teams were leadership, communication and teamwork. These themes were identified in nearly every article. Other NTS already identified as important factors for paramedics such as situation awareness and decision-making were not commonly associated with cardiac arrest teams.

Results

The 12 articles comprised of four simulated observational studies (28,35,36,40), one feasibility study (29), one semi-structured interview (37), three narrative literature reviews (38,39,44) one systematic literature review (41), one randomised controlled simulation trial (42) and one online survey (43). The locations of the research were predominately in Europe: Switzerland (28,35,36,38,39), Denmark (37), the UK (29,43,44) and Germany (41,42). The final location was Canada (40).

Half of the articles (N=6) employed simulation methods, using ad-hoc in-hospital resuscitation teams as participants (28,35,36,38,40,42). Interviews and surveys were also used (N=2), and this appeared to allow for a more in-depth exploration of team performance and NTS used in cardiac arrest management (37,43).

From the review, few sources (N=4) related specifically to NTS and OHCA management (28,29,43,44) but across the literature three NTS themes were most common: leadership, communication (28,29,35-39,41-44) and teamwork (28,29,35-41,43,44). All articles except one discussed and highlighted these three themes, with less discussion relating to planning, task distribution (sometimes referred to as 'task delegation' or 'management') and team hierarchy. Despite situation awareness and decision-making identified as key NTS for paramedics (27), only five articles highlighted these NTS. Leadership, teamwork and communication appeared to be intrinsically linked, with effective teams identifying a team leader, demonstrating effective communication, teamwork and effective clinical skills (28,40,41).

Across all in-hospital literature, articles often referred to leadership as a key NTS attribute (37,39-42). It was noted that where a team leader was hands-off, and therefore not performing any clinical tasks such as CPR or airway management, there were less interruptions in chest compressions and an overall improvement in CPR quality (42). This improvement in CPR was associated with an increased ALS algorithm adherence and timely defibrillation, with four articles noting an increase in return of spontaneous circulation (ROSC) in patients (37,38,41,42).

The literature highlighted further improvements in teamwork where a team leader was a clinician who had undertaken additional leadership training. This was reflected in reduced

Table 2. Common NTS themes

NTS theme	Reference/year											
	28 2009	29 2014	35 2004	36 2006	37 2010	38 2010	39 2011	40 2012	41 2013	42 2015	43 2015	44 2016
Leadership	■	■	■	■	■	■	■		■	■	■	■
Task distribution			■		■					■		
Team performance		■	■	■		■	■			■		■
Communication	■	■	■	■	■	■	■		■	■	■	■
Teamwork	■	■	■	■	■	■	■	■	■		■	■
Team coordination				■	■	■			■	■		
Situation awareness	■			■	■			■				■
Task delegation	■									■		
Task management					■			■	■			
Team hierarchy							■					
Decision making								■				■

error rates, such as reduced CPR interruptions and incidents of miscommunication (35,37,38,42). The review also highlighted that team performance was further improved when a hands-off leader used a cognitive aid such as a checklist (28,37,40). This was reflected in increased situation awareness for the team, with noted improved task distribution and planning. Task focus and overload also reduced, and the use of closed loop communication increased (28,35,37,38,40-42).

Despite effective leadership, communication was often acknowledged as a barrier to an effective team. Ineffective communication was connected to a poor understanding of roles, unclear task allocation and cognitive overload resulting in a poorly performing team (37,39,43). A poor understanding of closed loop communication was highlighted, with staff often asking questions at critical periods of the arrest resulting in unnecessary interruptions and delays (37). Of particular relevance to paramedics was the identification of a lack of confidence in communicating with others in an unfamiliar team and a lack of training in NTS (43).

There were noted hierarchical difficulties in two articles. Team members found it difficult in challenging a more senior or authoritative, confident team member, resulting in poor task distribution and poorly performed CPR (29,37). Effective communication was more common where a team was familiar, had training in NTS and an identified team leader (41,42). This resulted in the encouragement of team members to verbalise their clinical findings, allowing for a shared understanding and provided a challenge and response mechanism (38,39,41,42).

Simulation was a popular method for assessing NTS as it allowed for a safe, controlled and realistic environment (38-40). It also allowed for the filming of scenarios, which were used as feedback in the training of NTS (44). It was recognised that participants were open to the Hawthorne effect (45), but where simulation was immersive participants expressed similar levels of stress compared to real life incidents and appeared to forget that they were being observed (38,39). The use of simulation coupled with video review was identified as a useful process as it provided feedback, identified weaker NTS, offered strategies for improving teamwork and provided cognitive workload analysis (44). Two articles identified a correlation between clinical skills and NTS and highlighted the ability to assess both together (28,44).

There was an association between a high performing team who demonstrated effective NTS and good clinical skills, while teams with poor NTS often resulted in poor clinical skills (38,40). Overall where teams were unfamiliar, leadership, communication and teamwork suffered, caused by poor understanding of individual abilities and a lack of procedural knowledge. These poorly performing teams were associated with the rapid formation of an ad-hoc resuscitation team, resulting in limited planning time (37,39,43,44).

Discussion

This scoping review focusses on the effects of NTS in OHCA management and provides the first comprehensive evaluation of its kind. It was found that the evidence base for NTS in an OHCA was limited; however, there was a range of in-hospital literature that demonstrated a positive association between NTS and cardiac arrest team performance. Similar to general paramedic NTS (26), the three most common NTS associated with cardiac arrest teams were leadership, teamwork and communication.

Leadership was a common theme and reflects other literature that found it is essential for effective teamwork (15). Much of the in-hospital literature from this review identified that a hands-off team leader not only improved a team's performance and communication, it also resulted in increased rates of ROSC (41). It is important to recognise that this didn't translate into long-term survival rates, but it emphasises the importance of an effective team, the application of NTS to practice and the impact on clinical skills. It could be argued that an additional team leader is dependent on operational demand and potentially not possible, but despite the small sample size of the TOPCAT2 study, the use of an additional paramedic as a team leader for an OHCA was feasible (29). The positive effect on team performance included reduced task focus and overload and improved situation awareness (28,36,37,44), important aspects for an ad-hoc team, especially in an OHCA.

Task focus and cognitive load during a cardiac arrest situation can be further reduced by using checklists. It was recognised that the use of a checklist was associated with improved planning, timing of defibrillation and high-quality CPR if used by a hands-off team leader (41,44). Yet, the use of such checklists is dependent on investment in developing a specific cognitive aid, the provision of relevant training in their use, a clear understanding in how to use them and relevant time/resources to implement them (45-49).

A team approach is emphasised by the UK Resuscitation Council and it advocates the use of teamwork, situation awareness, leadership and decision making. This approach aims to achieve high quality CPR and ensure the best chance of survival (26). However, the NTS recommended only partially reflect the most commonly identified in this review and there appears to be a lack of consensus for NTS specific to an OHCA. As an emerging aspect of OHCA management, the identification of specific NTS for an OHCA are important, as their unscheduled nature results in an expectation that those managing it must function in incredibly short and critical timeframes (50,51). This could result in potential difficulty in applying hospital based NTS to an OHCA scenario, as there are subtle differences including little medical knowledge of the patient, varied numbers of team members and a need to remain focussed on providing support to a patient in a varied environment (52,53). However, regardless of these differences, the ad-hoc formation of both teams and use of ALS algorithms appear to be similar. These similarities result in the potential application of the three key NTS identified in this review to an OHCA, as early leadership, teamwork and effective communication appear to positively impact a team's performance.

The use of simulation was identified as a useful method to practise infrequently used clinical and non-clinical skills, as it improved team members' awareness and understanding of NTS. Simulation has been utilised across several areas of healthcare and is associated with an increased familiarity of roles, improved confidence and reduced cognitive load – all associated with a reduction in human error within resuscitation teams (54-57). In addition to simulated practise, the use of video-feedback using recorded OHCA was considered as advantageous when assessing a cardiac arrest team's cognitive load. The use of real-life recordings must be sensitive to ethical and legal considerations due to the filming of patients and clinical staff in highly demanding work environments (58,59). Yet, if used in conjunction with simulated OHCA scenarios, this method could provide valuable insight into the use and understanding of NTS and identify areas of improvement. The use of simulation and video feedback, in combination with an observational behavioural assessment tool, could provide clinicians with detailed feedback on their NTS use. The use of such tools is common in other areas of healthcare including anaesthesia, surgery and maternity practice (60-63). They can provide feedback specific to NTS, yet there is no current observational assessment tool for NTS in an OHCA and therefore more research would need to be undertaken to develop and design one.

Despite some barriers to the use of NTS in a cardiac arrest situation, this review has identified several positive effects on team performance. Recommendations based on this review include the use of a hands-off team leader at OHCA and a need to develop specific NTS relevant to an OHCA. Research using simulated OHCA scenarios and video feedback as well as interviews could be undertaken to identify additional NTS specific to OHCA ad-hoc teams. The identification of NTS specific to OHCA management has the potential to improve education and training for ad-hoc teams managing an OHCA with an aim to improving team performance.

Strengths and limitations

This scoping review followed an evidenced based approach to identify a wide range of literature (ie. initially 421 sources) associated with NTS and cardiac arrest management. This method allowed for the inclusion and comprehensive review of all available literature relating to NTS in an OHCA scenario, identifying key concepts and gaps that require further research. Despite only 12 articles being identified, there is a clear body of knowledge from in-hospital practice (with three articles focussed specifically on NTS and an OHCA) suggesting that further research is needed (28,29,43). The use of observed simulation for training and assessing NTS provides a controlled environment but it is difficult to reproduce realistic situations as simulations and participant performance may vary. Consideration is needed in the design of OHCA scenarios to the use of high-fidelity mannequins and a fundamental knowledge that the scenario was not real (64,65).

Literature specifically related to NTS and an OHCA was limited, and it is recognised that the use of doctors and nurses in many of the studies may not reflect the same demographics for paramedics, cardiac arrest exposure rates or the same clinical skill sets (20,21,66,67).

Conclusion

There would appear to be clear benefits in the use of NTS for in-hospital cardiac arrest management, yet there is a paucity of literature specific to the OHCA scenario. This review builds on resuscitation guidance and has identified three key NTS: leadership, communication and teamwork. Recommendations include the use of a hands-off team leader and regular training in NTS for ad-hoc teams as these enhance team performance, improve CPR quality and are associated with an increased ROSC rate. This review has highlighted that further research is required to identify specific NTS in relation to an OHCA in order to explore and enhance their use, understanding and incorporation into this specialised area of medical practice.

Competing interests

The authors declare no completing interests. Each author of this paper has completed the ICMJE conflict of interest statement.

References

1. Perkins GD, Brace-McDonnell SJ, on behalf of the OHCAO Project Group. The UK Out of Hospital Cardiac Arrest Outcome (OHCAO) project. BMJ Open 2015;5:e008736.
2. Cummins RO, Ornato JP, Thies WH, Pepe PE. Improving survival from sudden cardiac arrest: the chain of survival concept: a statement for health professionals from the Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee. Circulation 1991;83:1832-7.
3. de Visser M, Bosch J, Bootsma M, et al. An observational study on survival rates of patients with out-of-hospital cardiac arrest in the Netherlands after improving the 'chain of survival'. BMJ Open 2019;9:e029254.
4. Rajagopal S, Booth SJ, Brown TP on behalf of OHCAO collaborators, et al. Data quality and 30-day survival for out-of-hospital cardiac arrest in the UK out-of-hospital cardiac arrest registry: a data linkage study. ibid. 2017;7:e017784.

References (continued)

5. Larribau R, Deham H, Niquille M, Sarasin FP. Improvement of out-of-hospital cardiac arrest survival rate after implementation of the 2010 resuscitation guidelines. PLoS One 2018;13:e0204169.
6. Sasson C, Rogers MA, Dahl J, Kellermann AL. Predictors of survival from out-of-hospital cardiac arrest: a systematic review and meta-analysis. Circulation 2010;3:63-81.
7. Hasselqvist-Ax I, Riva G, Herlitz J, et al. Early cardiopulmonary resuscitation in out-of-hospital cardiac arrest. N Engl J Med 2015;372:2307-15.
8. Perkins GD, Lockey AS, de Belder MA, et al, on behalf of the Community Resuscitation Group. National initiatives to improve outcomes from out-of-hospital cardiac arrest in England. Emerg Med J 2016;33:448-51.
9. Nas J, Thannhauser J, Heramann JJ, et al. Changes in automated external defibrillator use and survival after out-of-hospital cardiac arrest in the Nijmegen area. Neth Heart J 2018;28:600-05.
10. Tiah L, Kajino K, Alsakaf O, et al. Does pre-hospital endotracheal intubation improve survival in adults with non-traumatic out-of-hospital cardiac arrest? A systematic review. West J Emerg Med 2014;15:749-7.
11. Jacobs IG, Finn JC, Jelinek GA, Oxer HF, Thompson PL. Effect of adrenaline on survival in out-of-hospital cardiac arrest: a randomised double-blind placebo-controlled trial. Resuscitation 2011;82:1138-3.
12. Stiell IG, Wells GA, Field B, et al. Advanced cardiac life support in out-of-hospital cardiac arrest. N Engl J Med 2004;351:647-6.
13. Cournoyer A, Notebaert E, Iseppon M, et al. Prehospital advanced cardiac life support for out-of-hospital cardiac arrest: a cohort study. Acad Emerg Med 2017;24:1100-9.
14. Weiss N, Ross E, Cooley C, et al. Does experience matter? Paramedic cardiac resuscitation experience effect on out-of-hospital cardiac arrest outcomes. Prehosp Emerg Care 2018;22:332-37.
15. Salas E, Sims DE, Burke CS. Is there a "big five" in teamwork? Small Group Res 2005;36:555-99.
16. McClellend G, Younger P, Haworth D, Gospel A, Aitken-Fell P. A service evaluation of a dedicated pre-hospital cardiac arrest response unit in the North East of England. British Paramedic Journal 2016;1:35-41.
17. Hinski S, Cooke NJ, McNeese A, Sen A, Patel B. A human factors approach to building high-performance multi-professional cardiac arrest teams: developing a code blue team performance metric. Proceedings of the International Symposium on Human Factors and Ergonomics in Health Care. 2017;5:68-71. Available at: https://doi.org/10.1177/2327857916051006
18. Panesar SS, Ignatowicz AM, Donaldson LJ. Errors in the management of cardiac arrests: An observational study of patient safety incidents in England. Resuscitation 2014;85:1759-63.
19. Brandling J, Kirby K, Black S, Voss S, Benger J. Emergency medical service provider decision-making in out of hospital cardiac arrest: an exploratory study. BMC Emerg Med 2017;17:1-8.
20. Smith MW, Bentley MA, Fernandez AR, et al. Performance of experienced versus less experienced paramedics in managing challenging scenarios: a cognitive task analysis study. Ann Emerg Med 2013;62:367-79.
21. Dyson K, Bray JE, Smith K, et al. Paramedic exposure to out-of-hospital cardiac arrest resuscitation is associated with patient survival. Circ Cardiovasc Qual Outcomes 2016;9:154-60.
22. Flin R, Patey R, Glavin R, Maran N. Anaesthetists' non-technical skills. Br J Anaesth 2010;105:38-44.
23. Kapur N, Parand A, Soukup T, Reader T, Sevdalis N. Aviation and healthcare: a comparative review with implications for patient safety. JRSM Open 2016;7:1-10.
24. Nallamothu BK, Guetterman TC, Harrod M, et al. How do resuscitation teams at top performing hospitals for in-hospital cardiac arrest succeed? A qualitative study. Circulation 2018;138:154-63.
25. Norris EM, Lockey AS. Human factors in resuscitation teaching. Resuscitation 2012;83:423-7.
26. Resuscitation Council (UK). Prehospital resuscitation. London, UK; 2015. Available at: https://www.resus.org.uk/resuscitation-guidelines/prehospital-resuscitation/
27. Shields A, Flin R. Paramedics' non-technical skills: a literature review. Emerg Med J 2013;30:350-4.
28. von Wyl T, Zuercher M, Amsler F, Walter B, Ummenhoffer W. Technical and non-technical skills can be reliably assessed during paramedic simulation training. Acta Anaesthesiol Scand 2009;53:121-7.
29. Clarke S, Lyon RM, Short S, Crookston C, Clegg GR. A specialist, second-tier response to out-of-hospital cardiac arrest: setting up TOPCAT2. Emerg Med J 2014;31:405-7.
30. Pham MT, Rajić A, Greig JD, et al. A scoping review of scoping reviews: advancing the approach and enhancing the consistency. Res Synth Methods 2014;5:371-5.
31. Anderson N, Slark J, Gott M. How are ambulance personnel prepared and supported to withhold or terminate resuscitation and manage patient death in the field? A scoping review. Australasian Journal of Paramedicine 2019;16. doi: http://dx.doi.org/10.33151/ajp.16.697
32. Munn Z, Peters MDJ, Stern C, et al. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Med Res Methodol 2018;18:2-7.
33. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol 2005;8:19-32.
34. MeSH on Demand. USA: U.S. National Library of Medicine. 2017. Available at: www.meshb.nlm.nih.gov/MeSHonDemand
35. Marsch SC, Muller C, Marquard K, et al. Human factors affect the quality of cardiopulmonary resuscitation in simulated cardiac arrests. Resuscitation 2004;60:51-6.

References (continued)

36. Tschan F, Semmer NK, Gautschi D, et al. Leading to recovery: group performance and coordinative activities in medical emergency driven. Hum Perform 2006;19:277-4.
37. Andersen PO, Jensen MK, Lippert A, Østergaard D. Identifying non-technical skills and barriers for improvement of teamwork in cardiac arrest teams. Resuscitation 2010;81:695-2.
38. Hunziker S, Tschan F, Semmer N, Howell MD, Marsch S. Human factors in resuscitation: lessons learned from simulator studies. J Emerg Trauma Shock 2010;3:389-4.
39. Hunziker S, Johansson AC, Tschan F, et al. Teamwork and leadership in cardiopulmonary resuscitation. J Am Coll Cardiol 2011;57:2381-8.
40. Riem N, Boet S, Bould MD, Tavares W, Naik VN. Do technical skills correlate with non-technical skills in crisis resource management: a simulation study. Br J Anaesth 2012;109:723-8.
41. Castelao EF, Russo SG, Riethmuller M, Boos M. Effects of team coordination during cardiopulmonary resuscitation: a systematic review of the literature. J Crit Care 2013;28:504-21.
42. Castelao EF, Boos M, Ringer C, Eich C, Russo SG. Effect of CRM team leader training on team performance and leadership behaviour in simulated cardiac arrest scenarios: a prospective, randomized, controlled study. BMC Med Educ 2015;15:116.
43. Miller J. Better together? Ambulance staff views of human factors in resuscitation. Emerg Med J 2015;32:P006.
44. Lowe DJ, Dewar A, Lloyd A, Edgar S, Clegg GR. Optimising clinical performance during resuscitation using video evaluation. Postgrad Med J 2016;93:449-3.
45. Arriage AF, Bader AM, Wong JM, et al. Simulation-based trial of surgical-crisis checklists. N Engl J Med 2013;368:246-53.
46. Burgess MR, Crewdson K, Lockey DJ, Perkins ZB. Prehospital emergency anaesthesia: an updated survey of UK practice with emphasis on the role of standardisation and checklists. Emerg Med J 2018;35:532-7.
47. Thomassen Ø, Espeland A, Søfteland E, et al. Implementation of checklists in health care; learning from high-reliability organisations. Scand J Trauma Resusc 2011;19:53.
48. Webster CS. Checklist, cognitive aids, and the future of patient safety. Br J Anaesth 2017;119:178-81.
49. Catchpole K, Russ S. The problems with checklists. BMJ Qual Saf 2015;24:545-9.
50. Ong ME, Perkins GD, Cariou A. Out-of-hospital cardiac arrest: prehospital management. Lancet 2018;391:980-8.
51. Anderson NE, Gott M, Slark J. Grey areas: New Zealand ambulance personnel's experiences of challenging resuscitation decision-making. Int Emerg Nurs 2018;39:62-7.
52. Krage R, Zwaan L, Tjon Soei Len L, et al. Relationship between non-technical skills and technical performance during cardiopulmonary resuscitation: does stress have an influence. Emerg Med J 2017;34:728-3.
53. Ågård A, Herlitz J, Casten N, Jonsson L, Sandman L. Guidance for ambulance personnel in decisions and situations related to out-of-hospital CPR. Resuscitation 2012;83:27-1.
54. Reeve S, Kitto S, Masiello I. Crew resource management: how well does it translate to an interprofessional healthcare context? J Interprof Care 2013;27:207-9.
55. Langdalen H, Abrahamsen EB, Sollid SJM, Sorskar LIK, Abrahamsen HB. A comparative study on the frequency of simulation-based training and assessment of non-technical skills in the Norwegian ground ambulance services and helicopter emergency medical services. BMC Health Serv Res 2018;18:509-22.
56. Gaba DM. Crisis resource management and teamwork training in anaesthesia. Br J Anaesth 2010;105:3-6.
57. Myers JA, Powell DM, Psirides A, et al. Non-technical skills evaluation in the critical care air ambulance environment: introduction of an adapted rating instrument—an observational study. Scand J Trauma Resusc Emerg Med 2016;(24):24.
58. Gaudry PL, Ryan JM, Aders HP. Protecting privacy during video recording resuscitations. Emerg Med 1996;8:141-5.
59. Gelbart B, Barfield C, Watkins A. Ethical and legal considerations in video recording neonatal resuscitations. J Med Ethics 2009;35:120-4.
60. Bracco F, de Tonetti G, Masini M, et al. Crisis resource management in the delivery room: development of behavioural markers for team performance in emergency simulation. Int Environ Res Public Health 2018;15:439-49.
61. Sui J, Maran N, Paterson-Brown S. Observation of behavioural markers of non-technical skills in the operating room and their relationship to intra-operative incidents. Surgeon 2016;14:119-28.
62. Fletcher G, Flin R, McGeorge P, et al. Anaesthetists' non-technical skills (ANTS): evaluation of a behavioural marker system. Br J Anaesth 2003;90:580-8.
63. Holly D, Swanson V, Cachia P, Beasant B, Laird C. Development of a behaviour rating system for rural/remote pre-hospital settings. Appl Ergon 2017;58:405-13.
64. Young MS, Lenné MG and Stedmon AW. Prologue. In: MS Young and MG Lenné (editors). Simulators for transportation human factors: research and practice. Florida: CRC Press, 2017, pp.3-18.
65. Smith JH. Elton Mayo and the hidden Hawthorne. Work Employ Soc 1987;1107-20.
66. Dyson K, Bray JE, Smith K, et al. Paramedic resuscitation competency: a survey of Australian and New Zealand emergency medical services. Emerg Med Australas 2017;29:217-2.
67. Steen E, Naess AC, Steen PA. Paramedics organizational culture and their care for relative of cardiac arrest victims. Resuscitation 1997;34:57-3.

Appendix C. Copy of Questionnaire ethics certificate P48036

Certificate of Ethical Approval P48036

Applicant:

Stef Cormack

Project Title:

Non-technical skills in the out-of-hospital cardiac arrest

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval:

30 March 2017

Project Reference Number:

P48036

Appendix D. Copy of P65504 Focus group ethics certificate

Certificate of Ethical Approval P65504

Applicant:

Stef Cormack

Project Title:

Development of Behavioural Marker System for assessing non-technical skills by out-of-hospital clinicians and student paramedics in an out-of-hospital cardiac arrest

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval:

14 December 2017

Project Reference Number: P65504

Appendix E. Focus group question guide

Explain purpose of focus group, an informal environment where open, honest discussion is encouraged to help guide the development of BMS for NTS in OHCA

Key topic areas include:

Leadership – feasibility of designated leader to coordinate roles, ensure clinical algorithm adherence, ensure effective communication

Task management - planning and preparation, prioritisation, adaptability, identifying and utilising resources

Team Working - coordination of team, exchanging information, diplomatic assertiveness, assessing capabilities and supporting others

Communication – verbal and non-verbal, altered language for public and other emergency services

(Shields and Flin 2013; Krage et al 2017).

Questions:

Opening question

Tell us who you are, which area you work in and what is your favourite thing to do when not at work

Introductory question

Can you describe your overall experience of an OHCA?

Transition questions

1. Think back to an OHCA that you considered was managed well; can you give a brief overview?
2. Think back to an OHCA that you considered was not managed well; can you give a brief overview?

3. Can you tell me about what you consider as the key non-technical skills for managing an OHCA?

Key questions

1. Do you feel a leader is feasible at an OHCA? Can you expand?
2. Do you feel that an OHCA is organised / events anticipated?
3. Can you describe your experiences of teamwork during an OHCA?
4. In your experience, do you feel people communicate well during an OHCA?
5. In your experience, what do you consider are the main barriers to an effective team managing an OHCA?
6. In your experience, what would you say are the most important non-technical skills for managing a paramedic led OHCA?

End question

Is there anything else you would like to say, or feel has been missed?

Appendix F. Copy of P72923 Subject matter expert semi-structured interview ethics certificate

Certificate of Ethical Approval P72923

Applicant:

Stef Cormack

Project Title:

Development of a Behavioural Marker Tool for Non-Technical Skills in the Simulated Out-of-Hospital Cardiac Arrest

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval:

23 July 2018

Project Reference Number: P72923

Appendix G. Copy of P75774 Subject matter expert researcher comparison step ethics certificate

Certificate of Ethical Approval P75774

Applicant:

Stef Cormack

Project Title:

Development of a Behavioural Marker Tool for Non-Technical Skills in the Simulated Out-of-Hospital Cardiac Arrest

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval:

03 September 2018

Project Reference Number: P75774

Appendix H. Interview schedule (July-Sept 2018) for subject matter expert semi-structured interviews

Aim: Interview a sample of subject matter experts (SME) about specific non-technical skills (NTS) for managing an out-of-hospital cardiac arrest (OHCA) and how these would be assessed using a behavioural marker system (BMS) using the semi structured interview schedule detailed below.

Time required: 30-60 minutes

Participants: Subject matter experts – consultant doctors, Helicopter Emergency Medical Service critical care paramedics and University paramedic educators.

Protocol

i. Brief participant about project (let SME re-read, explain, ask questions, and sign participant information sheet and consent form)

ii. Interview as per schedule

Interview Schedule

To work effectively as a team when managing an OHCA, you need to use specific NTS. This project is investigating the non-technical (cognitive and social) skills of student and qualified paramedics and this interview will ask you to discuss the observable NTS you think are important for an effective team. It will also ask you to discuss how you could observe these NTS using a BMS and how this could work as a feedback tool.

1. General guidance questions

Can you recall a challenging OHCA?

What observable NTS would you associate with an OHCA?

Can you expand on… (NTS discussed)?

Can you give a good/bad example of a NTS associated with an OHCA?

How would you differentiate between good and bad NTS observable behaviour?

Can you describe examples of observable behaviour?

How would you feedback to clinicians about their observable NTS?

Any other thoughts?

2. Prompt questions

Can you give me a bit more detail about that?

You said…what did you mean by that?

Tell me what you were thinking at that time?

Thank each SME at end of interview, include contact information.

Appendix I. Template analysis for initial coding

The aim of this research phase is to identify specific non-technical skill (NTS) categories, elements, and exemplar behaviour to produce a taxonomy for a behavioural marker system (BMS). Non-technical skills are defined as:

'Cognitive, social and personal resource skills that complement technical skills and contribute to safe and efficient performance'

The NTS used by student and qualified paramedics when managing an out-of-hospital cardiac arrest (OHCA) are the focus of this project. All NTS must be observable.

Non-technical skill category identification

This template consists of previously suggested general NTS for paramedics and key NTS identified from this projects scoping review, research phase questionnaire and focus group data. The eight *a priori* categories are:

- Communication: the sharing and delivery of information within teams, the public and onward medical care, shares information, uses effective verbal and non-verbal methods, considers timing
- Leadership: directing others, delegation, motivating and supporting others
- Teamwork: effective working together towards a shared goal, includes leadership and followership
- Situation Awareness: information gathering – from the scene, patients, bystanders, other clinicians, understanding/processing information, anticipates and plans ahead
- Situation Assessment: information gathering from the scene, patients, bystanders, other clinicians, making sense of the scene, uses knowledge and understanding of clinical algorithm to inform decisions
- Team Coordination: coordination and integration of a team, tasks, patient care, adaptability, and flexibility of roles to achieve a shared goal, shared responsibility, application of clinical knowledge to aid patient care, and management of tasks

- Decision-making: reaching a judgement when dealing with evolving, complex situations and incorporation of clinical algorithms, uses algorithm to aid decision making
- Task management: application of knowledge of clinical algorithm and equipment, prioritising tasks and problem solving

NOTE

If there is a recognised overlap between categories, please code each phrase as it best fits each category. If there is a phrase/comment that relates to an unlisted category, add to ‘other’ category and review.

Appendix J. Updated template analysis for axial coding

The aim of this research phase is to identify specific non-technical skill (NTS) categories, elements, and exemplar behaviour to produce a taxonomy for a behavioural marker system (BMS). Non-technical skills are defined as:

'Cognitive, social and personal resource skills that complement technical skills and contribute to safe and efficient performance'

The NTS used by student and qualified paramedics when managing an out-of-hospital cardiac arrest (OHCA) are the focus of this project. All NTS must be observable.

Non-technical skill category identification

This template consists of reviewed and updated non-technical skills for paramedics managing an OHCA identified from initial coding. The six categories are:

- Communication: the sharing and delivery of information within teams, the public and onward medical care, shares information, uses effective verbal and non-verbal methods, considers timing
- Leadership: directing others, delegation, motivating and supporting others
- Teamwork: effective working together towards a shared goal, includes leadership and followership
- Situation Assessment: information gathering from the scene, patients, bystanders, other clinicians, making sense of the scene, uses knowledge and understanding of clinical algorithm to inform decisions
- Team Coordination: coordination and integration of a team, tasks, patient care, adaptability, and flexibility of roles to achieve a shared goal, shared responsibility, application of clinical knowledge to aid patient care, and management of tasks
- Decision-making: reaching a judgement when dealing with evolving, complex situations and incorporation of clinical algorithms, uses algorithm to aid decision making

NOTE If there is a recognised overlap between categories, please code each phrase as it best fits each category. If there is a phrase/comment that relates to an unlisted category, add to 'other' category and review.

Appendix K. Copy of P89152 preliminary POHCAAT evaluation ethics certificate

Coventry University

Certificate of Ethical Approval P89152

Applicant:

Stef Cormack

Project Title:

Testing of a Behavioural Marker System for the out-of-Hospital Cardiac Arrest

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval:

28 May 2019

Project Reference Number: P89152

Appendix L. Copy of final evaluation POHCAAT evaluation ethics certificate

Certificate of Ethical Approval P94169

Applicant:

Stef Cormack

Project Title:

Final Simulated Testing of the Student Paramedic Out-of-Hospital Cardiac Arrest Tool – POHCAT

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval:

23 October 2019

Project Reference Number: P94169

Appendix M. Online information package for POHCAAT evaluation

Evaluation of the Prototype Paramedic Out-of-Hospital Cardiac Arrest Tool – POHCAAT

Online Information Package

Stef Cormack

Introduction

You are invited to assist in the evaluation of the usability and effectiveness of the Paramedic Out-of-Hospital Cardiac Arrest Assessment Tool – POHCAAT, an observational behavioural marker system (BMS). It is designed to assess and provide structured feedback of the following non-technical skills (NTS) situation assessment, team coordination, decision-making and communication of an individual in a simulated environment.

Prior to attending a one-day workshop, you will be asked to view an online presentation, which details the development and design of the POHCAAT, the specific NTS and use of a BMS. A participant information sheet and consent form are also included in the online package, which provide more detail of the ethical considerations.

The POHCAAT

The POHCAAT is an observational assessment tool designed to rate the NTS of an individual as part of a paramedic team managing an OHCA.

It comprises of four NTS, each with three elements (sub-components): shown in table 1.

Table 1. POHCAAT NTS, elements and definition

Non-Technical Skill and elements	**Definition**
Situation Assessment • Gathers information • Interprets information/makes sense of the scene • Uses algorithm to inform decisions and planning	The process of understanding the needs and conditions of a scene and team to inform decisions and plan
Team Coordination • Coordinates team • Motivates and supports others • Delegates roles and tasks	The processes and strategies to help teams collaborate more effectively to achieve individual and collective aims/tasks. Combines elements of leadership and followership, allows for change in role
Decision-making • Identifies options and prioritises tasks guided by algorithm • Reviewing/Re-evaluates options • Problem solving	The process of making choices to reach a judgement when dealing with evolving, complex situations, by identifying decisions, gathering information, and assessing alternative resolutions
Communication • Exchanging/sharing information • Actively listens, considers timing and others • Uses effective verbal/non-verbal communication methods	The sharing and delivery of information within teams, to the public, and onward medical care using verbal and non-verbal methods

Each NTS has a range of associated behaviours to assist the identification of poor and good performance. A rating option provides a scale to reflect the level of observed performance, shown in table 2.

Table 2. Rating Scale

Rating option	**Descriptor**
5 – Excellent (exceptional)	Exceptional performance. Observed behaviour is consistent, effective, safe and could be an example for others
4 – Good (strong)	Consistently high performance. Observed behaviour is frequently of high standard, effective and safe but can be improved
3 – Acceptable (adequate)	Satisfactory performance. Observed behaviour does not endanger patient or others, overall effective and safe but needs improvement
2 – Poor (concerning)	Concerning performance. Observed behaviour potentially compromises safety of patient and others. Ineffective at times, needs significant improvement
1 – Unacceptable (unsafe)	Unsafe performance. Observed behaviour does not meet ALS standards, patient and others endangered. Ineffective throughout; retraining required.

If you can attend the workshop, the day is divided into five areas:

1. Recap of information on NTS, BMS, the design, use, and aim of POHCAAT
2. Watch two training films as a group to assess one individual in each OHCA scenario using POHCAAT
3. Review evaluation results and discuss the use of the POHCAAT including any strengths/weaknesses/rater bias
4. Independently observe five test films using POHCAAT and review results as a group
5. Completion of POHCAAT questionnaire and final Q+A session

Also included in this package are links to further reading on NTS and human factors within healthcare and a workshop plan. Please take the time to read these, as they will assist with the evaluation of the POHCAAT.

Workshops are being held in July 2019, if you are interested, please contact me for more information and to book a place:

Stef Cormack (cormack3@coventry.ac.uk)

Senior Lecturer Paramedic Science

Coventry University

Richard Crossman building, room RC247

Director of Studies and supervisor – Dr Steve Scott (ab8575@coventry.ac.uk)

Further reading

https://chfg.org/

https://publicapps.caa.co.uk/docs/33/CAP%20737%20DEC16.pdf

https://www.who.int/patientsafety/research/methods_measures/human_factors/human_factors_review.pdf

http://www.hse.gov.uk/humanfactors/

POHCAAT trg and testing presentation.p

Prototype Paramedic Out-of-Hospital Cardiac Arrest Assessment Tool (POHCAAT)

Name of student/paramedic being observed……………………….Assessor name…………………………….Date…………..

Rating option	***Descriptor***
Excellent (exceptional)	Exceptional performance. Observed behaviour is consistent, effective, safe and could be an example for others
Good (strong)	Good performance. Observed behaviour is frequently of high standard, effective and safe but could improve in some categories
Acceptable (adequate)	Satisfactory performance. Observed behaviour does not endanger patient or others, adequate and safe but could improve in all categories
Poor (concerning)	Concerning performance. Observed behaviour potentially compromises safety of patient and others. Ineffective at times, needs significant improvement across all categories
Unacceptable (unsafe)	Unsafe performance. Observed behaviour does not meet ALS standards, patient and others endangered. Ineffective throughout: additional training required

Your score should reflect the one observed student/paramedic's behaviour throughout the simulated OHCA. Please provide a score for each category and a final summative score. The highest score possible is 20, the lowest 4, an acceptable score is ≥11.
Example behaviours can be found on page 3.

NTS Category	***Element***	***Behavioural Marker***	***Score***
Team Coordination Total score……	Coordinates team	Proactive in team coordination, considers teams experience, abilities, needs and workload and reviews Flexible can adapt between roles as more clinicians arrive on scene	
	Motivates and supports others	Supports others, guides, and directs, recognises tiredness, task focus, overload, and underload	
	Delegates roles and tasks	Establishes skill level early and allocates/accepts roles effectively; clinical, logistics, family management	

NTS Category	***Element***	***Behavioural Marker***	***Score***
Communication Total score……	Exchanging/sharing information	Shares/provides information about chosen course of action clearly and simply	
	Actively listens, considers timing and others	Listens, acknowledges receipt of information, and clarifies, when necessary, recognises task focus	
	Uses effective verbal/non-verbal communication methods	Adapts language, tone, and/or volume to suit, recognises body language	
Situation Assessment Total score……	Gathers information	Scans scene; verbalises and acts on hazards/surroundings with team and others	
	Interprets information/makes sense of the scene	Alters physical environment to ensure best access for team; patient, furniture, equipment, calls for additional resources	
	Uses algorithm to inform decisions and planning	Reviews algorithm/guidelines/checklists to cross-check information and plans	
Decision-making Total score……	Identifies options and prioritises tasks guided by algorithm	Uses observations and algorithm knowledge to prioritise clinical interventions, identifies course of action to aid decision/problem solving	
	Selects and manages options	Considers algorithm based on working and differential diagnosis. Considers patient options based on people, equipment, scene, and timing	
	Reviewing/Re-evaluates options	Reviews risks and prioritises tasks with other in response to patient condition	
Feedback			Summative score

Example behaviours

NTS Category	***Element***	***Example of good behaviour***	***Example of poor behaviour***
Team Coordination	Coordinates team	Assesses priorities of the situation, ensures safety for all involved including the need for early chest compressions and defibrillation Confirms patient condition and takes control of scene in a calm manner, establishes skill levels and roles needed for effective advanced life support	Not proactive in team coordination, does not consider priorities or safety aspects of scene/patient care Performs own tasks at inappropriate times without consideration to patient needs or condition
	Motivates and supports others	Supports others, recognises tiredness, task focus, guides and directs when needed, leads with no support required	Does not recognise or offer to help others if tired/task overloaded/under-loaded/stressed
	Delegates roles and tasks	Establishes skill level and allocates roles, accepts role/tasks/direction generally without question	Does not adapt or accept alternative tasks/roles as other clinicians arrive Does not accept role/tasks/direction, questions, and challenges throughout
Communication	Exchanging/sharing information	Frequently shares information and clarifies when requested	Does not share or exchange Information, even when requested
	Actively listens, considers timing and others	Actively listens, confirms, and follows instructions dependent on role, considers timing of communication	Asks irrelevant questions, unaware of concentration for clinical interventions, can verbally overload others
	Uses effective verbal/non-verbal communication methods	Communication is calm, precise, directed, timely and clear, discusses options with team Aware of own and others body language, looks for focused attention, impaired dexterity, signs of frustration or tiredness	Communication is not calm, precise, directed, timely or clear, does not respond to others Demonstrates abrupt/rude/dismissive behaviour

NTS Category	***Element***	***Example of good behaviour***	***Example of poor behaviour***
Situation Assessment	Gathers information	Scans scene, and continues throughout cardiac arrest, not focused on patient, considers location and position of patient, others on scene, and environment	Does not survey the scene, focuses on patient environment, does not recognise hazards/surroundings, or ask others about patient
	Interprets information/makes sense of the scene	Alters physical environment – asks for team input and help to move patient/furniture/equipment, to provide best access for the team to perform safe and effective resuscitation. Calls for help early	Makes no effort to alter the physical layout of the scene, starts resuscitation without moving anything, does not consider best access for safe and effective resuscitation. Does not call for help
	Uses algorithm to inform decisions and planning	Uses algorithm/guidelines/checklist to cross-check information to aid decision-making and planning relative to time on scene	Does not cross-check information or use algorithm/guidelines/checklist for decisions or plans, is not aware of time scene
Decision-making	Identifies options and prioritises tasks guided by algorithm	Uses and has good knowledge and understanding of algorithms, applies these to the patient to prioritise clinical tasks and guide decisions	Makes no reference to clinical algorithm, does not display acceptable knowledge of BLS/ALS algorithms, deviates from clinical algorithm
	Selects and manages options	Considers cause of OHCA, can be seen to plan and prepare for patient interventions/care and movement	Does not consider cause of OHCA, reversible causes or patient presentation, very limited planning of interventions
	Reviewing/Re-evaluates options	Reviews situation throughout entirety of OHCA, open to other’s views, alters decisions if appropriate/beneficial	Is not active in reviewing the situation, does not discuss/contribute to decisions, review, or consider alternatives

Appendix N. Rater evaluation workshop schedule

POHCAAT Preliminary Evaluation Workshop plan and timeline

SESSION TITLE	SESSION FACILITATOR
Training and Testing of the Paramedic Out-of-Hospital Cardiac Arrest Assessment Tool (POHCAAT) behavioural marker system	Stef Cormack PhD student, Coventry University

NUMBER OF LEARNERS	Dependent on location (max 10)	**LEARNER BACKGROUND**	Subject matter expert in OHCA and CRM, paramedic science lecturers (raters)

OVERVIEW

This workshop will explain the use and purpose of the POHCAAT. The training stage will involve a session on the purpose and design of the POCHAAT. This will include recording observations, rater bias, evaluation methods, general use and aim of the POHCAAT. Raters will test the tool as a group using two existing films of simulated OHCA scenarios. The training stage will use two short films (15mins max each) with each rater assessing one identified participant, and observation and application of the POHCAAT guided by the lead researcher. Upon completion of each film, all raters will review and discuss each film and scores. A testing stage will then be completed, using five films, where each rater will individually observe and assess the identified participant in each film. When all five observations are complete, each rater will complete a survey of 12 closed questions using a five-point Likert scale and two open questions to provide feedback on the ease of use, user information and any comments. A final review, debrief and feedback session will close the workshop.

LEARNING OUTCOMES

1. Understand and gain experience in the design, use, bias and aim of POHCAAT
2. Collect data to assess reliability, validity, and usability of the POHCAAT
3. Construct feedback on the use and rating of the POHCAAT
4. Identify strengths and weaknesses of the POHCAAT
5. Identify areas for improvement

DIFFERENTIATION	EQUIPMENT
Create a safe, non-judgemental environment PowerPoint, critical discussion, and practical use of POHCAAT	Paper copies of consent and participant information forms Paper and digital copies (controlled) of POHCAAT and survey, pens, water, post-it notes Software links/videos Working Wi-Fi

TIMELINE	LEARNER ACTIVITY	FACILITATOR ACTIVITY
0900-0905	Take seat in preferred area, connect to Internet	Set ground rules for session, give outline, learning outcomes, and ensure all have consent forms
0905-0910	Access POHCAAT (paper and digital copies available)	Hand out POCHAAT and support participants
0910-0930	Raters to listen to rationale of POHAAT and chance to ask questions	Short explanation of the session, design, use and aim of POHCAAT
0930-1000	Watch and interact with POHCAAT presentation, chance to ask further questions	Presentation on POHCAAT, explain reason, design, use, bias, formative feedback, observations, performance rating scale and general use of POHCAAT in detail
1000-1015	BREAK	BREAK
1015-1045	Continue with POHCAAT presentation, chance to ask further questions	Watch and interact with POHCAAT presentation, chance to ask further questions
1045-1105	Watch training film one and assess using POHCAAT as a group	Support practical learning and answer questions, guide discussion

1105-1150	Review training film one and discuss potential barriers and uses of POHCAAT, feedback	Guide critical discussion and answer questions
1150-1200	Review of morning and questions	Provide review and answer questions raised
1200-1300	LUNCH	LUNCH
1300-1305	Settle back into workshop	Settle in raters and short recap of morning session
1305-1325	Watch training film two and assess using POHCAAT as a group	Support practical learning and answer questions, guide discussion
1325-1410	Review training film two and discuss potential barriers and uses of POHCAAT, feedback	Guide critical discussion and answer questions
1410-1425	BREAK	BREAK

1425-1430	Explain next stage – individual observation of five films	Answer any questions, clarify, and ensure all are ready to rate
1430-1450	Raters independently observe film one and rate using POHCAAT	Play film one, assist as required
1450-1510	Raters independently observe film two and rate using POHCAAT	Play film two, assist as required
1510-1530	BREAK	BREAK
1530-1550	Raters independently observe film three and rate using POHCAAT	Play film three, assist as required
1550-1610	Raters independently observe film four and rate using POHCAAT	Play film four, assist as required
1610-1630	Raters independently observe film five and rate using POHCAAT	Play film five, assist as required
1630-1645	BREAK	BREAK
1645-1745	Review independent scores and Feedback on use of POHCAAT	Answer questions, takes note of question and answers
1745-1800	Raters to individually complete questionnaire	Hand out and collect completed questionnaires
1800-1830	Final questions and close workshop	Conclude and answer any questions. Ensure all have contact details. Close workshop

Appendix O. Rater preliminary POHCAAT evaluation survey

Paramedic Out-of-Hospital Cardiac Arrest Assessment Tool (POHCAAT) Questionnaire

This questionnaire aims to consolidate the practical testing of the use of the Paramedic Out-of-Hospital Cardiac Arrest Assessment Tool (POHCAAT). You will be provided with a participant information sheet and consent form, which must be completed before undertaking this questionnaire.

Your participation is voluntary with all answers and data anonymised.

Demographics

Gender; ………………………………………………. □ Prefer not to say

Age range; □18-29 □ 30-39 □ 40-49 □ 50-59 □ 60-69 □ 70+

Work Locality; □ Pre-hospital □ Hospital □ Education

□ Mix – please state……………………………………………………………………………

Clinical/educational position………………………………………………………………...

Previous experience of crew resource management/non-technical skills □ yes □ no

Please answer each question based on <u>your</u> experience and use of the POHCAAT, tick the box that you feel best suits your opinion – *PLEASE ANSWER AS HONESTLY AS YOU CAN, YOUR ANSWERS WILL HELP INFORM RESEARCH AND FUTURE PRACTICE.*

Questions	***Strongly Disagree***	***Disagree***	***Neither Agree nor Disagree***	***Agree***	***Strongly Agree***
1. The POHCAAT was easy to use					
2. The domains were well suited to an OHCA					
3. It was easy to associate the observed behaviour and the POHCAAT domains					
4. The POHCAAT was useful for structuring observations of the videos					
5. It was easy to differentiate observed behaviours					
6. The descriptions of the domains were clear					
7. The descriptions of the ratings were clear					
8. The wording for each domain was meaningful					
9. The information on the POHCAAT was adequate					

10. You feel confident in using the POHCAAT					
11. The POHCAAT accurately scores non-technical skills behaviour					
12. The POHCAAT can be used to assess student paramedics non-technical skills in the OHCA					
13. If you disagreed with any of the previous questions, please provide comments					
14. Any further comments please state here					

Many thanks for taking the time to complete this questionnaire, your comments will help inform future practice, thank you!!

If you would like to receive further information on the ongoing study, including results and links to publications please write your email address here (this will not be used as part of the study data and will remain confidential):

…………………………………………………………………………………………….……

Stef Cormack (Postgraduate research student, Coventry University). Email; cormack3@coventry.ac.uk

Supervisor; Steve Scott (Coventry University). Email ab8575@coventry.ac.uk

Appendix P. Copy of student paramedic final evaluation survey

Paramedic Out-of-Hospital Cardiac Arrest Assessment Tool (POHCAAT) Questionnaire student participants

This questionnaire aims to consolidate the practical testing of the use of the Paramedic Out-of-Hospital Cardiac Arrest Assessment Tool (POHCAAT). You will be provided with a participant information sheet and consent form, which must be completed before undertaking this questionnaire.

Your participation is voluntary with all answers and data anonymised.

Demographics

Gender: □ Male □ Female □ Prefer not to say

Age range; □ 18-29 □ 30-39 □ 40-49 □ 50-59 □ 60-69 □ 70+

Programme; □ FdSc □ DIPHE

Previous experience of crew resource management/non-technical skills □ yes □ no

Please answer each question based on your experience and use of the POHCAAT, tick the box that you feel best suits your opinion – *PLEASE ANSWER AS HONESTLY AS YOU CAN, YOUR ANSWERS WILL HELP INFORM RESEARCH AND FUTURE PRACTICE.*

Questions	*Strongly Disagree*	*Disagree*	*Neither Agree nor Disagree*	*Agree*	*Strongly Agree*
1. The POHCAAT provided me with useful feedback					
2. The feedback is easy to understand					
3. The amount of feedback is adequate					
4. The feedback will help me improve my non-technical skills in an OHCA					
5. The non-technical skills domains (left hand side) made sense					
6. The descriptions of the behaviour were easy to understand					
7. The POHCAAT accurately scores non-technical skills behaviour					
8. The POHCAAT can be used to assess student paramedics non-technical skills in the OHCA					

9. Any further comments please state here	

Many thanks for taking the time to complete this questionnaire, your comments will help inform future practice, thank you!!

If you would like to receive further information on the ongoing study, including results and links to publications please write your email address here (this will not be used as part of the study data and will remain confidential):

…………………………………………………………………………………………………..……

Stef Cormack (Post graduate research student, Coventry University). Email; cormack3@coventry.ac.uk

Supervisor; Steve Scott (Coventry University). Email ab8575@coventry.ac.uk

Appendix Q. Interview schedule and question guide for final evaluation semi-structured interviews

Aim: Conduct semi-structured interviews of raters following final evaluation of POHCAAT v2 to evaluate content and face validity.

Time required: 30-60 minutes

Participants: Consultant doctors, Helicopter Emergency Medical Service critical care paramedics and University paramedic educators.

Protocol

i. Brief each rater to remind what the project is about, including participant information sheets and consent forms.
ii. Interview as per schedule

Interview Schedule

Brief review of main thoughts, use general guidance questions and 'prompts' for clarification where more detail as required

1. General guidance questions

How did you find using the POHCAAT v2?

Can you tell me about this in as much detail as possible?

Did you have any difficulties using it?

What did you think about the simulated scenarios?

Were there any difficulties with watching the simulated scenarios?

What did you think about the design of the POHCAAT v2?

Is there anything you would alter/improve?

Do you think the POHCAAT can be applied to practice?

Any other thoughts/feedback?

2. Prompt questions

Can you give me a bit more detail about that?

You said…what did you mean by that?

Tell me what you were thinking at that time?

Thank rater and close interview, include contact details.

Appendix R. Final evaluation Wilcoxon signed-ranks test mean scores and SD for paired scenarios

	Scenario 1 (unacceptable)	***Scenario 2 (poor)***		
	Mean (SD)	Mean (SD)	Difference in means	*p* value
Overall rating	4.28 (0.48)	7.71 (0.48)	3.43	.016
Team Coordination	1.00 (0.00)	2.00 (0.00)	1.00	.008
Communication	1.00 (0.00)	1.85 (0.37)	0.85	.014
Situation Assessment	1.28 (0.48)	2.00 (0.00)	0.72	.025
Decision-making	1.00 (0.00)	1.85 (0.37)	0.85	.014

	Scenario 1 (unacceptable)	***Scenario 4 (acceptable)***		
	Mean (SD)	Mean (SD)	Difference in means	*p* value
Overall rating	4.28 (0.48)	12.2 (0.48)	7.40	.014
Team Coordination	1.00 (0.00)	2.85 (0.37)	1.85	.011
Communication	1.00 (0.00)	3.00 (0.00)	2.00	.008
Situation Assessment	1.28 (0.48)	3.14 (0.37)	1.86	.016
Decision-making	1.00 (0.00)	3.28 (0.48)	2.28	.014

	Scenario 1 (unacceptable)	***Scenario 6 (good)***		
	Mean (SD)	Mean (SD)	Difference in means	*p* value
Overall rating	4.28 (0.48)	14.8 (0.37)	10.52	.015
Team Coordination	1.00 (0.00)	3.85 (0.37)	2.85	.011
Communication	1.00 (0.00)	3.14 (0.37)	2.14	.011
Situation Assessment	1.28 (0.48)	4.00 (0.00)	2.72	.014
Decision-making	1.00 (0.00)	3.85 (0.37)	2.85	.011

	Scenario 1 (unacceptable)	***Scenario 5 (excellent)***		
	Mean (SD)	Mean (SD)	Difference in means	*p* value
Overall rating	4.28 (0.48)	18.2 (0.75)	13.92	.017
Team Coordination	1.00 (0.00)	4.85 (0.37)	3.85	.011
Communication	1.00 (0.00)	4.57 (0.53)	3.57	.015
Situation Assessment	1.28 (0.48)	4.28 (0.48)	3.00	.014
Decision-making	1.00 (0.00)	4.57 (0.53)	3.57	.015

	Scenario 2 (poor)	***Scenario 4 (acceptable)***		
	Mean (SD)	Mean (SD)	Difference in means	*p* value
Overall rating	7.71 (0.48)	12.2 (0.48)	4.49	.014
Team Coordination	2.00 (0.00)	2.85 (0.37)	0.85	.014
Communication	1.85 (0.37)	3.00 (0.00)	1.15	.011
Situation Assessment	2.00 (0.00)	3.14 (0.37)	1.14	.011
Decision-making	1.85 (0.37)	3.28 (0.48)	1.43	.015

	Scenario 2 (poor)	***Scenario 6 (good)***		
	Mean (SD)	Mean (SD)	Difference in means	*p* value
Overall rating	7.71 (0.48)	14.8 (0.37)	7.09	.016
Team Coordination	2.00 (0.00)	3.85 (0.37)	1.85	.011
Communication	1.85 (0.37)	3.14 (0.37)	1.20	.014
Situation Assessment	2.00 (0.00)	4.00 (0.00)	2.00	.008
Decision-making	1.85 (0.37)	3.85 (0.37)	2.00	.014

	Scenario 2 (poor)	***Scenario 5 (excellent)***		
	Mean (SD)	Mean (SD)	Difference in means	*p* value
Overall rating	7.71 (0.48)	18.2 (0.75)	10.46	.017
Team Coordination	2.00 (0.00)	4.85 (0.37)	2.85	.011
Communication	1.85 (0.37)	4.57 (0.53)	2.72	.016
Situation Assessment	2.00 (0.00)	4.28 (0.48)	2.28	.014
Decision-making	1.85 (0.37)	4.57 (0.53)	2.72	.016

	Scenario 3 (acceptable)	***Scenario 6 (good)***		
	Mean (SD)	Mean (SD)	Difference in means	*p* value
Overall rating	11.4 (0.53)	14.8 (0.37)	3.40	.015
Team Coordination	2.85 (0.37)	3.85 (0.37)	1.00	.014
Communication	2.85 (0.37)	3.14 (0.37)	0.29	.016
Situation Assessment	3.00 (0.00)	4.00 (0.00)	1.00	.008
Decision-making	2.57 (0.53)	3.85 (0.37)	1.28	.024

	Scenario 4 (acceptable)	***Scenario 5 (excellent)***		
	Mean (SD)	Mean (SD)	Difference in means	*p* value
Overall rating	12.2 (0.48)	18.2 (0.75)	6.00	.017
Team Coordination	2.85 (0.37)	4.85 (0.37)	2.00	.014
Communication	3.00 (0.00)	4.57 (0.53)	1.57	.015
Situation Assessment	3.14 (0.37)	4.28 (0.48)	1.14	.023
Decision-making	3.28 (0.48)	4.57 (0.53)	1.29	.014

Appendix S Final Evaluation inter-rater reliability assessed with r_{wg} (*Simulation)

	Sim 1*	*Sim* 2*	*Sim* 3*	*Sim* 4*	*Sim* 5*	*Sim* 6*	*Sim* 7*	*Sim* 8*	*Sim* 9*	*Sim* 10*	*Sim* 11*	*Sim* 12*	*Average r_{wg}*
Team coordination	1.00	1.00	1.00	0.97	0.97	0.97	1.00	1.00	0.98	1.00	0.98	0.95	0.98
Coordinates scene – leads or follows	0.99	0.99	0.96	0.99	0.98	0.98	0.98	0.95	0.96	0.99	0.98	0.97	0.97
Delegates roles/tasks	0.99	0.95	0.99	0.99	0.98	0.98	0.99	0.99	0.97	0.97	0.99	0.97	0.98
Supports others	0.99	0.93	0.99	0.98	0.97	0.97	0.97	0.98	0.96	0.91	0.97	0.97	0.96
Communication	1.00	0.97	0.97	0.97	0.94	0.97	0.97	1.00	0.94	0.95	0.94	0.97	0.96
Shares information	0.99	0.97	0.96	0.99	0.98	0.99	0.97	0.99	0.97	0.97	0.97	0.97	0.97
Considers timing of communication	0.99	0.98	0.95	0.98	0.97	0.99	0.97	0.99	0.98	0.94	0.99	0.99	0.97
Uses effective verbal and non-verbal methods	0.97	0.98	0.97	0.95	0.95	0.99	0.99	0.97	0.99	0.96	0.98	0.97	0.97
Situation Assessment	0.97	1.00	1.00	0.97	0.95	1.00	1.00	0.97	1.00	0.95	1.00	0.94	0.97
Gathers information	0.97	0.98	0.94	0.97	0.89	0.92	0.99	0.99	0.98	0.97	0.92	0.89	0.95
Uses information to make sense of the scene	0.97	0.98	0.95	1.00	0.99	0.95	0.97	0.96	0.98	0.96	0.94	0.99	0.97
Uses algorithm to inform decisions and planning	0.99	0.96	0.95	0.99	0.95	0.97	0.99	0.95	0.99	0.95	0.97	0.95	0.96
Decision-making	1.00	0.97	0.94	0.95	0.94	0.97	1.00	1.00	0.95	0.94	0.97	1.00	0.96
Prioritises decisions and tasks based on patient and resources	0.96	0.99	0.97	0.91	0.97	0.97	0.97	0.99	0.96	0.91	0.91	0.91	0.95
Safe decisions based on patient condition/scene	0.97	0.94	0.92	0.94	0.97	0.99	0.99	0.99	0.97	0.94	0.97	0.98	0.96
Reviewing/re-evaluates options	0.98	0.97	0.99	0.98	0.98	0.98	0.99	0.99	0.97	0.97	0.97	0.97	0.97
Average r_{wg} for film	0.98	0.97	0.96	0.97	0.96	0.97	0.98	0.98	0.97	0.95	0.96	0.96	

Appendix T. Final evaluation ICC, two-way mixed effects model, absolute agreement, single measures (*Simulation)

Rater	*Sim* 1 and 7 (95% CI)*	*Sim* 2 and 8 (95% CI)*	*Sim*3 and 9 (95% CI)*	*Sim* 4 and 10 (95% CI)*	*Sim* 5 and 11 (95% CI)*	*Sim* 6 and 12 (95% CI)*
1	0.91 (0.46-0.99)	1.00	1.00	0.97 (0.79-0.99)	0.98 (0.78-0.99)	1.00
2	1.00	0.96 (0.74-0.99)	1.00	0.99 (0.90-0.99)	0.99 (0.94-0.99)	0.99 (0.91-0.99)
3	1.00	0.97 (0.79-0.99)	0.95 (0.54-0.99)	0.98 (0.88-0.99)	0.98 (0.78-0.99)	0.98 (0.88-0.99)
4	0.91 (0.46-0.99)	1.00	0.98 (0.86-0.99)	0.98 (0.89-0.99)	0.99 (0.94-0.99)	0.99 (0.92-0.99)
5	0.91 (0.46-0.99)	0.96 (0.74-0.99)	1.00	0.98 (0.90-0.99)	1.00	0.99 (0.92-0.99)
6	1.00	0.96 (0.74-0.99)	0.98 (0.88-0.99)	0.98 (0.88-0.99)	0.99 (0.95-0.99)	0.99 (0.92-0.99)
7	1.00	1.00	1.00	0.98 (0.88-0.99)	0.98 (0.91-0.99)	0.96 (0.74-0.99)
8	1.00	1.00	0.98 (0.86-0.99)	0.98 (0.89-0.99)	1.00	0.99 (0.91-0.99)
Average	0.96 (0.90-0.99)	0.98 (0.95-0.99)	0.98 (0.96-0.99)	0.98 (0.95-0.99)	0.99 (0.97-0.99)	0.98 (0.96-0.99)