The University Of Sheffield.

Documentation of Vital Signs in Electronic Health Records:

A Patient Safety Issue

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Abstract

Background and aim: Hospitals in the developed world are increasingly adopting digital systems such as electronic health records (EHRs) for all kinds of documentation. This move means that traditional paper case notes and nursing records are often documented in EHRs. Documentation of vital signs is important for monitoring a patient's physiological condition and how vital signs are presented in a clinical record can have a profound impact on the ability of clinicians to recognise changes, such as deterioration in a patient's condition. Vital signs have received minimal attention with regard to how they are documented in EHRs which suggests that there is an urgent need for this to be examined.

Design, methodology and approach: A mixed methods study was conducted in a 372-bed county hospital in two phases. Phase one was a quantitative study, and was followed by a qualitative study in phase two. The aim of the quantitative study was to examine the vital signs documented in the electronic health records of patients who had previously suffered a cardiac arrest. The aim of the qualitative study was to investigate how medical and nursing staff measured, reported and retrieved information on vital signs. Observations were made and interviews were conducted in four clinical areas.

Findings: The quantitative study found that documentation of vital signs was incomplete in relation to current universal standards for monitoring vital signs, and that vital signs were dispersed inconsistently throughout the EHR. The qualitative study provided a detailed understanding of the routines and practices for monitoring vital signs and demonstrated variation in routines and in methods of documentation in the four clinical areas. Documenting and retrieving vital signs in the EHR was problematic because of usability issues and led to workflow problems. Workflow problems were solved at ward level by the creation of paper workarounds.

Contribution to knowledge: This thesis has shown that poor facilities for the documentation of vital signs in EHRs could have a negative impact on patient safety because it reduces the possibility of good record keeping. This leads to limited availability of easily accessible, up-to-date information, essential for identifying clinical deterioration and, thus, is a challenge to patient safety. Related to this, the thesis has identified possible solutions to usability problems in the EHR. Inconsistent routines and practices were also identified and suggestions were made for how this problem might be approached.

Keywords: patient safety, vital signs, electronic health records

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List of abbreviations and acronyms

Abbreviation	Explanation
ADDS	Adult Deterioration Detection System
BAS	Blodtryck, andningsfrekvens, saturation (Eng. blood pressure, respiratory rate, saturation of oxygen)
BP	Blood pressure
°C	degrees Centigrade
CCL	Cardiac Catheterisation Laboratory
CCOT	Critical Care Outreach Team
CICU	Cardiac Intensive Care Unit
CPR	Cardio-Pulmonary Resuscitation
DNAR	Do Not Attempt Resuscitation
ED	Emergency Department
EHR	Electronic Health Record
EWS	Early Warning Score
HDU	High Dependency Unit
HCA	Health Care Assistant
HR	Heart rate
ICU	Intensive Care Unit
MET	Medical Emergency Team
MERIT	Medical early response intervention and therapy
MEWS	Modified Early Warning Score
MS Word	Microsoft Word
NEWS	National Early Warning Score
NICE	National Institute for Clinical Excellence
NFR	Not for resuscitation
NPSA	National Patient Safety Agency
O_2	Oxygen
P	Pulse
PART	Patient At Risk Team

PDA	Personal Digital Assistant
PEWS	Paediatric Early Warning Score
R	Respiratory rate
RCN	Royal College of Nurses
RCP	Royal College of Physicians
RN	Registered Nurse
RRS	Rapid Response System
RRT	Rapid Response Team
SCA	Sudden cardiac arrest
SEWS	Standard Early Warning Score
SaO_2	Saturation of oxygen
SpO_2	Saturation of peripheral oxygen
SRICA	Swedish Register for In-hospital Cardiac Arrest
T	Temperature
TTS	Track and Trigger System
ViEWS	VitalPAC Early Warning Score
RETTS	Rapid emergency triage and treatment system

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Prologue

In this prologue, I present a personal narrative, using the active voice, to give the reader an understanding of how this work came about. This thesis is not the result of a long-term goal to gain a PhD, rather, it is the synthesis of a varied and interesting career.

My background was in nursing, first, as a registered nurse (RN), practising in surgical and medical wards, then as a registered midwife in a busy labour ward. Following this period as a midwife, I studied adult intensive care and subsequently worked in an intensive care unit (ICU). Caring for people who were critically ill was both challenging and rewarding. Later, I studied for a year to become a nurse teacher and subsequently taught at a school of nursing, teaching prospective registered nurses.

When I moved to Sweden, I studied English at university and was subsequently employed at the Department of English at the same institution to teach medical English. The students included doctors, nurses, physiotherapists, nursing students and others who worked in healthcare. Technology played a major role in the on-line courses that I taught and gradually this led to the subject of health informatics being incorporated into the courses. In 2007, I attended university to upgrade my nursing qualifications to bachelor degree level. One aspect of gaining this degree was to write a bachelor paper in the form of a literature review on a subject of my choice.

Coincidentally, at this time I accompanied a colleague, a lecturer of nursing, on a visit to an acute hospital ward to see the new electronic health record (EHR) system that had been launched several weeks earlier. My expectations were high; a user-friendly system suited to work processes and which provided good decision support. Contrary to these expectations, there were many aspects of the system that gave me cause for concern and fears for patient safety. For example, it appeared to be difficult to find information about patients and the interface seemed awkward to use. One of the most alarming aspects of the system was that there did not appear to be any equivalent to the 'obs' chart - the patient observation chart for recording vital signs, such as blood pressure, temperature, pulse and respirations.

Previously, paper observation charts would have displayed this information at a glance, providing an overview of a patient's physiological status and facilitating the viewing of trends. Thus, clinicians could be alerted to changes in a patient's clinical condition, for example, if there are any signs of clinical deterioration. However, my instinctive and

intuitive feeling was that the way in which these signs were now presented in the electronic system would make it difficult to monitor changes in a patient's clinical condition and that this could compromise patient safety. What I witnessed in this EHR went against everything I knew about monitoring patients.

Following this visit to view the EHR, in which nurses were to document all aspects of care, I realised my earlier plans to investigate compassion in nursing had to be shelved. It was more important to find out about vital sign documentation in the EHR. Patients are less likely to die of lack of compassion than they are to die from lack of vital sign monitoring.

The first part of this investigation was a literature review, to try to find out about nurses' experiences of using electronic health records. There was a dearth of literature in this area, but of the few articles found, it seemed that although nurses thought there were many positive aspects to EHR, there were many complaints about lack of overview and poor usability. The literature review also pointed to the need for more research in the area. Thus, I decided to continue with another study that would become part of a master's degree. This study was a qualitative study in which we interviewed nurses in focus groups to find out more about how they perceived using an EHR. Again, among the positive views, there were many complaints about the system being awkward to use and that it was difficult to view vital patient information at a glance.

It seemed surprising that these complaints from users had not led to improvements in systems. This led to the conclusion that the voices of users were not being heard and that further research was needed in this area. When I presented the results of the qualitative study at the International Symposium for Health and Information Management Research (ISHIMR) 2009, I had the good fortune to meet Dr Peter Bath. In-depth discussions with Peter helped me to confirm that I should continue along the path on which I had set out; there was still much research to be done in this field. Thus, the concept of this thesis was born and I began PhD studies, as though it were an inevitable step along the path of a varied and interesting career. My background in acute nursing with a deep understanding of caring for people who are acutely ill, an interest in health informatics and a strong desire to help promote safe care for hospital patients was the motivation for continuing this research. With Dr Bath's support, I applied for a scholarship for PhD study at the University of Sheffield (UoS). I was accepted to study for a PhD part time and was awarded a scholarship in 2010. Dr Peter Bath would be my main supervisor, and Dr Gunilla Nilsson and Professor Göran Petersson at the eHealth Institute, Linnaeus

University (LNU) kindly agreed to be my secondary supervisors. My own department, the School of Languages and Literature at LNU, supported me to continue working as a lecturer of English, while doing research part time. In addition, the eHealth Institute at LNU and Kalmar County Council with its County Hospital have financially supported my studies. By doing this study, I have been able to take forward my interests and concerns about the documentation of vital signs in EHRs.

Chapter 1 Introduction

1.1 Background

This thesis is an investigation into the use of electronic health record (EHR) systems for the documentation of critical clinical data, specifically, patients' physiological vital signs. Vital signs are literally 'the signs of life' and include measurements of temperature, pulse, respirations and blood pressure. It is also hoped that this research will contribute to improving patient safety by providing knowledge about the requirements of effective documentation of vital signs and informing the design of EHRs.

Information systems have revolutionised the way that information is managed, processed and stored (Narasimhadavara, Radhakrishnan, Leung, & Jayakumar, 2008). EHR systems are increasingly used for all aspects of healthcare documentation (Häyrinen, Saranto, & Nykänen, 2007) and therefore it is essential that these systems meet the requirements of health care organisations as well as the needs of end-users as they carry out their everyday responsibilities. This means that systems should be effective, efficient and user friendly, and take work processes into account. Work processes in acute clinical areas such as medical and surgical wards, and intensive care units are multi-faceted, and this imposes high demands on EHR systems. Furthermore, the demands for accurate documentation of clinical data are important. However, some studies have found that it can be difficult to enter and access clinical information in an electronic health record (Moody, Slocumb, Berg, & Jackson, 2004; Stevenson & Nilsson, 2012). Difficulty in accessing patient information could be particularly significant in caring for acute patients whose clinical conditions are vulnerable and susceptible to sudden change or deterioration.

In the event that a patient's condition does deteriorate, timely and appropriate action should be taken. However, sometimes, deterioration in clinical status is not detected, or not acted upon in time, with serious outcomes such as prolonged hospital stay or even death (McQuillan et al., 1998). Early detection of clinical signs of deterioration and timely management of patients has been shown to reduce the risk for in-hospital cardiac arrest and unplanned admission to critical care units (Bellomo et al., 2003; Bristow et al., 2000; Buist et al., 2002; Jones et al., 2005).

Careful monitoring of a patient's physiological status is the key to early detection of deterioration (Hutson & Millar, 2009; National Institute for Clinical Excellence (NICE), 2007, p. 20). By definition, the word 'monitor' means 'to watch and check something over a period of time in order to see how it develops, so that you can make any necessary changes' (Hornby, 2000, p. 823). Monitoring in a clinical situation can be defined as "the on-going assessment of a patient with the intention of (1) detecting an abnormality, and (2) triggering a response if an abnormality is detected" (DeVita et al., 2010, p. 376). Abnormal measurements of a patient's vital signs can indicate that one or more of the respiratory, cardiovascular or neurological systems may be failing. Monitoring criteria include respiratory rate, systolic blood pressure, heart rate, oxygen saturation and temperature. "The foundations of patient safety are laid through doing and recording [these] simple measurements well." (National Institute for Clinical Excellence (NICE), 2007, p. 5). In addition, these parameters need to be easily viewed so that clinicians can instantly identify changes or trends. On traditional paper charts, these vital signs were easy to view on visual graphs, but this type of information is increasingly documented in EHRs and may not be accessible.

In addition to these new systems for documentation, there are other factors that place high demands in health care settings today. For example, there is an increased number of elderly patients with co-morbid problems (James, Butler-Williams, Hunt, & Cox, 2010). This means that an increasing number of patients are at risk of becoming acutely ill due to their underlying diagnosis or previous medical conditions. Moreover, advanced medical treatment and surgical procedures have become available for previously untreatable illnesses. These growing demands in acute care settings have meant that accurate monitoring and documentation of clinical data in adult patients have become even more essential. Thus, the need for correct documentation of acute patients coupled with new systems for record keeping, the EHR, indicates that an investigation into the documentation of vital signs in EHRs is essential.

This section has provided a brief background on the importance of monitoring patient status (1.1). The next section gives a brief historical background to keeping medical records (1.2) and is followed by the rationale and motivation for this thesis (1.3). The aims and objectives are presented in 1.4. The structure of the thesis is explained in 1.5 and section 1.6 provides a conclusion to this chapter.

1.2 Historical background

Even though the practice of medicine dates back to ancient times, it was in the early 1800s that doctors first started to keep some records in ward notebooks and during the Crimean War in the 1850s, Florence Nightingale kept the first patient-oriented health records (Slater, 2007).

As well as realising the importance of record keeping, Florence Nightingale reminds us of why records are kept in relation to observation of the patient:

> "In dwelling upon the vital importance of *sound* observation, it must never be lost sight of what observation is for. It is not for the sake of piling up miscellaneous information or curious facts, but for the sake of saving life and increasing health and comfort". (Nightingale, 1860, p. 125).

In other words, closely observing patients by measuring and recording vital signs is carried out in the interest of keeping patients safe and not just for sake of collecting information; the information is used to make decisions about managing a patient's condition and planning future care. Nowadays, although documentation may have become more sophisticated, one of the main reasons for keeping records is still to promote safe and high quality patient care.

1.3 Rationale and motivation for this thesis

Patient records have traditionally been kept on paper. However, advances in information communication technology have led to the development and use of information systems and EHR systems. EHR systems are widely used in Sweden but few studies exist on how they have been implemented, the degree to which they are successful or the impact they may have on record keeping. More specifically, as demonstrated in Chapter 2, there are no studies available on the documentation of physiological vital signs in these systems.

In Sweden, as in many other countries, the outcome of EHR implementation is varied. For instance, in general practice, there is widespread success with these systems (Jha, Doolan, Grandt, Scott, & Bates, 2008). However, secondary health care has been slower to adopt such systems. One reason for this has been because of fears about patient confidentiality and integrity with much discussion and debate addressed to security threats (Samy, Ahmad, & Ismail, 2010). It is argued that data in patient records should be secure to maintain patient confidentiality. The issue of patient safety has gained less attention. Nevertheless,

worries about integrity would pale into insignificance if a patient's life were at risk. Medical decisions based on incomplete information could mean that inappropriate care might be given (Boaden & Joyce, 2006). In an emergency situation, the more that is known about a patient's history, the safer will be the treatment.

Crucially, there is a gap in knowledge about how EHRs might impact on patient safety. The results of an earlier literature review (Stevenson, Nilsson, Petersson, & Johansson, 2010) and a qualitative study (Stevenson & Nilsson, 2012) indicated that there might be serious threats to patient safety because of deficiencies in documentation in the EHR. These studies clearly identified that there may be risks for patient safety in relation to vital signs documented in EHRs. Consequently, there is an urgent need for research in this area.

1.4 Aims and objectives

The aim of this research was to investigate documentation of physiological vital signs in EHRs. More specifically the research was commenced with the following objectives:

1. to investigate the completeness of documentation of vital signs in the EHR
2. to identify actual problems or potential problems in documenting vital signs in the EHR
3. to report on the documentation of vital signs in acute care settings

The research questions for this thesis will be set out following the literature review in Chapter 2.

1.5 Structure of this thesis

The content of this thesis is divided in to seven chapters. Chapter 1 presents an introduction to the thesis. In chapter 2, there is an extensive examination of the literature to find current research on documentation of vital signs and how documentation is carried out in the EHR. Chapter 3 discusses the methodological choices that were made for this research, discussing how decisions were reached regarding methods. A mixed methods approach in two phases was used for the overall research. Chapter 4 describes the first phase/phase one of the research, a retrospective quantitative study. This study examined the documentation of vital signs in electronic health records of patients who had suffered a cardiac arrest. Chapter 5 reports on a qualitative study conducted as the second phase/phase two of this mixed methods research. Chapter 6 discusses the integrated findings of the quantitative study in phase one and the qualitative study in phase two.

Chapter 7 presents a conclusion to this thesis with implications for practice and recommendations for future research.

1.6 Conclusion

This chapter has provided an introduction to the thesis. This was followed by a background information and a historical background. The rationale for the study and the thesis was then presented, followed by the aims and objectives of the study. In the next chapter, Chapter 2, the related literature is examined and discussed to identify gaps in the research literature..

Chapter 2 Literature review

2.1 Introduction

Chapter 1 provided an introduction to this thesis. This chapter, Chapter 2, provides a review of the relevant literature. The literature review commences with an outline of the literature review methods (Section 2.2). It continues with background information to situate this research in relation to two previous studies by the author regarding documentation in the electronic health record (EHR) (Section 2.3). There is an explanation of why monitoring and documenting physiological information is essential for patient safety (Section 2.4). Next, there is a description of how physiological track and trigger systems have evolved over the last two decades since they were first introduced (Section 2.5). This is followed by an account of the current situation regarding rapid response systems (Section 2.6). The next part of this chapter examines the documentation of physiological information on both paper and in EHRs (Section 2.7). Finally, there is a synthesis of the reviewed literature (Section 2.8) and an identification of gaps in the current research (Section 2.9).

2.2 Literature review methods

A comprehensive literature search was performed at the beginning of this thesis and was updated throughout the research study. A review of the literature was carried out systematically by searching the following databases: Cinahl, Medline, Pubmed, Science Direct and Web of Knowledge. The key words included 'early warning scores', 'modified early warning scores', 'call-out criteria', 'rapid response teams', 'medical emergency teams', 'critical care outreach systems', 'documentation', 'record keeping' and 'electronic patient records'. No limits were set on dates or type of studies. The language of retrieved studies was restricted to English and Swedish. In addition, more general searches were conducted in Google and Google Scholar. Extensive searches were also conducted in the reference lists of key papers.

2.3 Background

Before beginning this thesis the author had carried out two studies. The first was for a bachelor's thesis in the form of a systematic literature review (Stevenson, 2008). The second was a master's dissertation in which a qualitative study was undertaken (Stevenson,

MSc, published in Stevenson & Nilsson, 2009) The systematic review examined existing literature on how nurses experienced electronic health record (EHR) systems for documentation. It focused on nurses working in acute hospital settings. The findings suggested that there was a lack of studies on how nurses experienced using electronic record systems. However, the results also established that nurses were largely dissatisfied with EHR as a means of documentation and that systems were not designed to meet the needs of clinical practice. They were not user-friendly, and could have a potentially negative impact on individualized care and patient safety (Stevenson et al., 2010). A subsequent qualitative study was undertaken with the aim of finding out how nurses perceived documenting clinical information in electronic record systems. Among other things, the findings of that study indicated that the electronic patient record did not support nursing practice when documenting crucial patient information and that this could imply that there were risks to patient safety. Patient safety in relation to monitoring vital signs and physiological status emerged as the most crucial issue and therefore indicated the need to focus further research in this area (Stevenson & Nilsson, 2012). Consequently, this research builds on these previous studies.

As stated in section 1.4, this research aims to investigate the documentation of vital signs in the EHR. Accurate and complete record keeping is crucial for safe, high quality patient care. Patient information should be carefully documented and communicated within the multi-disciplinary team. In addition, these records may be referred to in legal cases regarding medical errors. In legal judgements, the quality of care may be judged in relation to what is documented in a patient's records. If patient data are incomplete it may be difficult to make an adequate judgement on the quality of care (Hutchinson et al. 2010). One crucial area of record keeping is the documentation of patients' vital signs for monitoring patient status; this documentation allows clinical staff to observe any change in a patient's physiological condition.

2.4 Recognition of critical illness

Identifying abnormal vital signs is the key to detecting any deterioration in a patient's condition (Hutson & Millar, 2009; National Institute for Clinical Excellence (NICE), 2007). A common system to aid clinical assessment is the airway, breathing, circulation (ABC) system. Airway obstruction requires immediate attention to ensure a patient can breath. It is generally agreed that breathing problems are indicated if the respiratory rate is greater than 30 per minute although some sources even suggest that a respiratory rate greater than

20 is significant (Duckitt et al., 2007; Morgan, Williams, & M, 1997; Prytherch, Smith, Schmidt, & Featherstone, 2010). A raised respiratory rate indicates an increased demand for oxygen and may be caused by pulmonary or cardiac problems, or any form of shock. Raised respiratory rate is the most significant sign of critical illness and monitoring of respiratory rate is therefore essential in improving detection and treatment of critical deterioration (Goldhill & Sumner, 1998; Schein, Hazday, Pena, Ruben, & Sprung, 1990; Subbe, Davies, Williams, Rutherford, & Gemmell, 2003). Circulation problems can be detected if the systolic blood pressure is lower than the heart rate (positive-shock index) and is another sign of critical deterioration. Cold and clammy skin and poor capillary refill time are also significant signs of circulatory problems. In addition to ABC assessment, the patient's mental state should be observed in relation to deterioration, as confusion and altered conscious level are also early signs of clinical deterioration.

Routine checking of vital signs is an integral part of nursing, to monitor a patient's physiological status. These checks have traditionally included observations of temperature, pulse rate, respiratory rate and systemic blood pressure. Urinary output has also been included in patient observation and more recently, peripheral oxygen saturation (SpO_2) percentage. If the patient's vital signs are outside normal limits, clinical staff are expected to respond appropriately, for example, by increasing the frequency of recordings or calling for appropriate aid to initiate required treatment (Hutson & Millar, 2009). Nevertheless, these signs have often been missed by medical and nursing staff (Subbe, Slater, Menon, & Gemmell, 2006).

2.4.1 Sub-optimal care

In 1990, a study was carried out to identify possible clinical antecedents to cardiac arrest (Schein et al., 1990). The records of patients who had had a respiratory or cardiac arrest were reviewed. This study identified that there were documented signs of clinical deterioration within eight hours of cardiac arrest. However, the results also indicated that patient deterioration, although documented, had not been acted upon. The most prominent signs were related to deterioration in respiratory or mental functions; 53% showing altered respiratory function, 42% deterioration in mental function. Although this study implied that clinical criteria could be useful in triggering early intervention, it also highlighted the problem that there was lack of response to documented information. For example, an increase in respiratory rate did not always lead to appropriate respiratory therapy.

A subsequent study by Bedell et al (1991) also identified that failure to act on symptoms of breathlessness and increased respiratory rate could be directly related to events leading to a cardiac arrest. These findings prompted further studies which confirmed that patients with deteriorating physical conditions were receiving sub-optimal care; deterioration was not detected, not reported, not acted upon appropriately, or in time. These studies have demonstrated that patients in hospital have pre-emptive physiological signs prior to cardiac arrest (Franklin & Mathew, 1994; Rich, 1999).

In patients admitted to intensive care units (ICU), similar findings have been demonstrated (Goldhill & Sumner, 1998; McGloin, Adam, & Singer, 1999; McQuillan et al., 1998). McQuillan et al (1998) investigated the prevalence of sub-optimal care before admission to an ICU. They studied the quality of care received by 50 consecutively admitted adult emergency patients who were subsequently admitted to intensive care units. A confidential inquiry was conducted by completing detailed questionnaires during structured interviews with a clinical admitting team and an intensive care team. They found that 54% of patients received sub-optimal care prior to admission to the ICU. They also found that 39% of patients were admitted to intensive care late in the clinical course of their illness. They suggested that there was a fundamental problem in recognizing the importance of airway, breathing and circulation as being important for life. "Failure of organization, lack of knowledge, failure to appreciate clinical urgency, lack of experience, lack of supervision, and failure to seek advice" were identified as the main causes of sub-optimal care. Therefore, 'sub-optimal care' described the failure to identify, interpret and manage clinical signs of life (vital signs) (McQuillan et al., 1998).

2.4.2 Predisposing factors to sub-optimal care

There appear to be several factors that predispose to the prevalence of sub-optimal care. The first of these factors is related to the complexity of patients in hospital wards today. Current demographic trends demonstrate that, in western civilizations, people are living longer than ever before and hospitals now perform advanced procedures on much older patients. Furthermore, advanced technology, leading to the evolution of intensive care units and high dependency units, has made it possible to perform major surgery on patients with pre-existing conditions which previously would have been considered too high risk (Green & Williams, 2006). Thus, elderly patients with multiple diagnoses are now routinely treated in hospitals. Furthermore, many procedures are now performed as day cases, and shorter hospital stays greatly increase the turnover of patients, resulting in higher levels of acuity

among in-patient populations (Green & Williams, 2006; Johnstone, Rattray, & Myers, 2007). Therefore, acute hospitals tend to manage only seriously ill patients who require greater levels of monitoring and intervention (Hillman, Parr, Flabouris, Bishop, & Stewart, 2001).

A second predisposing factor is that an increasingly complex and elderly client group has led to an increase in workload. However, the increase in workload has not necessarily been matched by greater resourcing or an increase in qualified staff (NPSA, 2007). On the contrary, staffing on wards has suffered from a reduction in the number of qualified staff and inadequate nurse-patient ratios (Cutler, 2002). This puts increased pressure on staff in acute hospital wards and in turn may have led to an increased risk of poor detection of acute deterioration and patient co-morbidities (James et al., 2010).

A third predisposing factor is related to knowledge levels. There are studies that show that even qualified staff have overlooked important physiological findings (McGloin et al., 1999) These findings indicated the need for improved education (Bright, Walker, & Bion, 2004; Franklin & Mathew, 1994; McGloin et al., 1999; McQuillan et al., 1998). Lack of in-service study time has also been indicated as a reason for lack of knowledge and lack of appropriate action (McArthur-Rouse, 2001). The ALERT course was developed in response to the recognition of additional training needs for multiprofessional staff caring for acutely ill patients (Smith, Osgood, & Crane, 2002)

Finally, organisational problems may contribute to sub-optimal care. A global shortage of nurses has led to a lack of qualified staff, resulting in physiological parameters often being recorded by unqualified staff, such as Healthcare Assistants (HCA) who did not have the knowledge to interpret recordings and to notify a trained nurse (James et al., 2010; McArthur-Rouse, 2001). Furthermore, a lack of supervision of junior doctors and reluctance to call for help, could be another reason for sub-optimal care (NPSA, 2007).

To summarise, there are four distinct categories of problems that can predispose to sub-optimal care: patient complexity; healthcare workforce; education; and organisation (Quirke, Coombs, & McEldowney, 2011). As a result of the identified problem of sub-optimal care, systems were developed that would facilitate the early recognition of deteriorating patients at the earliest possible stage. These are described in the following section (2.5).

2.5 The development of new systems to identify deteriorating patients

This section will describe the development of track and trigger systems (TTS). Although the monitoring of a patient's physiological signs had been available for decades, as an integral part of medical and nursing practice these physiological observations did not have a defined point at which any action should be taken. Thus, decisions depended upon clinical interpretation of data and clinical judgment. In other words, the physiological 'tracking' did not have an explicit 'trigger' for when action should be taken (Morgan & Wright, 2007). Track and trigger systems therefore began to emerge, "tracking" being the monitoring of physiological status and "triggering" the point at which there was initiation of appropriate action. The action also became more specific with the development of rapid response systems (RRS) to initiate closer observation and provide expert treatment for the patient. More details of these response systems will be reviewed in section 2.6, but to begin with, physiological track and trigger systems will be discussed.

2.5.1 Physiological track and trigger systems

Over the past two decades several systems have been developed in an attempt to secure timely help for the critically ill. These can be classified into "single parameter" systems, "multiple parameter" systems and "aggregated weighted scoring" systems. To avoid confusion or ambiguity, these warning systems were given the generic name 'physiological track and trigger systems' and are summarised in Table 2.1 (Department of Health, 2003)

Table 2.1 Physiological track and trigger systems

Single parameter system	Multiple parameter system	Aggregated weighted scoring systems
One abnormal parameter initiates call-out of an emergency response team	More than one abnormal parameter initiates call-out of an emergency response team	Each parameter is given a score from zero to three. Algorithms guide the action to be taken: e.g., increase frequency of monitoring; doctor to assess patient; call out emergency response team.

2.5.1.1 Single parameter systems

The first 'calling criteria' to be developed were based on physiological observations and used a single parameter call-out system (Lee, Bishop, Hillman, & Daffurn, 1995). This meant that the medical emergency team (MET) would be called out if any one of the predefined parameters deviated from the norm. For example, the MET would be called out if the patient's systemic blood pressure fell below 100mmHg, or if the respiratory rate was more than 30 breathes per minute. The following criteria or 'triggers' were used: specific conditions, physiological/pathological abnormalities and 'any time urgent help is needed' (Lee et al., 1995). They claimed that the principles of early recognition and rapid response used in severe trauma situations could also be applied to acute medical conditions. The abnormal physiology is shown in the Table 2.2 (Lee et al., 1995).

Table 2.2 Values for 'abnormal physiology' (Lee et al. 1995)

Parameter	Thresholds for abnormal values
Temperature (°C)	<35.5 or >39.5
Systolic blood pressure (mmHg)	<100 or >200
Respirations/minute	<10 or >30
Pulse rate/minute	<40 or >120
Urine output over 24 hours (ml)	<500
Decreased or altered level of consciousness	

McQuillan et al (1998) suggested a variation to Lee et al.'s criteria. This was another example of a single parameter call-out system, where any one or more of the parameters deviating from the norm could trigger the call out of the medical emergency team (MET) Table 2.3 (McQuillan et al., 1998).

Table 2.3 Suggested minimal call-out criteria for medical emergency team (MET). (McQuillan et al. 1998 modified from Lee et al. 1995)

Parameter	Level requiring call-out
Airway threatened by	Impaired patency, obstruction e.g. stridor, burns, trauma. Impaired protection e.g. depressed consciousness, bulbar dysfunction
Breathing	Respiratory arrests
	Respiratory rate <8 or >30
Acute hypoxia	partial pressure of oxygen <8 kPa on fractional inspired oxygen 0.6 (maximum possible on ward)
Acute hypercapnia	partial pressure of carbondioxide >6.5 kPa
Circulation	Cardiac arrest
Pulse (in sinus rhythm)	<40 or >140 beats/min
Systolic blood pressure	<90
Acidaemia	pH <7.20 (hydrogen ions >62nmol/l)
Urine	Acute oliguria. <30 ml/hour or <0.5ml/kg/ hour
Glasgow coma scale	<12 or fall of two or more points
	Repeated or prolonged seizures
Miscellaneous	Patient causing concern to medical, nursing, or physiotherapy staff

A third example of a single parameter system, in which any one or more of the criteria can trigger the call out of the MET, was derived by Bellomo et al., (2003) (Table 2.4).

Table 2.4 MET call-out criteria. (Bellomo et al. 2003)

Staff member is worried about the patient
Acute change in heart rate to <40 or >130 beats/min
Acute change in systolic blood pressure to <90mm/Hg
Acute change in respiratory rate to <8 or >30 breaths/min
Acute change in pulse oximetry saturation to <90%, despite oxygen administration
Acute change in conscious state
Acute change in urine output to <50 ml in 4 hours

As can be seen from these tables, the choices of parameters were similar, although these were not the same. For example, a quantitative parameter such as systolic blood pressure does not have the same value in each table. Whilst Bellomo et al. (2003) and McQuillan et al. (1998) considered a systolic blood pressure of less than 90 mm/Hg to be the threshold, Lee et al. (1995) used the higher level of 100 mm/Hg as the threshold level. The authors did not give rationales for the choice of cut-off points. It is also illustrated that in some cases, qualitative data are used. For example, McQuillan et al. (1998) cited 'patient causing concern', and Bellomo et al. (2003) cited 'worried about the patient'. McQuillan et al. (1998) added seizures to the list of parameters. Hospitals tended to create their own physiological scoring systems, largely selected by subjective evidence and personal preferences (Subbe, Falcus, Rutherford, & Gemmell, 2003). This suggests that the choice of parameters was not evidence-based.

2.5.1.2 Multiple parameter systems

The "multiple parameter" system worked in a similar way to the single parameter system. The difference was that, instead of one parameter, it required any three or more of the parameters to be outside normal limits to trigger the call-out. (Goldhill, Worthington, Mulcahy, Tarling, & Sumner, 1999). An example is provided in Table 2.5.

Table 2.5 The PART protocol. (Goldhill, Worthington et al. 1999)

A: The senior ward nurse should contact the responsible doctor and inform them of a patient with:
Any 3 or more of the following:
Respiratory rate ≥25 breaths.min * (or <10)
Arterial systemic blood pressure <90mm/Hg
Heart rate ≥ 110 beats/min* (or <55)
Not fully alert and orientated
Oxygen saturation <90%
Urine output <100 ml over last 4 hours
OR a patient not FULLY alert and orientated **AND**
Respiratory rate ≥35 breaths.min * OR heart rate ≥140 beats.min *
Unless immediate management improves the patient, the doctor should consider calling the team. Exceptionally, (in an emergency when responsible doctor not immediately available) the senior ward nurse may contact the team directly.
B: A doctor of registrar grade or above may call the team for any seriously ill patient causing acute concern. this will normally be done after discussion with the patient's consultant.
The consultant responsible for the patient must be informed as soon as practical that the team has been called.

2.5.1.3 Aggregated weighted scoring systems

In the UK, most hospitals use track and trigger systems based on the original early warning scoring (EWS) systems derived by Morgan et al (1997) (Table 2.6). Variations to EWS such as Modified Early Warning Scores (MEWS) have been created, for example, that by Moon et al. (2011), which was widely used in the UK (Table 2.7).

Table 2.6 Original Early Warning Score (EWS) system. (Morgan et al 1997)

Score*	**3**	**2**	**1**	**0**	**1**	**2**	**3**
Respiratory rate		<8	8-11	12-20	21-25	26-30	>30
Heart rate	<40	41-50	51	100	101-110	111-130	>130
Blood pressure (systolic)	<70	71-80	81-100	101-179	180-199	200-220	>220
Central nervous system			Confusion	Awake and responsive	Responds to verbal command	Responds to painful stimuli	Unresponsive
Urine output last 4 hr/ml	<80	80-120	120-200		>800		
O_2 saturation %	<85	86-89	90-94	>95			
Respiratory support/O_2 therapy	Bi-pap/ CPAP	Hi-flow	O_2 therapy				

* each physiological value is allocated a score between 0 and 3, with 0 being within the normal range and 3 the greatest deviation from normal

Table 2.7 Modified Early Warning Scores (MEWS) (Moon et al. 2011)

Score*	3	2	1	0	1	2	3
CNS		Confused /agitated		Alert	Respond to voice	Respond to pain	No response
Respiratory rate	<8			8-20	21-30		>30
Heart rate	<40		40-50	51-100	101-110	110-130	>130
Systolic BP	<70	71-80	81-100	101-180	181-200	201-220	>220
Temperature	<34	34.0-35.0		35.1-37.5	37.6-38.5	38.6-40	>40
O2 Sats with appropriate oxygen therapy	<90%	91-93%		94-100%			
Urine output (over 2 hours or more)	<30ml /hr						

* each physiological value is allocated a score between 0 and 3, with 0 being within the normal range and 3 the greatest deviation from normal

These EWS systems use an aggregated weighted scoring system (AWTTS) (Prytherch et al., 2010). Aggregated weighted scoring systems generate a number that quantifies risk of critical deterioration. For example, each physiological value is allocated a score between 0 and 3, with 0 being within the normal range and 3 the greatest deviation from normal (Day, 2003; Prytherch et al., 2006), as shown in the top row of tables 2.6 and 2.7. Scores are then added up and the total score gives an indication of whether any action should be 'triggered'. Although there are many variations in the physiological parameters and cut-off points of these systems, the basic principle is the same; each physiological variable has a score associated with it. A slight elevation in score would, for example, indicate the need for closer observation of the patient with an increase in the frequency of recording the early warning scores. Higher scores indicate the need to call out help in the form of a doctor or some kind of emergency response team. An EWS system is used in conjunction with a flow chart or algorithm which guides the appropriate action to be taken in the case of an

elevated EWS score (Day, 2003; Gardner-Thorpe, Love, Wrightson, Walsh, & Keeling, 2006; Moon et al., 2011; Oakey & Slade, 2006; Sharpley & Holden, 2004).

The systems differ in that single parameter systems provide an 'all or nothing' response, in contrast to aggregated systems which offer a graded and escalating system of care (Smith, Prytherch, Schmidt, & Featherstone, 2008). It has been argued that aggregated weighted scoring systems have a greater potential than single parameter systems to identify patient deterioration, as more subtle changes can be detected when examining several vital signs at the same time. This could result in better detection rates and fewer false alarms (Preece, Horswill, Hill, & Watson, 2010)

2.5.1.4 The success of Early Warning Score systems

Following the conception of the original EWS, the concept of EWS spread nationally in the UK and elsewhere, with many successful outcomes according to subsequent studies. Morgan et al (1997) found that EWS had the positive effect of earlier referral of patients to high dependency units (HDU) and intensive care units (ICU). Subbe (2003) performed a study to measure the effect of introducing Modified Early Warning Score (MEWS) on the rates of ICU and (HDU) admission, cardio-pulmonary arrest and mortality. A control group from admissions in 2000 was used. Patients were classified: low risk MEWS 0-2, intermediate risk 3-4, high risk >4 (risk of catastrophic deterioration). Rates of admission to critical care, cardio-pulmonary arrest and death were calculated for each risk band. Outcomes in the patient group with the highest risk were not improved. However, the results showed that respiratory rate was the variable that had the greatest impact on identifying deterioration in a patient's condition and was best at discriminating between stable patients and patients at risk. This report also suggested that training of junior and senior medical and nursing staff would best impact outcomes in medical emergency admissions.

In a study to evaluate the use of MEWS on surgical patients it was found that 'an early warning system is an important risk management tool that should be implemented for all surgical in-patients' (Gardner-Thorpe et al., 2006, p. 7). This study observed the number of ward patients who triggered the call-out algorithm by scoring four or more on MEWS. Of the 334 patients in the study, 57 triggered the call-out algorithm and, of those, one in five was transferred to the intensive therapy unit (ITU) or a high dependency unit (HDU). The remaining four patients with physiological observations which were outside normal limits,

'undoubtedly needed review in order to optimize their management on the ward' (Gardner-Thorpe et al., 2006, p. 6).

There are a number of additional benefits of EWS. First, having quantifiable data such as EWS has given nurses more confidence in using medical language when reporting patient deterioration to medical staff and it helps improve communication between doctors and nurses (Andrews & Waterman, 2005). Being able to state a number to show that a patient is at risk, might also allow the nurse to feel that s/he is presenting more tangible evidence than if s/he presents one or two parameters from a single or multiple parameter system. In addition, flow charts or algorithms guide the definitive action that should be taken. Second, it has raised awareness among nursing staff about the importance of detecting and reporting deviations in vital signs (McCormick, 2005). Third, some studies show that it has increased awareness about the importance of recording certain signs, such as respiratory rate (McBride, Knight, Piper, & Smith, 2005; McCormick, 2005; Odell et al., 2007; Sharpley & Holden, 2004).

Many modifications to the original EWS model have evolved: modified early warning score (MEWS); standardised early warning score (SEWS); paediatric early warning score (PEWS). This wide range of TTS was the result of hospitals creating their own physiological scoring systems. These could vary greatly as each design was based on local preference, clinical experience and intuition (Johnstone et al., 2007; Prytherch et al., 2010; Sharpley & Holden, 2004), and was largely selected by subjective evidence and personal preferences (Gao, McDonnell, et al., 2007; Subbe, 2010). There was a general lack of statistical techniques in studies on TTS and, subsequently, these systems were not considered to be evidence-based. The feature that they had in common was that systems were put in place to tackle the question of sub-optimal care.

2.5.1.5 Problems with reliability of track and trigger systems

Some studies have shown that there could be a problem with reliability of TTS, with little evidence to suggest that they had a positive effect on clinical outcomes of sudden cardiac arrest and ICU admission (Cuthbertson & Smith, 2007; Subbe, Davies, et al., 2003). The problem with many hospitals that developed their own systems was that the sensitivity of

systems was low, although general specificity was acceptable (Gao, McDonnell, et al., 2007; Johnstone et al., 2007).[1]

Sensitivity and specificity are important in the identification of false negatives or false positives. In a TTS, if there is high sensitivity, this is because there are relatively few false negative results. This means that a patient who has not triggered the call-out criteria is unlikely to be critically ill. A high specificity is obtained when there are few false positives, therefore the patient is likely to be critically ill if they have triggered the call-out criteria. Ideally, there should be high sensitivity and high specificity (Mulligan, 2010).

In 2007, a review of TTS identified 25 different TTS and found wide variations in diagnostic accuracy (Gao, McDonnell, et al., 2007) i.e., sensitivity and specificity. Some studies have questioned the sensitivity of physiological scoring systems as well as MET call out criteria and therefore, there was a plea for more statistical evidence of the systems (Cuthbertson & Smith, 2007; Subbe, 2010).

2.5.1.6 Problems with calculating early warning scores

Another problem was that these 'home-grown' systems were often more complex than the original MET's calling criteria (Cuthbertson & Smith, 2007). For example, some physiological scoring systems used tables to calculate whether the patient blood pressure deviated from the patient's individual norm, rather than having a pre-determined cut-off value for 'normal' (Day, 2003; Sharpley & Holden, 2004). This made the system much more complicated. One study claimed that simple systems, such as the MET single parameter system (Table 2.1), were more reliable than physiological scoring systems (Subbe, Gao, & Harrison, 2007). There had been a lot of discussion regarding which physiological variables should be included in physiological scoring systems. In addition, there was a wide range of threshold values and there was clearly a need for studies to determine a reliable system (Cuthbertson & Smith, 2007). There have been several problems in relation to the accuracy of using EWS. For example, failure to comply with the protocols set out in EWS, such as escalation in the frequency of vital sign recordings, could reduce the effectiveness of early response to deterioration, in that it might not be early

[1] Sensitivity represents the proportion of cases that had an abnormal EWS score which correctly predicted that the patient was deteriorating - true positives. To calculate sensitivity, true positives are divided by all the positives.
Specificity represents the proportion of cases that did not have an abnormal EWS score which correctly predicted that the patient was not deteriorating - true negatives. To calculate specificity, true negatives are divided by all the negatives.

enough (Hands et al., 2013; Jones et al., 2011). The reasons for lack of compliance are not clear but it could be because it puts too much pressure on nursing staff to record vital signs frequently, or that they believe their clinical judgement is a better indicator of when to record vital signs (Hands et al., 2013). In addition, EWS scores are often calculated wrongly (Jones et al., 2011; Prytherch et al., 2006).

2.5.1.7 Subjective criteria identifying the deteriorating patient

It has been suggested that nurses often take an intuitive approach in decision-making (Thompson, 1999). There is a lack of consensus on the definition of intuition in clinical decision-making, but one definition is 'immediate knowing of something without the conscious use of reason' (Schrader & Fischer, 1987 p.45). Because of this phenomenon, some call-out criteria have included subjective information, such as being 'concerned' about the patient (Watson et al., 2005 p.107). One study emphasised the importance of 'concern' or 'worried about patient' being used as a trigger as it can account for a significant number of calls made to rapid response teams (Chen, Bellomo, Hillman, Flabouris, & Finfer, 2010) and some studies have found that calling Critical Care Outreach (CCO) for patients who did not meet the at risk score was justified (Parr, Hadfield, Flabouris, Bishop, & Hillman, 2001; Watson et al., 2005). A study to identify risk factors for in-hospital cardiac arrest, demonstrated that nurse or doctor concern was a significant factor (Hodgetts, Kanward, Vlachonikolis, Payne, & Castle, 2002).

Furthermore, in a paper describing the implementation of EWS in a district general hospital it was decided to record scores on 'any patient who did not seem 'just right' to the nurse' as it was considered essential that nurses' intuitive responses to patients' conditions were not undervalued (Sharpley & Holden, 2004 p.4). Moreover, in an audit on the time taken for doctors to attend calls for assistance it was reported that some medical and nursing staff were unable to identify signs of clinical deterioration although there were anecdotal accounts of nurses feeling 'something isn't right' or ' a gut feeling' (Day, 2003 p.7). In a study aimed at examining the contribution of health care assistants (HCA) as recognizer, responder and recorder of acutely ill patients within the general ward setting, the results showed that 74% of respondents described that they 'just knew' when a patient was deteriorating (James et al., 2010 p.551). However, some researchers are against subjective variables such as 'worried' as triggers, claiming that there could be problems of interpretation and therefore objective variables are preferable (Cuthbertson & Smith, 2007).

Nevertheless, the current literature seems to lean toward including intuitive decision-making in identifying at-risk patients.

2.5.2 The quest for the perfect early warning score.

In 2007, NICE published a report in the UK, which recommended that all adult patients in acute hospital settings should be monitored by physiological TTS to facilitate early recognition and timely management of patients with a deteriorating condition (NICE 2007). They recommended that a TTS should include measurement of heart rate, respiratory rate, systolic blood pressure, level of consciousness, oxygen saturation rate and temperature. Additionally, the Royal College of Physicians recommended a standardization of early warning score systems across the entire National Health Service (NHS). It should ensure the recording of a minimal clinical data set, resulting in an NHS early warning NEW score (Royal College of Physicians, 2007).

Subsequently, two new studies were published (Duckitt et al., 2007; Prytherch et al., 2010). One study claimed to have devised a more robust scoring system as it identifies the contribution of individual physiological markers to mortality, and derived a simpler scoring system for medical patients called The Worthing Physiological Scoring System (PSS) (Table 2.8) (Duckitt et al., 2007). This model is relatively simple compared to other available EWS. In addition, it agreed with Subbe (2001), that the most important measurement related to blood pressure (BP) is when the systolic arterial BP is ≤100 mm/Hg and that temperature recordings of hypothermia are significant whereas pyrexia (fever) is not. The cut-off point that gave the maximum sensitivity and specificity was a score of three. In addition, this study claimed that, unlike other systems that are derived from expert medical opinion, their system is derived from established methodology for constructing a new severity of illness classification system.

Table 2.8 The Worthing PSS. (Duckit et al 2007)

Score	0	1	2	3
Ventilatory frequency (respirations per minute)	≤19	20-21	≥22	
Pulse (beats per minute)	≤101	≥102		
Systolic blood pressure mm/Hg	≥100		≤99	
Temperature in Centigrade	≥35.3			<35.3
Percentage oxygen saturation on air	96-100	94 to <96	92 to <94	<92
AVPU	Alert			Other

Smith et al. (2006) claimed that even when track and trigger systems were used, the recording of vital signs was still sub-optimal. In response to this claim, they developed an electronic system to record vital signs in personal digital assistants (PDA) at the bedside. The system allowed EWS alerts to be made available to each patient's clinical team through a wireless local area network (W-LAN) (Smith et al., 2006). Subsequently, Prytherch et al (2010) undertook a large study with the Royal College of Physicians recommendations in mind. They carried out a study of nearly 40,000 patients from a large vital signs database (n=198,755), to develop a validated, computer-based EWS for use in a hand-held computer system called VitalPAC (The Learning Clinic Ltd, 2012). Taking the view that not all hospitals use electronic patient records, they wanted to develop a paper-based EWS that could serve as a template for a standardized EWS system. They also aimed to develop an EWS system which did not require the inclusion of the patient's age. The resulting new EWS was a system called ViEWS, and is illustrated in the Table 2.9. The performance of the ViEWS system was superior at predicting mortality than the other 33 aggregate weighted track and trigger systems tested (Prytherch et al., 2010). There is evidence which confirms the validity of ViEWS internationally (Smith, 2013a).

Table 2.9 ViEWS (Prytherch et al. 2010)

Score*	3	2	1	0	1	2	3
Pulse (bpm)		≤40	41-50	51-90	91-100	111-130	≥131
Breathing (rpm)	≤8		9-11	12-20		21-24	≥25
Temperature (C°)	≤35.0		35.1-36.0	36.1-38.0	38.1-39.0	≥39.1	
Systolic BP (mmHg)	≤90	90-100	101-110	111-249	≥250		
SaO_2 (%)	≤91	92-93	94-95	≥96			
Inspired O_2				Air			Any O_2
CNS (use AVPU scale)				Alert			Voice Pain Unresponsive

Note: ViEWS= early warning score for use in VitalPAC™ system (The Learning Clinic Ltd. 2012); bpm= beats per minute; rpm= respirations per minute; Systolic BP= systolic blood pressure; SaO_2= saturation of oxygen; CNS= central nervous system; AVPU= alert, responds to voice, responds to pain, unresponsive.

*each physiological score is allocated a score between 0 and 3, with 0 being within the normal range and 3 the greatest deviation from normal

In 2012, the Royal College of Physicians (RCP) developed a national early warning score (NEWS) which was based on ViEWS. Similarly to ViEWS, NEWS has been found to have a greater ability to predict risk of cardiac arrest, unplanned ICU admissions and death than other EWS systems (Smith, Prytherch, Meredith, Schmidt, & Featherstone, 2013).

It is still to be determined whether MET call-out criteria or EWS are best. Simple triggering systems, e.g., MET criteria are easier to use than complex ones, such as EWS (Subbe et al., 2007). Furthermore there are frequent errors when early warning scores are calculated by hand (Mohammed, Hayton, Clements, Smith, & Prytherch, 2009; Prytherch et al., 2006).

On the other hand, NEWS is both more sensitive and specific than MET criteria and encourages the recording of full sets of vital signs (Smith, 2013b).

2.6 Rapid response teams

This section reviews studies about teams within Rapid Response Systems (RRS). The term RRS according to De Vita et al. (2006), is most correctly used to describe both the recognition process such as early warning scores (EWS) (described in the section 2.5) and the responding team (DeVita et al., 2006). These teams are called out according to 'call-out criteria' and respond to all patients with a critical medical problem.

There is varied terminology used to describe the teams within rapid response systems that have emerged in the last two decades. There are Medical Emergency Teams (MET), Patient At Risk Teams (PART), Critical Care Outreach Teams (CCOT) and more recently, Rapid Response Teams (RRT). Because of the varying terminology, a group of experts reached a consensus on how these teams could be defined according to structure and functionality as the teams can vary in their constellations of professionals and in what they do (DeVita et al., 2006). For example, some teams are nurse-led, some include medical staff, and some have more authority than others. METs usually consist of physicians and nurses, and sometimes respiratory therapists. CCOTs are usually staffed by nurses and have the role of following up patients who have been discharged from intensive care units (ICU) as well as responding to call-outs on wards. RRTs usually consist of nurses, but have physician consultation available. The availability of teams has also varied from place to place; some provide 24-hour cover while others are available only during the day, Monday to Friday.

The terminology also appears to have historical and geographical links, probably because of how these teams have been constructed to suit local needs and cultures. For example, studies from Australia most often refer to MET, studies from the UK usually refer to CCOT, and the USA have often adopted the term RRT, although MET is also quite often seen there too. The terms used in this thesis are according to the terms used in the original studies cited in the review.

2.6.1 Background

In 1990, the concept of a medical emergency team (MET) was introduced in Australia to improve patient outcomes and prevent cardio-pulmonary arrest (Lee et al., 1995). The MET is usually made up of the same people who formally comprised the cardiac arrest team and are therefore trained in resuscitation. Indeed, according to Hillman (2001 p.107),

"the Medical Emergency Team was achieved by changing the name and adjusting the function of the cardiac arrest team". Instead of being called to a cardiac arrest, ideally the MET is summoned when a patient shows signs of clinical deterioration, according to a predetermined set of physiological criteria, described in (2.3.1.1). Hillman (2001) claimed that it was time for a new era of resuscitation that was wider in scope than cardiopulmonary resuscitation (CPR) and more appropriate for seriously-ill patients; early recognition of at risk patients, and rapid response to deterioration is vital to avoid the occurrence of major adverse events. It was suggested that medical emergency teams should be set up along the lines of Lee et al. (1995), as it would be better to prevent cardiac arrests than to wait for them to occur before attempting to revive the patient (Garrard & Young, 1998). The next part of this section describes studies about rapid response systems in Australia, UK and USA.

2.6.2 Medical emergency teams (MET)

The MET can have various constellations, usually depending on the size of the hospital. In larger hospitals it might comprise an ICU or emergency department (ED) registrar, and ICU or ED nurse and a medical registrar, whereas in smaller hospitals two nurses trained in advanced resuscitation may make up the team (Cretikos & Hillman, 2003).

2.6.2.1 The impact of Medical Emergency Teams

Several studies claimed that Medical Emergency Teams (MET) combined with physiological call-out criteria could improve patient outcomes regarding unplanned admissions to ICU, cardiac arrest and in-hospital deaths. In a study using a prospective, before-and-after intervention trial it was found that the incidence of in-hospital cardiac arrest decreased by two-thirds after the introduction of the MET and that appropriate response to physiological instability was the key to rescuing patients in time. There was also a reduction in the number of hospital deaths (Bellomo et al., 2003). A prospective controlled trial also found reduced mortality following introduction of the MET (Bellomo et al., 2004). In a retrospective cohort comparison of three hospitals, it was found that there was a reduction in the rate of unanticipated admission to ICU/HDU at the hospital using MET intervention. However, there was no reduction in the incidence of cardiac arrest or total death rate (Bristow et al., 2000). A non-randomised study compared the incidence of unexpected in-hospital cardiac arrest before and after the introduction of a MET and found that early intervention by MET reduced the incidence of cardiac arrest by

approximately half. In this study, they also claimed that subsequent mortality was reduced from 77% to 55% (Buist et al., 2002).

A study by Jones and colleagues suggested that the long-term effects of MET could be beneficial. They conducted a prospective study over a four-year period comparing three phases: before MET, during the education phase, and after the MET was fully implemented. In the pre-MET period, there were 4.06 cardiac arrests per 1000 admissions, in the education phase, 2.45 cardiac arrests per 1000 admissions and after full implementation, 1.90 cardiac arrests per 1000 admissions. These results showed a progressive improvement in reducing the rate of cardiac arrests by introducing MET (Jones et al., 2005).

However, these studies were limited, in that most had used historical controls and there was absence of randomisation (Hillman et al., 2005). To address this gap in research, Hillman and colleagues conducted a multi-centre cluster-randomised controlled trial of introduction of a MET system, known as MERIT (medical early response intervention and therapy). The aim was to investigate whether the MET system could reduce the incidence of cardiac arrests, unplanned admissions to intensive care units (ICU), and deaths. Twenty-three hospitals in Australia were randomised with 11 continuing to function as usual and 12 introducing a MET system. The results showed that the MET system did not affect the incidence of cardiac arrest, unplanned ICU admissions, or unexpected death, although there was an increase in the number of calls to the emergency team (Hillman et al., 2005).

2.6.3 Critical care outreach systems and critical care outreach teams

In the UK, there have also been concerns about the quality of care on general wards (Garrard & Young, 1998; McGloin et al., 1999; McQuillan et al., 1998). One study presented positive outcomes of introducing a Patient-at-risk team (Goldhill, Worthington, et al., 1999). This team assessed patients who showed abnormal vital signs. They found that visiting potential ICU patients on the wards could improve patient management, and that ICU admissions could be planned before critical admission was necessary. In the UK, this was one of the first approaches to the concept of 'outreach', in which members of the critical care team integrated critical care in general wards.

In 1999, the Audit Commission carried out a review of critical care resources. The recommendations they made aimed to help individual trusts improve their services. Their report recommended that highest priority be given "to improve services for patients on wards who are at risk of deteriorating" with three main objectives:

i. “review trainee doctor and senior ward nurse recognition skills of the early warning signs;

ii. agree ‘danger sign’ guidelines to help ward staff to identify when to call for specialist advice to prevent deterioration; and

iii. develop an ‘outreach’ service from critical care specialists to support ward staff in managing patients at risk” (Audit Commission, 1999)

In 2000, the Department of Health published a paper called "Comprehensive Critical Care: A Review of Adult Critical Care Services", which recommended the development of Outreach services as an integral part of the review of adult critical care (Department of Health, 2000, pp. 14-15). There were three main objectives of outreach services:

i. "to avert ICU admissions by identifying patients who are deteriorating and either helping to prevent admission or ensuring that admission to a critical care bed happens in a timely manner to ensure best outcome;

ii. to enable ICU discharge by supporting both the continuing recovery of discharged patients on wards and after discharge from hospital; and

iii. to share critical care skills with staff in wards and the community ensuring enhancement of training opportunities and skills practice and using information gathered from the ward and community to improve critical care services for patients and relatives".

Several reports endorsed the promotion of critical care outreach systems (CCOS) stating that every hospital should have outreach providing services 24 hours per day and seven days per week (Audit Commission, 1999; Intensive Care Society, 2002; Royal College of Physicians, 2002). The UK government provided 142 million pounds to support the implementation of these recommendations. The proposal was met with enthusiasm, with many clinicians and nurse consultants supporting this move, believing that the development of outreach services would improve quality of care. In order to follow the recommendations of the "The Comprehensive Critical Care Report" (Department of Health, 2000), health authorities across the United Kingdom began to develop CCOS to identify and manage those patients who required additional care. There was no prescribed model for CCOS and trusts were encouraged to customise the services to suit local needs (Gao, McDonnell, et al., 2007). This could account for the diversity of EWS and patient-at-risk call-out criteria, as well as the many constellations of professionals who made up CCO

teams. A national survey on the provision of critical care outreach services in England in 2007 found that, despite the recommendations, an estimated 27% of hospitals did not have a formal CCOS. Of the hospitals that had CCOS, there was a wide variation in the size and composition of the teams, the type of service they offered and the availability of the service (McDonnell et al., 2007). Their report concluded that the wide variation of CCOS could be due to the lack of evidence of the most effective approaches (McDonnell et al., 2007).

2.6.3.1 The impact of Critical Care Outreach Systems

The impact of CCOS is difficult to evaluate. Carrying out multicentre, randomized controlled studies implies obvious ethical issues in that outreach services should not be denied any patient who is in need of treatment. The wide variation in types of services offered and various stages of implementation also makes evaluation difficult (Gao, Harrison, et al., 2007).

However, there have been several studies that have attempted to examine the impact of CCOS. One of these was a 'before-and-after' study to determine patient survival to discharge from hospital, and after discharge from, or readmission to, intensive care. They found that the introduction of CCOS resulted in a significant increase in survival to hospital discharge and a significant decrease in the number of readmissions to intensive care (Ball, Kirkby, & Williams, 2003). An observational study set out to examine the impact of a critical care outreach team. It was found that there was a reduction in the number of unplanned admissions to ICU, and lower mortality in emergency admissions to ICU (Pittard, 2003). Another study aimed to examine whether the introduction of a critical care outreach team (CCOT) had an affect on re-admissions to critical care. They looked at the records of 100 patients who had been re-admitted to critical care, 49 before, and 51 after the introduction of the CCOT. They found that there was no change in patterns of re-admissions following the introduction of the CCOT. However, they pointed out that outreach was an important development for critical care and suggested it should be assessed using alternative parameters (Leary & Ridley, 2003). The first randomised controlled study to assess the impact of introducing a CCOT on general hospital wards was carried out by Priestley and colleagues (Priestley et al., 2004). There were 16 medical and surgical wards included in the study, which began as the control wards and, after four weeks of staff training, became the study wards. They found significant reduction in in-hospital mortality after intervention but pointed out several weaknesses of the study,

including that the sample only represented 480 beds in total, over a 32-week period (Priestley et al., 2004).

A systematic review investigating the effectiveness of CCOS concluded that while robust evidence of the benefits was not confirmed, neither was there evidence which suggested that CCOS were ineffective or that the development should be abandoned (Esmonde et al., 2006). In England, a major national study was carried out to analyse the impact of CCOS at the critical care unit level. 108 units were included in the analysis. "There was no effect on unit mortality for patients admitted to the critical care unit from the ward" (Gao, Harrison, et al., 2007).

2.6.4 Rapid Response Teams (RRT)

In the United States, rapid response systems have also been introduced and they mainly used the nomenclature Rapid Response Teams (RRT) to describe their emergency response teams.

2.6.4.1 The impact of Rapid Response Teams

Several studies on RRTs reported positive outcomes of implementing these teams. A prospective study performed after the implementation of an RRT found that the number of cardiac arrests decreased by 50% during the year after the implementation of the RRT, compared to the year before implementation (Offner, Heit, & Roberts, 2007). In a retrospective study, it was found that 85% of the RRT responses resulted in the prevention of further deterioration in patients the team responded to (King, Horvath, & Shulkin, 2006). They also suggested that RRTs have the potential to reduce the number of cardiac arrests and thus improve patient safety. In a prospective, before-and-after trial in a 350-bed teaching hospital, the results showed that the number of cardiac arrests decreased from 7.6 per 1000 discharges per month to 3.0 cardiac arrests per 1000 discharges per month. The introduction of the RRT was also associated with decreased rates of unplanned admissions to ICU (Dacey et al., 2007). A report of the implementation of an RRT in the US, claimed that cardiac arrest calls have decreased from 7 per 1000 patient days to 2 per 1000 patient days (Scott & Elliott, 2009). In another study, a retrospective analysis of 3269 MET responses over 6.8 years, declared a 17% decrease in the incidence of cardiopulmonary arrests (DeVita et al., 2004). Although these RRT studies appeared to have positive outcomes, there are those who claim that the published evidence on RRTs does not conclusively indicate any benefits for patients (Winters et al., 2007).

2.6.5 Lack of positive outcomes

There are varied views in response to the apparent lack of positive outcomes following the implementation of RRS. First, regarding MET there are claims that the true effectiveness of MET may not have been measured in the MERIT study as it is possible that despite patients requiring MET intervention according to call-out criteria, the MET may not have been called. Therefore, the effectiveness of MET could not be measured (Buist, Harrison, Abaloz, & Van Dyke, 2007). Furthermore, a high level of variation in MET services implies that many different approaches should be assessed if an evaluation is to be valid. It has also been suggested that the MET call-out criteria may not be sensitive enough and needs to be expanded to include other signs such as measurement of arterial blood gases (Jacques, Harrison, McLaws, & Kilborn, 2006). These complexities could have had an effect on the MERIT study and made it difficult to establish significant changes in patient outcomes (McDonnell et al., 2007).

Furthermore, the lack of positive outcomes of RRS have been attributed to poor knowledge levels and resistance to the systems. Thus, it has been suggested that it may be possible to improve outcomes for critically-ill patients by improving education and altering traditonal attitudes. Studies have shown that both medical and nursing staff are deficient in knowledge and skills in caring for patients in acute care and staff education is important when systems for preventing cardiac arrest are implemented (Deakin et al., 2010). A lack of awareness of MET-calling criteria, lack of expertise due to inexperience, non-recognition of abnormal vital signs and lack of effective education are other reasons cited for failure to call the MET (Jones, King, & Wilson, 2009). One report emphasised the importance of education as part of a 'chain of prevention' (Smith, 2010). This report suggested that education should include "how to observe patients, including vital signs measurement and recording; interpretation of observed vital signs; recognition of the signs of deterioration; the use of an early warning score (EWS) or medical emergency team (MET) call-out criteria; appreciating clinical urgency; . . . and end-of-life care" (ibid p. 1209). Moreover, a study by Buist and colleagues emphasised the importance of on-going education to improve patient surveillance, timely call-out and appropriate action. These studies emphasised the importance of an on-going multidisciplinary, multifaceted education system for clinical staff. However, there was also the suggestion that implementation of RRS takes time to mature. In a six-year audit of the MET, there had been a sustained decline in in-hospital cardiac arrest: from 2.4 per 1000 hospital admissions in the year 2000 to 0.66 per

1000 admissions in 2007. This result was attributed to professional development programmes (Buist et al., 2007).

Another reason for the lack of positive outcomes may be because of resistance to calling out the RRS because of engrained hospital cultures and hierarchal systems. In one study, it was found that nursing staff did not like changing from the hierarchy system of calling a junior doctor. In turn, the junior doctors opted to hand the problem to the next shift or to a more senior physician (Buist et al., 2007). It has also been claimed that traditional hierarchy structures impact on the clinicians ability to call for help (Coombs & Dillon, 2001). Another reason for resisting calling out the MET was that some nurses were fearful that they would be criticized for their lack of knowledge (Bagshaw et al., 2010).

2.6.6 Scepticism

It is worth noting that although there are many positive views on RRS, there are those who are less sure that the evidence on RRS is strong enough to embrace the whole concept. Compared to earlier studies, the results of the MERIT study (Hillman et al., 2005) and a national study in the UK (Gao, Harrison, et al., 2007) were disappointing and raised questions regarding the real benefits of rapid response systems; no significant improvement in survival rates could be established as an outcome. Similarly, a meta-analysis review concluded that there was weak evidence that RRS reduced cardiac arrest and improved mortality, and that the quality of the studies limited the reliability of results (Winters et al., 2007).

This has led to some experts recommending extreme caution regarding the widespread clinical implementation of RRS because of inadequate evidence in the literature (Cuthbertson, 2003; Winters et al., 2007). Although it is instinctive to assume that early intervention is better, aggressive treatment may not always be the most appropriate. For example, in some cases, aggressive treatment could lead to prolonged suffering and delayed death in an intensive care unit (Bright et al., 2004). It could be more important to identify patients who could benefit from intensive care. Previous studies have focused on identifying parameters which predict death. However, identifying patients who will not respond to aggressive intervention could be more important if these patients are to be allowed to have as normal and dignified a death as possible (Fletcher & Cuthbertson, 2010). Thus, there is a need for consistent approaches to assess and manage critically ill patients (Cuthbertson, 2003; Parr, 2004).

2.6.7 Positive outcomes

However, despite inconsistent results and cautious warnings, positive outcomes are apparent when the basic functions of rapid response systems are considered. These basic functions are to assess the patient and intervene, to diagnose, monitor, prevent, treat, palliate, or transfer the patient to a higher level of care (Cook, Montori, McMullin, Finfer, & Rocker, 2004). Studies have shown that the introduction of RRS was associated with reduced rates of cardio-pulmonary resuscitation (CPR) (Bellomo et al., 2004; Buist et al., 2002; Goldhill, Worthington, et al., 1999; Jones et al., 2005). In another study, there was a significant decrease in the number of patients who had received CPR prior to being admitted to a critical care facility (Gao, Harrison, et al., 2007). This could suggest that early intervention leads to early admission to critical care and prevents the occurrence of cardiac arrest.

Furthermore, research suggests that there are fewer attempts at resuscitation as an outcome of the introduction of RSS. It may be that improved assessment of sick patients leads to decisions about the patient's prognosis and more appropriate planning of care, for example, the issue of timely 'do not attempt resuscitation' (DNAR) orders. A pilot study found that in a review of the deaths of 105 patients, the MET had participated in a 'not for resuscitation' (NFR) decision in 10% of patients (Jones et al., 2007). An additional study has shown similar findings regarding NFR orders (Parr et al., 2001). A multicentre study carried out in Australia, Canada and Sweden also showed that RRS participated in decisions on end-of-life care (Jones et al., 2012). Another possible outcome is that patients are not admitted to critical care units because the Critical Care Outreach Team decide that no more can be done for the patient and that admission would be futile (Gao, Harrison, et al., 2007). It has also been claimed that RRS identify deficiencies in care, for example, the need for improved monitoring and appropriate care planning (Litvak & Pronovost, 2010). Thus, the MET may facilitate more formal planning of patient care, early declaration of resuscitation status and avoidance of futile resuscitation attempts (McKeown, 2004). These arguments provide plausible reasons for the continuation of RRS. Moreover, a meeting of experts was convened in June 2005 to discuss MET, CCOT and RRT and decide whether all hospitals should implement an RRS. They concluded that all hospitals should implement an RRS consisting of four elements: a "crisis detection" and "response triggering" mechanism; a pre-determined rapid response team and a governance administrative structure to supply and organise resources (DeVita et al., 2006). Therefore, the trend to introduce rapid

response systems continues in the US, Australia and the UK. Many hospitals in Sweden have also implemented RRS (Fridén & Andrén-Sandberg, 2013). This section has discussed rapid response teams (2.6). The following section examines how vital signs are monitored and documented (Section 2.7).

2.7 Documentation

2.7.1 Introduction

This part of the review concentrates on the monitoring and documentation of physiological vital signs. Earlier in this review (section 2.4) it was established that early detection of the deteriorating patient is vital for patients to receive timely and appropriate management. To this end, track and trigger systems, such as MET calling criteria and modified early warning scores (MEWS) have been designed to alert professionals to any signs of deterioration. The vital signs considered most important in predicting deterioration include respiratory rate, conscious level, blood pressure, heart rate, temperature and oxygen saturation (Armitage, Eddleston, & Stokes, 2007; Bellomo et al., 2003; Morgan et al., 1997; Subbe, Davies, et al., 2003). These vital signs were traditionally recorded on bedside observation charts: the mainstay of detecting patient deterioration (Chatterjee, Moon, Murphy, & McCrea, 2005).

2.7.2 Monitoring vital signs

Monitoring vital signs is a skill. Therefore, it is important that all clinicians who perform this skill have received adequate training to measure vital signs accurately, and according to recommended guidelines (Hutson & Millar, 2009). These include that the exact time is used when a recording is made to ensure the accuracy of the records. Temperature is most usually recorded electronically, for example, with a tympanic or electronic thermometer. The heart rate or pulse can be located in several parts of the body, but the most common location is the radial pulse. To take the patient's pulse, the nurse places two fingers over the radial artery and counts the number of beats for 30 seconds or one minute. Other aspects of the pulse should also be considered, such as volume and whether the pulse is regular. Respiratory rate is also measured for 30 seconds or one minute. To avoid the patient altering their breathing rate because they are aware it is being counted, a practical tip is to keep the fingers on the radial pulse and count the respirations in the second half of the minute when the pulse has been counted for 30 seconds or the second minute if counting for a full minute for each recording. Regarding breathing, the effort that the patient requires to breath should also be observed. Blood pressure is usually measured

electronically but it is preferential that clinicians are also skilled in using manual sphygmomanometers to double check readings if there is any doubt regarding accuracy. Peripheral oxygen saturation is measured by a sensor clip that is attached to the finger. Obtaining accurate vital signs is a skilled process, and often this task is often performed by the most junior personnel, for example health care assistants and student nurses (Clark, 2007; James et al., 2010; McArthur-Rouse, 2001). Personnel, therefore, need to be well-trained in these skills and also to document what they find accurately in the patient observation chart.

2.7.3 Observation charts

Observation charts can vary greatly from hospital to hospital, and can even vary within the same hospital, depending on preferences and clinical needs (Chatterjee et al., 2005). There is therefore, a wide range of observation charts, and because each health authority tends to create their own, there is perhaps unnecessary duplication of effort (Horswill, Preece, Hill, & Watson, 2010; Royal College of Physicians, 2007). It is generally agreed that to be effective, essential information such as physiological signs must be grouped in a way that allows trends to be viewed easily, giving an accurate indication of a patient's status (Hutson & Millar, 2009). Furthermore, observation charts should be at hand and easy to write (De Marinis et al., 2010) and it is important that the monitoring, charting and interpreting of these vital signs is precise (Goldhill, 2001; James et al., 2010; McArthur-Rouse, 2001). In the European Guidelines for Resuscitation 2010, Deakin et al recommends "[using] a patient charting system that enables the regular measurement and recording of vital signs and, where used, early warning scores" (2010). However, there is a lack of empirical evidence on what constitutes the most effective observation chart (Chatterjee et al., 2005; Horswill et al., 2010). Two studies have approached this issue in an attempt to design an evidence based observation chart, one from the UK and one from Australia.

2.7.4 Observation chart design

At a district general hospital in the UK, an evidence-based approach was used to redesign the patient observation chart (Chatterjee et al., 2005). The method used in this study was to enter physiological data onto five different patient observation charts (all from the same hospital). The information on the charts was then perused by various levels of clinical staff to see which abnormal physiological data they identified. Information from this part of the study was used to design a new observation chart. The clinical staff were trained in the use

of the new chart, which was subsequently evaluated three weeks after implementation. The results demonstrated an improvement in detection rates of physiological deterioration. Parameters that were plotted on graphs were easier to detect than written values. The authors concluded that the design of observation charts had a significant impact on the ability of clinical staff to detect patient deterioration and that poor chart design can contribute to failure in detecting deteriorating patients. The design of observation charts should therefore have an evidence-based and multi-disciplinary approach (Chatterjee et al., 2005).

The aim of a study from Australia was to investigate the design and use of observation charts in recognising and managing patient deterioration (Horswill et al., 2010). This study began by reviewing 25 observation charts from Australia and New Zealand. In these charts 1,189 usability problems were identified, which could lead to problems in documenting data and recognising patient deterioration. Based on these results, a new chart called "the Adult Deterioration Detection System" (ADDS) chart was designed. Current best practice and human factor principles such as not including any unnecessary information were also taken into account. The information on the ADDS chart included two track-and-trigger systems: a single parameter (MET criteria) and a multi-parameter colour coded system (ADDS scores). Colour intensity was shown according to the degree to which vital signs were abnormal. All information was provided on the same page to reduce cognitive load. Each vital sign was presented on a separate graph to enhance the view of trends and avoid clutter. Vital signs were placed in order of importance, for example, the most important vital sign, respiratory rate, was at the top left of the page. One of the ADDS charts included a blood pressure table. This was in order to take into account individual patients' 'normal' blood pressure. The second ADDS chart was based on a normal systolic blood pressure of 120 mm/Hg, making the second version potentially simpler to read.

The next stage was to test whether the ADDS chart was successful in minimising errors in recognising patient deterioration. To do this, a total of six charts were compared: the two versions of the newly designed ADDS chart and four existing observation charts from Australian hospitals. The results demonstrated that the ADDS charts scored significantly better regarding fewer errors and shorter decision times. Specifically, the results showed that coloured track-and-trigger charts outperformed non-colour charts, and that plotted graphs were superior to numerical data. Decisions were reached more quickly in the ADDS chart that did not use the systolic blood pressure table. (Horswill et al., 2010; Preece et al., 2010). The study concluded that "the design of observation charts has dramatic effects on

both the ability of individuals to detect abnormal vital signs as well as the time taken to make those judgements. . . [thus] the way that observation charts are designed is likely to have a substantial impact on patient safety." (Horswill et al., 2010)

Both of these studies agreed that there was a need for national standardised patient observation charts (Chatterjee et al., 2005; Horswill et al., 2010). In relation to patient safety and clinical effectiveness, the Royal College of Physicians also recommended improving the standard of patient clinical records and the standardisation of in-patient basic observation charts (Royal College of Physicians, 2007).

2.7.5 Documenting early warning scores

For scoring to be accurate in early warning scoring (EWS) systems, all relevant clinical parameters must be recorded. However, in some cases, it has been shown that charting of physiological observations has been prone to inaccuracies and miscalculations (Cuthbertson & Smith, 2007; Day & Oldroyd, 2010; Morris & Davies, 2010). Goldhill et al (1999) found that routine observations were seldom found in patients' notes, and were often recorded improperly and imprecisely, highlighting the issue of poor documentation. The respiratory rate was a recording that was often missed (Day & Oldroyd, 2010; Morris & Davies, 2010), despite the importance of respiratory rate as an early indicator of patient deterioration (Goldhill, White, & Sumner, 1999; Schein et al., 1990; Subbe, Davies, et al., 2003). However, in other studies, the introduction of modified early warning scores (MEWS) was found to be beneficial in improving the recording of respiratory rate (McBride et al., 2005; Odell et al., 2007; Sharpley & Holden, 2004).

2.7.6 Electronic documentation

Some studies have examined the impact of documenting EWS electronically. Prytherch et al (2006) performed a classroom study where documenting EWS using pen and paper was compared to documenting on a handheld computer or personal digital assistant (PDA), to determine completeness and accuracy of entry, and the calculation of weighted values of EWS. The participants, who were nurses familiar with the EWS, entered and charted five different sets of fictitious, physiological vital signs datasets. Each dataset was increasingly more complex. The participants processed the datasets using two methods – one with pen and paper and the other in a PDA. Half of the group started with pen and paper and the other with the PDA. They found that manual collection and charting was inaccurate in

28% of cases compared to an error rate of 9.5% with the PDA. A questionnaire demonstrated that participants preferred the PDA.

Another study also investigated whether the provision of computer-aided scoring could increase the accuracy and efficiency of EWS calculations when compared to the pen and paper method, and to find out the degree of user acceptability. The 26 nurses in the study were familiar with recording EWS with pen and paper. In the study, the nurses entered data and derived EWS using both pen and paper, and in a PDA. The results were compared for accuracy, the time taken and user perceptions. Results demonstrated that more accurate calculations of EWS could be attained by using PDAs, that PDAs could save time and that computer-aided EWS were acceptable to nurses (Mohammed et al., 2009). These studies emphasise the role that technology could play in accurate recording of EWS.

2.7.7 Lack of studies

However, although electronic patient record systems are increasingly prevalent and utilised in documenting vital signs, studies which specifically focused on the documentation of physiological vital signs in electronic patient records were not found through the extensive literature search (described in section 2.2). One qualitative study aimed at exploring nurses' perceptions of using an electronic patient record in everyday practice, found that there were difficulties encountered in documenting vital signs (Stevenson & Nilsson, 2012). These difficulties were related to problems with navigability and overview of patient information. Another study claimed that nurses preferred to chart vital signs at the bedside but that this had not been possible because computers were too slow with insufficient memory (Moody et al., 2004). Usability studies have shown that electronic systems should allow easy access to relevant clinical information (Carrajo, Penas, Melcon, Gonzalez, & Couto, 2008), and be streamlined to the working practices of the end-user (Peute, Spithoven, Bakker, & Jaspers, 2008).

On the other hand, work has been carried out to facilitate the design of software for creating electronic graphs that display physiological vital signs. User needs were the main focus with emphasis on numerical presentation of physiological data to assist in clinical decision-making (Microsoft, 2008). The guidance defines key factors that influence the user's ability to interpret data correctly.

2.8 Synthesis of the literature

The existing literature demonstrates the importance of early detection of patient deterioration. Deterioration in a patient's clinical status can be identified by monitoring vital signs to detect changes in respiratory, cardiovascular and neurological systems. Failure to identify, interpret and manage clinical signs of life can result in sub-optimal care with patients not receiving appropriate treatment in time. As a result of this, track and trigger systems have been developed where "track" refers to monitoring physiological status and "trigger" refers to the point at which certain actions should be taken. Several track and trigger systems have emerged, each with the aim of securing timely treatment for the deteriorating patient. In addition, various constellations of emergency response teams have been developed to respond to patients with a critical medical problem and ensure that patients receive expert help.

Many studies have been undertaken to establish the benefits of these systems and efforts have been made to produce evidence-based track and trigger systems. The advantages of early warning systems and rapid response systems include early assessment of acutely ill patients so that appropriate treatment can be determined. Appropriate treatment could be to save the patient by instigating life-saving treatment at the bedside, or transferring the patient to a higher level of care such as high dependency or intensive care. On the other hand, the most appropriate care could be palliative and deciding that a 'do not attempt resuscitation' order would be the most humane way to care for the patient. It may not always be that the patient can be rescued or brought back from the brink, for instance, in cases where death is inevitable as the natural outcome. Consequently, rapid response systems have an important role to play in identifying and assessing the acutely ill patient, supporting life where appropriate, and assisting in making decisions for end-of-life care when it is not.

The importance of presenting clearly accessible documentation of patients' vital signs has been highlighted. For example, the process of documenting patients' vital signs on patient observation charts has been examined to find optimal methods of representing this type of information. Studies have indicated that the design of these charts has a profound impact on how accurately and quickly clinicians can identify deteriorating patients. However, these studies have focused on paper charts.

This literature review also emphasised the importance of good documentation routines and that vital sign documentation should be presented in a manner that ensures interpretation is

efficient. Furthermore, the literature review established that monitoring of vital signs was an essential element of patient care. Specifically, a large number of studies highlighted the following three points:

i. early detection of deterioration in patients is vital in order to prevent disastrous outcomes such as prolonged hospital stay or death;

ii. awareness of the importance of detecting deterioration in patients has led to world wide use of rapid response systems;

iii. clear visual representation of vital signs enables clinicians to identify patients whose conditions are deteriorating;

However, the most striking feature of the extensive literature review was that there was very little scientific work related to vital signs documentation in the EHR. Table 2.10 provides a breakdown of the studies found that were a) related to the role of front line staff in recording and using vital signs data in electronic documentation and b) on the way EHR links with abnormal responses to vital signs, and triggers responses to assist the patient.

Table 2.10 Studies on vital signs documentation in EHRs

Studies on role of front line staff in recording and using vital signs data in electronic documentation.		
	Number of studies	Methodology and Findings
Studies that focused specifically on documentation of vital signs in EHR	None	
Studies which mentioned documentation of vital signs in EHR.	Two studies	Descriptive study • nurses preferred to document vital signs at the bedside • in current system, not possible to document at the bedside • had to record on paper first then transfer data to the EHR system Moody et al., 2004 (Section 2.7.7)
		Qualitative study • essential information, e.g., vital sign recordings, was difficult to enter and difficult to locate in the EHR • unclear where specific information should be documented Stevenson & Nilsson, 2012 (Section 2.7.7)
Studies on the way EHR links with abnormal responses to vital signs, and triggers responses to assist the patient.		
Studies found:	One study	Description of hand-held computer • electronic system to record vital signs in personal digital assistants (PDAs) • EWS alerts made available to each patient's clinical team through a wireless network. (Smith et al., 2006) (Section 2.5.2)

Points i-iii clearly indicated that monitoring vital signs was a priority in current health care. However, as the information in Table 2.10 indicates, there was a dearth of literature on vital signs documentation in EHRs. This demonstrates the gaps in scientific research that this thesis will strive to fill. Frequent checking of the literature during the time that the current research was undertaken did not reveal any findings that would have affected the design of this study.

2.9 Limitations of existing research

While documentation of vital signs on paper patient observation charts has been addressed, methods for documenting vital signs in electronic patient records have not. All hospitals in Sweden now use electronic patient records. However, it appears that the documentation of vital signs in these systems has not received adequate attention, indicating a need for research in this area. The research questions which have therefore arisen as a result of this literature review are:

- How complete is the documentation of vital signs in the EHR?
- Are there actual or potential problems in documenting vital signs in the EHR?
- Can documented vital signs reveal information about a patient's risk of deterioration?

Following the literature review, these questions became the focus of this study.

2.10 Conclusion

In this chapter, the literature on current measurement and documentation of vital signs in order to recognise critical illness has been reviewed. The importance of measuring and documenting patients' vital signs has been emphasised with systems for identifying deteriorating patients described. Current methods of documenting vital signs on paper charts have been explained. The documentation of vital signs in electronic health records systems has received minimal attention with no studies available that describe documentation of vital signs in an EHR. As the literature has emphasised the importance of good documentation of vital signs, this research aims to answer the research questions detailed above (2.9). Having set out the research questions, the next chapter will describe the methodology adopted to answer them.

Chapter 3 Methodology

3.1 Introduction

Chapter 2 served to situate this thesis within the relevant research literature regarding rapid response systems, detecting patient deterioration, monitoring vital signs and documentation of vital signs in electronic health records (EHR). The chapter concluded by identifying the gaps in the literature and formulating the research questions. This chapter describes how the literature review, and particularly the research questions, influenced the methodology of this thesis (Creswell & Plano Clark, 2007). The term methodology refers to the way in which decisions about methods of investigation are taken in order to address the research questions and to give accurate and valid results (Polit & Beck, 2008). Creswell and Clark (2007, p. 4) suggested that methodology "refers to the philosophical framework and fundamental assumptions of research". The methodology for the current research is described in this chapter.

This chapter begins with a discussion of research paradigms used in various types of studies. This includes a discussion on pragmatism which was considered the most suitable paradigm for mixed methods research (Section 3.2). This is followed by a description of the research approaches in this study, how the research questions formulated the methodology and how decisions about methods of investigation were reached (Section 3.3). The research strategy is discussed (Section 3.4) and research methods are outlined in section 3.5. Next, there is a description of sampling and recruitment (Section 3.6), which is following by an outline of the ethical issues in this research (Section 3.7) and how they were addressed. Sections 3.8 and 3.9 discuss data analysis and validity respectively. Finally, a conclusion to this chapter is provided in section 3.10.

3.2 Research paradigm

A paradigm is a set of assumptions about the world (Punch, 2014) and a research paradigm is an underlying set of beliefs about how elements of research fit together (Wisker, 2001). These basic beliefs guide the action to be taken in research (Denzin & Lincoln, 2013). A paradigm may also be called a 'worldview' and is influenced by experiences, culture and history (Creswell & Plano Clark, 2007).

Research paradigms or inquiry paradigms, as they are sometimes called, define the limits of inquiry. Punch (2014) suggested that inquiry paradigms address three fundamental questions: ontological, epistemological and methodological questions. Others have described this slightly differently stating that a research paradigm for human enquiry can be characterised in terms of four basic philosophical concepts or assumptions: ontologic, the nature of reality; epistemologic, the way that knowledge is gained; axiologic, ethical aspects and the role values play in research; and methodologic, the process of research (Creswell & Plano Clark, 2007; Denzin & Lincoln, 2013; Polit & Beck, 2008). These philosophical assumptions are embedded in the interpretive frameworks of theoretical paradigms or worldviews (Creswell, 2013a) and illustrate the connections between methods and philosophical issues (Punch, 2014).

Paradigms have been discussed extensively in the research literature (Bryman, 2012; Creswell, 2013a; Denzin & Lincoln, 2013; Kumar, 2011; Polit & Beck, 2008; Punch, 2005). Discussions on paradigms have become complex and many research paradigms have been proposed, for example, positivist, naturalistic, post-positivist, constructivist, transformative and pragmatist. Some scholars have more recently claimed that research paradigms can be narrowed down to include two main positions: positivism and interpretivism or constructivism. Positivism is usually associated with quantitative methods and interpretivism/constructivism is usually associated with qualitative methods (Punch, 2014).

The basic assumptions of some of these paradigms are described here. The positivist paradigm, generally connected with quantitative research, has its roots in the physical sciences (Kumar, 2011). It is based on the assumption that there is a reality that can be studied and known (Polit & Beck, 2008). Positivist research, is based on the idea that the world can be described objectively (Punch, 2014). On the other hand, post-positivism, as the name suggests, represents the thinking after positivism and challenges the belief that there is an absolute truth. The post-positivist paradigm involves both positivist and naturalistic research, in which both quantitative and qualitative methods are employed, and can be used in mixed methods studies (Creswell, 2009). Creswell (2007) suggested that post-positivism can be associated with quantitative approaches, in which researchers make claims of knowledge based on determination, reductionism, empirical observation and measurement, and theory verification. The naturalistic paradigm, most often used in research in the social sciences, is typically associated with qualitative research. Naturalistic research examines settings in their natural state (Punch, 2014). Creswell (2013b) extended the number of paradigms or worldviews to include constructivism, transformativism and

pragmatism. Constructivism, according to Creswell (2013b), is associated with qualitative approaches and is about understanding meaning through subjective views. For example, constructivists presume that people wish to understand the world in which they live. Interpretivism focuses on understanding behaviour (Punch, 2014). A transformative worldview implies that research should be related to politics in order to challenge social oppression of marginalised groups.

Pragmatism may also be described as a worldview (Creswell, 2013b). Pragmatism emerged as a philosophical approach in parallel with new ideas in methodological thinking, for example, the increasing prevalence of mixed methods research. Scholars have struggled with situating this method into an appropriate world view or paradigm (Creswell & Plano Clark, 2007; Venkatesh, Brown, & Bala, 2013). The traditional world views of positivism associated with quantitative approaches and interpretivism, associated with qualitative approaches, are naturally opposed to each other. Therefore, a suitable paradigm that incorporates both approaches has been pursued. Researchers have had to move beyond warring about which paradigm was best and may be willing to use multiple paradigms (Punch, 2014). Pragmatism does not conform to one philosophical system in particular and can therefore be applied to mixed methods research in which both qualitative and quantitative approaches are employed (Creswell, 2013b). Perhaps because of this, the most popular paradigm emerging for mixed methods research is pragmatism. Pragmatism "can provide a philosophy that supports paradigm integration and helps mixed research to peacefully coexist with the philosophies of quantitative and qualitative research" (Johnson, Onwuegbuzie, & Turner, 2007, p. 125). Thus, 'opposing' paradigms may be finally brought together by using a mixed methods approach that exploits the positive characteristics of both approaches and neutralises the weaknesses of each.

Pragmatism diverges from theoretical perspectives in the previously mentioned traditional paradigms to a more practical world view. It emphasises solutions to research problems and has been formally linked to mixed methods research. Not all questions are theory based and pragmatism enables more concrete and practical questions to be addressed without placing the research in a theoretical framework (Patton, 2002). A pragmatist paradigm focuses attention on the research problem and uses pluralistic approaches to examine the questions. Punch compared paradigm-driven approaches to pragmatic approaches (2014). He explained that a paradigm-driven approach is one that begins with the paradigm and from there, research questions and methods are developed. The

pragmatic approach begins with the research questions and appropriate methods are chosen to address these questions.

Pragmatists do not see a unified world and therefore look at problems from various perspectives. Similarly, mixed methods researchers tackle problems from different perspectives and use varied methods of inquiry such as those available in both quantitative and qualitative research. Researchers choose the methods, techniques and procedures that will provide the best understanding of the research problem. They simply want to use methods that 'work' to solve the problems. The pragmatist paradigm was selected as the most appropriate world view for the overall study in the current research because the research began with a practical problem that warranted investigation. The research in this thesis is therefore viewed from a pragmatist perspective (Creswell, 2013b; Creswell & Plano Clark, 2007). Mixed methods research, which, as already stated, combines both quantitative and qualitative research approaches, was employed as the method of enquiry.

Within the pragmatist paradigm, the mixed methods approach adopted both quantitative and qualitative elements. A two-phase study was carried out sequentially. A quantitative approach was considered the most appropriate for the first phase of the study. The reason for this was that a positivist line of enquiry is the most suitable when examining categorical and numerical data such as the recording of physiological vital signs. For the second phase of the study, a qualitative approach was selected. The primary aim of qualitative research is to understand what happens in a setting. This was considered the most suitable approach as the aim of this phase was to gain greater understanding of the results produced in phase one and an understanding of users' perceptions and attitudes towards vital signs and documentation in the EHR.

In terms of philosophical assumptions, paradigms for human enquiry respond to philosophical questions which can be ontologic, meaning to enquire about the nature of reality, or epistemologic which relates to the relationship between the inquirer and that which is being studied. Regarding the philosophical assumptions in the phase one study, the ontology was to describe the reality of how vital signs were presented in the EHR. This description would provide information on the reality of the documentation of vital signs. The epistemology of this approach was to use quantitative data and statistical analysis to answer the research questions objectively, as an objective way of knowing. The ontology in the qualitative second phase of the study was the actual work processes, and users' perceptions and attitudes towards the EHR. In qualitative research, the reality can be

multiple and subjective. The epistemology was adopting qualitative methods to allow the researcher to gain a deep understanding of users' perceptions and attitudes, and with the researcher interacting with those being studied.

3.3 Research approaches

The philosophical perspectives in each paradigm and the aims of the research should guide the choice of approach for conducting research (Kumar, 2011). As suggested in section 3.2, there are three approaches available to the researcher: qualitative, quantitative and mixed methods, the latter being a combination of the qualitative and quantitative methods.

When deciding upon research approaches, consideration should be given to the research design. Creswell (2009 p.3) claimed that "research designs are plans and procedures for research that span the decisions from broad assumptions to detailed methods of data collection and analysis". The research design is basically a road map determining how the main research questions in a study will be answered. Thus, it should include the study design, the sampling strategy, data collection and method of analysis. It should also explain and justify how decisions about the research design were taken. Therefore, a research design has two main functions. The first is to develop procedures to undertake the study. The second is to ensure that the chosen approaches can obtain valid, objective and accurate answers to the research questions (Kumar, 2011).

In line with the pragmatist paradigm, a mixed methods approach was considered the most appropriate approach to address the research problem and answer the research questions. Moreover, mixed methods has been found to be particularly beneficial when investigating information systems (Venkatesh et al., 2013). This is because a more holistic understanding of information systems can be gained by including both quantitative and qualitative approaches (Venkatesh et al., 2013), the information system in this case being the electronic system used to document vital signs, among other patient data. The next section describes mixed methods approaches. This is followed by an outline of the main features of both qualitative and quantitative approaches as these are integrally included in mixed methods research.

3.3.1 Mixed methods approach

Mixed methods research can be defined as "an approach to enquiry involving collecting both quantitative and qualitative data [and] integrating the two forms of data" (Creswell, 2013b). Additional terms such as 'multi-method' have been used to describe this type of

research but current trends favour the term 'mixed methods' (Bryman, 2012). Mixed methods research is a relatively new approach from the late 1980s and early 1990s and is increasingly popular in the field of social and health sciences research. A fundamental motivation for embarking on this relatively new type of research is that it can provide a deeper understanding of the research problem than when only a qualitative or a quantitative method is used, by exploiting the strengths of the two methods (Creswell, 2009); it draws on the strengths of both qualitative and quantitative research and therefore diminishes the weaknesses of both. The aim of using two or more approaches is to achieve confirmation or completeness of the data; confirmation refers to overcoming the bias of using a single method of enquiry and increasing confidence in the results, and completeness provides deeper understanding of complex issues (Begley, 1996). Gaps left by one method can be filled by another (Bryman, 2012) and can provide a more complete understanding of research problems. Mixed method procedures can be used when researchers wish to explain the findings of qualitative research with quantitative research or vice versa (Creswell, 2009). For instance, by comparing different perspectives of the two types of data, it can explain the results of a quantitative study by following up with a qualitative study, and providing a more complete picture of the phenomenon under scrutiny. A disadvantage of using only one kind of data is that there may not be sufficient evidence to tell the whole story (Creswell & Plano Clark, 2007). Thus, the advantage of combining two forms of data in the same research can provide different types of information and enrich the overall study. A simple analogy for the strengths of mixed method research is the 'synergy effect', in which results of the overall study yield more that the sum of the component parts, i.e., one plus one equals more than two. In mixed methods research there are three procedural issues, namely, priority, implementation and integration (Ivankova, Creswell, & Stick, 2006), that must be considered. These are described in the following three sub-sections.

3.3.1.1 Priority

The first issue, 'priority', refers to which approach, quantitative or qualitative, is given most weight throughout the study. In sequential explanatory design the weighting usually favours the quantitative approach as it usually comes first in the sequence, but the research questions may also guide the choice of priority. It is also possible that a researcher decides to give equal weight to both approaches (Ivankova et al., 2006).

Regarding choice of 'priority' in the current research, no decision was made on weighting at the outset, but as the study progressed it became apparent that the quantitative and qualitative approaches had approximately equal weighting. This decision was influenced by the aim of the study, which was to examine the documentation of vital signs in an EHR. After descriptions of documentation of vital signs in the EHR were established in the phase one study, the follow-up investigation in phase two was designed to investigate and explain the results of the quantitative study.

3.3.1.2 Implementation

The second procedural issue is 'implementation'. This refers to different types of mixed methods design in terms of timing and sequencing of the data collection. The design can be concurrent or sequential. The three most common types are: convergent parallel mixed methods (also called triangulation design) (Creswell, 2007), in which quantitative and qualitative data are collected concurrently; explanatory sequential mixed methods, in which data are collected in sequence with quantitative data collected first, followed by the qualitative component to provide a more complete picture; and exploratory sequential mixed methods, in which data are collected in sequence with qualitative data collected and analysed before collecting the quantitative data (Creswell, 2013b). This type of design is sometimes called triangulation for confirmation. This is because the small scale qualitative study findings can be confirmed in a large scale quantitative study, the results of which should be generalisable to the wider population.

In the current study, the design for the 'implementation' was also considered carefully. Bowling (2009) suggested that the first method to use in case study research should be qualitative with a follow-up quantitative study . However, prior to embarking on this PhD programme, a qualitative study had been performed in this setting and had informed the need for this research (Stevenson & Nilsson, 2012). This assisted the decision on sequencing of the current research. Although the previous qualitative study was not considered part of a mixed methods study, it provided a foundation for continued research

in the same hospital setting. Thus, background information, which facilitated the planning of the quantitative study, was already available (Punch, 2005). Another important practical reason for choosing a sequential design was that the study was carried out by a single researcher and the investigation could be divided into two manageable tasks. Therefore, explanatory sequential mixed methods was the design used in the current research and was guided by the work of Creswell (2013). The aim of this design was that the qualitative data would provide better insights into, and a deeper understanding of, the quantitative results.

The explanatory sequential mixed methods design involved a two-phase study whereby quantitative data were collected first. In this method, the quantitative results identify new questions and the data collected in the phase two qualitative study are directly related to the outcomes of the phase one study (Ivankova et al., 2006). New questions arising from phase one can be answered by collecting qualitative data to explain the quantitative results in more detail. Data collection was performed in two separate phases. In this strategy, careful planning was required to identify which quantitative results needed further explanation as the qualitative data collection should build on quantitative results. A strength of this design was being able to explain how variables interact. An illustration of explanatory mixed method design is given in Figure 3.1.

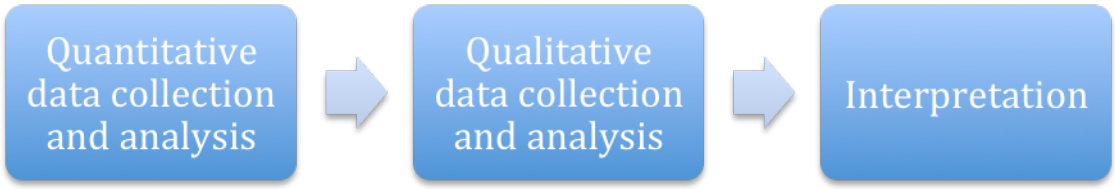


Figure 3.1 Explanatory sequential mixed methods design (inspired by Ivankova et al. 2006)

3.3.1.3 Integration

'Integration' is the stage or stages in which quantitative and qualitative approaches are combined. A major concern of mixed methods research is pinpointing when integration or mixing of methods, if at all, takes place. Some authors have suggested that quantitative and qualitative methods are completely independent of each other in mixed methods research and that there is little integration between the two methods e.g., (Bryman, 2012; Feilzer, 2010). However, Johnson (2007) suggested that there is the potential for mixing at all stages. Ivankova et al. (2006) proposed several stages during which integration between quantitative and qualitative methods takes place: at the beginning of the study while the

purpose is being formulated; in the intermediate stages when the results of data analysis from the first phase can guide the questions and data collection of the second phase and where the first phase can guide the development of data collection tools for the second phase, and whilst interpreting the results of quantitative and qualitative phases (Ivankovo 2006).

3.3.1.4 Mixed methods approaches in current research

The analysis of the data was carried out separately for the quantitative and qualitative phases of the study. Quantitative and qualitative studies within a mixed methods approach should be executed with the same rigour as they would receive if they were carried out as stand alone studies (Creswell, 2013). The next section outlines the quantitative and qualitative approaches used within the mixed methods approach. Figure 3.2 provides a visual model of the mixed methods sequential explanatory design used in this research.

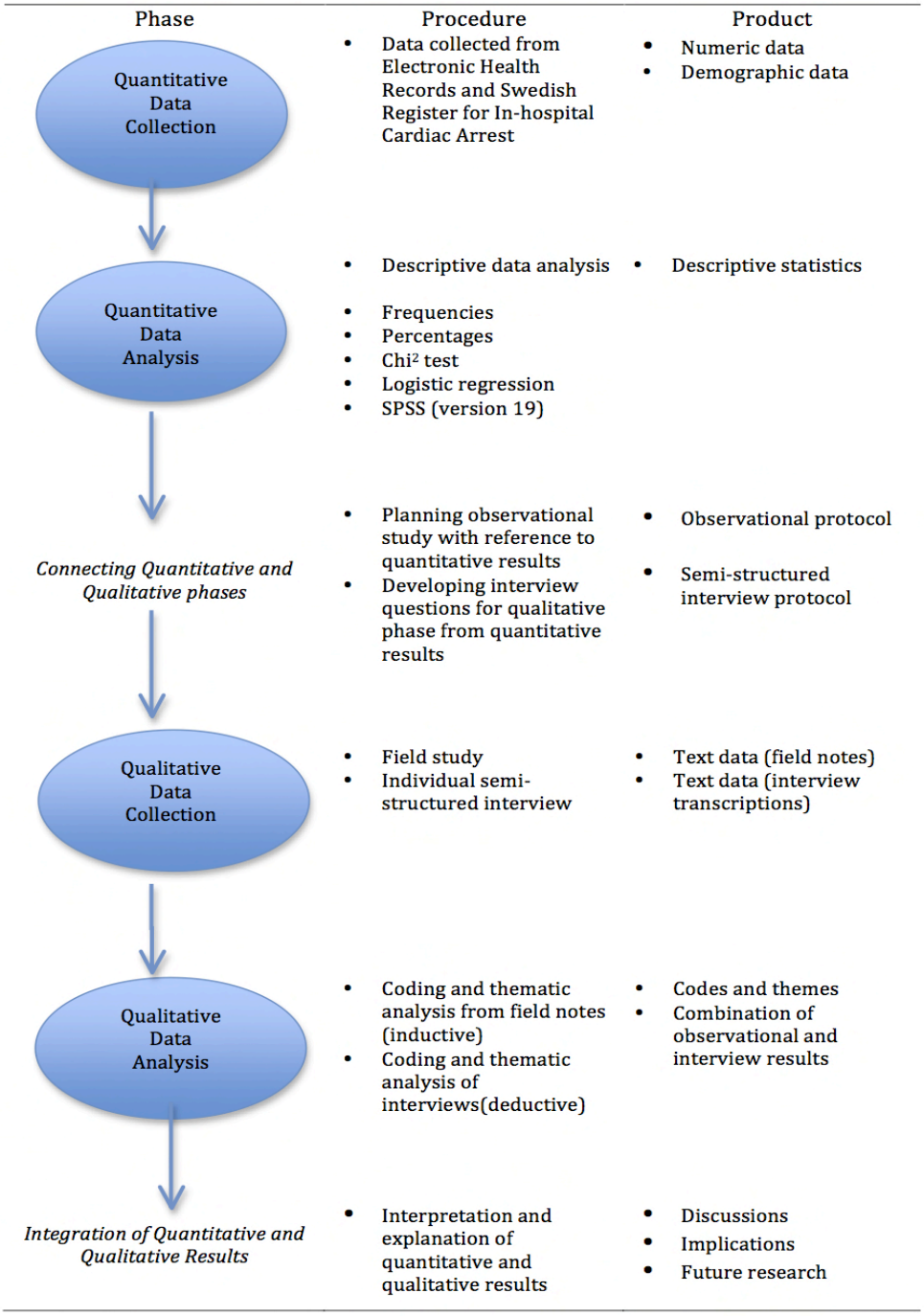


Figure 3.2 Visual model for mixed methods sequential explanatory design as applied to this study (adapted from Ivankova et al. 2006)

3.3.2 Quantitative approach

The design of a quantitative study should provide strong evidence to answer the research questions. A quantitative approach is associated with ordered disciplined procedures to acquire information (Polit & Beck, 2008). In a quantitative approach, data are gathered systematically, adhering to an established plan, and categorical and numerical (continous) data are analysed systematically using statistical procedures. Quantitative research deals with quantities and relationships among variables (Bowling, 2009), and examines reality in terms of measuring variables and making comparisons (Creswell, 2009; Polit & Beck, 2008). A retrospective design can be used to investigate issues that have happened in the past and can be conducted on the basis of the data available (Kumar, 2011).

3.3.2.1 Quantitative approaches in the current research

A quantitative approach was selected for the first phase of this research. As the literature review had revealed that research describing documentation of vital signs in an EHR was very limited (Section 2.8.7), it was decided to adopt an approach that would provide detailed information about this phenomenon. The issue to be investigated in this research included the presence or absence of recorded physiological vital signs; which, where and how vital signs were documented in electronic health records. It was felt that a quantitative approach could describe the level of documentation of vital signs in the EHR. The study design was retrospective in that it would be carried out using existing records.

3.3.3 Qualitative approach

Qualitative research originated from anthropology, sociology and the humanities and procedures for carrying out qualitative inquiry are discussed extensively in the research literature (Creswell, 2013b; Mason, 2002; Punch, 2005). According to Bowling (2009, p380), qualitative research is "a method of naturalistic enquiry which is usually less intrusive than quantitative investigations and does not manipulate a research setting". This approach is appropriate when issues are complex and there is a need for explanation. It can provide deeper meaning and understanding to problems.

3.3.3.1 Qualitative approach in the current research

A qualitative approach was used in the second phase of the current research with the aim of examining the meaning of the results from the first phase study. This approach has the possibility to answer the question 'why', for example, why were the results (obtained in phase one) the way they were? The approach could also examine deeper meanings that

were related to the attitudes and beliefs of the people using the EHR. In addition to decisions on research approaches, a strategy for the research is required. The choice of research strategy is discussed in the following section.

3.4 Research strategy

A research strategy indicates the specific form of enquiry taken to answer the research questions (Punch 2014). A case study is an example of a strategy of enquiry. A case study strategy involves "the detailed and intensive analysis of a single case" and can explore an issue through a case (Bryman, 2012, p.52). It is associated with extensive examination in which the nature of the complexities of the case in question can be investigated (Bryman, 2012). It can involve the examination of a single unit which could be a person, a group, a setting, an event or an organisation (Bowling, 2009; Wisker, 2001). It is a useful design when exploring an area where little is known and can help explain the unique features of an object of interest (Kumar, 2011). Case studies may be used for the development of theories, but some case studies do not contribute directly to theory, instead they can be used to provide good descriptions of phenomena. A case study used to provide description of phenomena is referred to as an idiographic case study approach (Bryman, 2012; George & Bennett, 2005).

Case studies can also be distinguished by whether they are single case studies or multiple cases. In the former, the focus is within the case and in the latter, the focus is both within and across the cases (Punch, 2005). Punch (2005) stressed the variation in case studies and, thereby, the difficulty in providing a conclusive definition. However, from the varied definitions made in the literature, he outlined four characteristics of case studies. Firstly, a case has boundaries, which means that the researcher should clearly identify the boundaries of a case. This refers to the geographical boundaries as well as the context of the case to be examined. Secondly, there needs to be identification of what the case is about to give a clear focus to the research and determine the unit of analysis. Thirdly, a case should be holistic so that the unity of the case can be preserved and maintain a specific focus. Finally, multiple methods of data collection may be used, indicating that case studies can be both qualitative and quantitative (Punch, 2005). Creswell (2007) disagreed with this and claimed that case study strategy is only used in qualitative approaches. However, there are examples of case study research in which multiple methods can be employed (Bowling, 2009). Given this, it was felt that a mixed methods approach to the case study, incorporating quantitative methods, as described in section 3.3, would be appropriate.

There are some pitfalls to single case study research, e.g., selection bias or over-generalisation of results. This can be avoided by ensuring that the selected case is relevant to the research objectives of the study and that the data reflect the theoretical framework. Specification of the data to be obtained is also essential when conducting case study research (George & Bennett, 2005). By studying a single case, it may not be possible to generalise the results. However, the findings from a case study may be potentially valid to other cases (Punch, 2005).

3.4.1 Research strategy in the current study

The aim of this research was to investigate the documentation of physiological vital signs in electronic health records. To achieve this aim, it was decided to examine the recording of vital signs in an EHR in a single hospital setting. These clear boundaries made this research suitable for a single case study. There was also a clear focus with the recording of vital signs as the unit of analysis (Punch, 2005). Moreover, the descriptive perspective to the study provided strong links to idiographic case study research (Bryman, 2012; George & Bennett, 2005) and thus, a case study strategy was considered the most appropriate strategy for the current study. Furthermore, no previous studies have examined the documentation of vital signs in an EHR and a case study can be a valuable strategy in the early stages of research (Bowling, 2009). Moreover, "case studies are frequently sites for the employment of both quantitative and qualitative research" (Bryman, 2012, p.53) so was appropriate for a mixed methods approach. Since, case studies often employ multiple research methods to investigate situations of which there is little previous knowledge and there has been a dearth of studies that have examined the documentation of vital signs in EHR systems, this strategy was deemed to be appropriate for the current research.

The descriptive nature of idiographic case study research indicated that the quantitative study would be a descriptive study to describe the nature and intensity of any identified problems. The follow-up qualitative study would provide a deeper understanding of the results obtained in the quantitative study. Having established this, the following section describes the research methods that were adopted for this study.

3.5 Research methods

Research methods are "the techniques used to structure a study and to gather and analyse information in a systematic fashion" (Polit & Beck, 2008, p.765). In a mixed methods study, as discussed in section 3.3.1.2, using explanatory sequential mixed methods design,

quantitative data are collected in the first phase of the research and qualitative data are collected in the second phase. The former is associated with the positivistic paradigm, utilising structured methods, precise measurement and quantification of variables, so that numeric data can be analysed. The latter is associated with more flexible methods such as observation and interview, and data analysis is built up inductively from specific to general themes (Kumar, 2011; Polit & Beck, 2008).

Data sources can be broadly classified into primary data and secondary data. Primary data refers to data collected from primary sources, e.g., determining user-satisfaction with a computer system by undertaking interviews. Conversely, secondary data is collected from existing sources of data such as hospital records. Data collected from secondary sources are used in both qualitative and quantitative research. In qualitative research the secondary data could be historical, e.g., from diaries or letters (Polit & Beck, 2008), or narrative in nature, e.g., when an individual provides stories about their lives (Creswell, 2009). On the other hand, secondary quantitative data from medical records could consist of categorical and numerical variables. An example of a categorical variable could be 'gender' or whether or not a specific vital signs has been recorded or not. An example of a numerical variable could be the actual value of a recorded physiological vital sign such as body temperature or blood pressure. Polit and Beck (2008) emphasised that existing records are an important source of secondary data in healthcare research; hospital records and patient charts are considered to be rich sources of data.

Data collection from secondary sources can be relatively straightforward when compared to data collection from primary sources; primary source data utilise questions and interviews and this can cause problems stemming from people's awareness of a study, the so-called 'Hawthorne effect' (Kumar, 2011), which is when people respond or act differently because they know they are being studied (Polit & Beck, 2008). A problem with collecting data from secondary sources can be that sometimes it is difficult to gain access to institutional records so it is important to ensure that the required data are available and accessible (Kumar, 2011; Polit & Beck, 2008). Similar to planning questionnaires and interviews for primary data collection, researchers collecting data from existing records must make important decisions about the data to be gathered.

3.5.1 Appropriateness of mixed methods research

Venkatesh (2013, p. 45) suggested that the purpose of employing a mixed methods approach should be explained to "demonstrate the appropriateness of conducting mixed

methods research". There were several reasons for employing a mixed methods approach in the current research. It allowed the research problem to be perceived from several angles and therefore was not constricted in the way that single research methods might be. By conducting mixed methods research, the researcher is more likely to find useful answers and provide valuable knowledge that will benefit society as a whole (Feilzer, 2010). By examining the initial aims and objectives of this research, the reasons for choosing a mixed methods approach can be further clarified. As stated in section 1.4, the aim of this research was to investigate documentation of physiological vital signs in electronic health records. More specifically, the objectives included to investigate the completeness of documentation of vital signs in an EHR and to report on the documentation of vital signs in an acute care setting. These objectives could be examined from a positivist perspective and a quantitative approach to identify exactly how vital signs were represented in the EHR. The remaining objective was to identify the specific problems related to documenting vital signs in the EHR and to examine the reasons for the existence of these problems. These perspectives required a naturalistic approach to enquiry and thus a qualitative study was deemed appropriate and designed for this investigation. This approach would allow problems to be investigated at close range, in which every detail related to measuring and documenting vital signs could be scrutinised. Combining the two approaches into a mixed methods approach was the most appropriate way to address these research questions in order to provide a holistic understanding; the quantitative research could provide breadth (Johnson et al., 2007; Venkatesh et al., 2013) by examining the representation of vital signs in the EHRs of a number of high risk patients. Qualitative research could provide a deep understanding of the practices and attitudes of the people who were caring for these patients and identify the reasons for problems associated with using the EHRs for documentation.

3.5.2 Quantitative research method

When collecting data in a quantitative method, a vital step is to identify the specific information that is needed, pragmatically, the data that are needed to solve the problem. With this in mind, the first practical step is to design a research instrument or data collection tool (Kumar, 2011). The data collection tool should be developed with research objectives in focus so that it is linked directly to the objectives. Further, the researcher needs to decide upon a broad framework of what needs to be found out and design the data collection tool accordingly (Kumar, 2011). Questionnaires and structured interviews

are typical examples of such instruments and designing these requires careful consideration so that all aspects of research questions are addressed (Bryman, 2012). Similarly, data collected from secondary sources such as existing records need a detailed and functional instrument to ensure that appropriate data are generated to answer the over-arching research questions. In the current study the data collection tool provided a standardised form that could be used systematically for collecting data from existing records. Details of the development and use of the data collection tool are described in Chapter 4 (Section 4.3.4.8).

3.5.3 Qualitative research methods

In qualitative research approaches, the two main methods of data collection are observations and interviews. In the current study, the second phase of the mixed methods research employed a qualitative approach. An observational study was conducted first and this was followed up by an interview study. A description outlining the data collection in these two methods is provided below.

3.5.3.1 Observational method

An observational study can promote understanding of complex situations through the observation of actions and activities (Bowling, 2009). This type of study can be a rich source of information as it enables the researcher to capture what people do rather than what they say they do (Wisker, 2001).

When collecting the data during observational studies, the researcher should not assume to understand all aspects of what is observed. For instance, the researcher's previous experience may affect the interpretation of what s/he observes. As a means of ensuring accurate data if there is any uncertainty whatsoever, questions should be asked. This means that a researcher should ask follow-up questions during observations in less busy moments to clarify and verify what is being observed, to assess thinking processes and to gain direct views. These types of questions are known as 'opportunistic interviews' (Saleem et al., 2011).

However, carrying out an observational study is not limited to 'observing' and research carried out in the field is more comprehensive than this and termed more generally as 'field work'. Field work can be described as "observing, participating, interrogating, listening and communicating, as well as a range of other forms of being, doing and thinking" and can be a demanding task for the researcher (Mason, 2002 p.87). As Mason (2002) also mentioned,

collecting data in the field demands special efforts to create a good rapport with those being observed.

In the current research, measures were taken to ensure a good rapport and are described in section 5.4.3. Data were generated by observing the behaviour and practices of the health care professionals within the setting and communicating with those observed (Mason, 2002). A factor that can affect data collection during observations is observer intrusion. Those being observed may feel ill at ease when they feel they are being constantly watched. For this reason, it is extremely important that the researcher takes measures to put those observed at ease as far as this can be achieved. One way to deal with this situation is to select the type of observer that the researcher will be. When conducting an observational study, researchers can choose to be a participating or non-participating observer. In non-participant observation, the researcher adopts the role of detached observer, meaning that there is no interaction with the people who are being observed (Punch, 2005). Participant observation by contrast is when the researcher is immersed in the field, becomes part of the group being observed and 'goes native' (Creswell, 1998). In the current study, the researcher's background in nursing facilitated collecting the data as a participant observer. The advantages of being a participant observer include that those being observed feel more comfortable in the situation and that it feels natural to have another person in the group, in contrast to an observer who watches and says nothing. In addition, being a participant observer may ameliorate the negative impact of the Hawthorne effect. The Hawthorne effect means that people may change their behaviour in some way if they know they are being observed (Bowling, 2009). On the other hand, a participant observer may make the research less objective because of a closer relationship with the participants.

3.5.3.2 Interview method

An interview study is an appropriate method for collecting data when "people's perceptions, meanings, definitions of situations and constructions of reality" (Punch, 2005, p.168) are being investigated. Interviews can be categorised according to the degree to which they are structured. Structured interviews have several characteristics. They have pre-determined questions with limited response possibilities; standardised questions are posed in the same format for each responder and are most often used in quantitative research. The other end of the scale is unstructured interviews, which are non-standardised, open-ended, in-depth and flexible. A third type is the semi-structured interview, which lies between these two extremes. It is also flexible but questions are planned so that specific

topics are covered and the interviewees have considerable flexibility in how they reply. For semi-structured interviews, an interview guide is prepared but questions may not adhere exactly to the schedule (Bryman, 2012). This allows the interview to progress in a conversational manner, rather than having a strict script, but ensures that all topics are covered. It also enables the researcher to use follow-up questions based on responses from the participants to gather richer data.

Another type of interview method is focus group interviews, in which several participants can be interviewed at the same time and can generate richer data because of the interactions among participants (McLafferty, 2004). However, for this study individual interviews were selected as it was reasoned that the participants may not have wanted to share all of their opinions and ideas with their colleagues. For instance, the topic may have been potentially sensitive if some participants were not documenting information. In addition, the interviews would entail participants temporarily leaving the clinical area for a period of time and it would not have been practical to ask several professionals to be absent at the same time.

In the current study, semi-structured individual interviews were conducted because they were felt to be the best way of generating rich data and enabling complex issues to be addressed. The aim was to provide an in-depth understanding of views and experiences of the personnel (Punch, 2005) and interviews, conducted after completion of observations in each clinical setting, would augment and corroborate data collected during observations. This section has explained the research methods used in this study. The next section describes sampling and recruitment.

3.6 Sampling and recruitment

Sampling is involved in all research as a single study cannot include everyone and everything (Punch, 2005, 2014). Quantitative studies usually involve the researcher(s) sampling where a sample is taken from the population of interest. The sample is analysed and the findings can then be generalised back to the population from which the sample was taken. The degree to which findings can be generalised to the population depends on how representative a sample was of that population (Bryman, 2012). To achieve representativeness, probability sampling is used and is usually some form of random selection, in which each individual has an equal chance of being included in the sample (Punch, 2005, 2014).

However, a sampling plan is also dependent on the research aim and the research questions. This means that "the sampling plan should have a logic that fits in with the research questions" (Punch, 2005; 2014, p. 244). When representativeness is the aim, there is a need for a form of representative sampling. However, in some instances, deliberate or purposive sampling may be more appropriate if the research questions are about relationships between variables or making comparisons. Sampling in quantitative research is moving away from strict mathematical sampling strategies. Because of problems in accessing large appropriate samples, researchers are now more inclined to utilise what is available (Punch, 2005, 2014).

Punch (2005, 2014) emphasised that sampling in mixed methods research should ensure that the sampling selection logically fits the overall logic of the study. The logic of this is that the research questions drive decisions about methodology and thus decisions about sampling. In a case study using a mixed methods approach, the case is the major focus of the investigation and sampling from the case can reveal valuable information (Teddlie & Fu, 2007). Within the bounds of the case, the researcher makes a decision on which people and research sites can provide the appropriate information and a sample is determined according to what is needed to provide the appropriate data.

In the quantitative phase of this research, the aim was to examine the documentation of vital signs in an EHR of patients who had suffered cardiac arrest, and thus, the sample had to reflect this group. It would not be possible to study all patients in this population, therefore, the sample was the electronic records of all patients who had suffered a cardiac arrest in the study hospital and on whom resuscitation had been attempted between 2007 and 2011. This was a purposive, and at the same time, convenience sample and therefore not the kind of sampling that quantitative researchers traditionally advocate, i.e., it was not randomly selected. However, this type of sample reflects what is written in more recent literature - that "the researcher must take whatever sample is available, and the incidence of convenience samples (where the researcher takes advantage of an accessible situation that happens to fit the research context and purposes) is increasing" (Punch, 2005, 2014, p.243). This is also in accordance with the pragmatist view that the main concern is to get the study done effectively and validly (Kervin, 2000).

Sampling strategies in qualitative research are equally important to those of quantitative research. Case studies require sampling within the case and involve selecting a focus (Punch, 2005, 2014). In qualitative research, purposive sampling is used to select

individuals who are good sources of information (Creswell, 2007). Purposive sampling is sampling in a deliberate way with a particular focus in mind. Convenience samples are often used to take advantage of informants who are easily accessible (Punch, 2005, 2014). Snowball sampling is when informants know additional people who can be good sources of information and is appropriate in cases where it is difficult to reach an adequate number of suitable participants. Essentially, sampling should provide the data needed to answer the research questions (Mason, 2002).

In mixed methods explanatory sequential design, in which a quantitative study has been performed first, the sampling in the qualitative second phase is guided by the results of the first phase study. Information provided in the quantitative results is used to inform the requirements of the sample in the qualitative study (Teddlie & Fu, 2007). Specific issues that need further explanation are identified and qualitative data are collected from respondents who can give the best explanation of these results (Creswell & Plano Clark, 2007).

In the current study, the sample was required to generate meaningful data that would help explain the quantitative results. Clearly, the most appropriate participants for the sample were the people who used the EHR for documenting vital signs, i.e., health care professionals. Thus, the sampling strategy was purposive in that the nurses and doctors who used the EHR and worked in the hospital settings were selected for interview. These health care professionals were considered good sources of information who could provide meaningful data in context and where data could be generated to advance understanding (Mason, 2002). The sample was a purposive, convenience sample in that it involved people working within the case study setting who were available to be observed and interviewed at the time the researcher was available to visit the units to undertake the study. A more detailed account of sampling and recruitment for phases one and two of this research are presented in Chapters 4 and 5 respectively.

3.7 Ethical issues

Ethical conduct in research is based on three basic principles: beneficence, non-maleficence and autonomy (Polit and Beck, 2008). Basically, beneficence means to do good. Ideally, research should benefit the participants and, if possible, society as a whole. Non-maleficence is to do no harm and this includes ensuring that there is respect for human dignity. Autonomy means that research participants are able to act and make decisions independently, with the assumption they can do this on the basis of having access to

appropriate information and decide voluntarily whether they want to participate in research (Polit & Beck, 2008), i.e., make an informed and independent decision.

To ensure that ethical principles are applied and that there is no infringement on the rights of the individuals involved, research ethics policies and committees exist to decide whether ethical approval is required and, if so, to make decisions on applications and ensure that the research is carried out with respect to the rights and well-being of individuals. The need for ethical approval for the studies in phases one and two was assessed according to the guidelines of the Ethics Committee of South-East Sweden, which found that ethical approval was required to protect the confidentiality of patients as well as the staff involved in their care. Therefore, applications were sent to the Central Ethical Review Board, Linkoping, Sweden and approval for the studies was received. (More details about ethical approval are provided in Chapters 4 and 5). In addition, permission to collect data from the Swedish Register for In-hospital Cardiac Arrest was obtained and the managers at the study hospital agreed that retrospective data could be collected from the EHR. Managers also gave their permission for observations and semi-structured interviews to be performed in the respective clinical areas (Appendix IVc, IVd)). Furthermore, the Secretary for the University of Sheffield Research Ethics Committee confirmed that additional approval was not required from the University because of the aforementioned approval in Sweden (Appendices II and III): this was deemed to be as robust as the University's processes so further ethics approval was not required.

3.8 Data analysis

Data analysis can be defined as the process of organising and synthesising data in order to answer research questions. In explanatory sequential mixed methods design, quantitative data and qualitative data are analysed separately. However, both quantitative and qualitative analysis involve similar step-by-step procedures: preparing, exploring and analysing the data, followed by representing and validating the data (Creswell & Plano Clark, 2007). This section presents methods of quantitative (3.8.1) and qualitative (3.8.2) analysis respectively and is followed by a description of the data analysis used in this research (3.8.3).

3.8.1 Quantitative data analysis

This section describes methods of data analyses for quantitative studies. "Quantitative data analysis is the manipulation of numeric data through statistical procedures for the purpose of describing phenomena or assessing the magnitude and reliability of relationships among

them." (Polit & Beck, 2008, p. 763). In quantitative research, there are several types of analyses available including: univariate analysis, bivariate analysis and multivariate analysis.

Univariate analysis means to analyse one variable at a time and is used to organise and summarise sample data to enhance understanding. There are several approaches in univariate analysis. First, frequencies and distributions can be described in both numbers and percentages; frequency tables can be used to display results. If there are interval variables, such as ages of respondents, these can be grouped to avoid too many different categories. Second, measures of central tendency can be calculated to provide the arithmetic mean and/or the median for continuous data and the mode for categorical data. Finally, measures of dispersion can be calculated to estimate the variation in a sample. For example, the range can be measured by subtracting the minimum value from the maximum value in a distribution of values (Bryman, 2012). However, this is limited in that it only considers the extreme values and is affected by outliers. In contrast, the standard deviation can be calculated to measure the average amount of variation around the mean, and therefore takes account of all the values. Univariate statistical analyses thus describe the structure and distribution of the data and are often termed 'descriptive statistics'.

Bivariate analysis is used to assess whether there is a relationship between two variables. This means that variables are examined to find out whether variation in one variable corresponds with variation in another variable. However, it is important to emphasise that bivariate analysis does not demonstrate causality, only that there is a relationship between the two variables. Several techniques are available to detect relationships between variables, and the choice of technique depends on the types of variables being analysed and the distribution of the data. Correlation coefficeints and contingency tables (cross-tabulations) are the two most common methods for describing relationships between two variables. Correlation is useful to demonstrate the extent to which two continuous variables are related to each other but it does not have any predictive ability. Contingency tables allow researchers to search for patterns of association by viewing data at a glance (Bryman, 2012). Chi squared tests can be performed to determine the level of association between two categorical variables and whether these relationships are statistically significant or not.

Regression analysis is used for making predictions. In simple linear regression there are two continuous variables, one independent and one dependent variable. It can be used to predict the value of one variable (the dependent variable) from the values of the other (the independent variable). Multivariate analyses include sophisticated procedures that allow the

analysis of complex relationships. For example, multiple linear regression can be undertaken to describe the relationship between one continuous dependent variable and two or more independent variables. Another form of multiple regression is logistic regression which allows the researcher further investigative opportunities, for example, to measure the degree of association between several continuous or categorical variables and a binary dependent variable (Bowling, 2009; Creswell & Plano Clark, 2007). Thus, if a researcher wants to know which variables have the greatest level of association with, for instance, survival after a cardiac arrest and resuscitation procedure, several continuous and categorical variables can be included in the analysis to find out which variable had the strongest association.

Bivariate and multivariate statistical analyses are referred to as inferential statistics and are carried out to further refine analysis. Inferential analyses allows the researcher to draw inferences about relationships and to make estimates about a population based on a sample obtained from that population (Onwuegbuzie & Combs, 2010). Therefore, inferential analysis makes inferences from the sample to the wider population (Heiman, 2004; Polit & Beck, 2008).

3.8.2 Qualitative data analysis

Analysing qualitative data is the process of making sense of the data that have been collected (Holliday, 2002). Qualitative data are rich and complex and this has resulted in a range of approaches to analysing qualitative data. The diversity of approaches means that it is impossible to define a single 'right' way to analyse data but the method can depend on the purpose of the research (Punch, 2005, 2014) and the nature of the data that will be, or have been, collected. There are two main approaches to qualitative data analysis: analytic induction and grounded theory. In analytical induction, the researcher tries to find universal explanation of phenomena. Grounded theory is a specific approach in which theory is derived from the data (Bryman, 2012). Theory can be derived from additional approaches to grounded theory, for example, by conducting a single case study. Furthermore, the term 'grounded theory' is sometimes used more generally to describe an inductive process to identify categories as they emerge from the data (Pope, Ziebland, & Mays, 2000). Whichever method is selected, researchers should strive to ensure that the data analysis procedure is as rigorous and scholarly as possible by describing the method clearly and in a way that it can stand up to close scrutiny (Punch, 2005, 2014).

Creswell defined qualitative data analysis as "preparing and organising the data (i.e., text data as in transcripts, or image data as in photographs) for analysis, then reducing the data into themes through a process of coding and condensing the codes, and finally presenting the data in figures, tables or a discussion. Across many books on qualitative research, this is the general process that researchers use." (Creswell, 2007, p. 148)

There is general agreement that coding is central to the analysis of qualitative data. Coding can be carried out by hand or can be facilitated using computer software. In both methods, the texts from field notes and/or interview transcriptions are divided into small units such as phrases, sentences or paragraphs. If the coding is performed manually, each unit is coded by writing appropriate labels in the margins. In the initial coding phase, labels are often descriptive but as the researcher becomes more familiar with the data more interpretative codes may be allocated. This implies that the coding becomes more sophisticated and analytical, and inferences beyond the descriptive data can be made. When coding of the entire data set is complete, codes can be pulled together to create categories and/or themes (Creswell & Plano Clark, 2007).

A common approach to qualitative data analysis is thematic analysis (Bryman, 2012). Braun and Clarke (2006) argued that thematic analysis should be considered an approach to qualitative data analysis in its own right. This analysis method involves identifying, analysing and reporting patterns, and the aim is to organise and describe data in rich detail. The term 'theme' should illustrate an important aspect of the data in relation to the research question. One of the advantages of thematic analysis is that it can be applied across a range of research approaches (Braun & Clarke, 2006).Within data analysis, an inductive or deductive approach may be taken. Analytic induction or an inductive approach is suitable when little is known about a phenomenon. It is a 'bottom-up' approach where inductive data moves from the specific to the general and categories or themes are derived from the coded data. Conversely, a deductive approach is used when the structure of analysis is based on previous information or knowledge (Elo & Kyngäs, 2008).

A benefit of qualitative data analysis is that it can provide detailed and in-depth interpretation of a phenomenom and the rich data can be used to provide logical explanations to phenomena (Mason, 2002). Furthermore, qualitative data analysis is useful when there is little pre-existing knowledge about a subject (Bowling, 2009). On the other hand, a disadvantage of qualitative data analysis is that the views and experiences of the researcher may have an influence on interpretations (Polit & Beck, 2008). Moreover,

qualitative data is limited to a smaller sample size than quantitative data and is therefore less representative of a wider population, although cross-contextual generalisations from focused studies may be possible (Mason, 2002) and/or transferability to other settings or groups (Polit & Beck, 2008).

3.8.3 Mixed methods analysis

Creswell and Plano Clark (2007, p. 128) defined mixed methods analysis: "Data analysis in mixed methods research consists of analysing the quantitative data using quantitative methods and qualitative data using qualitative methods". Time sequence is included as a dimension of the typologies of mixed methods analysis and there are many examples available. The quantitative and qualitative analyses can be conducted concurrently or sequentially. If the quantitative analysis is conducted first, it informs the subsequent qualitative phase and is known as sequential quantitative-qualitative analysis. After two independent analyses of quantitative data and qualitative data have been performed, the next stage is to link, combine and integrate these analyses into meta-inferences (Onwuegbuzie & Combs, 2010). Meta-inferences can be defined as "theoretical statements, narratives, or a story inferred from an integration of findings from quantitative and qualitative strands of mixed methods research" (Venkatesh et al., 2013, p. 38). Therefore, meta-inferences draw together conclusions from an entire mixed-methods study.

3.8.4 Data analyses in this research

For the first phase of this study, the quantitative study/phase one, univariate, bivariate and multivariate analyses were performed. The Statistical Package for Social Sciences (SPSS) version 19, also known as PASW™, was used for descriptive analyses to determine the completeness of vital sign recordings, the location of vital signs within the EHR and whether patients showed clinical signs of deterioration in the 24-hour period prior to cardiac arrest. In addition, logistic regression was undertaken to identify the association between a number of factors that could affect survival after resuscitation and survival to discharge. Details of the analyses procedure are provided in Chapter 4.

For the second phase of this research, the qualitative study/phase two, thematic content analysis was carried out in line with Braun and Clarke, and influenced by Graneheim and Lundman (Braun & Clarke, 2006; Graneheim & Lundman, 2004). Braun and Clark (2006) recommended thematic analysis in six stages: data familiarisation, generation of initial codes, identifying themes, reviewing and naming themes, collating and refining themes, and

lastly, converging data sets. The analysis of the observational study used an inductive approach and the analysis of the interview study was based on a deductive approach (Elo & Kyngäs, 2008). Details of the analyses procedures are provided in Chapter 5.

Following independent analyses of the first and second phase studies the quantitative results were integrated with the qualitative findings. The aim of this integration was to create a coherent analysis of the entire study. By integrating both quantitative and qualitative findings, researchers can make inferences and meta-inferences (Onwuegbuzie & Combs, 2010). The development of meta-inferences is the entire narrative or story that is inferred from the integration of both quantitative and qualitative phases of the mixed methods research. Integration can occur at several stages of a study and culminates in the integration of the findings when the meta-inferences are developed.

This concludes the section on data analysis. The following section presents a discussion of ways to ensure the overall quality of the research, an important aspect of all research.

3.9 Reliability and validity

The quality of research can be evaluated in terms of how accurately research questions are answered and ultimately on the overall quality of the research carried out. Trustworthiness is essential in all types of research. In quantitative research, trustworthiness is referred to in terms of reliability, validity and generalisabilty (Wisker, 2001). While these terms may be suitable criteria for evaluating quantitative research, Lincoln and Guba (1985) argued that an alternative yardstick is required to evaluate qualitative research. Thus, the criteria of trustworthiness and authenticity were proposed by Lincoln and Guba to evaluate the rigour of qualitative research (1985). Furthermore, the terms credibility, dependability and transferability are often selected to refer to trustworthiness in qualitative research (Polit & Beck, 2008). These aspects of quality are discussed in this section.

3.9.1 Reliability

The most important criteria used to assess scientific merit or the quality of a study in quantitative research is reliability and validity. Reliability is based on the extent to which an instrument used in measurement of the data is consistent and accurate. Reliability can be measured in terms of stability or consistency over time. In other words, a measure is reliable if the same results are generated repeatedly either over time or when undertaken by different researchers. The stability of an instrument over time can be evaluated by test-retest reliability (Polit & Beck, 2008). This test requires the same measuring instrument to

be used on two separate occasions and to produce the same, or similar results. Internal consistency is the extent to which an instrument measures the same trait and can be evaluated by the coefficient alpha (Cronbach's alpha). This evaluation method is known as a split-half technique where items in the test are divided into two matched halves and scores correlated. In this way, tests for stability and internal consistency are used to estimate the reliability of instruments (Punch, 2005, 2014).

3.9.2 Validity

Validity is related to the quality of evidence: the extent to which the research is accurate, well-founded and free from bias. It refers to how well an instrument measures what it claims that it will measure. According to Polit and Beck (2008), there are four types of validity: statistical conclusion validity, internal validity, construct validity and external validity. Statistical conclusion validity means that inferences drawn from statistics genuinely have an empirical relationship. There are several threats to statistical conclusion validity and researchers should take steps to avoid these. For instance, samples should be large enough to avoid Type II errors and ensure reliable results, samples should have enough variability to detect relationships, and intervention studies benefit from standardisation of procedures to ensure correct implementation of the intervention.

Internal validity is related to whether relationships between variables are correctly interpreted (Punch, 2005, 2014). For example, whether the independent variable was most directly associated with the dependent variable, or whether the association was mediated by some other, more important, variable(s). Thus, internal validity is determined by whether a conclusion implied by a relationship between two variables is trustworthy. In experimental research, control groups and randomised selection of participants allow rival explanations to be eliminated (Bryman, 2012). On the other hand, internal validity in correlational designs, or observational studies, are often threatened by additional explanations which compete with results. Using a strong research design which has control mechanisms can help to reduce problems with internal validity (Polit & Beck, 2008).

Construct validity refers to "how well a measure conforms to theoretical expectations" (Punch, 2014, p.240). A measure can exist in a theoretical context and can therefore be compared to other constructs within the same context (Punch, 2014). For instance, researchers can deduce a hypothesis from a theory that is relevant to a concept and examine relationships between two constructs based on the deduction. Construct validity can be weakened by misguided deductions or theories (Bryman, 2012). To enhance

construct validity, it is important that constructs are carefully selected and well-explained before the study is commenced (Polit & Beck, 2008)

"External validity concerns inferences about the extent to which relationships observed in a study hold true over variation in people, conditions, and settings as well as over variation in treatments and outcomes." (Polit & Beck, 2008, p. 301) This means whether generalisations made in controlled research settings can subsequently be applied in the real world, is an important issue in external validity. For example, a question could be whether findings from research conducted in a classroom setting can be applicable to children's behaviour more generally. In order to enhance external validity, it is important that the research sample is representative of the population to which the results are to be generalised and also that the context within which the research is conducted is considered (Polit & Beck, 2008).

3.9.3 Quality in qualitative research

As mentioned above, qualitative research uses the terms credibility, dependability and reliability. Credibility refers to the extent to which confidence in the truth of the data and truth of interpretations of data can be established (Polit & Beck, 2008). It is related to the selection of participants, the approach to data collection, and selecting categories or themes which cover the entire data set (Graneheim & Lundman, 2004). Dependability refers to the stability of data over time, which suggests gaining similar findings if the study were replicated with similar participants in a similar context (Polit & Beck, 2008). Unlike quantitative research, which strives toward generalisability, qualitative research aims to achieve transferability, i.e., be able to transfer findings to other (similar) settings and groups.

There are several measures available to qualitative researchers to determine validity. For example, member checking is a strategy in which a summary of the findings is presented to a selection of study participants. They are then asked to comment on whether the findings accurately describe their experiences. Triangulation of data can also help to establish validity. Triangulation means to examine data from varied sources, such as interview transcripts and observational field notes or between qualitative and quantitative studies (Creswell & Plano Clark, 2007). To establish transferability, researchers are required to give detailed, rich descriptions of the research findings, which may then allow findings to be transferred to similar situations.

In interpretive qualitative research, the emphasis is on trustworthiness with the researcher being seen as the key instrument. Thereby, trustworthiness is greatly dependent on the relationship the researcher has with the data and research questions. The quality of qualitative research has been criticised for lacking objectivity and being prone to researcher bias (Mays & Pope, 1995). Because of this, every effort was made by the researcher to maintain an objective, unbiased approach and to adopt the above-mentioned methods of triangulation and member checking to ensure that the research was trustworthy. Nevertheless, at the end of the day, only the reader can decide the extent to which a study is trustworthy (Airey, 2009).

3.9.4 Quality in mixed methods research

Assessing the quality of mixed methods research is also important but, to date, specific criteria for checking quality are not available (Creswell & Plano Clark, 2007). However, three approaches for assessing the quality of mixed methods research have been suggested: the generic approach, the individual components approach and the mixed methods approach. The generic approach suggests that generic tools that are used in all study designs could be used for mixed methods. Unfortunately, these tools have been found to be too general and fail to satisfy the demand for quality in assessment (O'Cathain, 2010).

In the individual components approach, quantitative methods are assessed using traditional validation principles for quantitative approaches and qualitative methods are assessed using traditional criteria for qualitative approaches (O'Cathain, 2010; Venkatesh et al., 2013). However, this does not take into account that a mixed methods approach is more than the sum of these two components (Creswell & Plano Clark, 2007).

The mixed methods approach for assessing quality in mixed methods research is still under development. A number of scholars have proposed quality criteria for mixed methods research and some believe that criteria should be design specific. Some scholars emphasise the quality of data and methodological rigour (Creswell & Plano Clark, 2007; Onwuegbuzie & Johnson, 2006; Venkatesh et al., 2013). Because of the complexity and volume of criteria, it has been suggested that some approaches are simply too difficult and time consuming. Perhaps because of this, another proposal has been for an integrated framework that could be applied to both quantitative and qualitative components of the entire study (O'Cathain, 2010). Within an integrative framework, the terms inference quality and data quality are used. Inference quality relates to validity. It includes the assessment of design quality, meaning consistency and accuracy of analysis, and interpretive rigour,

meaning interpretive accuracy and drawing authentic conclusions. Data quality relates to reliability and includes the quality of measurement tools and the quality of observations (O'Cathain, 2010; Venkatesh et al., 2013).

Potential threats to validity should be considered when conducting mixed methods research. For example, in sequential designs there may be data collection issues: inappropriate selection of participants, inappropriate sample sizes, unsuitable instruments, or data analysis issues: following up weak quantitative results in the qualitative study or vice versa (Creswell & Plano Clark, 2007). These types of threats can be minimized by being aware of them and making informed decisions about data collection and data analysis to avoid them.

3.10 Conclusion

This chapter has provided an overview of the methodological planning of the research in this thesis. It describes how decisions about the research design for the overall research were made. The methodologies used in this research have been discussed. This includes explanations about how decisions on research approaches were taken. To begin with, research paradigms were reviewed. Pragmatism was discussed in more detail as the paradigm adopted for this research. A discussion on case study was presented as the appropriate strategy for the overall research. Research approaches were presented, beginning with a discussion on quantitative approach used in the first phase of the research, followed by a presentation of the qualitative approach used in the second phase of the research. In relation to this, a mixed methods approach was reviewed as the overall approach in the current research. Finally, reliability and validity were discussed in relation to mixed methods research.

The current research was carried out using a mixed methods approach. In the first phase of this research, a quantitative study was performed, which is described in Chapter 4. This was followed by a qualitative study, described in Chapter 5. In mixed-methods research this is known as an exploratory sequential design whereby an initial quantitative study is followed by a qualitative study. The quantitative study provided a description of vital signs in the EHR. The data in the phase one study were collected from secondary sources and thus a data collection tool was designed on which to base the data collection. The data were obtained from EHRs in the study hospital and the Swedish Register for in-hospital Cardiac Arrest. The data for the second phase of the research were collected from primary sources in the form of observations and semi-structured interviews. An explanatory sequential

design was used in which the second phase study explained the results from the study in the first phase. The results from both studies were integrated to complete the mixed-methods approach and allow sequential between-methods interpretation (described in Chapter 6).

The next chapter (Chapter 4) describes the quantitative study executed in the first phase of this mixed methods research. This is followed by Chapter 5, which describes the second phase of the research, the qualitative study.

Chapter 4 Documentation of vital signs in electronic health records

4.1 Introduction

The literature review in Chapter 2 revealed a gap in knowledge regarding how vital signs were documented and represented in electronic health record systems and led to the refinement of the research questions for this study. Chapter 3 describes the way in which decisions about methods of investigation were taken in order to address the research questions. In this chapter, the first phase of the mixed methods research for this thesis is described. First, the aim and objectives are outlined (Section 4.2) This is followed by a description of the research methods, including the study design, research setting, sampling, preparation for data collection (4.3) and ethical issues (4.4). A report of the pilot study is provided in Section 4.5, and a presentation of the quantitative study is provided in Sections 4.6-4.7. There is a discussion of the results, strengths and limitations and a conclusion in Sections 4.8-4.10.

As no previous studies had been found which examined the documentation of vital signs in an electronic health record (EHR), a hospital which used an EHR system was selected as a single case study (Punch, 2005). Applying a case study approach, utilising quantitative methods provided a strategy through which an investigation of the documentation of vital signs in an EHR could be undertaken. Details of this strategy are available in Chapter 3.

4.2 Aim and research objectives

The overall aim of this phase of the study was to examine the documentation of vital signs in the EHR of patients who subsequently suffered a cardiac arrest. More specifically, the objectives were:

- to identify how complete the documentation of vital signs was in the EHR,
- to describe actual problems or potential problems in documenting vital signs in the EHR, and
- to examine whether documented vital signs could reveal information about a patient's risk of deterioration and survival.

4.3 Research methods

This section presents details of the quantitative methods carried out in phase one of this research. Moreover, it provides an insight into how the pilot study guided the data collection of the phase one study and how carrying out the data collection guided the variables to be tested in the Statistical Package for Social Sciences Version 19 (SPSS 19).

4.3.1 Study design

As noted above, this study aimed to examine the EHR documentation of vital signs of patients who had suffered a cardiac arrest. These vital signs could be described by mapping out all vital sign data in the EHR of patients who had suffered a cardiac arrest in the study hospital. The case study method, as defined in Chapter 3, was used as this was a single setting using a single EHR system. This was a retrospective, descriptive case study in which a quantitative approach was used to collect a wide range of data.

4.3.2 Research setting

The research setting was a district general hospital with 372 beds in the south-east of Sweden. The hospital had a policy that all cardiac arrests that occur within the hospital should be reported to the Swedish Register for In-hospital Cardiac Arrest (SRICA). The cardiology department was responsible for collating information on cardiac arrest from all areas of the hospital and adding it to the register. Therefore, data collection was carried out in the cardiology department where access could be gained to both the SRICA and the EHR of all the patients in the study.

4.3.3 Sample

The study sample comprised the records of all patients who had suffered cardiac arrest in the study hospital and on whom resuscitation had been attempted from 2007-2011. The study hospital began using the EHR in the same year as it joined the SRICA, i.e., in 2007 so these records were available for the research. To facilitate access to these records, the lead nurse for cardiopulmonary resuscitation organised computer access for the researcher. As seen in Chapter 3, careful consideration was needed to find a suitable sample for investigation and to decide which data should be collected.

4.3.4 Preparation for data collection

This section provides a detailed account of the preparation for data collection for the quantitative study in the current research. There were two main issues to consider regarding data collection for the quantitative study in phase one. The first was to establish a suitable source of the necessary data and the second was to find the best means of investigating documentation of vital signs in the EHR. With these issues in mind, and guided by the literature review in Chapter 2, preliminary choices were made regarding the type of data to be collected, and a strategy for data collection was planned.

The rationale for decisions on data collection was based on four intentions. First, it was necessary to identify a source for a suitable cohort of patients in an acute hospital setting and to be able to access their electronic records. More specifically, it would be useful if the patients were from a group of patients whose condition was potentially at-risk of deterioration, and therefore information on vital signs might need to be collected. Secondly, the literature had revealed many constellations of vital signs used in detecting patient deterioration and decisions had to be made on which would be the most appropriate vital signs to examine. Thirdly, the way in which these observations were documented in an electronic record should be examined to get a clear picture of which signs were present, e.g., temperature, pulse and respiration, where each sign was documented, and how each vital sign was documented in the EHR. Finally, it was important to determine whether documented vital signs could reveal information about each patient's physiological condition and, therefore, the degree of risk of deterioration. The goals of the data collection are outlined in Table 4.1

Table 4.1 Goals of data collection

	Goals
1	to identify a sample of patient records and sources of data
2	to decide which vital signs should be collected
3	to examine if, which, where and how vital signs were represented in electronic health records
4	to assess the documented vital signs to find out what they could reveal about a patient's risk of deterioration

These four goals are examined in detail in the next sections.

4.3.4.1 Identifying a sample and sources of data

To find a cohort of patients who had been at-risk of deterioration, patients who had previously suffered a cardiac arrest were considered a suitable group of patients to study. It is well-established that, prior to a cardiac arrest, the physiological status of patients deteriorates (Bellomo et al., 2003; Bristow et al., 2000; Buist et al., 2002; Jones et al., 2005) and, in fact, deteriorates to such a degree that their hearts cease to function, which is when the cardiac arrest occurs. Such patients were therefore deemed to be a suitable cohort.

Sources of data for a group of patients who had previously suffered cardiac arrest were also identified. In Sweden there is a register for patients who have suffered cardiac arrest in a hospital setting: the SRICA (Herlitz, 2009) The SRICA was initiated in 2005. It is an on-going national survey. Fifty-four of the 73 hospitals in Sweden (74%) have joined the SRICA (Herlitz, Aune, Claesson, & Svensson, 2010); the hospital in which this study was performed joined in 2007. This database registers all patients who have suffered an in-hospital cardiac arrest and on whom resuscitation attempts have been made, and was therefore an important source of information. In the SRICA, it was possible to select the registry entries from specific hospitals and therefore the study hospital could be selected to locate all of the patients from the study hospital who had suffered a cardiac arrest since 2007. The patients from the hospital were a sub-group of the entire population contained in the register. Therefore, the sample consisted of patients who had suffered a cardiac arrest in the study hospital and who could be located in the register. This would then be considered a case study sample of an entire set of patients (Polit & Beck, 2008) from the study hospital.

The SRICA was used to obtain information about the cardiac arrest and its outcome: i.e., the date and time of cardiac arrest, the cause and type of cardiac arrest, whether the patient survived to discharge, or the date and time of death. From the register, it was also possible to obtain the patient identification number, which could then be used to locate each patient's hospital records. In 2007, the study hospital implemented an EHR system, a few months after it began to register all in-hospital cardiac arrests. The patient identification number obtained from the register could be entered into the EHR system, Cambio Cosmic, and each patient's individual electronic records accessed. Access to these records made it possible to review patient status in the period prior to cardiac arrest retrospectively by examining their vital signs.

The patients in the Register included patients from both general ward care and higher levels of care such as cardiac intensive care and general intensive care. Although most studies on identifying clinical deterioration in the literature review had been carried out in general wards (Bright et al., 2004; McQuillan et al., 1998; Schein et al., 1990), in the present study a decision was made to include patients from both general wards and intensive care areas. The rationale for this was that all areas of the hospital had recently implemented electronic records, which were the focus of this study, and therefore should be examined. Patients were classified into two categories: those receiving care in general wards and those cared for in intensive care areas. Within intensive care areas there is a higher level of observation and a higher nurse to patient ratio. Intensive care areas comprised the coronary care unit, the cardiac catheterisation laboratory and the intensive care unit. For the purpose of this study, other areas were classified as general ward care. In the event of a patient having had a cardiac arrest in other parts of the hospital, for example, in the X-Ray department or out-patient department, this was classified as general ward care, considering the level of observation was expected to have been similar to that on a general ward. Thus, the study sample included patients from these two levels of care.

4.3.4.2 Investigating which vital signs to include in the data collection

Appropriateness and accuracy of the data collected will influence the validity of research and emphasises the importance of collecting the correct data to answer the research questions (Kumar, 2011). According to the review of the literature in Chapter 2, section 2.8.7, there were no studies detected which examined the 'completeness' of vital sign recording in the EHR and, hence, there was a need for this investigation. First of all, it was important to determine exactly what was implied by 'complete' vital signs. Once that was decided, it would be possible to compare the documentation of vital signs in the study hospital to that which was considered 'complete'.

In deciding what 'complete' vital sign recordings implied, universal recommendations for observation of patients in hospital were examined. A fundamental aim of patient observation is to recognise changes in a patient's clinical condition and, in particular, to detect signs of deterioration (Bellomo et al., 2004; Buist et al., 2007). According to the UK National Institute for Health and Clinical Excellence (NICE 2007), minimum physiological observations should include heart rate, respiratory rate, systolic blood pressure, level of consciousness, oxygen saturation and temperature, and these should be monitored at least every 12 hours (NICE 2007). The same parameters were recommended by a group of

experts who convened to discuss how to identify and monitor patients at risk of deterioration (DeVita et al., 2010). In the literature regarding detection of deterioration in a patient's clinical condition, many systems were available. Although, the general features of each system were similar, there were some variations regarding which vital signs should be included, as well as varying threshold levels. Details of these vital signs are given in the literature review (Section 2.4).

The duration of the retrospective time period for the data collection was also considered and guided by the current literature on pre-emptive signs of cardiac arrest. Studies have shown that signs of deterioration are often present in the 24-hour period prior to cardiac arrest (Goldhill, White, et al., 1999); therefore, the presence or absence of each vital sign being recorded in the 24 hours prior to cardiac arrest was required for the study.

4.3.4.3 Examining where and how vital signs were represented in electronic records

The study set out to investigate how vital signs were represented in the EHR; therefore, the location of each vital sign and how it was represented in the EHR was important for the study. Within the electronic patient record, there were three possible locations where vital signs could be documented. These were referred to as the patient journal, the report sheet and a template, and data from each of these locations were examined.

4.3.4.4 Assessing documented vital signs to find out what they revealed about the patient's risk of deterioration

In addition to examining the completeness of vital signs, and how these were represented in the EHR, another consideration in planning the data collection was to find out what the documented vital signs could reveal about patient status and risk of deterioration. This could be achieved by checking each patient's vital signs in relation to currently available track and trigger systems (TTS) for recognising patients whose condition was deteriorating. At the outset of this study, it was difficult to discern which of the many TTS would be most suitable for analyses in the descriptive study. In order to ensure that the necessary information was collected, four systems were initially considered for possible standards for the analyses. One system, BAS (see below and table 4.2), was currently in use in the study hospital, so this was an obvious choice of TTS for inclusion in the study. The other three systems initially selected were early warning score (EWS) systems (Moon et al., 2011; Morgan et al., 1997; Prytherch et al., 2010), which are outlined below.

The system used in the study hospital, BAS, was a type of track and trigger system. BAS is an acronym for B, 'blodtryck' (systolic blood pressure), A, 'andnings frekvens' (respiratory rate) and S, 'saturation' (oxygen satuaration). It is a single parameter system, i.e., if any one (or more) of the vital signs is abnormal, according to the threshold values shown in Table 4.2, this could indicate patient deterioration. Thus, a systolic blood pressure of less than 90, a respiratory rate of more than 30 or an oxygen saturation of less than 90% would be considered warnings of patient deterioration.

Table 4.2 BAS 90-30-90 (Blodtryck, Andning, Saturation - system in use at study hospital)

Vital sign	Threshold values
B Systolic blood pressure	<90 mm/Hg
A Respiratory rate	>30 breaths per minute
S Oxygen saturation	<90%

The selection of the remaining TTS was guided by the current literature described in the literature review (Chapter 2). Although there were many systems, it was decided to begin with three possible models of EWS systems for the reasons explained below. The first was a modified early warning scores (MEWS) system derived by Moon et al. (2011) which appeared to be widely used in the UK (see table 2.7, Chapter 2). The second was ViEWS (see table 2.9, Chapter 2) and was selected because it represented the results of a study which claimed to be based on sound clinical data in a system that was validated, and demonstrated a performance superior to all other published TTS (Prytherch et al., 2010). A third EWS option was the MEWS system used at Växjö County Hospital, Sweden and the University Hospital, Linköping, Sweden as it represented a EWS system which had been implemented in Sweden. Thus, all of the vital signs included in BAS and three EWS systems were included in the data collection to ensure that a wide range of systems was covered. A summary of the rationale guiding the data collection is given in Table 4.3.

Table 4.3 Rationale guiding data collection

	Goal	Rationale
1	To identify a sample and sources of data	The Swedish Register for In-hospital Cardiac Arrest identified patients who had been at risk The register subsequently led to these patients' EHR
2	To decide which vital signs should be used in the data collection	The literature review guided the choice of vital signs
3	To examine whether, which, where and how vital signs were represented in electronic records	Within the EHR, the relevant information on the representation of vital signs could be found
4	To assess the documented vital signs to find out what (if anything) these could reveal about the patient's risk of deterioration	Four track and trigger systems were preliminarily selected to establish if patients showed signs of deterioration

4.3.4.5 Additional data

All potentially useful data should be collected at the time of data collection as this is preferable to collecting too little data and having to return to the data at a later date (Polit & Beck, 2008). To supplement the data described above, additional data that would be or might be needed for the analyses were collected. One source of additional data was from the SRICA itself, which provided important demographic information: the patient's age and gender, and the name of the department in which the patient was housed at the time of arrest. In addition, it provided information about the actual cardiac arrest: the date and time of the cardiac arrest, the initial cardiac rhythm, the cause of the arrest, whether the arrest was witnessed, the time to treatment, whether the patient was intubated during the procedure, any medication given during the resuscitation procedure, if the patient survived the resuscitation procedure and if the patient survived to discharge. The admission and discharge cerebral performance categories were also included. Incorporating all of this information within the data collection ensured that a wide range of analysis options was possible. The other source of additional data was the EHR from which data on any interventions were included, e.g., if intravenous fluids were commenced because of low blood pressure. This was because it might be possible to analyse associations between

interventions and patient status. Also, data on each patient's latest ECG and prescribed cardiac medications were included with a view to future analyses.

4.3.4.6 Additional time period for data collection

As indicated in section 4.3.4.2, the appropriate time period for data collection of vital signs was the 24-hour period prior to cardiac arrest. In the event that any of these vital signs had not been documented in the 24-hour period prior to cardiac arrest, a further piece of data was collected: the last documented recording of the vital sign, for the period prior to the 24-hour period preceding cardiac arrest, stating when it was documented.

4.3.4.7 Summary of data collection planning

The records of all patients who had suffered a cardiac arrest in the study hospital between 2007 and 2011 were included. The study sample was obtained by identifying patients who had suffered an in-hospital cardiac arrest in the study hospital who were registered in the SRICA. Data were collected from the SRICA and each patient's EHR.

Documentation of vital signs was reviewed by collecting and studying all patients' vital signs documented in the 24-hour period prior to cardiac arrest. A wide range of vital signs, based on current systems for detecting patient deterioration was collected to enable analysis on the completeness of vital sign recording. These included the vital sign parameters recommended by NICE (2007), as well as the additional vital sign parameters used in the models described in the literature review. Thus, the data collection included the following vital signs: respiratory rate; systolic blood pressure; heart rate; temperature; oxygen saturation; conscious level and hourly urinary output. 'Complete' documentation of vital signs would imply that all of these vital signs were measured at least twice per day. These data provided a detailed account of the completeness of documentation of vital signs in the study hospital. To find out how this information was represented in the EHR, data were collected relating to the location and representation of each piece of data in the record.

4.3.4.8 Designing the data collection tool for the phase one study

The previous sections provided details of which data needed to be gathered to answer the research questions. Using this information, a data collection tool was developed. The data collection tool had four sections, as described below in Table 4.4.

Table 4.4 Sections in data collection tool

	Sections in the data collection tool
1	Demographic information and details about the cardiac arrest
2	Overview of latest ECG and prescribed cardiac medications
3	Which vital signs, vital sign values and the location of each vital sign within the EHR
4	Possible clinical interventions, such as oxygen therapy, intravenous therapy, blood tests or medication

The data collection tool was created in MS Word and paper copies produced for hand-written data collection. An example of the final data collection tool can be viewed in Appendix II. In order to test the data collection tool, a pilot study was carried out. The pilot study is described in section 4.5.

4.4 Ethical considerations

Prior to commencing the study, ethical approval was sought and granted from the Central Ethical Review Board, Linkoping, Sweden. Copies of the documents related to ethical approval are available in Appendix I. When undertaking the study, it was necessary to ensure patient confidentiality, so when the patient record was accessed, codes were used for identification, thus ensuring anonymity and that the researcher could not link participants to the data. Similarly, not writing any names and treating all staff that had carried out the recordings and documentation, as a generic group of hospital personnel, secured the anonymity of staff.

4.5 Pilot study

The aim of the pilot study was to test the adequacy and appropriateness of the data collection tool and to examine the appropriateness of the data collected for performing statistical analyses.

4.5.1 Method

The data collection tool was designed to include demographic information, details of the cardiac arrest, physiological vital signs, the location of the documented vital signs in the EHR and any interventions that were initiated in relation to abnormal vital signs. There were two main data collection sources. The first data source was the SRICA, from which demographical data and data regarding the cardiac arrest were obtained. The second source of data was the patient records, the EHR.

Selecting the patients/ Selection protocol

At the time of data collection for the pilot study, there was a total of 310 patients from the study hospital in the SRICA, but 62 of those did not have an EHR as the register was introduced before the EHR was implemented in June 2007. This meant that there were 248 cardiac arrest patients in the register. It was estimated that 20 patients would be an appropriate cohort for the pilot study. Twenty patients were selected through systematic sampling (Polit & Beck, 2008). To obtain a systematic sample, the number of patients available in the register was divided by 20 to determine the sampling interval. This gave a sampling interval of 12. Thus, every 12th patient in the register was selected, beginning with the latest patient in the register and then taking every 12th patient after that. In this way, data was successfully collected data from 17 patients. However, for the eighteenth patient there was no EHR available, although the date was 17 October 2007. It may have been that some wards and units were not fully utilising the EHR at that time. As the cohort was three patients short of the goal of 20 for the pilot study, further patients were selected by returning to the beginning of register and selecting the patient who was second on the list and the next two 12th patients after that. In this way, the patients from the pilot study were selected using systemic sampling to give a total of 20.

Paper copies of the data collection tool were used with all data being transferred from the register and the EHR according to the pre-designed tool. The data collection tool had some final additions after discussions with the clinical professor of cardiology who requested data to be collected on the patient's most recent electrocardiograph (ECG), prior to the cardiac arrest. These details included: evidence of previous myocardial infarction, obvious ischaemic changes, atrio-ventricular block, and right or left bundle branch block. Furthermore, the professor requested that a selection of medications, if prescribed in the patient record, were also added. These additions were made to the data collection tool very close to the commencement of data collection. As described above, patients were selected

according to the systematic selection protocol. The information was systematically collected from the register according to the data collection tool.

When all necessary information had been collected from the register, the patient's EHR was accessed from the patient's identity number on the register. From the EHR, data were collected according to the data collection tool in the order below.

First, the patient's latest ECG was accessed – the last taken prior to cardiac arrest – and details from the ECG were noted. Second, the patient's medical prescription sheet was accessed and prescribed cardiac medication was recorded according to the data collection tool. (N.B. The ECG and cardiac medication data were not used in the current study.)

The next undertaking was to collect the information on vital signs from the EHR. The following is a detailed description of the three sections of the EHR in which vital sign information was found: the journal, the template and the report sheet. The first section was the journal section, which was selected by clicking on 'journal' in the toolbar at the top of the page. The 'journal' section was where all members of the health care team could enter data on the patient, although medical staff were the most frequent users. It was organised in chronological order with the most recent entry at the top of the page. Therefore, one could scroll down to the date when the patient had suffered the cardiac arrest and gather any information on recorded vital signs for the 24-hour period prior to the incident. These were written in numerical form.

The next section was the template and was used by both medical and nursing staff. This was accessed by selecting a drop-down menu at the left hand side of the screen next to the journal. This led to a template section where all the vital signs could be documented. Here, there were the headings: temperature, pulse, respiratory rate, blood pressure and oxygen saturation. Alongside each heading there was the option to click on 'history' which led to a list of, for example, all the temperatures that had previously been recorded for that patient. After that, by clicking on each temperature, it was possible to see the value and the exact time that it was taken.

The final section was the report sheet, used exclusively by nurses, and was also accessed from the left hand margin of the open journal page. This page was empty when opened and in order to get information from a specific day, the dates had to be selected in a calendar system. To view this data, the dates from the 24-hour period before the arrest were selected. In this section, there were notes written by nurses on various aspects of

patient care and the care process, so data collection involved reading through all the notes for any additional information on vital signs.

Data on each of the vital signs in the 24-hour period prior to arrest were collected from all three of these areas. The documented vital signs were noted in the data collection tool. If the patient had more than six vital signs documented in the last 24 hours, only the final six were used in the study. In the event that none of these variables had been documented in the 24-hour period prior to the cardiac arrest, the last documented recording of the variable, if found, was taken stating the date and time on which it was documented.

The location of each vital sign was also noted describing whether it was found in the journal, the report sheet or the template. All data on vital signs were collected from each of these sections in the EHR. Collecting data on patients' vital signs from the 24-hour period prior to cardiac arrest proved to be the most challenging part of the data collection as the vital signs were scattered inconsistently throughout the EHR because of the three separate sections in which they could be found. Once the data had been collected using the paper form, they were transferred to SPSS.

SPSS version 19 was used for carrying out the descriptive analysis to describe the results.

4.5.2 Results of pilot study

The results of the pilot study are presented below. First, there is a brief account of reflections made during the data collection as these are important findings from the pilot study which guided the data collection in the phase one study. Secondly, a descriptive analysis is presented with some key descriptive statistics that demonstrated that the planned data collection for the phase one study would provide appropriate information to answer the research questions.

4.5.2.1 Reflections from data collection

The template was the most frequent location for the body temperature, heart rate (pulse), respiratory rate and blood pressure (TPR and BP) to be recorded. In this section, there was also provision for documenting oxygen saturation and fluid balance. Collecting data on fluid balance presented a problem as any information on this was infrequently recorded. To find information about urinary output, all three sections were searched, and very occasionally urinary output was mentioned. Likewise, finding data on the level of consciousness posed a problem. There was no specific location in the template section for recording level of consciousness. Sometimes it was possible to find some reference to

conscious level in the journal section or in the report sheet which included comments such as 'patient confused' or 'patient alert and orientated'. The data on oxygen saturation was most often found in the template section.

Data on interventions were particularly challenging to locate. Data were difficult to find, and scattered throughout the three sections. This meant combing through all parts of the EHR to find relevant information. For example, if the oxygen saturation was low, a check was made to see if there was any record of the patient commencing oxygen therapy. This meant checking in the template section, the journal and report sheets. Sometimes oxygen therapy was noted in the template section beside oxygen saturation. In a few instances, comments on oxygen therapy could be found in the report sheet section. Similarly, if the patient's temperature was high, further checks were made to find out whether blood cultures had been taken, or whether intravenous fluids or medication had been commenced in relation to vital signs. However, often the information was ambiguous; it was difficult to see whether a particular intervention was due to an abnormality in a vital sign recording or for some other reason. Thus, there were doubts about the accuracy of this part of the data collection; it may have been incomplete or inaccurate and therefore the reliability of this data was unclear. For this reason, a discussion was held to decide if it was still useful to attempt to collect this type of data. Eventually, it was decided to include these as far as possible, as this in itself was a result demonstrating the difficulty in finding information and hence the difficulty in being able to follow the process and progress of patient care.

As the study hospital used the BAS alert system, the search for interventions was restricted to those patients who had scored an abnormal BAS according to the system. For example, if the oxygen saturation percentage was below the threshold limit of 90%, the researcher checked to see whether the patient had been commenced on or had an increase in oxygen therapy.

4.5.2.2 Descriptive analysis

Of the 20 patients in the pilot study, 14 were male and six were female. The age range was 25–94 years, mean=78 years and SD=15.8. Initial analysis showed that the type of data collected would provide informative results in the phase one study. Details of the cardiac arrest were easy to find as these were documented in list form in the SRICA. Difficulties in collecting data from the EHR have been described above.

In Figure 4.1, the bar chart shows the number of patients out of 20 who had these vital signs measured in the 24 hours prior to cardiac arrest. This was an indication of the kind of results that could be obtained in the phase one study.

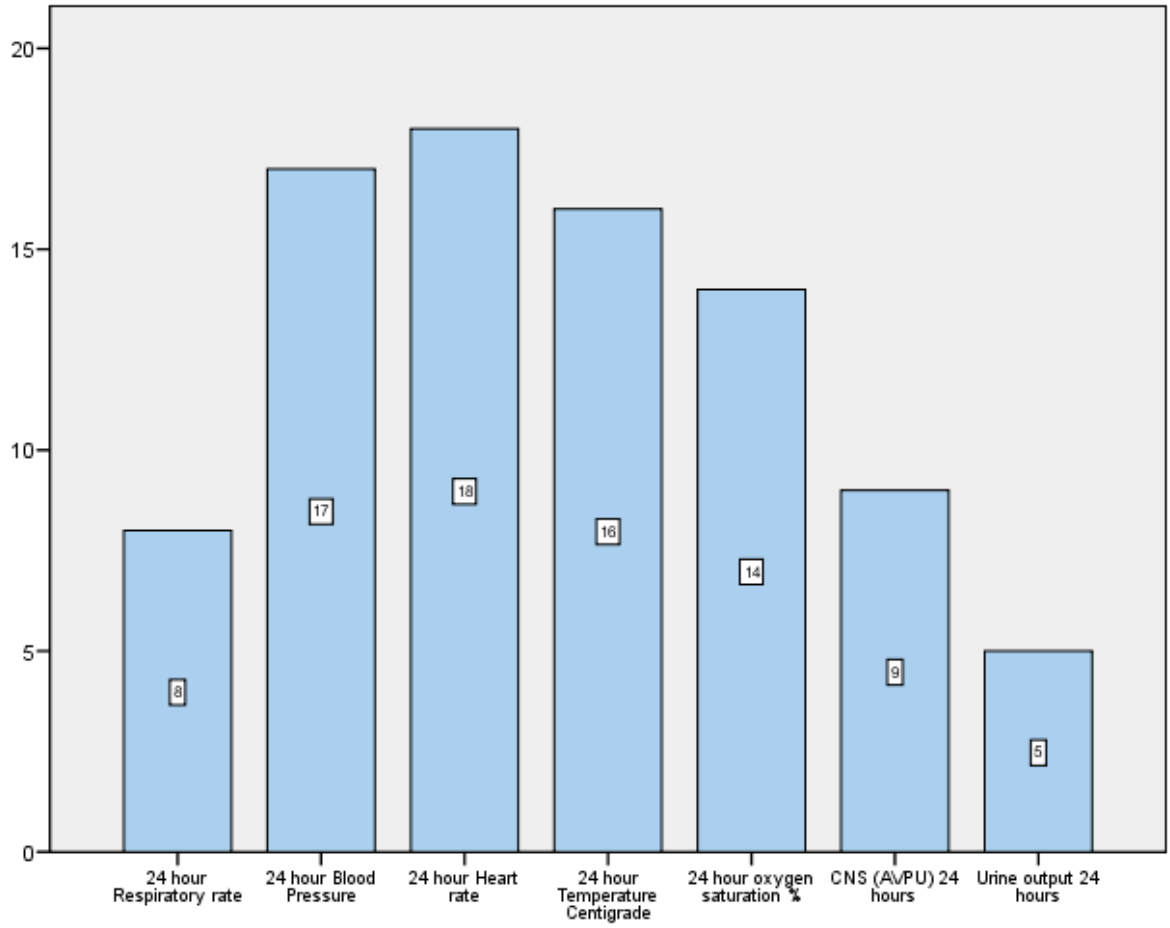


Figure 4.1 The number of patients out of the 20 in the sample who had these vital signs measured in the 24-hours prior to cardiac arrest

The pilot study also indicated that physiological vital signs were presented in text form but no visual graphs were apparent. An example of textual documentation is given in Figure 4.2, a screenshot of the template section of the EHR.

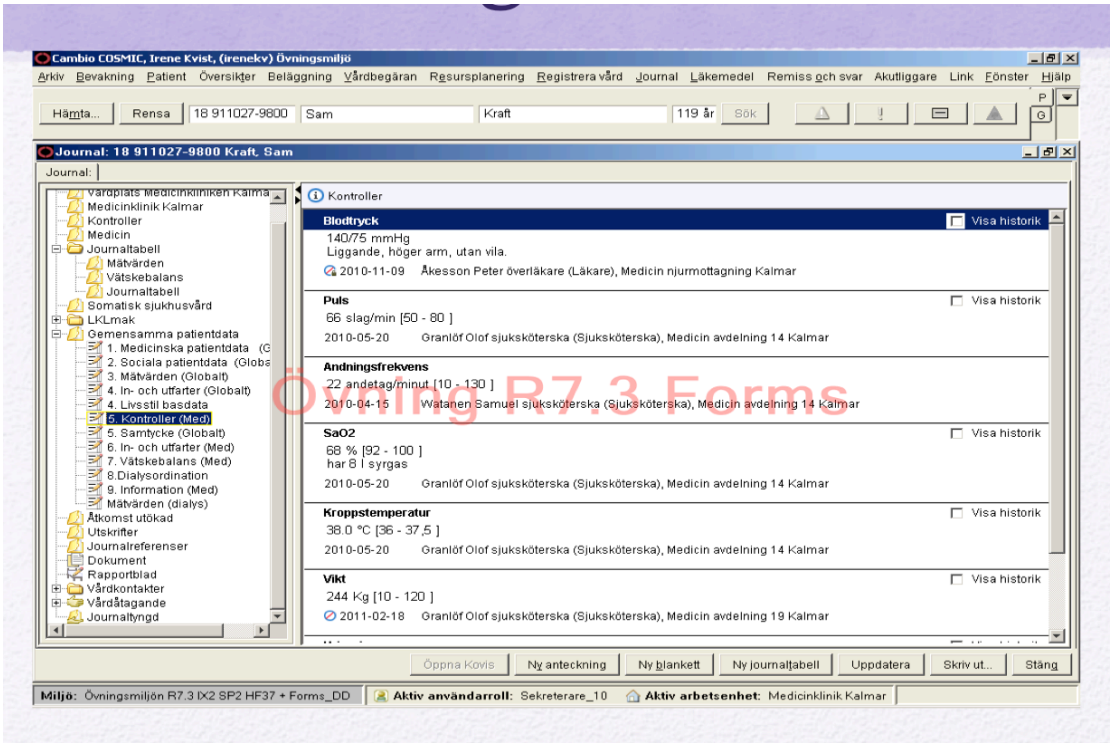


Figure 4.2 Screenshot of template section of the EHR (N.B. a sample, not an authentic record)

4.5.3 Lessons learned from the pilot study

The pilot study highlighted that data collection for the main study would be challenging and time-consuming. Moreover, it was easy to overlook some of the variables when they were documented in more than one place. Physiological vital signs could be found in various sections of the EHR: the journal, the report sheet or the template. The template section was the most frequently used location for recording body temperature, heart rate (pulse), respiratory rate and blood pressure (TPR and BP). However, sometimes they were in one, two or all three of these locations. Fluid balance, conscious level and oxygen therapy, if documented, could be found in any of the three sections. For these reasons, it was necessary to be particularly vigilant and systematic when collecting the data for the phase one study.

4.5.3.1 How the pilot study guided the choice of early warning score system ViEWS

Before conducting the pilot study, it was unclear which EWS system was the most appropriate for data collection. In addition, it was not obvious which EWS system would be most suitable when it came to determining levels of patient deterioration. The pilot study presented two important results. The first was the results regarding urinary output. Out of 20 patients, only one record of urinary output was found in the template section.

Urinary output was otherwise mentioned in the journal and report sheet, but not in enough detail to establish the volume of urinary output. This meant that urinary output would not be a useful parameter. Many EWS systems used this parameter so using one of those would not be optimal. However, ViEWS did not include urinary output as a parameter (Prytherch et al., 2010) and could therefore be considered appropriate. This consideration was supported by the second result which helped to make a decision about which EWS system to use, i.e., the result regarding oxygen therapy. Although it was difficult to find accurate information on interventions, it appeared that it was often well documented when oxygen therapy had been administered. ViEWS used oxygen therapy as a parameter, because of the rationale that any patient who requires oxygen has signalled some degree of risk. Thus, the decision was taken to adopt the parameters used in ViEWS as the EWS system for this study. ViEWS would serve two functions: determining which vital signs data should be collected and as an early warning score system to estimate patient deterioration. Thus, ViEWS was considered the 'gold standard' with which to compare vital signs for 'completeness' of documentation.

4.5.4 Conclusion of pilot study

This was a study based on a small sample size, which was appropriate for the pilot study in this phase. The findings revealed that the data collection tool included adequate detail for the information required. Initial analysis indicated that there would be adequate data for statistical analysis in the main study. The study also suggested that the biggest challenge was in locating the information required in the EHR. Preliminary evidence confirmed the need for further research to ascertain the impact of an EHR on patient surveillance.

Furthermore, the pilot study provided important information for further development of the data collection tool. Regarding which data to collect on vital signs in the main study, ViEWS was used as the foundation for these parameters for three reasons: it was a validated system; it did not include measurements of urinary output which were difficult to find in the EHR and not recorded in many records; and it did include inspired oxygen therapy which was an intervention that appeared to be recorded frequently in the EHR. It should be mentioned that oxygen therapy is not an actual physiological vital sign although it is a parameter used in ViEWS. However, for the purpose of this study, it is usually recorded under the heading of vital signs. Further, an addition was made to the data collection tool to include the department/ward to which a patient had been admitted. This was important for determining the level of care as it could be important during analysis.

Finally, the pilot study indicated that there would be adequate data for statistical analysis in the phase one study.

4.6 Phase one study

This section describes the phase one study for this research. This study was planned according to lessons learnt from the pilot study. Guided by the pilot study, the data collection tool was refined (Appendix II). Furthermore, the pilot study helped to refine the research objectives for the phase one study; these are described in the next section.

4.6.1 Aim

The overall aim of this study was to examine the documentation of vital signs in the EHR of patients who subsequently had a cardiac arrest. The objectives were:

- to identify the extent to which vital signs were recorded in the EHR in the final 24 hours prior to cardiac arrest in an acute hospital,
- to establish the location of the vital sign recordings within the EHR, and how they were documented, and
- to examine whether documented vital signs could reveal information about a patient's risk of deterioration by aligning these to two track and trigger systems (BAS and ViEWS).

4.6.2 Method

The method regarding hospital setting and data sources are described earlier in this chapter (4.3.2-4.3.4) so the description of method for the principle study begins with the data collection.

4.6.2.1 Data collection

As mentioned, the study hospital joined the SRICA in January 2007. The total number of patients in the register for the study hospital was 310, but 62 of those did not have an EHR as the register was introduced before the EHR was implemented in June 2007. The patients in the register from 1 January to 31 May 2007 were therefore excluded. This left 248 patients that were in the register who had an EHR.

The data collection began on 29 September 2011 and ended on 15 November 2011. Paper copies of the data collection tool were used and all the required data were collected from

the register and the EHR according to the pre-designed tool. Twenty of these 248 cases were excluded from the study for various reasons. For example, it was observed during data collection from the register that some patients had a series of cardiac arrests within a relatively short period and each of these were registered in the register. In these cases, only the data related to the first cardiac arrest were collected from the EHR. The rationale for this decision was that the data collected would record the vital signs that were taken before the first cardiac arrest. In two cases, patients were known by the researcher, so these were set aside immediately after being recognised to avoid any breaches of confidentiality. The final number of patients from whom data were collected was 228. Thus, the main phase of the study included 228 patients who suffered a cardiac arrest in the study hospital between 2007 and 2011 and who had an EHR for their period of care.

It was noted during data collection that some patients did not have any vital signs recorded in the EHR prior to the cardiac arrest. There were three possible reasons for this. First, it could be that a patient had a cardiac arrest on admission to the ED, before anyone had time to take any vital sign recordings. Second, patients who were diagnosed with an acute myocardial infarction before admission (for example, in the ambulance via mobile ECG readings) were taken directly to the cardiac catheterisation laboratory for immediate angiography and treatment. This involves the insertion of a catheter into the heart via an artery. The nature of this procedure may over-stimulate the cardiac muscle which may then cause a life-threatening cardiac rhythm such as ventricular fibrillation. Ventricular fibrillation is a cardiac rhythm, with loss of cardiac output, and is one type of cardiac arrest. It requires immediate cardio-pulmonary resuscitation (CPR). Thus, if this happened during cardiac intervention, it was registered as a cardiac arrest. A third possibility was that patients who were transferred directly to the cardiac catheterisation laboratory were critically ill and may have had a cardiac arrest in the laboratory because of their critical cardiac condition. Therefore, when conducting the data collection, additional information was added in the note section of the data collection tool to clarify the reason why patients belonging to the above categories did not have any vital signs recorded.

From the register, for each case the required information was collected according to the data collection tool. Next, the patient's unique ten-figure identification (ID) number was used to access each patient's EHR. These ID figures were jotted down in pencil and erased after each EHR had been accessed, to ensure patient confidentiality. Patient names were not used at any point in the data collection.

The next stage was to collect all of the patient's vital signs. These could be found in three separate sections: the template, the journal and the report sheet (described in more detail in Section 4.5.1 of this chapter). Here, there were the headings: temperature, pulse, respiratory rate, blood pressure and oxygen saturation. The information was transferred to the data collection tool systematically.

The next section to be examined was the 'journal', selected by clicking on 'journal' in the toolbar at the top of the page. The 'journal' section is where all members of the health care team can enter data on the patient. The last section was the report sheet, which was also selected from the left hand margin of the open journal page. Data from each of the vital signs recorded were collected in the same manner from the three sections of the EHR. Entries were also made in the data collection tool to show in which section of the EHR vital signs were documented. It was noticed that all vital signs were documented in numerical form and no visual graph was available.

4.6.2.2 Observations during data collection with implications for SPSS

Several observations during the data collection were important for refining the variables for data analysis and as a result of these observations several changes were made to the variables entered into SPSS. For example, in cases where a patient's cardiac activity was being continuously monitored by telemetry, the heart rate varies by the second. Thus, in the EHR it was sometimes documented as being between two numbers, for example, 80-120. In these cases the mean of the two values was calculated to obtain one value for the data collection. A new variable was added to show if the respiratory rate had been recorded in the Emergency Department (ED), as it was observed during the data collection that respiratory rate was often recorded while patients were in the ED. In the pilot study, only two variables regarding levels of care were specified and included in the SPSS programme: intensive care or general ward care. However, during data collection for this study, it was found necessary to be more specific about the exact location of patients when they had a cardiac arrest. Thus, five new categories were added to the variables in SPSS: Emergency Department (ED), general ward, catheterisation laboratory, cardiac intensive care unit (CICU) and intensive care unit (ICU).

4.6.2.3 Signs of deterioration

Another important aspect of preparing for analysis was in relation to detecting deteriorating patients. To enable this, it was decided to calculate the values of vital signs according to two track-and-trigger systems, to investigate whether or not patients exhibited

signs of deterioration. The first TTS, BAS/90-30-90, was selected as it was currently used in the study hospital (table 4.5).

Table 4.5 BAS 90-30-90 Blodtryck, Andning, Saturation (BAS)

Vital sign	Threshold value
B Systolic blood pressure (blodtryck)	<90
A Respiratory rate (andning)	>30
S Oxygen saturation % (saturation)	<90

The second system was the aggregated weighted scoring system called ViEWS (Prytherch et al., 2010) (shown in table 4.6). In this system, there are seven vital parameters with each vital parameter being given a score between zero and three depending on a graded scoring system. As a result of the pilot study, ViEWS had been selected as the 'gold standard' model on which to base the choice of vital signs to be collected. However, ViEWS was not used at the study hospital, therefore the variables used in this system would not have been required to be routinely recorded. Nevertheless, it was decided to allocate ViEWS values to each set of vital signs so that a calculation could be made on the vital signs which were available. In this way, risk of patient deterioration could possibly be detected. (See Chapter 2, section 2.5.2).

Table 4.6 ViEWS (Prytherch et al., 2010)

Score	3	2	1	0	1	2	3
Pulse (bpm)		≤ 40	41-50	51-90	91-100	111-130	≥131
Breathing (rpm)	≤ 8		9-11	12-20		21-24	≥ 25
Temperature (C°)	≤ 35.0		35.1-36.0	36.1-38.0	38.1-39.0	≥ 39.1	
Systolic BP (mmHg)	≤ 90	90-100	101-110	111-249	≥ 250		
SaO_2 (%)	≤ 91	92-93	94-95	≥ 96			
Inspired O_2				Air			Any O^2
CNS (use AVPU scale)				Alert			Voice Pain Unresponsive

Note: ViEWS = early warning score for use in VitalPAC^{TM} system (The Learning Clinic Ltd, 2012); bpm= beats per minute; rpm= respirations per minute; Systolic BP= systolic blood pressure; SaO_2= saturation of oxygen; CNS= central nervous system; AVPU= alert, responds to voice, responds to pain, unresponsive

4.6.2.4 Data analysis

Once the data had been entered manually, they were entered into SPSS. SPSS 19 was used to carry out the analyses and describe the results. Although a wide range of data had been collected, the information that was analysed in SPSS pertained to descriptive statistics of demographic variables, the hospital departments and details about vital signs. Univariate descriptive analysis, bivariate analysis and logistic regression analyses of the data were also performed. Logistic regression was employed to identify any association between a number of independent variables, (for example, vital signs and hospital departments) and survival to resuscitation and survival to discharge, the dependent variables.

Reliability and validity of the quantitative data

As noted in Chapter 3, the quality of quantitative data is assessed in terms of reliability and validity. Reliability and validity of the quantitative data was established by carefully considering the research questions and the design of the data collection tool. A discussion about reliability and validity of the quantitative data is provided in Section 6.4.1.

4.7 Results section

This section describes the results of the phase one study, first, presenting the univariate results (section 4.7.1 to 4.7.6), secondly, the results of the bivariate analyses (section 4.7.7), and thirdly, logistic regression results (4.7.8). The records of a total of 228 patients (n=228) were available for inclusion in the study. The results of the univariate analyses have been divided into the following sub-sections:

- Demographics
- Level of hospital care
- Vital signs recorded in 24 hour period prior to cardiac arrest
- Location of vital signs in the EHR
- Deterioration detected according to BAS or EWS
- Survival rate

The first sub-section is a demographic report of the age and gender of patients in the study.

4.7.1 Demographic characteristics of the sample of patients

The age of the 228 patients ranged from 16 to 96 years, with a mean age of 74 and standard deviation (SD) of 13.4. These were grouped into 10-year age groups for the purpose of the analyses. The distribution is illustrated in Table 4.7. The lowest frequency was in the less than 40 years group, constituting 1.8% of the total (n=4). The highest frequency (n=74) was in the 70-79 years group, constituting 32.5% of the total, closely followed by the 80-89 years age group.

Table 4.7 Demographic characteristics of patients in study (n=228)

		Frequency n (%)
Gender	Male	152 (66.7)
	Female	76 (33.3)
Age group	≤ 40	4 (1.8)
	40 - 49	7 (3.1)
	50 - 59	9 (3.9)
	60 - 69	45 (19.7)
	70 - 79	74 (32.5)
	80 - 89	67 (29.4)
	90 - 99	22 (9.6)

Regarding gender, the total number of male patients was 152 (66.7%) and the total number of females was 76 (33.3%), a ratio of males to females of 2:1. In Swedish national statistics for patients who suffer from cardiac arrest and on whom cardiopulmonary resuscitation has been attempted there is also a 2:1 ratio of male to female (Herlitz, 2009). This suggests that the sample of patients in this study may be representative of the wider population of people experiencing a cardiac arrest in a Swedish hospital.

4.7.2 Level of hospital care

Table 4.8 shows the distribution of patients in the various care areas. Of the 228 patients in the study, 101 (44.3%) were being cared for in critical care areas. Critical care areas are those in which there is a higher staff-patient ratio, CICU, ICU and the cardiac catheterisation laboratory. The remaining 127 patients (55.7%) were in general wards or the ED.

Table 4.8 Type of department or ward

Department or ward	Frequency (%)
ED	18 (7.9)
General ward	109 (47.8)
Total in non-critical care areas	127 (55.7)
CICU	46 (20.2)
CCL	55 (24.1)
ICU	0 (0)
Total in critical care areas	101 (44.3)

4.7.3 Vital signs in 24-hour period prior to cardiac arrest

This sub-section describes the numbers of patients who had each, or any, of the seven vital signs documented during the 24-hour period prior to cardiac arrest. These seven parameters are based on those used in ViEWS (Table 4.6), the EWS system (described in section 2.5.2). These vital signs are respiratory rate in breaths per minute, blood pressure in millimetres of mercury (mmHg), oxygen saturation as a percentage, heart rate in beats per minute, temperature in degrees centigrade and conscious level (CNS) which was measured according to AVPU, where A= awake, V= responds to verbal stimuli, P= responds to painful stimuli and U= unconscious. Administration of oxygen therapy is included as a parameter, as recommended by Prytherch et al (2010).

The frequency and percentage of the documented vital signs in the 24-hour period are illustrated in Table 4.9 and Figure 4.3. The most frequent recording was of blood pressure and the least frequent was conscious level.

Table 4.9 Vital signs documented in final 24 hour period prior to cardiac arrest

Vital sign	Frequency documented (%)	Frequency not documented (%)
Respiratory rate	68 (29.8)	160 (70.2)
Blood pressure	179 (78.5)	49 (21.5)
Oxygen saturation (%)	150 (65.8)	78 (34.2)
Heart rate	156 (68.4)	72 (31.6)
Temperature °C	148 (64.9)	80 (35.1)
Conscious level	35 (15.4)	193 (84.6)
Oxygen therapy	91 (39.9)	137 (60.1)

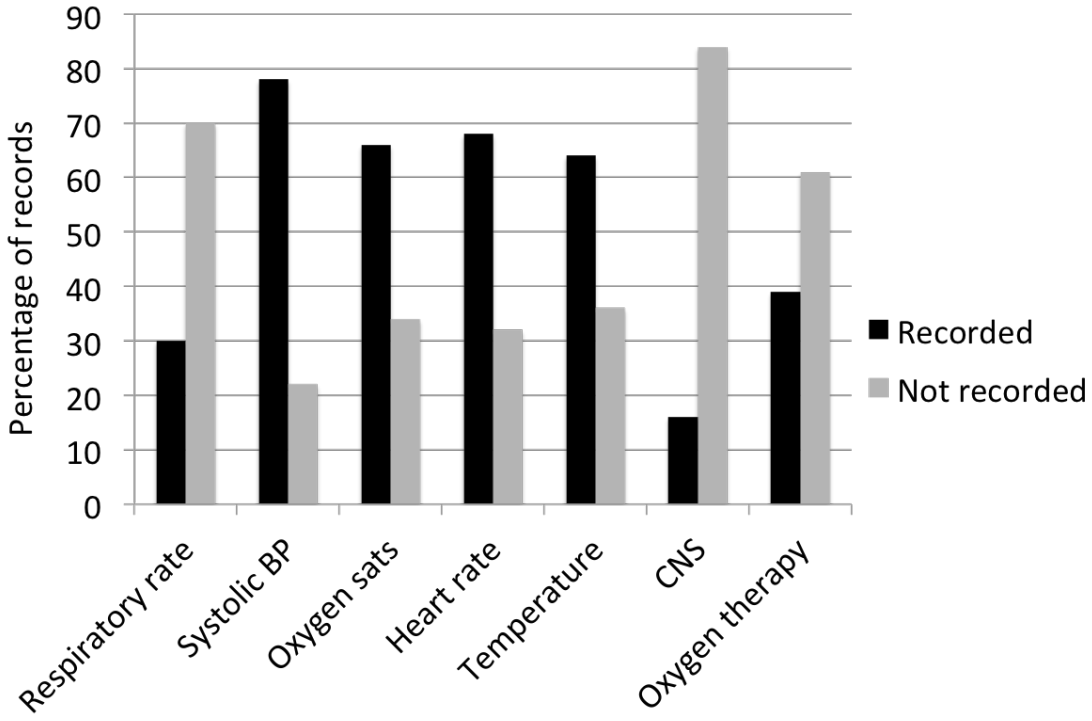


Figure 4.3 Percentage of records in which vital signs and oxygen therapy were recorded or not recorded in the final 24-hour period prior to cardiac arrest (n=228)

The total number of vital signs recorded in patients during the 24 hours prior to cardiac arrest is illustrated in Table 4.10 and Figure 4.4. Thirty-five patients (15.4%) did not have any vital signs documented.

Table 4.10 Total number of vital signs recorded per patient in last 24 hours

Number of vital signs	Number of patients. n (%)
No vital signs	35 (15.4)
One vital sign	15 (6.6)
Two vital signs	18 (7.9)
Three vital signs	25 (11.0)
Four vital signs	43 (18.9)
Five vital signs	42 (18.4)
Six vital signs	31 (13.6)
Seven vital signs	7 (8.3)

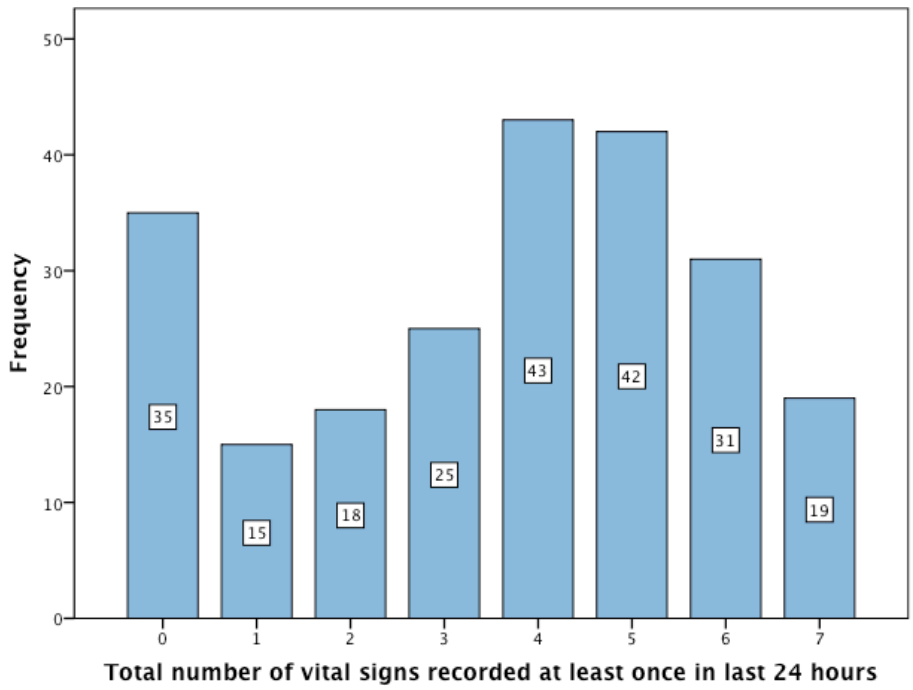


Figure 4.4 Total number of vital signs recorded in patients in last 24 hours (n=128)

4.7.4 Location of vital signs in the EHR

This sub-section reports on the location in which the last recordings of each or any of the seven vital signs were documented within the EHR. As described previously, there were three locations within the EHR in which vital signs could be found: the template, the journal and the report sheet. There was no graphical presentation of any of the parameters; all information was presented in numerical text form. Each sign could be found in one or

more locations; sometimes the same sign could be, and was, found in one, two or three of the possible locations. This is illustrated in table 4.11 and the most noteworthy features are highlighted in the next section.

Table 4.11 Number of records, *n,* (%) in which vital signs were documented in 24-hour period prior to cardiac arrests and their location within the electronic health record (EHR)

VS	Not documented	Documented	Template	Journal	Report sheet	Template and Journal	Template and Report sheet	Journal and Report sheet	Template, Journal and Report sheet
RR	160 (70.2)	68 (29.8)	29 (12.7)	8 (3.5)	1 (0.4)	30 (13.2)	0 (0.0)	0 (0.0)	0 (0.0)
BP	49 (21.5)	179 (78.5)	114 (50.0)	8 (3.5)	14 (6.1)	39 (17.1)	3 (1.3)	0 (0.0)	1 (0.4)
HR	72 (31.6)	156 (68.4)	79 (34.6)	14 (6.1)	27 (11.8)	33 (14.5)	1 (0.4)	0 (0.0)	2 (0.9)
SaO_2	78 (34.2)	150 (65.8)	80 (35.1)	9 (3.9)	19 (8.3)	36 (15.8)	6 (2.6)	0 (0.0)	0 (0.0)
T	80 (35.1)	148 (64.9)	100 (43.9)	7 (3.1)	3 (1.3)	36 (15.8)	2 (0.9)	0 (0.0)	0 (0.0)
CNS	193 (84.6)	35 (15.4)	5 (2.2)	17(7.5)	7 (3.1)	6 (2.6)	0 (0.0)	0 (0.0)	0 (0.0)
O_2	137 (60.1)	91 (39.9)	47 (20.6)	11(4.8)	15(6.6)	8 (3.5)	8 (3.5)	2 (0.9)	0.(0.0)

Note: VS=vital sign; RR=respiratory rate; BP=blood pressure; HR=heart rate; SaO_2=oxygen saturation; T=temperature; CNS=conscious level; O_2=oxygen therapy

4.7.4.1 Respiratory rate

There were 160 cases (70.2%) in which the respiratory rate was not documented. Respiratory rate was most frequently documented in both the template and the journal (n=30, 13.2%). There were 29 recordings of respiratory rate (12.7%) in the template only and eight (3.5%) were documented in the journal only.

4.7.4.2 Blood pressure

Blood pressure was not recorded in 49 cases (21.5%). The template was the most frequently-used location for the documentation of blood pressure, (n= 114, 50%). Thirty-nine cases (17.1%) were recorded in both the template and journal. Fourteen cases (6.1%)

were documented in the report sheet only, and eight (3.5%) were documented in the journal only.

4.7.4.3 Heart rate

Heart rate was most frequently documented in the template, n=79 (34.6%). Thirty-three patients (14.5%) had heart rate documented in both the template and the journal. The report sheet was the location of 27 (11.8%) heart rate documentation and 14 (6.1%) were in the journal.

4.7.4.4 Temperature

Most temperatures were documented in the template only, n=100 (43.9%). Some cases, n=36 (15.8%) were documented in the template and journal. In seven cases (3.1%), it was recorded in the journal alone and in three cases it was recorded only in the report sheet (1.3%).

4.7.4.5 Oxygen saturation

The most common location for oxygen saturation, n=80 (35.1%), was in the template. Oxygen saturation was documented in the template and the journal in 36 cases (15.8%). In 19 cases (8.3%), oxygen saturation was documented in the report sheet only and in nine cases (3.9%) it was reported in the journal only.

4.7.4.6 Conscious level

Conscious level was not recorded in 193 cases (84.6%). When it was recorded, it was most frequently documented only in the journal, n=17 (7.5%). The distribution of the remaining conscious level recordings indicated that seven (3.1%) were in the report sheet, six (2.6%) were in the template and journal, and five (2.2%) were in the template alone.

4.7.4.7 Oxygen therapy

Oxygen therapy was most frequently documented in the template, n=47 (20.6%), then in the report sheet n=15 (6.6%), and in the journal, n=11 (4.8%). The template and journal, and template and report sheet had the same frequency of documentation, n=8 (3.5%) each.

4.7.5 Detecting signs of deterioration

This sub-section deals with detecting patient deterioration. The number of patients who showed signs of deterioration in the 24-hour period prior to cardiac arrest was analysed. These analyses were based on two systems used for detection of deterioration in hospital

patients (Section 4.5.2.3). These were selected to find out how many patients in the study showed signs of deterioration according to their documented vital signs. The most abnormal set of vital signs in the 24 hours prior to cardiac arrest was taken for each patient for the calculation of both BAS and ViEWS. These scores were calculated for each case and added to the data in SPSS.

Table 4.12 shows the number of patients who showed signs of clinical deterioration when estimated using BAS and ViEWS. Using the BAS threshold levels of 90-30-90, 36.4% of patients had a positive BAS parameter, meaning that one or more of the vital signs of systolic blood pressure, respiratory rate or percentage of oxygen saturation was abnormal according to the parameters for that system. In the ViEWS system, 61.8% scored one or more, and 53% scored three or more.

Table 4.12 Number of patients, n, (%) who exhibited signs of deterioration according to BAS and ViEWS

Signs of deterioration	Yes	No
Abnormal BAS recording	83 (36.4)	145 (63.6)
Score ≥ 1 ViEWS	141 (61.8)	87 (38.2)
Score ≥ 3 ViEWS	121 (53.0)	107 (47.0)

The next sub-section examines survival rates of the patients in the study.

4.7.6 Survival

Two variables on survival were available from the SRICA: the number of patients who survived following resuscitation and the number who survived to be discharged from hospital alive. The number of patients who survived following resuscitation procedure was 116 (50.9 %). The number of patients who survived to be discharged from hospital was 76 (33.3 %). This is illustrated in Table 4.13.

Table 4.13 Number of patients who survived resuscitation and the number of patients who survived to discharge

Survival	Frequency of survival (%)	Frequency not survived (%)	Total (%)
After resuscitation	116 (50.9)	112 (49.1)	228 (100)
To discharge from hospital	76 (33.3)	152 (66.7)	228 (100)

The univariate analyses have been described according to six different categories: demographics; vital signs recorded in 24 hour period prior to cardiac arrest; level of hospital care; location of vital signs in the EHR; deterioration detected according to BAS or ViEWS; and survival rate. The next section presents the results of the bivariate analysis.

4.7.7 Chi-squared test results

Chi-squared tests were carried out on the documentation of all vital signs in relation to the following six categories and are reported in the sections indicated in parenthesis: age group (section 4.7.7.1), gender (4.7.7.2), the department in which the patient was at the time of cardiac arrest (4.7.7.3), whether the patient was receiving intensive care or not (4.7.7.4), survival after resuscitation and survival to discharge (4.7.7.5), survival rates in relation to department (4.7.7.6).

4.7.7.1 Age

There was no significant association between documentation of any of the vital signs and age as shown in table 4.14.

Table 4.14 Chi² test showing vital signs and age group. n (%)

	Age group					Total	*p* value
	<60	60-69	70-79	80-89	90-99		
Resp. rate							0.445
No	17 (85)	32 (71.6)	48 (64.9)	46 (68.7)	17 (77.3)	160 (60.2)	
Yes	3 (15.0)	13 (28.9)	26 (35.1)	21(31.3)	5 (22.7)	68 (29.8)	
BP							0.952
No	5 (25.0)	11 (24.4)	16 (21.6)	13 (19.4)	4 (18.2)	49 (21.5)	
Yes	15 (75.0)	34 (75.6)	58 (78.4)	54 (80.6)	18 (81.8)	179 (78.5)	
Heart rate							0.236
No	8 (40.0)	19 (42.9)	23 (31.1)	18 (26.9)	4 (18.2)	72 (31.6)	
Yes	12 (60.0)	26 (57.8)	51 (68.9)	49 (73.1)	18 (81.8)	156 (68.4)	
Temp °C							0.058
No	9 (45.0)	22 (48.9)	19 (25.7)	25 (37.3)	5 (22.7)	80 (35.1)	
Yes	11 (55.0)	23 (51.1)	55 (74.3)	42 (62.7)	17 (77.3)	148 (64.9)	
O_2 Sats							0.506
No	9 (45.0)	18 (40.0)	23 (31.1)	23 (34.3)	5 (22.7)	78 (34.2)	
Yes	11 (55.0)	27 (60.0)	51 (68.9)	44 (65.7)	17 (77.3)	150 (65.8)	
CNS							0.456
No	15 (75.0)	39 (86.7)	66 (89.2)	54 (80.6)	19 (86.4)	193 (84.6)	
Yes	5 (25.0)	6 (13.3)	8 (10.8)	13 (19.4)	3 (13.6)	35 (15.4)	
O_2 therapy							0.400
No	15 (75.0)	30 (66.7)	42(56.8)	39 (58.2)	11 (50.0)	137 (60.1)	
Yes	5 (25.0)	15 (33.3)	32 (43.2)	28 (41.8)	11(50.0)	91 (39.9)	
Total	20 (100)	45 (100)	74 (100)	67(100)	22(100)	228 (100)	

4.7.7.2 Gender

There was no significant association between documentation of any of the vital signs and gender as shown in table 4.15.

Table 4.15 Chi² test showing vital signs and gender. n (%)

		Gender		Total	*p* value
		Male	Female		
Resp. rate	No	104 (68.4)	56 (73.7)	160 (70.2)	0.506
	Yes	48 (31.6)	20 (26.3)	68 (29.8)	
BP	No	30 (19.7)	19 (25.0)	49 (21.5)	0.459
	Yes	122 (84.9)	57 (65.8)	179 (78.5)	
Heart rate	No	47 (26.3)	25 (42.1)	72 (31.6)	0.880
	Yes	105 (73.7)	51 (57.9)	156 (68.4)	
Temp °C	No	58 (38.2)	22 (28.9)	80 (35.1)	0.220
	Yes	94 (61.8)	54 (71.1)	148 (64.9)	
SaO_2	No	53 (34.9)	25 (32.9)	78 (34.2)	0.882
	Yes	99 (65.1)	51 (67.1)	150 (65.8)	
CNS	No	134 (88.2)	59 (77.6)	193 (84.6)	0.060
	Yes	18 (11.8)	17 (22.4)	35 (15.4)	
O_2 therapy	No	94 (61.8)	43 (56.6)	137 (60.1)	0.534
	Yes	58 (38.2)	33 (43.4)	76 (39.9)	
	Total	152 (100)	76 (100)	228 (100)	

4.7.7.3 Department in relation to vital signs

This section describes whether there was a relationship between each documented vital sign and the department in which the patient was located at the time of cardiac arrest. Details of the results can be seen in table 4.16 and a short explanation to each vital sign is provided below the table.

Table 4.16 Chi² test for departments in which patients were located in relation to whether vital signs were recorded in last 24 hours prior to cardiac arrest. n (%)

	Department				Total	*p* value
	ED	Ward	CICU	CCL		
Resp. rate						0.029
No	10 (55.6)	73 (76.7)	30 (65.2)	47 (85.5)	160 (70.2)	
Yes	8 (44.4)	36 (33.0)	16 (34.8)	8 (14.5)	68 (29.8)	
Systolic						<0.001
No	3 (16.7)	18 (1.5)	2 (4.3)	26 (47.3)	49 (21.5)	
Yes	15 (83.3)	91 (83.5)	44 (95.7)	29 (52.7)	179 (78.5)	
Heart rate						<0.001
No	6 (33.3)	28 (25.7)	7 (15.2)	31 (56.4)	72 (31.6)	
Yes	12 (66.7)	81 (74.3)	39 (84.8)	24 (43.6)	156 (68.4)	
Temp ° C						<0.001
No	4 (22.2)	21 (19.3)	13 (28.3)	42 (76.4)	80 (35.1)	
Yes	14 (77.8)	88 (80.7)	33 (71.7)	13 (23.6)	148 (64.9)	
SaO_2						<0.001
No	6 (33.3)	28 (25.7)	10 (21.7)	34 (61.8)	78 (34.2)	
Yes	12 (66.7)	81 (74.3)	39 (84.8)	21 (38.2)	150 (65.8)	
CNS						0.730
No	14 (77.8)	94 (86.2)	36 (78.3)	49 (89.1)	193 (84.6)	
Yes	4 (22.2)	15 (13.8)	10 (21.7)	6 (10.9)	35 (15.4)	
O_2 therapy						<0.001
No	12 (66.7)	58 (53.2)	19 (41.3)	48 (87.3)	137 (60.1)	
Yes	6 (33.3)	51 (46.8)	27 (58.7)	7 (12.7)	91 (39.9)	
Total	18 (100)	109 (100)	46 (100)	55 (100)	228 (100)	

Respiratory rate

There was a significant association between the department in which a patient was housed at the time of cardiac arrest and the recording of the respiratory rate (p=0.029). A significantly higher proportion of patients did not have respiratory rate recorded in the cardiac catheterisation laboratory (CCL) compared to the other locations. Forty-seven (85.5%) of the 55 patients in the CCL did not have respiratory rate recorded in the 24-hour period prior to cardiac arrest, and eight (14.5 %) had respiratory rate recorded. In comparison, ten of the 18 patients in the ED department (55.6%) did have the respiratory rate recorded. Thirty-six (33.0%) of the 109 patients in the general wards had respiratory rate recorded and 16 (34.8%) of 46 patients had this vital sign recorded in the Coronary Care Unit.

Blood pressure

The department was also significantly associated with whether blood pressure was taken or not (p<0.001). Blood pressure was recorded in 44 of the 46 patients (95.7%) in the CICU. The CCL had the lowest proportion of patients in which blood pressure was recorded, 29 of 55 (52.7%).

Heart rate

Heart rate was significantly associated with the department in which a patient was located (p<0.001). Heart rate was recorded in a high proportion of patients in the CICU, 39 of the 46 patients (84.8%). The CCL had a lower proportion of patients in which heart rate was taken in the previous 24 hour: 24 of the 55 patients (43.6%).

Body temperature

The department was significantly associated with the recording of body temperature (p<0.001). Of the 109 patients on the general wards, body temperature was recorded in a high proportion of patients, 80 (80.7%). Conversely, only thirteen of the 55 (23.6%) patients who had a cardiac arrest in the CCL had temperature recorded in the 24 hours prior to cardiac arrest.

Oxygen saturation

The department in which a patient was located was significantly associated with recording oxygen saturation (p<0.001). Oxygen saturation was recorded in 39 of 46 patients (84.8%) in the CICU. The number of patients who had oxygen saturation recorded if they had a cardiac arrest in the CCL was 21 of 55 (38.2%).

Conscious level

The recording of conscious level was the only vital sign that did not show a significant association with the department in which a patient was housed at the time of cardiac arrest.

Oxygen therapy

The Chi-squared test indicated a significant association between the administration of oxygen therapy and the department in which patients were located ($p<0.001$). Twenty-seven of the 46 (58.7%) patients in the CICU were recorded as receiving oxygen therapy, compared with seven of the 55 patients (12.7%) in the CCL.

4.7.7.4 Intensive care or not, in relation to vital signs

The Chi-squared test indicated that there was a significant association between receiving intensive care and recording of two vital signs: body temperature and oxygen saturation. For temperature $p<0.001$ and oxygen saturation $p=0.012$. Whether a patient was receiving intensive care or not was not significantly associated with the recording of the remaining vital signs.

4.7.7.5 Survival rates in relation to vital signs

There were significant associations between whether certain vital signs had been recorded and survival. This applied to survival following resuscitation, as well as survival to discharge. Details of these results can be seen in tables 4.17 and 4.18.

There was a significant association between whether patients survived or not following resuscitation and blood pressure being recorded ($p=0.034$). Similarly, survival to discharge was significantly associated with the recording of blood pressure ($p=0.002$). One hundred and twenty-nine of the 152 patients (84.9%) who did not survive to discharge had had their blood pressure taken. In comparison, 80 of 152 (52.6%) of patients who did not survive were receiving oxygen therapy ($p<0.001$). Thus, patients who had their blood pressure taken in the 24 hours prior to cardiac arrest were less likely to survive the resuscitation procedure or survive to discharge.

The other vital signs that were significantly associated with survival to discharge were heart rate, temperature, oxygen saturation and oxygen therapy. Tables 4.17 and 4.18 provide the numbers and proportions of the relationships between vital signs being recorded in the last 24 hours prior to cardiac arrest, and survival after resuscitation and survival to discharge respectively.

Table 4.17 Chi² test showing survival after resuscitation in relation to vital signs

	Recorded	Survival after resuscitation n (%)		Total	*p* value
Vital sign		No	Yes		
Resp. rate	No	76 (47.5)	84 (52.5)	160 (100)	0.544
	Yes	36 (52.9)	32 (47.1)	68 (100)	
BP	No	17 (34.7)	32 (65.3)	49 (100)	0.034
	Yes	95 (53.1)	84 (46.9)	179 (100)	
Heart rate	No	28 (38.9)	44 (61.1)	72 (100)	0.050
	Yes	84 (53.8)	72 (46.2)	156 (100)	
Temp ° C	No	24 (30)	56 (70)	80 (100)	<0.001
	Yes	88 (59.5)	60 (40.5)	148 (100)	
SaO_2	No	29 (37.2)	49 (62.8)	78 (100)	0.014
	Yes	83 (55.3)	67 (44.7)	150 (100)	
CNS	No	97 (50.3)	96 (49.7)	193 (100)	0.534
	Yes	15 (42.9)	20 (57.1)	35 (100)	
O_2 therapy	No	55 (40.1)	82 (59.9)	137(100)	<0.001
	Yes	57 (62.2)	34 (37.4)	91 (100)	
	Total	112 (49.1)	116 (50.9)	228 (100)	

Table 4.18 Chi² test showing survival to discharge in relation to vital signs

		Survival to discharge (%)		Total	*p* value
Vital sign		No	Yes		
Resp. rate	No	102 (63.8)	58 (36.3)	160 (100)	0.201
	Yes	50 (73.5)	18 (26.5)	68 (100)	
BP	No	23 (46.9)	26 (53.1)	49 (100)	0.002
	Yes	129 (72.1)	50 (27.9)	179 (100)	
Heart rate	No	40 (55.6)	32 (44.4)	72 (100)	0.023
	Yes	112 (71.8)	44 (28.2)	156 (100)	
Temp °C	No	38 (47.5)	42 (52.5)	80 (100)	<0.001
	Yes	114 (77)	34 (23)	148 (100)	
SaO_2	No	40 (51.3)	38 (48.7)	78 (100)	<0.001
	Yes	112 (74.7)	38 (25.3)	150 (100)	
CNS	No	128 (66.3)	65 (33.7)	193 (100)	0.948
	Yes	24 (68.6)	11 (31.4)	35 (100)	
O_2 therapy	No	72 (52.6)	65 (47.4)	137 (100)	<0.001
	Yes	80 (87.9)	11 (12.1)	91 (100)	
	Total	152 (100)	76 (100)	228 (100)	

4.7.7.6 Survival rates in relation to department

Table 4.19 shows the association between the hospital department and survival after resuscitation and survival to discharge. The Chi-squared test showed a statistically significant association between the hospital department and whether the patient survived after resuscitation ($p<0.001$), and whether they survived to discharge ($p<0.001$).

Table 4.19 Chi² test showing association between department and survival after resuscitation and survival to discharge

	Department				Total	*p* value
	ED	General ward	CICU	CCL		
	n(%)					
Survival after resusc.						<0.001
No	5 (27.8)	75 (68.8)	23 (50.0)	9 (16.4)	112 (49.1)	
Yes	13 (72.2)	34(31.2)	23 (50.0)	46 (83.6)	116 (50.9)	
Total	18 (100)	109 (100)	46 (100)	55 (100)	228 (100)	
Survival to discharge						<0.001
No	9 (50.0)	91 (83.5)	32 (69.6)	20 (36.4)	152 (66.7)	
Yes	9 (50.0)	18 (16.5)	14 (30.4)	35 (63.6)	76 (33.3)	
Total	18 (100)	109 (100)	46 (100)	55 (100)	228 (100)	

In general wards, 91 (83.3%) of 109 patients did not survive to discharge. In the CCL, 35 (63.6%) of 55 patients survived to discharge.

Based on the results of the Chi square tests, further analyses were undertaken to identify the impact of a selection of variables on survival. Logistic regression was employed for these analyses.

4.7.8 Logistic Regression

Following undertaking Chi-squared tests, multivariate analyses were undertaken to identify the association between a number of factors (as independent variables) that might affect both survival after resuscitation and survival to discharge (as dependent variables in separate models). Logistic regression was employed for these analyses. This section

presents the results of logistic regression analyses that were undertaken to identify the factors that could affect survival after resuscitation and survival to discharge.

The first set of logistic regression models were for each of the six independent variables, i.e., the documentation of vital signs investigated in the study. Logistic regression was undertaken to assess the relationship between each individual vital sign (independent variable) in relation to survival after resuscitation (dependent variable). Table 4.20 presents the results of this analysis.

Table 4.20 Unadjusted logistic regression models for each individual vital signs separate models in relation to survival after resuscitation (95% CI = 95% confidence interval)

Independent variable	*p* value	Odds ratio	95% C.I.
Resp. rate	0.452	0.80	0.46, 1.42
BP	0.024	0.47	0.24, 0.91
Heart rate	0.037	0.55	0.31, 0.96
Temp °C	< 0.001	0.29	0.16, 0.52
SaO_2	0.010	0.48	0.27, 0.84
CNS	0.421	1.35	0.65, 2.79

As shown in Table 4.20, four of the independent variables were statistically significant: blood pressure, heart rate, temperature and oxygen saturation - in relation to survival after resuscitation. This meant that patients were less likely to survive if they had these vital signs measured in the 24-hours preceding cardiac arrest.

Logistic regression was undertaken to assess the impact on survival after resuscitation when six independent variables, the vital signs, were added to a single model together. The model contained the six vital signs used in the study. The results are presented in Table 4.21.

Table 4.21 Adjusted logistic regression model for all six vital signs in a single model in relation to survival after resuscitation

Independent variable	*p* value	Odds ratio	95% C.I.
BP	0.499	0.73	0.29, 1.83
CNS	0.167	1.8	0.79, 4.02
Heart rate	0.959	0.98	0.42, 2.30
SaO_2	0.816	0.91	0.39, 2.10
Resp. rate	0.533	1.26	0.61, 2.58
Temp °C	<0.001	0.30	0.14, 0.62

As can be seen in Table 4.21, the analysis indicated that a patient's temperature, p=0.001, was the most important determinant of whether a patient survived after a resuscitation procedure. In other words, if the patient's temperature had been recorded in the 24-hours preceding cardiac arrest, the patient was significantly less likely to survive. Possible reasons for this are discussed in section 4.8.3.

In addition to assessing the impact that documenting vital signs had on survival, further factors were analysed. Logistic regression was undertaken to assess the impact of gender, age and department in relation to survival after resuscitation. The results are presented in Table 4.22.

Table 4.22 Adjusted logistic regression for six vital signs, gender, age and department in relation to survival after resuscitation

Independent variable (reference category)	Category	*p* value	Odds ratio	95% C.I.
Vital signs	BP	0.612	0.77	0.27, 2.17
(not recorded)	CNS	0.322	1.5	0.64, 3.97
	Heart rate	0.956	1.03	0.40, 2.64
	O_2 sats	0.948	0.97	0.39, 2.44
	Resp. rate	0.598	1.24	0.56, 2.72
	Temp °C	0.130	0.52	0.22, 1.21
Age group (<60)		0.389		
	60-69	0.063	0.26	0.06, 1.07
	70-79	0.065	0.28	0.07, 1.08
	80-89	0.051	0.27	0.07, 1.01
	90+	0.100	0.27	0.06, 1.28
Gender (male)	Female	0.461	1.28	0.66, 2.48
Department (ED)		< 0.001		
	General ward	0.006	0.20	0.06, 0.62
	CICU	0.186	0.43	0.12, 1.50
	CCL	0.549	1.51	0.39, 5.79

As shown in Table 4.22, the results revealed that the most important determinant for survival after resuscitation was the department in which a patient was housed at the time of cardiac arrest. A patient was more likely to survive after resuscitation if they were in the emergency department (ED) compared to a general ward.

The total number of vital signs documented in the 24 hours preceding cardiac arrest were analysed in relation to survival after resuscitation. The additional variables, age, gender and department were added as controls to the model and analysed as co-variates. The results of these analyses are presented in Table 4.23.

Table 4.23 Logistic regression for total number of vital signs in relation to survival after resuscitation, and in relation to age, gender and department

Independent variable (reference category)	Category	*p* value	Odds ratio	95% CI
No. of vital signs recorded in 24 hours before arrest		0.002	0.82	0.73, 0.93
Age group (<60)		<0.001		
	60-69	0.204	0.19	0.02, 2.47
	70-79	0.216	0.21	0.02, 2.50
	80-89	0.218	0.207	0.02, 2.54
	90+	0.239	0.208	0.02, 2.83
Gender (Male)	Female	0.438	0.771	0.40, 1.49
Department (ED)		0.624		
	General ward	0.004	0.184	0.06, 0.59
	CICU	0.238	0.471	0.14, 1.65
	CCL	0.381	1.808	0.48, 6.8

As shown in Table 4.23, the number of vital signs recorded in 24 hours before arrest was statistically significant for survival after resuscitation (p=0.002). This indicates that the more vital signs that were recorded the lower was the chance of surviving (OR=0.82). Age and gender were not statistically significant. Patients were less likely to survive resuscitation in a general ward compared to the other departments in the study (p=0.004).

Logistic regression was also undertaken to assess the impact on each individual vital sign (independent variable) in relation to survival to discharge (dependent variable). Table 4.24 presents the results.

Table 4.24 Results of separate logistic regression models for each individual vital sign in relation to survival to discharge

Independent variable	*p* value	Odds ratio	95% C.I
Resp. rate	0.154	0.63	0.34, 1.19
BP	<0.001	0.34	0.18, 0.66
Heart rate	0.016	0.49	0.28, 0.88
Temp °C	<0.001	0.27	0.15, 0.48
SaO_2	<0.001	0.36	0.20, 0.64
CNS	0.795	0.90	0.47, 1.96

As shown in Table 4.24, in separate models, four vital signs were statistically significant - blood pressure, heart rate, temperature and oxygen saturation - in relation to survival to discharge. This meant that patients were less likely to survive if they had these vital signs measured in the 24-hours preceding cardiac arrest.

Logistic regression was undertaken to assess the impact on survival to discharge when six independent variables, the vital signs, were added to a single model together. The model contained the six vital signs used in the study. The results are presented in Table 4.25.

Table 4.25 Logistic regression for all six vital signs in a single model in relation to survival to discharge

Independent variable	*p* value	Odds ratio	95% C.I.
BP	0.141	0.49	0.19, 1.27
CNS	0.511	1.35	0.56, 3.26
Heart rate	0.489	1.39	0.55, 3.52
SaO_2	0.359	0.66	0.27, 1.60
Resp. rate	0.598	1.25	0.55, 2.81
Temp °C	0.004	0.34	0.16, 0.71

These results indicated that if the patient's temperature had been recorded in the 24 hours preceding cardiac arrest, the patient was significantly less likely to survive to discharge (p=0.004)(Table 4.25).

Similarly, logistic regression was undertaken for six vital signs, gender, age and department in relation to survival to discharge. The results are presented in Table 4.26.

Table 4.26 Logistic regression for six vital signs, gender, age and department in relation to survival to discharge

Independent variable (reference category)	Category	p value	Odds ratio	95% C.I.
Vital signs	BP	0.162	0.46	0.15, 1.37
(not recorded)	CNS	0.919	0.95	0.35, 2.61
	Heart rate	0.322	1.72	0.59, 5.03
	SaO_2	0.442	1.43	0.58, 3.56
	Resp. rate	0.598	1.24	0.56, 2.72
	Temp °C	0.206	0.56	0.22, 1.37
Age group (<60)		0.006		
	60-69	0.013	0.17	0.04, 0.69
	70-79	0.001	0.11	0.03, 0.41
	80-89	< 0.001	0.09	0.02, 0.33
	90+	0.038	0.19	0.04, 0.91
Gender (male)	Female	0.589	1.23	0.59, 2.56
Department (ED)		0.001		
	General ward	0.011	0.22	0.07, 0.71
	CICU	0.321	0.11	0.03, 0.41
	CCL	0.747	1.23	0.36, 4.20

As shown in Table 4.26, an important determinant for survival to discharge was the department in which a patient was housed at the time of cardiac arrest. Patients were less likely to survive to discharge if they had a cardiac arrest in a general ward than in an ED. Age was also statistically significant: relative to the youngest age group (<60 years) each of the older age groups had a significantly reduced chance of surviving to discharge (p value

<0.05). In summary, a general ward was the department in which a patient was least likely to survive resuscitation procedure or survive to discharge.

The impact of the total number of vital signs taken in the 24 hours preceding cardiac arrest was analysed in relation to survival to discharge. The additional variables, age, gender and department were added to the model and analysed. The results of these analyses are presented in Table 4.27.

Table 4.27 Logistic regression for the total number of vital signs in relation to survival to discharge, and in relation to age, gender and department

Independent variable (reference category)	Category	*p* value	Odds ratio	95% C.I.
No. of vital signs recorded in 24 hours before arrest		< 0.001	0.75	0.65, 0.85
Age group (<60)		<0.001		
	60-69	0.068	0.10	0.01, 1.19
	70-79	0.030	0.07	0.01, 0.77
	80-89	0.016	0.05	0.00, 0.57
	90+	0.103	0.11	0.01, 1.22
Gender (male)	Female	0.802	0.910	0.43, 1.91
Department (ED)		0.04		
	General ward	0.006	0.184	0.06, 0.62
	CICU	0.287	0.498	0.14, 1.80
	CCL	0.661	1.318	0.38, 4.52

As shown in Table 4.27, the number of vital signs was statistically significant with a *p* <0.001 for survival to discharge. This indicates that the more vital signs that were recorded the lower was the chance of surviving. Patients were less likely to survive to discharge in a general ward compared to the other departments in the study (*p*=0.006). Age was also statistically significant in relation to survival to discharge. The age groups 70-79 (*p*=0.030) and 80-89 (*p*=0.016) were less likely to survive to discharge compared to people in the youngest age group (<60 years).

The next section provides a discussion of these results.

4.8 Discussion

The method and results for the phase one study have been described (4.6-4.7). This section provides a discussion of the results in relation to the available literature. Firstly, the key findings are outlined (4.8.1). The results are then discussed in detail (4.8.2-4.8.8). The strengths and limitations of the study are described separately (4.9). Finally, there is a conclusion with reasons for conducting a second phase of this research (4.10).

4.8.1 Summary of key findings

There were four key findings in this study. First, there was a noticeable lack of completeness of vital sign documentation in the EHR in this acute hospital setting. Secondly, where documentation of vital signs took place within the EHR, it was fragmented and inconsistent. Thirdly, although vital signs were largely incomplete, both ViEWS and BAS had the potential to detect clinical deterioration, with ViEWS demonstrating greater predictive ability than BAS. However, the third finding should be viewed with caution because of the small sample size (n=228). Finally, it was found that the more vital signs that were recorded, the lower the chances were that the patient would survive after resuscitation or survive to discharge.

4.8.2 Completeness of documentation

The results of this study demonstrate that documentation of vital signs was incomplete in the 24-hour period prior to sudden cardiac arrest, when aligned to recommendations for the observation of acute patients (Prytherch et al., 2010; Royal College of Physicians, 2012; Royal College of Physicians of Ireland, 2012). Studies have suggested several reasons for inadequate documentation of vital signs. These include: lack of resources, e.g., not enough staff and lack of time (James et al., 2010; NPSA, 2007); lack of training and lack of knowledge regarding the importance of vital sign documentation (Bright et al., 2004; Franklin & Mathew, 1994; McArthur-Rouse, 2001; McGloin et al., 1999; McQuillan et al., 1998); and lack of explicit routines for vital sign recording (Royal College of Physicians, 2007). Another possibility is that there might have been cases where vital signs had been taken, but had not been documented in the EHR; this study only shows what was documented. Thus, although the data on vital signs in the EHR appeared to have many gaps, it is possible that vital signs might have been recorded elsewhere, for example, on paper charts if paper documentation had been used alongside the EHR. If this were the

case, paper charts may have been kept in a separate paper folder and these vital signs would not have been accessible in the EHR. Another possibility is that paper charts were scanned and archived in an electronic repository that was not retrievable when the data were collected for the phase one study. If there were paper documentation that was either not found or not retrievable, the quantitative data figures might be altered and might explain some of the apparent absence of vital sign data in the EHR. Consequently, there is the possibility that vital signs had been recorded but not documented in the EHR and could therefore explain why some records appeared deficient.

The completeness of vital signs was also found to have associations with several variables when tested using the Chi-squared test. Procedures were conducted to test for relationships between vital signs and the following categories: age group, gender, the department in which the patient was at the time of cardiac arrest, whether the patient was receiving intensive care or not, survival after resuscitation and survival to discharge. No relationships were revealed in connection to age and gender.

One of the significant results was that a considerably higher number of patients had blood pressure recorded if they were in the CICU in contrast to a much lower number who were in the cardiac catheterisation laboratory. This demonstrates a high frequency of blood pressure recording in the CICU. The low frequency of vital sign recordings of patients who were in the CCL when they had a cardiac arrest may have two possible explanations in relation to the reason for the patient having a cardiac catheterisation. First, if the patient had been diagnosed in the ambulance and taken directly to the laboratory for stent insertion the patient would not have been observed in the hospital as a patient prior to this. Second, for an elective cardiac catheterisation, the patient would have been admitted as a day patient on the same day. Conscious level was not significantly associated with any other variables. This is probably because conscious level was a vital sign that was seldom documented.

A further important result was that a significantly higher number of patients from the cardiac catheterisation laboratory 35 (63.6%) of 55 patients survived to discharge. This result supports the notion that in some cases the catheterisation procedure may have been the trigger to the cardiac arrest, in contrast to the cardiac arrest occurring as a result of deterioration in the patient's condition. This procedure involves the insertion of a catheter into the heart via an artery and may cause over-stimulation of the cardiac muscle, inadvertently invoking a life-threatening cardiac rhythm, which is then registered as a

cardiac arrest. However, these patients are constantly monitored during the procedure and staff are on hand to take appropriate action, i.e., to perform resuscitation procedures such as defibrillation to revert the life-threatening arrhythmia immediately. This could be an explanation for the significantly high number of patients who survive to discharge after sustaining cardiac arrest in the cardiac catheterisation laboratory.

Furthermore, survival rate following resuscitation and survival to discharge was significantly associated with patients having blood pressure recorded. This means patients who did not survive the resuscitation procedure or survive to discharge were more likely to have had their blood pressure taken in the 24 hours prior to cardiac arrest. This could suggest that blood pressure, as well as some other vital signs, were more frequently recorded in patients who were perceived by staff to be ailing. This could indicate that these patients were seriously ill and therefore less likely to survive a cardiac arrest.

4.8.3 Logistics regression

The results of the logistic regression analysis also revealed some interesting findings. When assessing the impact of the total number of vital signs recorded in the 24 hours prior to cardiac arrest, it was found that the more vital signs were recorded, the less chance the patient had of surviving after resuscitation (p=0.002) or surviving to discharge (p<0.001). This is potentially a rather confounding finding but there could be a reasonable explanation, for example, that sicker patients, whose survival chances were already poor, were observed more closely and therefore more vital signs were recorded, but they were also at greater risk of dying.

Logistic regression was also undertaken to assess the impact of combined vital signs on survival. This analysis showed that the more often a patient had temperature recorded, the less likely they were to survive the resuscitation procedure (p<0.001) or survive to discharge (p=0.004). These results are perhaps surprising as the most frequently recorded signs in the study were blood pressure, pulse and oxygen saturation respectively. However, the Chi-squared test had shown that a high proportion of patients (80.7%) had temperature checked in general wards. It could also be that in critically ill patients, staff checked temperature more frequently than usual in those areas.

Similar to the Chi-squared test result in which a high proportion of patients in general wards did not survive resuscitation or survive to discharge, logistic regression analysis revealed that a general ward was the clinical area in which a patient was least likely to survive resuscitation (p=0.004) or survive to discharge (p=0.006). This is possibly related to

lower nurse-to-patient ratios on general wards (Hunt, 2009). Another possible reason might be that patients in today's general wards tend to be more acutely ill because of multi-morbidity and shorter hospital stays (Green & Williams, 2006).

4.8.4 Does the EHR support the documentation of vital signs?

Superficially, the EHR appears to support the documentation of vital signs inasmuch as it is possible to record this information in the system. However, this study revealed that the vital signs could be found in any one or more of three different sections of the EHR and this suggests that there was lack of clarity about the specific location in which they should be documented. This could be because there was no clear policy for where vital signs should be documented and that none of the three areas were deemed ideal for the documentation of vital signs.

4.8.5 Usability issues

In addition to the confusion about the correct location of vital signs, there were usability issues. During the data collection it was noted that entering data on vital signs was a complex process as it would involve multiple screen changes for each sign to be documented (Darbyshire, 2000, 2003; Moody et al., 2004; Stevenson & Nilsson, 2012; Timmons, 2003). In a busy ward environment, this may have deterred staff from documenting the vital signs, even if they had been measured. Additionally, they may have felt there was little point in entering vital signs if they were to be lost in the system. However, further investigation would be required to investigate how staff actually felt. Moreover, obtaining an overview of vital signs was not possible, an issue that has been reported in previous studies (Darbyshire, 2000; Rose et al., 2005; Smith, Smith, Krugman, & Oman, 2005; Stevenson et al., 2010). Vital signs could not be viewed in a graphical format, only as numbers, and it was not possible to view the vital signs for consecutive recordings on the same screen. This would mean that users would have to remember each of the vital signs as they clicked from one screen to another to be informed about variations and possible trends. This would place additional demands on memory and cognition, thereby reducing the ability to interpret data and detect changes, e.g., deterioration in a patient.

4.8.6 Viewing vital signs

The design of observation charts has received more attention in recent years (De Marinis et al., 2010; Deakin et al., 2010; Goldhill, 2001; James et al., 2010; McArthur-Rouse, 2001)

and vital signs which are visually accessible have been shown to improve early detection of patient deterioration (Chatterjee et al., 2005; Horswill et al., 2010). For instance, plotted charts are more easily interpreted than written numerical values (Chatterjee et al., 2005). It has also been noted that colour-coded track-and-trigger charts have preferable performance to non-colour charts. Subsequently, the design of observation charts can enhance the performance of individuals in detecting vital signs that are not within normal limits, and improve the promptness of making these assessments. Because of this, the design of observation charts can have a noticeable effect on patient safety (Horswill et al., 2010). This has led to the development of standardised paper charts for early warning systems such as the Scottish Standardised Early Warning Scores (SEWS) (Paterson et al., 2006) and National Early Warning Scores (NEWS) in both England and Ireland (Royal College of Physicians, 2012; Royal College of Physicians of Ireland, 2012).

Despite the importance of presenting vital signs in a format that can support decision-making, the EHR in this study did not seem to have this functionality present. It appeared to have some usability problems that affected the documentation and retrieval of vital signs, e.g., poor navigability, poor facilities for documentation and lack of options to represent vital signs in a useful way. Because it was difficult to view a patient's clinical status, it is possible that the EHR could impede the identification of clinical deterioration; the EHR made it difficult to access and assess essential patient data. This could mean that data required for decision-making were not easily available. Doctors frequently inspect the "observation charts" when assessing acutely ill patients (Frost & Wise, 2012) but a patient's vital signs could not be quickly assessed in this EHR. This could mean a potential threat to patient safety and suggest that this technology was not beneficial to clinical care (Walsh, 2004). The study hospital's intensive care unit (ICU) did not accept the EHR for documentation of vital signs and retained their paper charts. The charge nurse stated, "We decided not to use the EHR for documentation of vital signs as you can't get an overview of vital signs in the EHR (Charge nurse, personal communication, 2013). The staff of the ICU may have had a similar view to that of Coiera (1997, p. 64), who suggested, "it is possible for a well-designed set of paper forms to be far more effective in improving the quality of a medical record than a poorly designed computer-based one".

4.8.7 Assessing the ability of BAS and ViEWS to identify at-risk patients

BAS is not a validated TTS and was originally implemented by some health authorities in Sweden with the specific aim of identifying sepsis (Gårdlund et al., 2011). In this study, blood pressure was the most frequently recorded parameter in 78.5% of cases, and respiratory rate had the lowest frequency, in 29% of cases. Poor charting of respiratory rate is not uncommon (Day & Oldroyd, 2010; Gordon & Becket, 2011; Ludikhuize, Smorenburg, de Rooij, & de Jonge, 2012; Nurmi, Harjola, Nolan, & Castren, 2005) and has earned it the label "the neglected vital sign" (Cretikos et al., 2008, p.657), despite its importance (Goldhill, White, et al., 1999; Schein et al., 1990; Subbe, Davies, et al., 2003). Introducing TTS has been shown to improve the documentation of respiratory rate (Andrews & Waterman, 2005; McBride et al., 2005) and, since the BAS system was in use, the frequency of respiratory rate recordings might have been expected to be higher. However, BAS had been implemented at the hospital in 2007 and, since then there had not been any further in-service education (personal communication, 2013). Studies have shown that on-going education is necessary for such documentation to be sustained after TTS are introduced (Buist et al., 2007; Deakin et al., 2010; Gordon & Becket, 2011). Because the vital signs were incomplete, it is difficult to tell how efficient BAS was at detecting deterioration. However, even with incomplete data, BAS would have identified 36% of patients in the 24-hour period prior to cardiac arrest. This suggests that BAS has the potential to track many more cases of deterioration if it were fully utilised.

4.8.8 Assessing the ability of ViEWS to identify at-risk patients

ViEWS is a validated TTS (Prytherch et al., 2010; Royal College of Physicians of Ireland, 2012) which comprises widely accepted traditional vital signs. The data on vital signs required for ViEWS were largely incomplete. In particular, the levels of documentation of respiratory rate and level of consciousness were exceedingly low. This is a cause for concern as these are the most prominent indicators of existing, or developing, deterioration (Schein et al., 1990). However, it could not be expected that vital signs would be complete when aligned with ViEWS, as the system was not used in the study hospital. Nevertheless, when calculating ViEWS scores, 121 patients (53%) had a score of 3 or more, the score which indicated that the nurse in charge and senior house officer should be alerted and the frequency of observations increased to four hourly (Royal College of Physicians of Ireland, 2012). These results indicate that, even with incomplete sets of recordings, ViEWS would have been sensitive in detecting clinical deterioration in more than half of the patients in

this sample. Consequently, full sets of ViEWS recordings may have detected additional cases of deterioration.

4.9 Strengths and limitations

A strength of this study was that each of the patients whose records were examined had suffered a cardiac arrest and therefore may have deteriorated in the final 24 hours prior to arrest. The fact that they had a cardiac arrest indicated that they belonged to an at-risk group and it was therefore presumed that they may have been under close monitoring, have additional vital signs documented and thus provide rich data about vital signs in the EHR. A limitation of this study is that it is not known whether documentation would have been more complete if paper records had been used as such a study was not conducted before implementation of the EHR. This study is limited in that it only includes a relatively small cohort of 228 patients. Another limitation is that the results are from just one EHR system in one hospital setting, so, in essence, it is about one case. However, a case study may be potentially valid to other cases (Punch 2005). Thus, although the results are not generalisable to all EHRs, this study has identified issues that are of relevance and importance and the results could be transferred to similar settings. For example, an organisation developing/implementing an EHR could benefit from the findings of this study.

4.10 Conclusion

Although the results may not be generalisable to the wider population, this study does identify and clarify issues that manufacturers should take into account in design, and that organisations need to consider before purchasing an EHR. In this way it could assist organisations in making decisions about which type of EHR to adopt. It can help to identify features which are essential for facilitating clinical documentation to an appropriate level. Moreover, this study deduces the potential benefits that EHRs which incorporate a TTS, could have for patient safety. A user-friendly facility in the EHR could enhance adherence to policies regarding routines for measuring and recording vital signs. It may also indicate the need for a more robust TTS that is in line with evidence-based recommendations for monitoring acute patients, for example, a validated system such as ViEWS which incorporates additional parameters, e.g., conscious level. The educational needs of staff caring for acute hospital patients would be inherent to this development.

Summary of key findings and discussion from phase one study

- there was a lack of completeness of vital sign recordings in EHR, in particular, respiratory rate
- documentation in the EHR was fragmented and inconsistent
- there is a need for a bespoke site for documentation of vital signs in EHR
- vital signs should be easy to document (EHR should be simple to navigate/user-friendly)
- vital signs should be easy to view at a glance to gain a clinical picture (one click graphical formats)
- this suggests that there are potential benefits of incorporating a track and trigger/early warning score system to assist in identification of deteriorating patients

Further research

On completion of the phase one study, some assumptions were made about the results but, at best, these were only speculations. Although the quantitative study contributed to the body of knowledge about how vital signs were represented in the EHR, it also posed new questions regarding *why* vital signs were represented in this way. The quantitative study identified lack of completeness of vital signs but could not identify *why* the vital signs were incomplete. Furthermore, the quantitative data could not explain *why* vital signs were recorded inconsistently, with one vital sign being documented more than another. In addition, it could not be discerned from the quantitative data *why* vital signs were spread out in different sections of the EHR. Further research would be required if these results were to be understood at a deeper level. To find out more about the documentation of vital signs it would be necessary to examine this in greater detail: one approach would be to observe routines and procedures for the documentation of vital signs and to speak with the people involved. This would necessitate a qualitative approach to identify the actual problems medical and nursing staff encountered when entering and retrieving information at patient level. Thus, a further study using a qualitative design was proposed and conducted to gain an in-depth knowledge of procedures and actions when documenting vital signs in the EHR. This was phase two of the mixed methods research. The findings from such a study may identify problems and provide information that could be used to inform the design of electronic record systems in order to ensure patient safety. This study is described and reported in the following chapter (Chapter 5).

Chapter 5 Observation and interview study

5.1 Introduction

In phase one of this research, described in chapter 4, a quantitative study was carried out to investigate the documentation of vital signs in electronic health records (EHR) of patients who had subsequently suffered cardiac arrest. The results of the study revealed that there was a noticeable lack completeness of documentation and that vital signs were inconsistently documented in three different sections of the EHR. Although the quantitative study provided information about how vital signs were represented in the EHR, a limitation of the research was that it could not give reasons for the lack of completeness, and fragmented representation of vital signs. This is an important issue as effective monitoring of vital signs is essential for patient safety.

Effective monitoring of vital signs and detecting deterioration is a complex, challenging process. First, vital signs must be measured regularly and accurately. Second, these measurements must be documented promptly and precisely, and third, the vital signs must be presented in a way that allows interpretation of any abnormalities in vital signs. Discussions on the results in the phase one study, suggested several possible reasons for the lack of completeness of vital signs.

One suggested reason was that there may have been a lack of routines for monitoring patients, and this has been noted in the literature (Royal College of Physicians 2007). The hospital in the present study used BAS (BAS is an acronym for: B 'blodtryck' (systolic blood pressure), A 'andnings frekvens' (respiratory rate) and S 'saturation' (oxygen saturation)) as a TTS which, according to hospital policy, should be measured and documented on admission and at least once per day. Thus, it might be expected that the BAS parameters of systolic blood pressure, respiratory rate and oxygen saturation would have been documented at least once per day, but the results from Chapter 4 showed that they were not. A possible reason for this was that, although BAS had been implemented at the hospital in 2007, since then there had not been any further in-service education on it.

There were also indications from the researcher's experience of collecting the data, that the design of this system meant that it was awkward to use, not intuitive, and increased the

workload of staff. Thus, the EHR did not appear to be user-friendly and made documentation of vital signs challenging. This may have deterred staff from documenting the vital signs, even if they had been measured. Furthermore, because of these possible usability issues, there were no apparent means of viewing a patient's clinical status effectively or efficiently. Thus, the study suggested that the EHR could impede the identification of clinical deterioration because of the difficulty in accessing essential patient data required when making life-saving decisions.

For these reasons, further research was required to identify the reasons for lack of documentation. A qualitative study was therefore planned to investigate why documentation was incomplete and why it was dispersed throughout the three sections of the EHR. The answers to these questions could contribute to the body of knowledge about documentation of vital signs in the EHR, inform the development of EHRs, and provide practical suggestions for improving patient monitoring. The outcomes could support medical and nursing staff in their work and improve patient safety.

This chapter presents the research process used in phase two of this research, which aimed to develop a better understanding of how staff recorded vital signs. The introductory section is followed by the research questions in 5.2. Section 5.3 presents the research methods and describes the study design, research setting, and sampling and recruitment. In 5.4, the data collection and analysis of both an observational study and an interview study are described. Section 5.5 presents the findings of these studies. A summary of the key findings is presented in 5.6.

5.2 Aim and research questions

The aim of this study was to investigate how medical and nursing staff measure, report and retrieve vital signs. The research questions were:

1. What are the routines for measuring vital signs - when, which, why and how often?
2. What are the routines/procedures within the workflow that medical and nursing staff use to document vital signs?
3. What are the routines/procedures within the workflow that medical and nursing staff use to retrieve information on vital signs?
4. How do medical and nursing staff experience incorporating the EHR into their workflow when documenting vital signs and reviewing patient status?

5. To what extent does the EHR support documentation of vital signs?

5.3 Research methods

This section presents details of the qualitative research. It begins by describing the study design, the research setting, and sampling and recruitment.

5.3.1 Study design

As mentioned in Section 5.1, the quantitative study described in Chapter 4 had identified a lack of documentation of vital signs in the EHR and further research was required to identify and explain the reasons for these gaps in documentation. To find these reasons and explanations, deeper, richer and more complex meanings needed to be explored. A qualitative approach is the most appropriate for this type of investigation and was selected as the second phase in this mixed methods research to get a more complete picture of problems associated with documenting vital signs in the EHR. As noted in Chapter 3, a case study strategy was used to encompass both phases of the entire research on documentation of vital signs in an EHR system in one hospital. The key reason for adopting a case study strategy was to contain the case within the boundaries of one site, that is, the study hospital, and to one EHR system, the one used within the study hospital. Case study method is discussed in Chapter 3, section 3.2.

5.3.1.1 Research setting

The research setting for the case study was a district general hospital in the South-East of Sweden with 372 beds. The following four separate clinical settings were included in the current study for the reasons explained below: one acute medical (the cardiology department), one acute surgical ward, an infection ward and an emergency department (ED). The cardiology department consisted of two wards (28 bed), a high dependency unit (HDU) (6 bed) and a cardiac intensive care unit (CICU) (6 bed). The surgical ward had 28 beds and the infection ward had 18 beds. The ED treated approximately 35,000 patients per year (Kalmar County Council, 2015).

Research settings are selected in relation to providing appropriate data to answer the research questions. In addition, the researcher must be able to gain access to the research setting (Punch 2007). In the phase one study, records from all parts of the hospital in

which a cardiac arrest had occurred between 2007 and 2011 were included in the study. Initially, for this next study, only one clinical area was to be included in the qualitative study: the cardiology department. This department had been chosen for three main reasons. First, cardiac arrest most frequently occurs in cardiac patients; therefore, it made sense to observe and interview staff from the cardiology department to examine their work processes for measuring and documenting vital signs in patients at risk of cardiac arrest. Secondly, research for the first phase of the case study was based there and a working relationship had already been established with the personnel. This meant that staff were potentially accessible for recruitment as respondents and could provide a suitable sample (Punch, 2014). Thirdly, the department provided a variety of levels of care, i.e., both general and intensive and it had been reasoned when planning the study that both general and intensive care levels should be included in the study as both areas used an EHR for documenting vital signs, and the documentation of vital signs was the main concept of the research. In the early stages of planning the study, therefore, only the cardiology department had been selected as a setting.

However, in qualitative research it is not always possible to make final decisions on sampling in advance. Mason suggested that "it is useful to see qualitative sampling as an organic practice, in the sense that it is something which grows and develops through the research process" (2002, p. 127). There were several reasons for extending the research to additional clinical areas at the hospital. First, it was contemplated that a wider range of data would be desirable in order to 'reach theory-saturation point' (Mason, 2002, p. 134). Second, it was already known that different clinical areas had different practices (Stevenson & Nilsson, 2012) suggesting that sampling from more than one setting would provide more comprehensive data. Third, the ethics committee, whilst approving the study, also suggested that more than five interviews might be desirable. For these reasons, a decision was made to include at least three clinical areas and, finally, a total of four settings were attained for the study.

As stated above, contact with the cardiology department was well-established as the first study had been carried out there. However, such relationships did not exist in other parts of the hospital, so the decision to recruit participants from additional clinical settings required new contacts to be made. Contact and recruitment from the additional clinical areas came about in a rather fortuitous way. A seminar was held at the hospital to present the results of the phase one study and this was attended by staff from throughout the hospital. During discussions at the seminar a great deal of interest for the research was

stimulated. As a result, new contacts were established in other parts of the hospital which were useful for recruiting new clinical areas.

Negotiation with the relevant gatekeepers is essential in order to gain access to research settings (Mason, 2002). Meetings were held with the relevant gatekeepers of the additional clinical settings, during which information about the study was provided. The managers from these areas subsequently gave their written consent to the study to take place there (Appendix IVc, IVd).

Ethical approval

Before conducting the study, ethical approval was sought and received from the Central Ethical Review Board, Linköping, Sweden (Section 3.7). The documents concerning ethical approval can be viewed with English translations in Appendix III. These concern both the original ethical approval documents as well as those related to the inclusion of additional clinical areas. The managers were given written information about the study and asked to give their written consent by signing a consent form. These documents can be viewed in Appendix IV. Nursing staff were informed about the study at staff meetings or at shift changeover when many of the staff were assembled at one time. Potential participants, including doctors, were given written information sheets about the study. A copy of this document, as well as an English translation is available in Appendix IVe and IVf. The nurses and doctors who volunteered only gave their verbal consent to participate in the study. Written consent was not requested. At the time, as it was reasoned that they were well-informed about their participation and agreed to partake in observations and/or an interview. Moreover, they were assured that they could withdraw from the observation or interview at any time. They were also informed that there anonymity was protected and that their anonymity was guaranteed by removing any identifying features from observational protocols and interview transcripts.

5.3.2 Sampling and recruitment

Once the settings had been identified, and ethics approval had been obtained (see section 5.3.1), the next stage was to recruit potential respondents for the study. The phase one study had been carried out in the cardiology department so the researcher was already known among the nursing staff there, thus, recruiting participants was relatively straightforward. The nurses were informed about the study at a staff meeting. The findings

of the previous study were outlined and information given about how this study would provide a deeper understanding of complex material, and how ultimately it was hoped that this study could lead to easing workload for the staff and improving patient safety. Nursing staff were invited to take part in the study, by verbally asking for volunteers at the end of the meeting. Several nurses volunteered immediately and others approached the researcher individually on the days and weeks in which the researcher was carrying out observations in the cardiology department. During observation sessions, the researcher had the opportunity to recruit further volunteers to be interviewed. In this way, participants in the first setting were identified and recruited. The process of recruiting personnel for the observations and interviews can be described as a purposeful, convenience sample with some snowballing. The logic of purposeful sampling is that it provides information-rich data (Patton, 2002). Convenience sampling means that researchers use samples that are easily accessible (Punch, 2014). Snowball sampling is a means of finding further participants by asking recruited participants to suggest others who may be interested in participating in the study (Punch, 2014). Details of sampling methods are described in Section 3.6.

The remaining three clinical areas were also informed about the study at staff meetings. Managers suggested nurses who might be available for observations and they agreed to take part in the study; therefore, recruitment for observations was from a convenience sample. During observations, possible interview candidates were identified and approached by the researcher. In this way, snowballing was used to recruit interviewees.

5.4 Methods of data collection and data analysis

The data collection for the study was carried out using two separate but linked methods: an observational study and an interview study. As described in section 3.5.2, an observational study can be a rich source of information as it enables the researcher to capture what people do rather than what they say they do (Wisker, 2001). An interview study is an appropriate method for collecting data about people's perceptions, values and how they experience their reality (Punch, 2014) p168. There was some overlap between these two methods when observing in the field as it was sometimes necessary to ask questions in relation to observations on the spot. For example, the researcher might observe an action which she did not fully understand and therefore could ask an opportunistic question in order to find out the reason behind such an action. This is a means of generating data, i.e.,

first observing and then asking questions in direct relation to the action. This is known as opportunistic interviews (as explained in Section 3.5.2).

5.4.1 Recruitment methods for observational study

In preparation for carrying out the observations, a data collection tool was designed: an observation protocol (Appendix Va). The protocol was designed to gather information on all aspects of measuring, documenting and retrieving vital signs, and to generate both descriptive and reflective data. In addition to planning data collecting, a critical aspect of preparation was to ensure that the researcher was accepted by the participants who would be observed, so time was spent in establishing good relationships, and social interactions were carefully developed. This involved arranging a time and place to meet the participants, explaining the purpose of the study carefully and giving the participants an opportunity to ask questions. Before observations began, participants were asked to read the information about the study on a prepared document (Appendix IVe). The participants were informed that they could discontinue the observation at any time without giving any explanation. This process helped nursing staff to avoid feeling coerced into taking part, and that they could withdraw, if they knew it could be stopped at any time.

5.4.2 Pilot study for observational data

A pilot study was carried out during a one-day visit to the first clinical area, the cardiology ward. The aim of the pilot study was to test the data collection instrument, (the observation protocol, Appendix Va), and for the researcher to become familiar with the "research environment".

The findings of the pilot study to test the data collection tool were very useful for several reasons. To begin with, due to the complexity of the ward situation and the *ad hoc* manner in which events unfolded, it was found that having a strict protocol for data collection was not practical and therefore the instrument was abandoned in favour of taking field notes freely on a note pad. Nevertheless, preparing the instrument in detail was valuable as it clarified what should be observed, the data that should be collected and the understanding that could be gained from the observations. Mason (2002) argued that it can be difficult to decide what to observe and that doing observations can feel unfocused and vague. This study, however, did not present this problem; it was clear that the focus should be on all aspects of vital signs and thus it was relatively easy to apply the appropriate focus (Mason,

2002). Moreover, the one-day pilot study ensured that the researcher became familiar with the research setting and was well prepared for the main part of the data collection.

5.4.3 Process of data collection for observational study

As discussed in Chapter 3, the researcher took the role of participant observer. To help blend into the busy ward setting a nurse uniform was worn, as the researcher is a qualified nurse as well. The effect of dressing similarly helped the researcher to fit into the setting; the health care professionals then rather naturally treated the researcher as 'one of them'. In addition, the researcher not only looked like a nurse, but participated by helping staff with small tasks, e.g., making beds, fetching patients' food, removing an intravenous cannula and ECG leads, taking laundry to the sluice and recording patients' vital signs. These small actions created valuable opportunities for establishing a rapport with the nursing staff. This promoted the ready sharing of information.

Data collection was carried out by observing nurses carrying out their normal duties with particular focus on all activities and actions related to vital signs. Opportunistic interviews were conducted, as appropriate, in quieter moments to ensure that workflow was not interrupted, to clarify points and to develop a better understanding of the salient issues.

During observations, data were recorded in field notes on an A4 note pad and after each observation session field notes were immediately written up on a word processor in Microsoft Word (MS Word) files, where further reflections and interpretations were added. Field notes can be defined as the raw data, which are gradually built up into a data set (Mason, 2002). In each clinical setting, observations were undertaken until data saturation was reached.

5.4.4 Analysis of observational data

The phase one study had described how, what and where vital signs were presented in the EHR. The phase two study aimed to find out why the vital signs were presented the way that they were. Specifically, the aim of the analysis was to obtain a deeper understanding of the documentation of vital signs in EHRs. The first data set to be analysed was the field notes from the observational study. For this analysis, an inductive approach (Elo & Kyngäs, 2008) was selected as this would promote coding of all aspects of the data and explore in greater detail how and why information about vital signs was documented in the EHR.

The following sub-section provides a detailed description of the data analysis. It is described in five stages, partly drawn from Braun and Clarke (2006) and influenced by Graneheim and Lundman (2004) (Section 3.8.4). However, some additional steps were included to create a method of analysis that was transparent and well-organised. Altogether, there were twelve observation occasions across the four clinical areas: five within cardiology ward, four within the ED, two within infection and one within surgical. The data from each of the clinical areas were analysed separately in stages 1-4. In stage 5, the data were collated and refined to include three main themes. When there are two data sets, i.e., one data set from the observational study and one from the semi-structured interviews, stage 6 is the point at which the analysis of both data sets should converge (Braun and Clark, 2006). The first five stages in the analysis of the first data set, the observational data, are described below. The analysis process began by organising the data.

Stage 1 Data familiarisation

The first step in analysis was to become familiar with the data, to immerse in the data and become acquainted with all its aspects and nuances. A benefit was that the researcher had been actively involved in the collection and generation of the data, and thus already had a good knowledge of the data. This meant that some analytical thoughts about the data had already developed. Each of the field notes were read through to obtain a sense of the whole and an initial search for meanings and patterns was performed.

Stage 2 Generating initial codes

During subsequent readings, the data were coded. This involved writing codes in the margins of the field notes collected during observations to generate initial codes (Braun & Clarke, 2006). In Braun and Clarke's description of thematic analysis, coding involves 'generating an initial list of ideas about what is in the data' (Braun & Clarke, 2006, p. 18). Coding identifies features of interest to the analyst that can be assessed in a meaningful way, and organises data into meaningful groups. Using this method, the researcher used a pen to bracket off segments of text that were meaningful, thus deriving 'meaning units' (Graneheim & Lundman, 2004). Each meaning unit was then given a code, e.g., 'verbal reporting', 'use of paper'. Braun and Clarke (2006) recommended coding for as many potential themes/patterns as possible, being careful to include enough of the surrounding data so as not to lose context. In this way, all of the text in the data set was coded.

Stage 3 Identifying themes

In this stage, a decision was made to use a matrix, in accordance with Granheim and Lundman (2004), to ensure that meaning units were systematically analysed. Following the initial coding, the observational field notes were scrutinised again and all the identified meaning units were transferred to a matrix. An example of the matrix can be seen in Figure 5.1.

Meaning unit	**Condensed meaning unit and description close to the text**	**Condensed meaning unit and interpretation if underlying meaning**	**Sub-theme**	**Theme**
Nurse writes VS in her notebook after each patient checked	Writes VS in notebook	Using paper instead of EHR	Documentation on paper in notebook	Documentation
Nurse takes the VS: T,P, BP and SaO_2 of the other patient in this room	Takes vital signs- T,P, BP and SaO_2	Selecting which vital signs taken according to routine or individual patient needs	Clinical judgement	Measurement

Note: VS= vital signs; T=temperature; P=pulse; BP=blood pressure; SaO_2= oxygen saturation

Figure 5.1 Examples of meaning units, condensed meaning units, categories and themes

Meaning units were condensed to give a description close to the observational text. This description was semantic. The next step was to interpret the semantic description of the condensed meaning units to assign, where possible, an underlying meaning, and thus a latent description or interpretation. Both the descriptive and interpretive meaning units were then viewed as a whole and abstracted into sub-themes and themes (Graneheim & Lundman, 2004). This was done chronologically for all data for each of the observation sessions. As some initial codes might become main themes (Braun & Clarke, 2006), initial

codes from the margins were then systematically cross-checked with the derived sub-themes and themes. In this way it was possible to ensure that all data had been categorised. Comparing initial codes with the derived themes also gave the opportunity to reflect over the interpretations and to assess whether appropriate themes had been assigned; this, therefore, provided a means of double-checking the codes and interpretations.

Stage 4 Reviewing and naming themes

The aim of this phase was to review the data again and name the themes. As Braun and Clarke's description of this phase was vague, some logical steps were added. First, the themes and sub-themes were transferred to a fresh matrix for each of the four clinical areas. The themes were then checked and adjusted so that, for example, the same words were used to describe duplicate themes and so that themes that were very similar could be merged and re-named if necessary. Second, mind-mapping software, Inspiration® Version 9.0, was used to map out themes and sub-themes. Descriptions from the meaning units, condensed meanings and interpretations were added to the mind-map to exemplify the sub-themes. If data were the result of opportunistic questions or information volunteered by the person being observed, an asterisk (*) was added to show that this information was at a higher, or interpretive, level (Mason, 2002; Punch, 2014). Similarly, reflections by the researcher were added as a 'note' or marked with two asterisks (**) to the appropriate observation. In this way, both literal and interpretive data were illustrated on the mind map. Creating a mind map with derived themes and sub-themes, and adding the details from the initial matrix provided the opportunity to go through all of the data again. Thus, the researcher was highly familiar with the data and had had many chances to identify relationships within the data. Third, a MS Word document consisting of numbered lists was created from the 'Inspiration' mind map giving a comprehensive view of the data. The next stage was to review and refine the themes and to ensure that the data within the themes corresponded in a meaningful way.

Stage 5 Collating and refining themes

In this phase, the Inspiration documents from each of the four clinical areas were collated onto a single MS Word document. When collated, it could be seen that ED and the Infection ward each had the same five themes: documentation in EPR; measuring vital signs; documentation on paper; verbal communication; and clinical decision making. The cardiology department had the same themes, with one additional theme, i.e., usability. On

further examination of the data, the analysis was refined to include three main themes: measuring vital signs, documenting vital signs and verbal reporting.

In summary, the method for organising the data from the observational study was one of thematic analysis. The analysis of the data from the observations adopted an inductive approach, in which themes emerged from the data. These were used to inform the questions and themes for the semi-structured interview study. The interview study is described in the following sub-section.

5.4.5 Methods for interview study

This section describes methods used in the interview study, beginning with methods of data collection followed by methods of analysis. The observational study was conducted and analysed prior to conducting the interviews. The themes for the interview study were pre-determined from the analysis of the observational study. This meant that the interview study was carried out using a deductive approach, as it used the themes already identified in the observational study (described in Sections 5.4.1-5.4.4). A deductive approach moves from general to specific and is based on former knowledge (Elo & Kyngäs, 2008) (Section 3.8.2). The first two themes were 'measuring vital signs' and 'documenting vital signs', the same as two of the themes which emerged in the observational study. The third theme from the observational study was 'verbal reporting'. However, at this stage a decision was made to change 'verbal reporting' to 'retrieving vital signs' because, although verbal reporting had emerged as a theme in the observational study, a more general theme, 'retrieval of vital signs' would be preferential to use in the interview guide so as not to 'lead' the interviewee, and to make it possible for more varied answers. In other words, this more general theme would promote finding out about all forms of retrieving information on vital signs, not just relating to the EHR.

An interview guide was designed based on the analysis of the observational study. Semi-structured questions were related to the three main themes: measurement, documentation and retrieval of vital signs in the EHR. In addition, there were semi-structured questions to try to ascertain staff attitudes towards vital signs in general. There was one open-ended question about general views on using the EHR. At the beginning of the interview, the interviewees were asked to give some demographic and background information about themselves. Copies of the interview guide are included in Appendix Vb and Vc.

5.4.6 Pilot study for interview data

The first interview was used as a pilot study and revealed that the questions should be sequenced differently to ensure that the semi-structured questions were answered first. More specifically, when the open-ended general question was posed at the beginning of the interview, it produced very diverse answers and some of the semi-structured questions were answered spontaneously. This made the interview very unstructured, difficult to transcribe and complicated to analyse. Thus, this question was moved to the end of the interview guide.

5.4.7 Process of interview data collection

Prior to the interviews, participants were given the information sheet to read (Appendix IVe) so that they were aware of their rights and were informed regarding the purpose of the study. Descriptions of the interview were given and, with their permission, their voices would be recorded. They were assured that all content related to the interviews would be kept confidential, and their names and any potentially identifying information would be anonymised.

The interviews were conducted in quiet rooms in each of the clinical settings where interruption was unlikely. However, as the interviews took place within normal working hours, colleagues were made aware of where the interviewees could be found in case of any urgent incidents, in which case they could discontinue the interview without further ado. Fortunately, this did not happen during any of the interviews.

Data were collected using an audio recorder during the semi-structured interviews. An informal, flexible approach was used and the interviewer adapted the order of questions as necessary, for example, if a question from later in the interview guide was answered prematurely. Prompt questions were posed as required to maximise the quantity and quality of the data that were collected. In each clinical setting, interviews were undertaken until data saturation was reached.

5.4.8 Method of analysis of interview study

A similar method of analysis was used for organising the data from the semi-structured interviews as was used in the observational data. This is described below. To begin with, there is a description of how interviews were translated and transcribed.

Interviews were conducted in Swedish by the researcher and data were collected using digital audio recording equipment: a Dictaphone with built in microphone. Digital files were transferred to a computer and a foot-pedal controlled transcription machine with headphones was utilised for transcription.

Transcriptions of the interviews were undertaken as soon as possible after the actual interview. The first interview was transcribed verbatim in Swedish. The document was then translated into English. However, the researcher found that translating a written text seemed soulless, inexpressive, and non-dynamic and felt that some of the deeper meaning was missing when the voice could not be heard. Therefore, an experiment with the second transcription was carried out by listening to the dynamic Swedish recording of the interview, translating it mentally into English and typing the transcription directly in English. This provided a richer more accurate translation, as it was easier to grasp the context and meaning of the spoken word. The result was a transcription that provided a more accurate and a truer account of the interview.

To validate this technique, the first interview was re-transcribed using the latter method. The results were very similar, occasionally different vocabulary was chosen but, in essence, the latter form of transcription produced the same result as the former. Therefore, as the latter method was less time-consuming and felt overall to be more satisfactory, it was selected as the method of translation/transcription and subsequent transcriptions were translated directly from Swedish to English during transcription. Some parts of the interviews had to be listened to several times to ensure that translation was as close to the original recording as possible in meaning. After each transcription, the researcher listened again to the interview whilst at the same time reviewing the script to check for any inaccuracies and make any final changes. Whilst this was time-consuming, this was felt to be the most appropriate way to develop a true account of the interview in English, prior to analysis.

5.4.9 Analysis of interview data

As there were pre-determined themes, the analysis of the interview data was carried out using a deductive approach. In deductive data analysis, themes are already established and data can be analysed under each of the themes (Elo & Kyngäs, 2008). However, the data still needed to be organised. To accomplish this, the interviews were coded in a similar manner to the observational data. This entailed going through all of the interview data and coding everything that was relevant. Meaning units were identified and condensed. These

were then interpreted and categories and sub-categories were identified in the coded data. From there, rich data, in the form of notes and interview excerpts, were identified to illustrate the themes. Typically, in qualitative analysis, the process involved working back and forth through the data to ensure all aspects of the relevant data were described, i.e., it was an iterative process (Graneheim & Lundman, 2004).

As mentioned in section 5.4.4, stage 6 of thematic analysis is the point at which analysis for both data sets converge. All of the data from the observational study and interview study had been organised into themes, and an important decision had to be made as to whether to combine the data sets as one corpus. In other words, should the themes from the observational studies be combined with the themes from the interviews or should the data be organised in the order in which it was collected, i.e., chronologically. Holliday (2002) suggested that it may be advantageous to show the two separate stages of data collection and analysis as this is an example of progressive focusing (Holliday, 2002).

However, describing the data in two separate stages was not successful as it was found that the information was similar and risked sounding repetitive. Therefore, the former method was chosen whereby the data sets were combined to make one corpus and were presented as themes. Combining the data from the observational analysis and the interview analysis was carried out systematically for each of the four clinical areas. To illustrate how this was done, an example of how the cardiology data was combined is outlined. The mind map from the observational analysis from cardiology was copied onto a sheet of A3 paper. The cardiology observations mind-map was then used as the framework on which the interview analysis from cardiology was superimposed. This allowed the themes from the observational studies and interview studies to be combined.

Throughout further analysis, data from the field notes of the observational study and interview transcripts were used to corroborate one another. Each clinical area was presented separately as it was noted that there were quite different practices from one area to another.

In summary, the analysis of the observations was based on an inductive approach and the analysis of the interviews was carried out using a deductive approach from the three themes, measuring vital signs, documenting vital signs and retrieval of vital signs. The observational data set was combined with the interview data set from each of the clinical areas.

Credibility and trustworthiness of the qualitative data

As noted in Chapter 3, quality in qualitative research is assessed in terms of credibility, dependability and reliability. Triangulation, member checking and 'thick' description were the strategies employed in this research, to verify the validity of the qualitative data. A discussion about credibility and trustworthiness of the qualitative data and findings is provided in Section 6.4.2.

5.5 Findings

This section begins with a description of the characteristics of the sample (Section 5.5.1). Next, there is a presentation of the findings of the study which is written in four parts: cardiology, emergency department, infection ward and surgical ward, i.e., one for each clinical area (5.5.2-5.5.5). As the practices varied from one clinical area to another, presenting the findings separately provides a more comprehensive account of each. In the presentation of the findings, brief reflections are offered in regard to some of the issues as they arise. This is followed by a summary of the key findings. A comprehensive analysis and discussion are available in Chapter 6, in which both phases of the research are interpreted.

5.5.1 Sample characteristics

In this qualitative study, a total of 68 hours of observations were carried out and 14 interviews were undertaken. Observation times varied between 2-9 hours. Interview times varied between 10-35 minutes with a mean of 18 minutes 46 seconds. The data collection from each of the clinical areas was not evenly distributed. The largest data set was from cardiology and the second largest was from the ED. The smallest data sets were from infection and surgery where the data volume was fairly equally distributed. There were several reasons for these differences. To begin with, cardiology had the largest data set but was also the largest clinical area, therefore accounting somewhat for the larger volume of data. It included a CICU, an HDU and two wards. Furthermore, the researcher was familiar with this clinical area and the staff, and this meant that there was a willing list of volunteers in this setting. Additionally, this was the first clinical area in which data collection took place. In the early stages of data collection there was a great deal of new information about how the electronic records worked and how data could be entered and retrieved. To ensure accurate data collection, the researcher required a good understanding of these concepts. Thus, many hours of observation were required to ensure that the

system was fully understood. The second clinical area from which the second largest data set was collected was the ED. Although the researcher arrived with a good knowledge of the EHR, an additional documentation system was in use there, which had to be observed and understood. The final two clinical areas for data collection took a relatively short amount of time as the EHR in these areas was used in a similar way to that of the cardiology unit. Consequently, the researcher was familiar with the system and could quickly attain the information needed on vital signs. The distribution of the observations and interviews are represented in Tables 5.1 and 5.2.

Table 5.1 Distribution of observation time spent in each setting

Field study session	Setting	Hours	Total hours
1	Cardiology	5	
2	Cardiology	9	
3	Cardiology	4	
4	Cardiology	8	
5	Cardiology	6	32
6	ED	4	
7	ED	6	
8	ED	5	
9	ED	3	18
10	Infection	8	
11	Infection	2	10
12	Surgical	8	8
Total: 12			Total: 68 hours

Table 5.2 Record of interviews in each setting

Interview	Setting	Minutes and seconds
1	Cardiology nurse	22.45
2	Cardiology nurse	18.41
3	Cardiology nurse	13.09
4	Cardiology nurse	18.58
5	Cardiology nurse	28.05
6	Cardiology nurse	21.50
7	Cardiology doctor	20.00
8	Cardiology consultant	10.45
9	ED nurse	13.40
10	ED nurse	35.00
11	Infection nurse	10.40
12	Infection nurse	17.23
13	Infection doctor	4.57
14	Surgical nurse	25.36
Total: 14		Total: 261 minutes 29 seconds Mean: 18 minutes 46 seconds

5.5.2 Findings: Cardiology

Thirty-two hours of observation and eight interviews were carried out in the cardiology department. The results of the analysis of data from observations and interviews in the cardiology unit were merged and are presented in the following section according to the three main themes: measuring vital signs; documenting vital signs; and retrieval of vital signs. These themes are broken down to categories and sub-categories for presentation of the results. An outline of this is given in Figure 5.2.

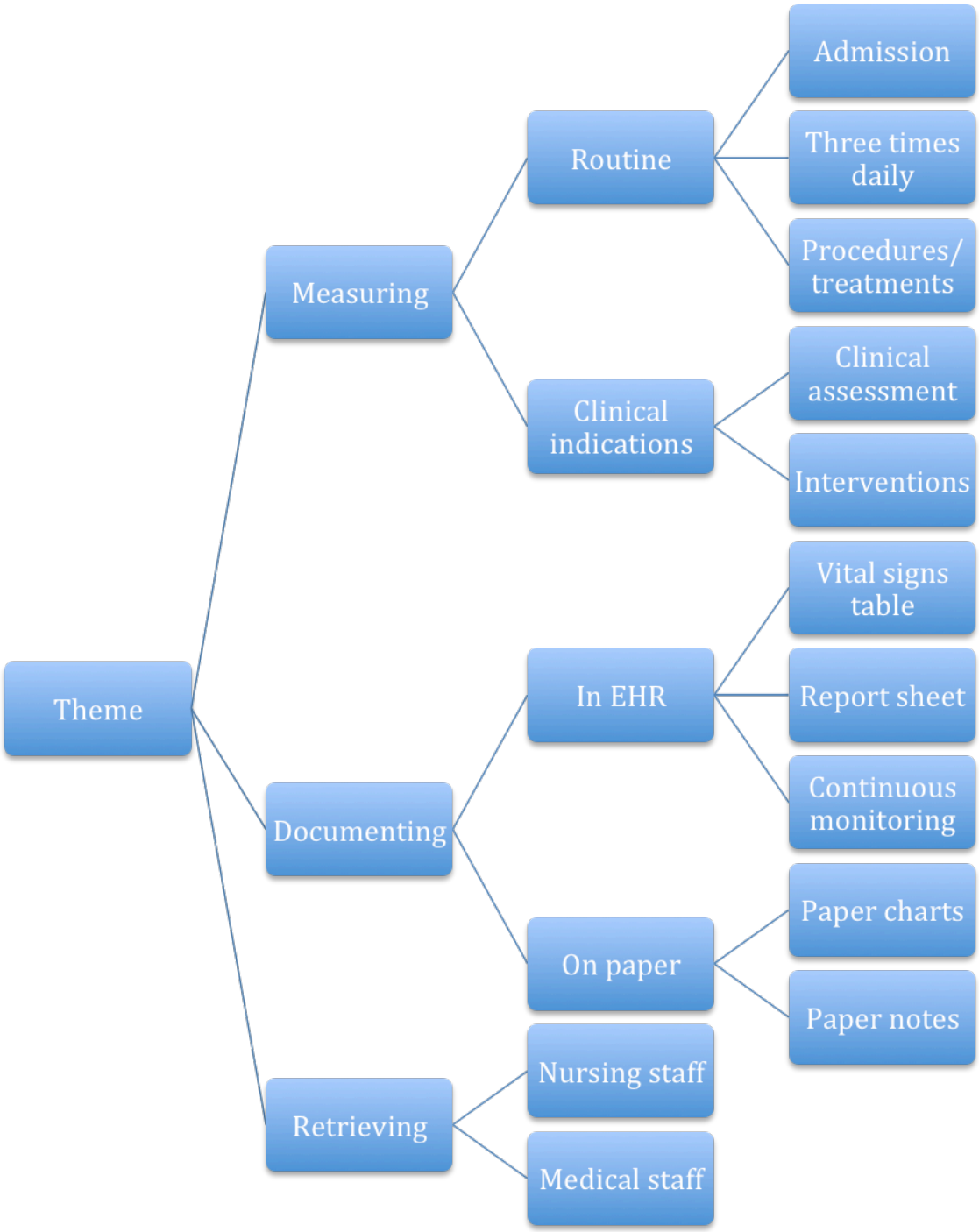


Figure 5.2 Analysis Cardiology Unit: themes, categories and subcategories

Theme 1: Measuring vital signs

This theme describes the various aspects of measuring vital signs. It is divided into two categories 'Routine recordings' and 'Clinical indications'.

Category 1. Routine recordings

Routine recordings of vital signs had three sub-categories: admission, three times daily recordings and following procedures or treatments.

Sub-category 1. On admission

Vital signs were always recorded when a new patient was admitted. Most nurses agreed that vital signs recorded on admission included BAS (see Table 4.2 and section 4.3.4.4), i.e., blood pressure (BP), respiratory rate and oxygen saturation, with the addition of pulse and temperature.

> *"It varies a little but when the patient arrives I do a BAS check, as I want to have a broad understanding about the patient. I take the blood pressure, pulse, respiratory rate, saturation and temp." (Interview 3. Nurse)*
>
> *"Every time you get a new patient you check them [the vital signs]." (Interview 3. Nurse)*
>
> *"We take BAS signs when patients arrive from the ED, then we should do a new BAS check with blood pressure, pulse, saturation, temp, respiratory rate - respiratory rate is what I am most careless with." (Interview 6. Nurse)*

A cardiology consultant said that with an emergency admission he wanted to know,

> *"Blood pressure, heart rate, saturation, respiratory rate, yes, respiratory rate is something that I assess in the patient myself rather quickly, to see if it is affected." (Interview 7. Doctor)*

An observation describes that, on admission to the CICU, patients had vital signs checked when the patient was attached to the electrocardiograph (ECG) monitor, as shown by this field note.

> *CICU (evening shift Nurse): A new patient is admitted. Patient is connected to ECG monitor. The BP cuff is attached and to measure the BP a button is pressed. The BP is then displayed on the monitor. The pulse is displayed continuously on the monitor. The oxygen saturation sensor is attached to the patient's index finger and this is measured continuously. The ECG monitor also measures the respiratory rate. (Field note 3)*

These examples indicate that there were standard vital sign recordings that should be taken on admission, although one nurse indicated that she perhaps did not record the respiratory rate every time. The lack of respiratory rate recordings in the phase one study (section 4.6.4.1) indicates that respiratory rate may have often been overlooked.

Sub-category 2: Three times daily

During the observation study, it was noted that vital signs were taken routinely three times per day: at the end of the night shift, i.e., at 0600, during the day shift, i.e., at 1400, and in the evening, i.e., 2000. This was confirmed when nurses were interviewed.

> *"The routine is to measure three times a day, morning, afternoon and evening". (Interview 2. Nurse)*
>
> *"It is mostly at 06.00, 14.00 and 20.00 hrs." (Interview 5. Nurse)*

Thus, there was consensus regarding the times for routine recordings of vital signs. However, during interviews it was noted that there was considerable variation in which vital signs were recorded at those routine times. Most nurses agreed that in cardiology, BP and pulse were the most frequently recorded, with oxygen saturation also often recorded. Four more nurses made almost identical statements to this one:

> *"It's blood pressure, pulse, saturation. It's always blood pressure and pulse as a routine, you could say." (Interview 2. Nurse)*

Nurses also decided which vital signs should be measured according to the type of patients they were caring for. The following quotes indicate some of the judgements nurses made regarding the vital signs that should be measured.

> *"If the patient has not had difficulty with breathing then maybe I don't check saturation so often as blood pressure and pulse and temp. If I see that it is a very stable patient, without any breathing problems, then I probably don't measure the respiratory rate. " (Interview 5. Nurse)*
>
> *"Temp, maybe I don't check either if there isn't any indication to check it". (Interview 5. Nurse)*

Researcher with Nurse, Interview 1: "Do you measure respiratory rate?"

> *Nurse: "I'm bad at that. Now we have new monitors in CICU - when they're connected, you see respiratory frequency on a monitor, but otherwise, I'm really bad at this I would say." (Interview 1. Nurse)*

These interview excerpts display a wide range of views regarding which vital signs would be recorded routinely. Most nurses thought that blood pressure and pulse were most important, with saturation being the next preferred. Unless there were special indications to check respiratory rate or temperature, these were often not checked. Although there was a routine to measure vital signs three times daily, these rarely included the 'full sets' of vital signs identified in the literature and which are recommended to be monitored at least twice daily (De Vita 2010). In the phase one study, respiratory rate was rarely documented and the results of this qualitative study suggest that nurses did not consider that respiratory rate needed to be measured routinely. As respiratory rate is the vital sign that gives the earliest

indication of deterioration (Schein et al., 1990), it could be beneficial to always include this in routine vital sign measurements.

Sub-category 3: Following procedures or treatments

There were also routines for recording patients' vital signs after some procedures, such as cardio-angiography. During observations it was noted that when a patient had a cardio-angiogram, vital signs were routinely measured frequently. The following field note describes frequent observations when the introducer [2] in the groin was removed.

> *(HDU) (Day shift. Nurse): The introducer is removed and pressure applied to the groin site. BP and pulse are checked frequently, every 5, 10 and 15 minutes then half hourly. (Field note 4)*

Another reason for measuring vital signs routinely was if a patient had commenced a new medication. For example:

> *"If a patient is started on a blood pressure medication, then there can also be more frequent recordings - every other hour on certain patients."(Interview 5. Nurse)*

These are considered routine recordings as they are always required when patients have certain procedures or treatments. The 'documentation' theme describes how there were special paper charts for these occasions (Appendix VIa).

Category 2. Clinical indications

During the observational study, it became apparent that many decisions regarding which vital signs should be taken and when, were directly related to clinical decisions taken by individual nurses. Furthermore, interventions were often initiated in direct relation to nurses' clinical assessments. Thus, this section has two sub-categories: clinical assessment and interventions. These are described below.

Sub-category 1. Clinical assessment

There were several examples of clinical assessment. The first is of a nurse who explained that she would check vital signs if a patient became poorly as described in the following field note:

> *Cardiology ward (Day shift. Nurse): One nurse volunteered the following information. "We would take vital signs if a patient became poorly. Then we measure temperature, pulse and blood pressure, and oxygen saturation - those four. Sometimes we measure respiratory rate if a patient is breathless." (Field note 1)*

[2] A short hollow tube that is inserted through the skin and into an artery for insertion of cardiovascular catheters (Cleveland Clinic, 2015)

This was confirmed during interviews when several indications were given for vital signs to be recorded outside routine times, e.g., if a patient's condition deteriorated or was unstable, or if it was specifically ordered by a doctor, as shown in the following quotes.

> *"If you have a patient that seems unstable you take [vital signs] more often or if there are instructions from the doctor to take vital signs." (Interview: Nurse 2)*

> *"In CICU, it [measuring vital signs] can be done more often depending on which patient you have in front of you. And what illness/condition they have." (Interview 5. Nurse)*

Clearly, this indicates that the recording of vital signs is prompted or initiated by nurses noticing that a patient looks or seems unwell. Whilst this is important, it has been claimed that deteriorating patients can be captured at an earlier stage of deterioration if full sets of vital signs are measured routinely twice per day (DeVita et al., 2010).

The following section provides some specific information on attitudes towards assessing respiratory function. It was not always measured in breathless patients as can be seen in the following field note:

> *Ward (Night shift. Nurse): A patient (A) has said he feels breathless. Nurse measures temperature, pulse and blood pressure, and oxygen saturation. Oxygen therapy at one litre is commenced (Field note 2)*

At interview it was confirmed that oxygen saturation would be measured in a breathless patient.

> *"If they have difficulty in breathing, you check the saturation." (Interview 2. Nurse)*

There were several iterations regarding measuring respiratory rate:

> *"It is difficult to take if the patient is speaking." (Interview 6. Nurse)*

> *"Respiratory rate is what I am most careless with - I don't know if there is a reason why, often it's the case that you speak with the patient and then forget about respiratory rate." (Interview 6. Nurse)*

> *"I'm really bad at it, I can say. But sometimes, you kind of feel it, you can see it. Sometimes it is when you talk to a patient that they can get really out of breath, then you know that they have a higher rate even though you don't stand and count it. . . So indirectly one measures it [respiratory rate] by talking to the patient." (Interview 1. Nurse)*

This indicates that nurses were quite often aware that a patient was breathless. Indeed, in the phase one study, it was noted that breathlessness was quite frequently recorded in the report sheet of the EHR but that respiratory rate was not counted or documented as a vital sign. Due to the importance of measuring and documenting respiratory rate, it could be important to consider methods for improving the recording of this vital sign such as further education for nursing personnel as described in previous studies (Smith, 2010; and Stevenson, Israelsson, Nilsson, Petersson, & Bath, 2014, reporting results of Chapter 4).

The following section provides some specific information on attitudes towards assessing body temperature. During the observational study it was noted that not all patients had temperature recorded routinely and nurses made decisions about which patients required to have their temperature recorded as an additional recording at another time, as seen in this field note:

> *Ward (Day shift. Nurse)The nurse is going round the patients at 08.00 and administering medications. With two patients who had surgery (Intra-cardiac device (ICD) insertion) the day before, the nurse checked and documented their temperatures. She also checked and documented the BP of another patient. (Field note 1)*

The interviews revealed some specific reasons for when nurses thought that temperature should be measured rather than being taken routinely:

> *"Temperature I think you should check if there is an infection and on those who have had an operation." (Interview 4. Nurse)*
>
> *"But I maybe don't check for fever if they are not on antibiotics. Then you would check it." (Interview 6. Nurse)*
>
> *"You see by looking at a patient if they have a fever." (Interview 6. Nurse)*

From this, it can be seen that decisions about when to check temperature depended on nurses' clinical judgements. As clinical judgement obviously played an important role in assessing patients, one nurse was asked about this.

Researcher with Nurse 3: " . . . and clinical judgment - how important is that?"

> *"It is also crucially important, for if you have worked for a while, then you can see in a patient when they are poorly. I see it if a patient is poorly. I do, I see it in their skin colour, I feel it on the skin when I touch a patient, I understand with my senses, something .... to read a text is more of an intellectual job, but if you see a person, then all the senses involved as well - sight, hearing, touch. These you also use as a nurse. " (Interview 3. Nurse)*

In early warning systems 'concerned about the patient' is usually one of the criteria. Therefore, the notion of being able to know a patient's condition intuitively is acceptable (Cioffi, Conwayt, Everist, Scott, & Senior, 2009). However, current research emphasises the importance of regular checking and documenting of vital signs as well (DeVita et al., 2010; Fullerton, Price, Silvey, Brace, & Perkins, 2012).

Sub-category 2. Interventions

Vital sign recordings were often interpreted and interventions taken as a result. Nurses had the authority to make certain interventions in relation to a patient's clinical signs and symptoms. The following interview excerpts provide some examples:

> *"If there is a deviation from normal, I try to find the reason if I can correct this myself, e.g., if there is a patient who has low blood pressure because they have not drunk enough or if they*

have a high fever, then I can give paracetamol. It can also be that I start a drip if they have a low blood pressure - sodium chloride for example. So I see what I can do myself first." (Interview 3. Nurse)

"If it's low blood pressure I can tip up the foot of the bed and start a drip. I'm allowed to do this. And then I can spray nitro-glycerine spray. With certain patients there are medicines which can be given when needed (as required) that the doctor has written up for example, ' if high BP give this for example, or with a fast rate, inject Xylocaine. So that there is a plan." (Interview 2. Nurse)

The following field notes provide examples of interventions:

Cardiology ward (Day shift. Nurse): [Researcher going round with nurse administering morning medications and meeting patients] One patient (B) complains of feeling breathless. Nurse checks oxygen saturation and the result is 91%. She commences oxygen therapy at the rate of one litre. After 10 minutes, she checks the oxygen saturation again, with the result 92-93%. She increases oxygen therapy to two litres. (Field note 2)

CICU (Night shift.Nurse): A patient has a low oxygen saturation level. The nurse tells the patient that low saturation could be because the patient had taken off the oxygen mask. The patient was given Combivent via nebuliser and 8 litres oxygen. She volunteers the information that it is the nurse who checks the vital signs and decides if anything should be done, e.g., give oxygen therapy or if someone should be informed. "It is our assessment and clinical assessment of the patient's vital signs which guides the follow-up care of the patient. This is fine when the nurse is experienced but for a junior newly-registered nurse this is not so easy". (Field note 2)

These field notes indicate that the results of measurements were interpreted by the nurses and would often lead to some kind of intervention. For example, a patient whose oxygen saturation was found to be low might be commenced on oxygen therapy, or given medication through a nebuliser. However, as suggested in the field note above, less experienced nurses may not have the knowledge to take appropriate actions related to abnormal vital signs.

Theme 2. Documenting vital signs

The documentation theme had two categories: 'documentation in electronic health record (EHR)' and 'documentation on paper'.

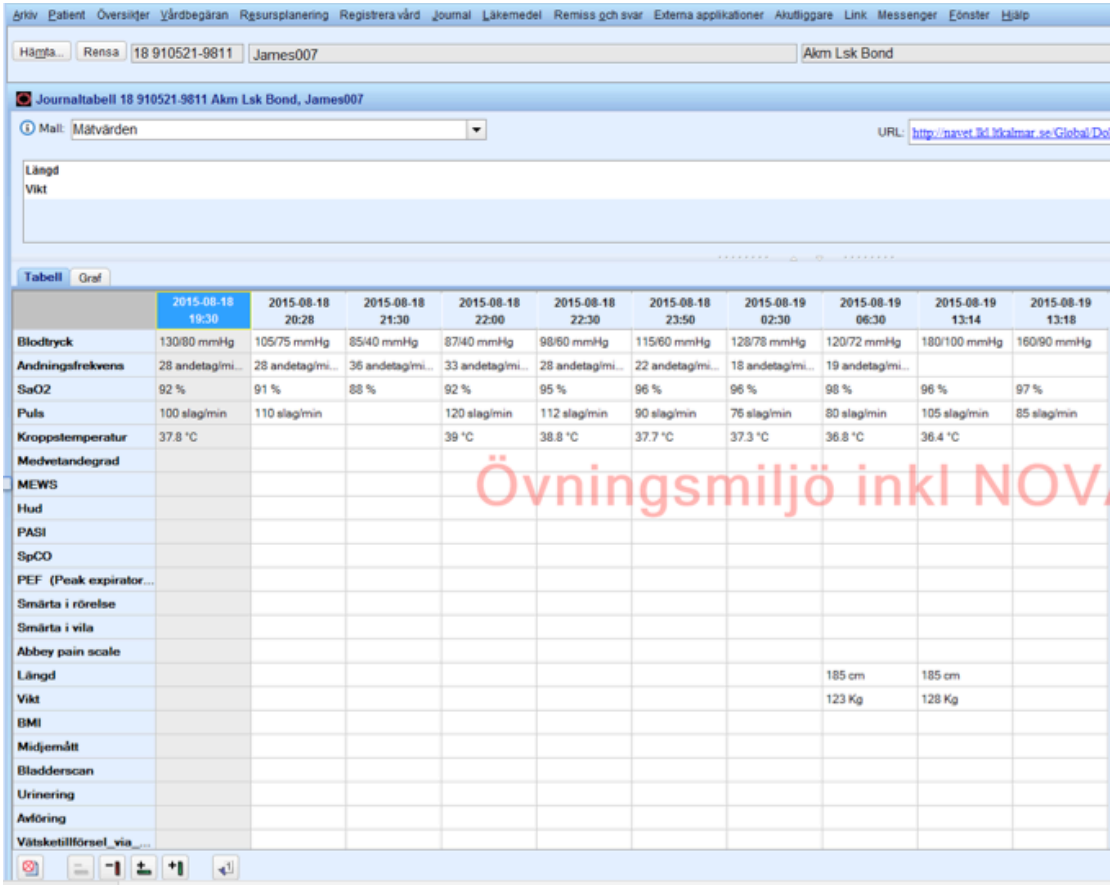
Category 1: 'Documentation in Electronic Health Record (EHR)

The EHR category was divided into three sub-categories: Vital signs table, report sheet and continuous monitoring.

Sub-category 1. Vital signs table in the EHR

The vital signs table was considered the 'correct' place for documenting vital signs, the specific part of the EHR identified for the documentation of vital signs and was widely used for all patients. However, the observation study noted usability issues in relation to

documenting in the table. Nurses documented vital signs in a table format. Each column had the date and time written at the top and the vital signs entered below. A screenshot of a table is available in figure 5.3.



	2015-08-18 19:30	2015-08-18 20:28	2015-08-18 21:30	2015-08-18 22:00	2015-08-18 22:30	2015-08-18 23:50	2015-08-19 02:30	2015-08-19 06:30	2015-08-19 13:14	2015-08-19 13:18
Blodtryck	130/80 mmHg	105/75 mmHg	85/40 mmHg	87/40 mmHg	98/60 mmHg	115/60 mmHg	128/78 mmHg	120/72 mmHg	180/100 mmHg	160/90 mmHg
Andningsfrekvens	28 andetag/mi...	28 andetag/mi...	36 andetag/mi...	33 andetag/mi...	28 andetag/mi...	22 andetag/mi...	18 andetag/mi...	19 andetag/mi...		
SaO2	92 %	91 %	88 %	92 %	95 %	96 %	96 %	98 %	96 %	97 %
Puls	100 slag/min	110 slag/min		120 slag/min	112 slag/min	90 slag/min	76 slag/min	80 slag/min	105 slag/min	85 slag/min
Kroppstemperatur	37.8 °C			39 °C	38.8 °C	37.7 °C	37.3 °C	36.8 °C	36.4 °C	
Medvetandegrad										
MEWS										
Hud										
PASI										
SpCO										
PEF (Peak expirator...										
Smärta i rörelse										
Smärta i vila										
Abbey pain scale										
Längd								185 cm	185 cm	
Vikt								123 Kg	128 Kg	
BMI										
Midjemått										
Bladderscan										
Urinering										
Avföring										
Vätsketillförsel_via_...										

Figure 5.3 Screenshot of a journal table for vital signs (N.B. a sample, not an authentic record)

The following field note describes the procedure:

> *Cardiology ward (Day shift. Nurse). To reach the location to document the vital signs in the EHR the nurse clicked on the patient's name then 'journal' from a dropdown list, in the journal there was a menu to the left hand side. Here she clicked on 'measurements'. This led to a table with a list of vital signs down the left hand side. (Field note 1)*

Nurses were in agreement that it was good to have a table specifically for vital signs but there were several usability issues for which they expressed dissatisfaction and frustration. For example, the table was not automatically available in the EHR, but had to be created for each new patient as can be seen in the statements below:

> *". . . every time you get a new patient you have to create a new one [table]. Actually, it would be better if a table were already built in [to the EHR], that there was already a table for vital signs." (Interview 1. Nurse)*

> *"You must click on 'new journal table', and then you have to click into the journal table you want, . . . and then you have to click on the vital signs you need, or what you want, you know . . ." (Interview 3. Nurse)*

As all patients in acute settings inherently require the documentation of vital signs, it could be expected that this function would have been there automatically and not require end-users to create a new one each time. Unfortunately, this type of problem can occur when designers of EHR systems have little understanding of the work processes for which they create these systems (Goorman & Berg, 2000).

When the table was created there seemed to be some unnecessary clicks in that the department had to be named each time. For example:

> *" . . . and then you have to click the cardiology ward or cardiac intensive care unit (CICU) whichever they have been admitted to. This must be done every time you enter a new blood pressure. Then you have to fill in which department you are in, and if it is the ward or CICU." (Interview 3. Nurse)*

Another issue was the procedure for entering vital sings into the EHR. Documenting vital signs was both complex and time consuming. All the nurses complained about the 'many clicks' required. Some excerpts on this issue from the interviews are provided below:

> *"It is a little awkward to get to where vital signs are recorded, and the columns. It would be better with a simpler system. There are many clicks." (Interview 3. Nurse)*

Directly after her interview, one nurse demonstrated the process to document a blood pressure. This involved 17 clicks, in addition to the actual typing of the numbers for the systolic and diastolic blood pressure. If pulse, temperature, respiratory rate and oxygen saturation were also added, i.e., five vital signs, the total number of clicks would be 28, in addition to entering the numbers. Usability issues in relation to EHRs being cumbersome have been identified in other studies (Darbyshire, 2000; Stevenson & Nilsson, 2012).

Another problem was that when the vital signs table was used for frequent recordings, it became long:

> *"You don't write down every time you check the saturation as this would create many new columns . . . then we entered the first BP and the final BP in [the EHR] instead of filling in each pulse and blood pressure in the patient table or it would have been really long." (Interview 1. Nurse)*

This indicates that the table in the EHR was not suitable for frequent recordings of vital signs. This is another indication that the function for documenting vital signs in this EHR was unsuitable. One reason for this, frequently noted in the literature, is that system designers may have little understanding of the complexity of documentation within health care (Goorman & Berg, 2000). Furthermore, there is an the old adage which states, 'if it

isn't documented, it isn't done'. If documentation is not performed correctly and accurately, there is no evidence to support that an action has been taken and, thus, there could be legal implications in relation to how closely a patient has been observed (Carlson, 2011).

Sub-category 2. Report sheet

The second sub-category was 'report sheet'. The report sheet is another section of the EHR, in which any documentation is in the form of free text. This section is used by nurses only. The report sheet was frequently mentioned by nurses for the documentation of vital signs and four main reasons were asserted for documenting vital signs there: for abnormal vital signs, for interventions, it was faster and it allowed nurses to 'tell the whole story' as one nurse stated during an interview.

The most common reason for documenting vital signs in the report sheet was when they were outside the normal range. The following field note and interview excerpts illustrate this:

> *Ward (Day shift Nurse): The nurse checked the oxygen saturation level and wrote it in the report sheet, but not in the table. She also wrote in the report sheet that the patient finds it difficult to breath and has increased pressure in the chest when breathing in. (Field note 2)*
>
> *"But of course if there is a very abnormal recording, then I can write in the report sheet so as to draw attention to it." (Interview 2. Nurse)*
>
> *"In text form in the report sheet . . . I write if a patient is deteriorating." (Interview 1. Nurse)*

Writing abnormal vitals signs in the report sheet also helped to alert nurses on the next shift to any abnormalities and emphasise that there had been a problem. However, as can be seen later in these findings, not all nurses read report sheets and this could result in poor flow of information on vital signs.

During observations in CICU, it was clear that the report sheet was used for both documenting vital signs and for reporting which actions had been taken for vital signs that were outside normal limits. It was also used to document interventions and actions taken by the nurses.

> *"You write in the report sheet that the patient needs continuous positive airway pressure (CPAP)." (Interview 1. Nurse)*
>
> *CICU (Night shift. Nurse): The nurse writes up the actions she has taken for a patient's low oxygen saturation in the report sheet. (Field note 2)*

Although she documented it in the report sheet, one nurse was not convinced that this was the best place to record the interventions that she initiated. This experienced nurse

questioned whether nurses should report the care process in a different section of the EHR than that used by medical staff, as shown in the following field note.

> *CICU (Night shift. Nurse): the nurse indicates that she thinks there should be a better way of reporting this as it is separate from the journal notes, where other members of the care team document. She thinks it would be better if there were search words for all the aspects of care and then this would appear in the journal part which everyone reads so that others can see all the care that is provided. (Field note 2)*

This is an important observation because it is only through documentation of nursing actions that the care carried out by nurses can be seen. If these actions are 'hidden' in a report sheet that are only viewed by nurses it could make them powerless in relation to organisational or medical staff (Manojlovich, 2007) and undermine their contribution to patient care.

As well as interventions, the outcomes to these interventions were added to the report sheet. Thus, it allowed them to tell the whole story as can be seen in this interview excerpt:

> *"If the blood pressure is low, did this and so on. Then I can do more, I can tell the whole story there . . . if the patient becomes poorly, I think that the next nurse needs to be able to read what has happened, what I did and how it turned out." (Interview 3. Nurse)*

Another reason for using the report sheet section in the EHR was that it was quicker to document there than in the designated table, according to some nurses. Thus, documenting in the report sheet was also related to usability. This was also important for nurses when under time pressures as seen in the next quote:

> *"I use the report sheet, because it is faster, if I don't have time to create a column, then I quickly write it in the report sheet so that it will be there. Sometimes, on some shifts it can be really busy all the time and then you must document quickly too." (Interview 3. Nurse)*

This is connected to usability issues in the EHR. If it takes longer to document in the assigned table, nurses may take steps to save time when they are busy by using a workaround, in this case, documenting more quickly in another part of the EHR.

Sub-category 3. Continuous monitoring

Observations in the CICU, revealed varied practices regarding how often vital signs were documented. Patients in CICU were attached to cardiac monitors, which gave a continuous display of the ECG and pulse both at the bedside monitor. At the nurses' station further visual displays were available on monitors. Examples are given in the following field notes:

> *CICU (Day shift. Two nurses). ECG and pulse displayed on monitors. No additional vital signs were taken or documented during the six hours observation and no vital signs were entered into the EHR. The nurses said it was not needed because they could see the monitors all the time. (Field note 5)*

CICU (Day shift. Nurse). At the end of a night shift, the night nurse went round four of the patients and measured the blood pressure and pulse, saturation and temperature. She did not make any notes, as these recordings could be seen on the monitor at the central nurses' station as the last recordings taken. From there the latest recordings were entered into the table section of the EHR. (Field note 2)

CICU (Evening shift. Two nurses). Recordings measured hourly and documented directly into table of the EHR, even respiratory rate. The nurses entered the recordings into the EHR every hour, although the patients were also on continuous monitoring. This way results could be seen in the EHR, even though constant display on monitor. (Field note 3)

These observations suggest that there is variation in the routines for documentation of vital signs in patients who were being monitored continuously. This may have been related to personal preference of the staff. It could also be influenced by how serious was the condition of the individual patients. (This issue is discussed more deeply in Chapter 6)

During one of the interviews, several nurses said that in CICU because of continuous monitoring giving a constant overview, there was no need to write the vital signs so often in the EHR.

"Before you finish a shift you document it in the EHR." (Interview 6. Nurse)

"If they are in CICU we can see them automatically, if we are going to take them [vital signs] every 10 minutes, then you just look at the monitor and then you see if it looks OK and then you don't write anything . . . it doesn't work to sit and write the whole time. It's about treating the patient." (Interview 2. Nurse)

This suggests that vital signs were measured and observed but not always documented and could be one reason for incomplete documentation in the EHR in the phase one study. It may also imply an attitude that nurses have towards documentation, for example, in the above quote, the nurse seemed to be offering an argument for not documenting and indicating that it is a time-taking task which is not prioritised. However, if vital signs are not documented, then staff caring for the patient at a later time would not have access to this information. (This is discussed in greater detail in Chapter 6)

Category 2. Documentation on paper

The second category, 'paper' was divided into two sub-categories: paper observation charts and paper notes.

Subcategory 2. Paper charts

Several paper observation charts were used for documenting vital signs and all were in the form of tables (see Appendix VIa). Reasons for using paper charts (workarounds) were numerous but the underlying reason was when patients required more frequent observations.

One of these instances was when patients were very ill or unstable and required frequent vital sign recordings.

> *"Then it can be that you have an acutely sick patient and you don't have time to document all this. Then it is a paper charts that are suitable. And then you have to document in the EHR afterwards, unfortunately."*
>
> *"Sometimes paper charts are used in the HDU. That's because we might be taking the vital signs every 5 minutes, so we don't put all of these in the EHR." (Interview 4. Nurse)*

These quotes may indicate important reasons for nurses not documenting in the EHR. (This is discussed further in Chapter 6.)

> *"We have one standard vital signs chart that you can use for everyone . . ." (Interview 2. Nurse) (Appendix VIa)*

Others paper observation charts were created for specific situations, e.g., for a patient recently commenced on a medication or a patient who required continuous positive airway pressure (CPAP), both of which could affect the vital signs as seen in the following quote:

> *"There can be those who have different infusions - nitro-glycerine for example, and then we have individual papers which we print out from the computer from our website . . . you fill in (the vital signs) on a paper which you have beside the patient." (Interview 6. Nurse)*
>
> *" . . . in CICU when we have a nitro-glycerine infusion, we have an observation chart instead of writing it in here (the EHR) . . ." (Appendix VIa)*
>
> *Researcher: "A paper chart?"*
>
> *"Yes, there is a paper chart. (Nurse laughs) an A4 paper called a monitoring chart. And it is of course that you can write pulse , blood pressure, oxygen saturation and diuresis and so on." (Interview 1. Nurse)*

A selection of what was recorded on paper was added to the EHR:

> *"It must be written in the EHR, . . . and then we only write certain times in the EHR." (Interview 4. Nurse)*
>
> *"For example, if I start up a nitro infusion, maybe I'd take 10 blood pressures, but I would never put 10 blood pressures in the EHR, I would enter a few of them to show how it was when we started and how it went." (Interview 3. Nurse)*

These quotes indicate that a selection of what was measured was documented. The EHR could not accommodate all the vital signs, as it would take up too much space in the EHR table, so a few were written in the EHR to give information about some of the vital signs

and to show that they had been taken. (Further discussion on this issue is provided in Chapter 6.)

The following quote describes how the paper observation chart promoted a good overview and that it was possible to follow a patient's progress:

> *"You get a quick overview of how it was when we put the drip up and how it is now. You could just as well write it in in the EHR, but it would be very many, maybe you take it every 15 minutes, the blood pressure at the start, in order to see [the effect]." (Interview 6. Nurse)*

Nurses pointed out that recording the vital signs on paper was easier and quicker:

> *"On the paper it is certainly easier to see. Then you don't need to click in the EHR, you don't always have the page with the table open in the EHR, so if you have it there on paper, then you can see it quickly." (Interview 3. Nurse)*

They pointed out that the table in the EHR would become too long if all frequent vital signs were added:

> *"There was a patient who required to have blood pressure recorded once per hour, so we used this chart instead, and wrote the BP every hour for 6 hours . And then we entered the first BP and the final BP in the EHR instead of filling in each pulse and BP in the patient table or it would have been really long. Six blood pressures within that time." (laughs a little) (Interview 1. Nurse)*

These workarounds are important for understanding why information is not recorded and are discussed in more detail in Chapter 6.

The use of paper charts was mainly directed towards usability problems. The bespoke table in the EHR was not suitable for multiple recordings as the additional columns made it too long. Moreover, nurses found that they could get a better overview of vital signs on a paper chart, and it was easier and quicker to document on paper. A problem with recordings being made on paper was that a doctor in another part of the hospital who wanted to check vital signs in the EHR could not be sure that it was the latest set of vital signs, because often only some were entered in the EHR and those that were entered were often entered much later than the time of recording.

When patients were discharged, the ward secretary scanned the paper observation charts into the EHR in a special section for scanned files. No reference to these scanned files was made anywhere the EHR.

Sub-category 2. Paper notes

Notes were in the form of paper note pads, 'post-its' and sometimes paper towels and were used for noting vital signs in various circumstances.

A practice noted during observations was that nurses frequently left the trolley with the laptop outside the room when they went to check vital signs and made notes in a notepad about the vital signs. They said that sometimes it was cumbersome to take the trolley with them into the room as the blood pressure equipment was also on a stand that had to be wheeled into the room; therefore, the proximity of the EHR in relation to the patient may have played a role in the need for the use of notes. One example of using a paper notebook and then transferring to the EHR can be seen in the following field note:

> *Ward (Night shift 06.00. Nurse). A nurse writes down the vital signs in a notebook. Then she takes the vital signs of the second patient in the same room and writes down in her notebook. The nurse goes to the trolley in the corridor and writes in the report sheet in the EHR how the patient has slept and that one patient has difficulty with breathing. She also transfers her notes on vital signs from the notebook to the table in the EHR. (Field note 2)*

In some cases, the trolley remained at the small nurses' station in that part of the ward, as can be seen in the field note below, which was made during observations at the end of a night shift and beginning of a day shift:

> *Ward (Night shift 07.00. Nurse). The night nurse had written all the patients' vital signs as a list in a notebook. Most patients had had temperature, pulse and blood pressure recorded. After the change over report, the nurse added the vital signs to each patient's EHR which was on a trolley at a small nurses' station. (Field note 1)*

During the interviews, nurses explained why they used paper notes and confirmed what the researcher had noted during observations.

> *"Most often you have a paper in your pocket or a paper towel, (laughs) whatever, so that you have something to write on and make it easy. That's the way it is. . . If a patient is being barrier nursed then I can't take the computer in anyway." (Interview: Nurse 5)*

One reason for using notes was that the EHR was not at the patient's bedside when vital signs had been taken. There were instances of a laptop being outside the room on a trolley or a stationary computer at the nurses' station. In these situations, the nurses found it was more convenient to take the vital signs of each patient in the room, write down the values on a note and document it later. There were many quotes similar to the following:

> *"If I'm working nights, e.g., then you want to disturb as little as possible so then you don't go in with the computer and the trolley. So then I write on a paper, and take room for room - then you sit down and write in all of them." (Interview 2. Nurse)*
>
> *"If it is at lunch time then you go round and talk to the patients and write it up on a piece of paper and then write it directly in the EHR." (Interview 4. Nurse)*

These quotes are in contrast to the following quote:

> *"Sometimes I have the trolley with me in the room. I have that in the evening and in the afternoon. Then I write it in Cosmic straight away." (Interview 6. Nurse)*

This indicates that there is varied practice regarding whether the trolley is in the room or not at different times of the day and whether vital signs are directly entered into the EHR or noted on paper first.

In CICU, laptops were not used so the computers were at the nurses' station.

> *"Yes, I use paper sometimes because if I am standing beside a patient and observe them. If I am, for example, in CICU and I don't have the computer with me, that is, in the patient's room." (Interview 3. Nurse)*

> *"I maybe have to take the blood pressure and saturation often, then I write it down on a paper beside me so that I remember it until I get to a computer." (Interview 4. Nurse)*

Sometimes the vital signs from the notes were entered into the EHR directly after the nurse left the room, but if there was an interruption or something more important came up, entry into the EHR could be delayed till the end of the shift.

> *"And sometimes that may be towards the end of my shift, as it can be very busy." (Interview 3. Nurse)*

The issue of double documentation was also apparent:

> *"We often double document. Most often we write on a paper because it is easier to have a paper with you beside the patient, than the big trolley with the computer on it. So you often go round with the blood pressure machine and then you have a little paper where you write down all the vital signs. Then you go out and then you write it in in the table for measurements in the EHR." (Interview 5. Nurse)*

Thus, using paper is an example of how nursing staff adopted the use of workarounds to enable them to carry out their normal duties.

During interview, one nurse offered her view of how it could be if more advanced technology were available:

> *"Well they could make the system simpler - the EHR could be simpler in some way. "*
>
> *Researcher: "Make the system simpler? "*
>
> *Nurse: "For entering information. I think it would be easier if you could connect things together. If you had, for example, there are small mobile phones or an iPad or whatever that could take in with you to the room. Instead of writing it down on a paper, if you could maybe put them on an iPad and then you could send it over to the EHR as they are so little and simple. For example, they could be in the little basket that hangs on the blood pressure equipment. It would save time for me and also the more often you write the same thing the higher the risk is that it can be wrong." (Interview 2. Nurse)*

This might suggest that some nurses were aware of, and ready to embrace, more suitable technology, having seen that there were possible risks with the current system. As this nurse pointed out, there could be a risk for error during transcription and appropriate technological solutions might reduce the likelihood of errors.

Theme 3. Retrieving vital signs

Nursing and medical staff differed somewhat in how they retrieved vital signs and retrieval proved to be a bigger problem for doctors than nurses. Therefore, this section has been assigned two categories, namely nursing staff and medical staff.

Category 1. Nursing staff

Nurses had various practices for how they would retrieve a patient's vital signs. For example, at the start of a shift, the most common practice in cardiology was to look in the table first, followed by the report sheet. Verbal reporting was also mentioned as a frequent means of finding out about a patient's vital signs. Below are some examples of what nurses said regarding retrieval.

> *"If I work a morning shift, I get the report from the night nurse. Most often they tell me the blood pressure, if it has been fine, or if it is high or low." (Interview 6. Nurse)*
>
> *"First I prefer to read the journal part with the admission notes or journal notes for the day and then I go in to the report sheet to give me a picture. . . we have got used to the system and therefore it is easy to get information out." (Interview 5. Nurse)*
>
> *"I usually read the journal and a little in the report page. I usually do not go in so often on the table for vital signs." (Interview 1. Nurse)*

As can be seen above, nursing staff had mixed opinions regarding their preferred method of retrieving information from the EHR. Regarding paper charts, there were also various opinions on the best type of paper chart. (All the paper charts were designed in table format). Some said they would have preferred to have a graph as it would be easier to read. Others were content with the table as this allowed them to see specific numbers.

Most nurses thought that the table gave a good overview of vital signs, although some mentioned that they would have preferred a graph. One nurse demonstrated how a graph could be created in the EHR but she said it was 'never' used as most nurses did not know how to carry out this rather complex series of steps. This complex procedure was not user-friendly and was thus another usability problem. Table 5.3 provides a brief outline of how the nurses who were interviewed retrieved information at the beginning of a shift.

Table 5.3 How nurses retrieved information on vital signs in the cardiology unit

Nurse	Observation
Nurse 1	Read the journal, the report sheet and get a verbal report on 'anything special'. Does not usually look at the table.
Nurse 2	Read the table. If patient has been transferred from ED, looks for vital signs in the journal as this is where the first ED vital signs are written. Verbal report on abnormalities in vital signs.
Nurse 3	Look at table then report sheet to see if there is anything about the patient from the last shift. Verbal report if anything important in vital signs.
Nurse 4	Looks at table.
Nurse 5	Looks at journal first (to see what has been happening). Then looks at report sheet. Looks at table last but finds it 'messy' to look at. Frequent verbal reporting.
Nurse 6	Table first. Also looks at report sheet but vital signs easy to miss as so much text there. Also verbal from nurse during handover report.

Category 2. Medical staff

Of the personnel interviewed, it was doctors who expressed most concern about retrieving vital signs. One doctor from cardiology said that it was difficult to get an overview of the patient's vital signs and that it took many clicks to see anything in the EHR.

> *"It's quicker to ask the nurses what the vital signs are than it is to find them in the EHR." (Interview 7. Doctor)*

This doctor demonstrated what had to be done in order to look at vital signs in the EHR. It took nine additional clicks after accessing the patient's EHR with the patient's security number. Showing a table in a patient's EHR, she pointed out how difficult it was to interpret the information in the table when she had to read every number.

What she wished for was to open a patient's journal, click on one flap and then get a full view of all the vital signs on a graph. She emphasised how important it was to:

- know base line recordings so that individual patients normal recordings could be taken into account
- be able to see trends, e.g., if a patients BP went up or down

- be able to see all vital signs in relation to each other, e.g., between pulse and BP - to be seen together. She gave the example of the systolic BP crossing/becoming lower than the pulse
- be able to see all vital signs on same graph
- see trends rather than individual measurements and how seeing vital signs on a graph was so much easier to interpret.

A cardiology consultant stressed the importance of finding out the vital signs of acutely sick patients quickly. Usually this was done by looking at the continuous monitor, which displayed all the vital signs. This consultant also expressed the difficulties of accessing vital signs in the EHR.

> *"It is very hard to get to this information in Cosmic[3]. I must make many clicks to see those vital signs I need, to find them in Cosmic. They are not easily accessible." (Interview 8. Consultant)*

He also commented that it was good that he could see the information on a table but that a graphical format, like the ones previously used on paper charts was much easier to interpret. He continued,

> *"We need a better Cosmic. I would like all the information on one page. One glance, yes. At the moment it is very difficult for doctors to see. You have to choose to take away a filter so you can see them. It is just very difficult to get to the vital signs." (Interview 8. Consultant)*

He then went on to demonstrate how he accessed vital signs by demonstrating this on the computer on his desk.

> *"You click here and here but then there are two places and it might look like nothing is written, and you can miss things. Then there is the filter. Now I get two choices. Here you can go wrong. You can also click here. You don't know. You can also click . . . Sometimes it looks as though it is not written. And you can't be sure that you have got the latest." (Interview 8. Consultant)*

He pointed out the various steps saying that sometimes it can look as though there are no vital signs because of there being two different places to look. For doctors, there is also a filter that they have to remove in order to get to the vital signs. He also pointed out that he could not be sure that it was the latest set of vital signs as sometimes they may not yet have been written in.

> *The cardiology consultant said that information on vital signs "is related verbally if the vital signs are abnormal and I have been contacted by telephone because of that." (Interview 8. Consultant)*

[3] Cosmic was the name of the EHR system used in the study hospital. Staff frequently referred to the EHR with this name

The cardiology doctor said that if a patient deteriorated, it was quicker to ask the nurse what the vital signs were than it was to find them in the EHR. This indicates that verbal reports were important for doctors to know about patients' vital signs.

This concludes the findings from the observational and interview studies in the cardiology department. In the following section, the findings for the emergency department are presented.

5.5.3 Findings: Emergency department (ED)

This section describes the results from the emergency department (ED). To begin with there is an explanation of the triage system, 'rapid emergency triage and treatment system' (RETTS) (Widgren, 2013), used in the ED. This is followed by a presentation of the findings from observation and interview studies carried out in the ED. The results are divided into three themes: measuring vital signs, documenting vital signs and retrieving vital signs.

Triage system RETTS

All patients admitted to the ED are triaged. A triage system aims to prioritise patients safely, so that the most serious and urgent cases are treated first (Stugemo 2012, Widgren 2008). RETTS prioritises patients according to three categories:

- vital signs (Fig. 5.4) (English translation Fig. 5.5)
- presenting problem (emergency signs and symptoms (ESS))
- assessment of the patient by a doctor or a nurse

The first category, vital signs, is described below and presented in Figure 5.4. 'A', the first item shown in the figure is for Airway, describing whether the airway is clear or obstructed. The vital signs in RETTS are B (breathing) - respiratory rate and oxygen saturation, C (circulation) - blood pressure and pulse, D (disability) - conscious level, and E (environment or exposure) - body temperature. (Widgren 2013).

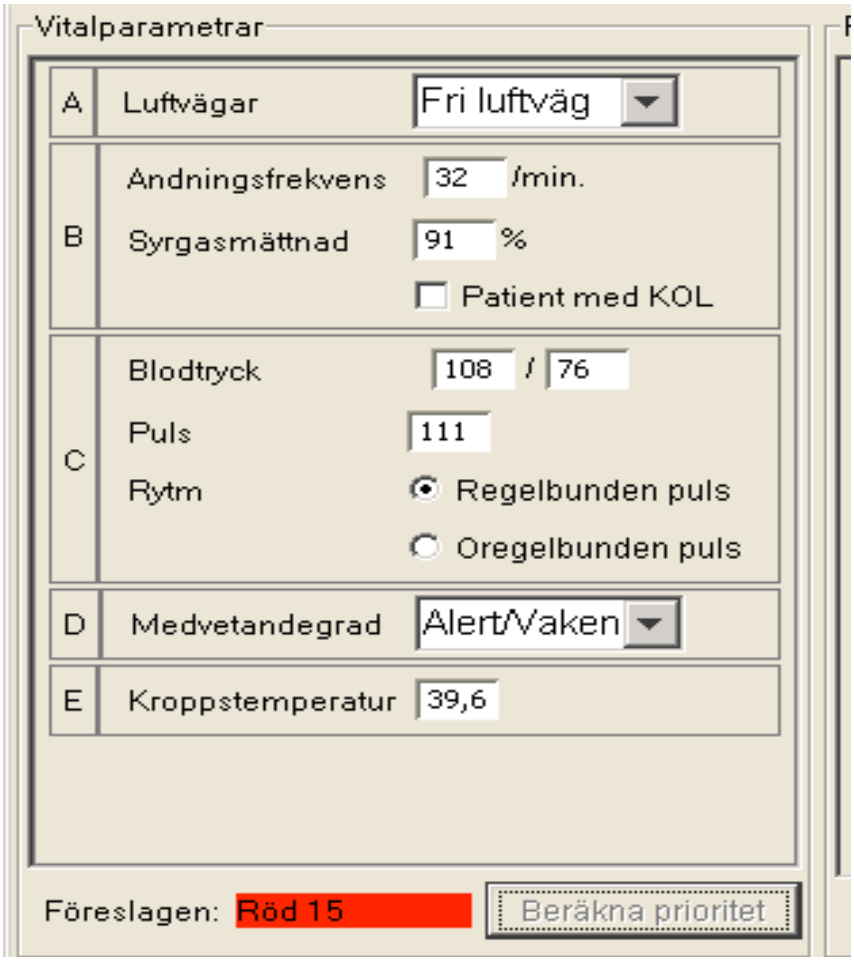


Figure 5.4 RETTS vital signs (Swedish)

Vital signs		
A	Airway	Free airway
B	Respiratory rate	32
	Oxygen saturation	91%
C	Blood pressure	108/76
	Pulse	111
	Rhythm	Regular pulse
		Irregular pulse
D	Conscious level	Alert/Awake
E	Body temperature	39.6
Suggestion	Red 15	Estimate priority

Figure 5.5 RETTS vital signs (English translation) with readings used from Figure 5.4

The RETTS software has been integrated with Cosmic, the EHR system, used in the ED. This triage system provides an objective standardised means of priortising patients. Thus, the result will be the same regardless of who is using the system. It is also a decision support system indicating how often patients should be monitored; it selects a monitoring frequency according to the priority level into which the patient is allocated.

When the vital signs have been entered in the appropriate spaces, the priority calculator (Beräkna prioritet) is clicked and the patient is allocated one of six categories of severity of illness: red, amber, yellow, green, blue or grey, with red being the most severe and grey the least severe.

The vital signs from RETTS are then automatically transferred to the journal section of the EHR (Cosmic) and are presented as a list as shown in Column 1, Table 5.4.

Table 5.4 Presentation of RETTS vital signs as viewed in journal section of the EHR using values from Figure 5.4

Swedish	English
AF: 32	Respiratory rate: 32
SaO_2: 91%	Saturation of oxygen: 91%
Blodtryck: 108/76 mm/Hg	Blood pressure: 108/76 mm/Hg
Puls: 111	Pulse: 111
Rytm: Regelbunden	Rhythm: Regular
Medvetengrad: Alert/Vaken	Conscious level: Alert/awake
Kroppstemperatur: 39.6°C	Body temperature: 39.6°C

In the above example of RETTS (Figure 5.4 and Table 5.4), the priority is RED, in which case vital signs would be recorded every hour or continuously on a monitor.

The information from RETTS is relayed to the first page (known as a 'ledger') of the computers at the nurses' station. This ledger displays a list of all patients currently in the ED. It provides an overview of all the patients, their triage priority colour, the frequency of monitoring required and a countdown to the time the next set of vital signs should be taken. When vital signs are taken, the priority level is reset by clicking on the 'priority calculator' and manually selecting the correct colour. The countdown for the next set of vital signs will then begin. This was a brief description of the RETTS triage system.

Findings from observations and interviews

This section presents the findings of the observations and interviews in the ED. In the ED, there were eighteen hours of observation and two interviews. The results from observations and interviews have been merged and are presented together. There were three main themes: measuring vital signs, documenting vital signs and retrieving vital signs. These themes had categories and subcategories as shown in Figure 5.6.

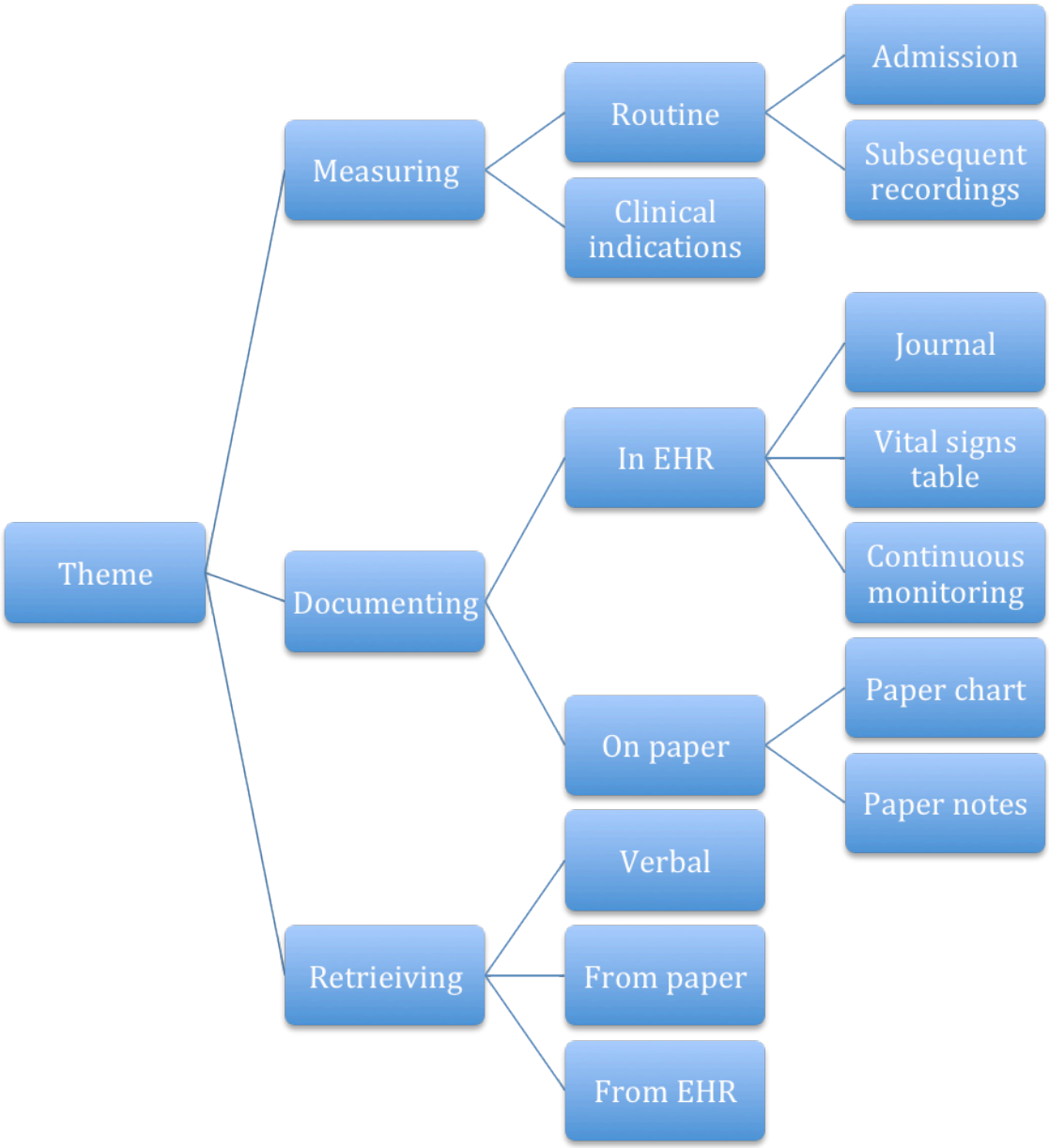


Figure 5.6 Analysis Emergency Department (ED): themes, categories and sub-categories

Theme 1: Measuring vital signs

The first theme was measuring vital signs and is divided into two categories: routine recordings and clinical indications.

Category 1. Routine recordings

Routine recordings of vital signs had two sub-categories: Admission recordings and subsequent recordings.

Sub-category 1. On admission.

In the ED vital signs are measured on admission according to the RETTS protocol, which requires temperature, pulse, respiratory rate, blood pressure, oxygen saturation and conscious level.

During the interviews, nurses explained this system in detail:

> *"We have, as you know, a triage team which receives all the patients who come to the ED. We use a triage tool called RETTS where the recording of vital signs is included." (Interview 9. Nurse)*
>
> *"Vital signs are always taken on admission. That's the first we do and then we measure TPR, BP and sats." (Interview 10. Nurse)*

The thresholds in the RETTS system had similarities to the BAS system. For example, the highest priority (red) thresholds in RETTS for blood pressure, respiratory rate and oxygen saturation were the same as the thresholds in BAS 90-30-90. The nurses appreciated that RETTS and BAS were in harmony with each other, as BAS had been used since 2007 and RETTS was introduced in 2012.

> *"The thing that is good about this system (RETTS) is that it is in agreement with the BAS system that we use, BAS 90-30-90, that we use here at this hospital. If the colour is red it implies that the patient should see a doctor immediately. . . if the patient has a blood pressure under 90 systolic or a respiratory rate over 30 or a saturation under 90%." (Interview 9. Nurse)*

Nurses also indicated that the introduction of BAS had improved the measurement of vital signs:

> *"It was not until we started to use BAS 90 30 90 . . . that we had our eyes opened to how important it was to take all the vital signs, not just take a blood pressure, and above all that we are careful to check the respiratory rate. Ten years ago, we were not so careful at taking the respiratory rate on patients." (Interview 10. Nurse)*

Clearly, the importance of respiratory rate was emphasised in these two systems and appreciated by nursing staff. However, BAS was mainly considered important for the detection of sepsis as can be seen in the following interview excerpts.

"We use BAS 90-30-90 primarily to detect sepsis. . . now we take it on everyone to capture those who can be in the risk zone for developing sepsis, for example."

Researcher: "or something else?"

Nurse: "Yes, but it is especially about sepsis that 90-30-90 is concerned with." (Interview 10. Nurse)

This seems to suggest that BAS was considered mainly as a tool for detecting infection rather than a track and trigger system (TTS) in general. In an ED, which manages all kinds of cases, perhaps it is a little surprising that BAS was not considered as a more general tool for detecting all kinds of deterioration. Whilst it is crucial that sepsis patients are identified at an early stage, many other conditions would be expected to have the same priority regarding changes in vital signs. (discussed in greater detail in Chapter 7, section 7.5.2)

Sub-category 2. Subsequent vital signs

After vital signs had been taken, the triage system, RETTS, assigned a priority colour code to the patient. As well as indicating how quickly a patient needed to be seen by a doctor, it provided a decision support by indicating when the next set of vital signs should be taken. Thus, the frequency of vital signs recordings depended on the triage colour as seen in the following interview excerpts.

"Depending on the triage colour, we follow up the vital signs. A patient who has red, the highest priority, will have a nurse at the bedside all the time, and the vital signs are continuously monitored." (Interview 10. Nurse)

"And these colours . . . can be seen in the acute ledger where all the patients are listed . . . to indicate when it is time to take the next set of vital signs. For example, if we have an orange patient, the vital signs should be taken every hour. Then there's a clock that does a countdown so that you know when it is time to take the next vital signs. When the patients are yellow or green, then the vital signs are taken two hourly." (Interview 9. Nurse)

If the countdown clock ticked all the way down to zero, a red cross appeared and the clock kept counting but then with a minus (-) in front of the number of minutes, indicating how delayed the next set of vital signs was. When the ED was very busy, nurses considered it even more important to have the countdown clock.

"If there is a lot to do, many patients, it is really helpful to have these colours. Then you focus on those orange. The reds are always taken care of first, then you focus on the oranges . . . for they have the highest risk of becoming worse, or having a serious illness." (Interview 9. Nurse)

This shows how RETTS functions as a decision support system, i.e., by reminding staff to take vital signs. Furthermore, RETTS functioned as a triage system with automatic calculation by the computer software to indicate the priority colour for each patient. However, after the initial triage/admission recordings, RETTS software did not calculate

new priorities. Subsequent recordings were calculated manually to give the priority colour. To establish which priority 'colour' should be allocated from subsequent recordings, nurses had to consult a table in a paper manual contained in a folder at the nurses' station. A copy of this table (RETTS protocol), with an English translation, is available in Appendix VIb. Some nurses carried a laminated copy of the table from the manual in their pockets to which they could refer. However, more experienced nurses rarely consulted the table as they knew the thresholds by heart. Thus, after triage the responsibility of identifying any deterioration was left to the nurses with the aid of the RETTS chart in a paper manual (Appendix VIb). Moreover, subsequent recordings were recorded in the 'table' for vital signs in the EHR, whereas the triage recordings were documented in the journal of the EHR. This would mean that the patient's baseline recordings (the first set of vital signs taken on admission) were documented in a different location to subsequent recordings. This issue is discussed more deeply in Chapter 6, section 6.2.1.3 .

During the observational study, a senior nurse made the following statement:

> *(Day shift. Nurse.) "It would be good if it [RETTS] could be used all the time as it could be useful to flag up deteriorating patients. Now it depends on the nurses to interpret each set of vital signs and sometimes they can be really busy and maybe don't react if a patient was deteriorating. But if they had it in the computer that abnormal vital signs were automatically identified if they began to deteriorate, it would be a lot safer. At the moment, it depends on the RN to make the interpretation . . . so that a new prioritisation can be made . . . noting if vital signs have become worse or better and giving the patient a new colour code if necessary." (Field note 8)*

Clearly, the benefits of RETTS making the initial automatic calculations were appreciated; RETTS facilitated the initial assessment to indicate how sick was the patient; therefore, it would seem feasible to continue using some kind of automatic system for subsequent vital signs so that vital signs could identify deteriorating patients without nurses having to interpret those themselves. As recognised in the literature, documented vital signs that are abnormal are not always acted upon (Wakefield, 2008).

The next category describes how vital signs could be checked at additional times to those recommended by RETTS.

Category 2. Clinical indications

Sometimes vital signs were recorded more often than recommended by the RETTS system, if nurses assessed that this was necessary. For example, a nurse might find that she wanted to raise the priority level.

"It can be that a[n orange] patient is near the level of a certain colour- a BP of 100 systolic. And you can worry that it might drop. Then you check it more often. The patient is not 'red' but you are anyway worried. The "clinical glance" suggests that the patient should be a higher priority." (Interview 10. Nurse)

" Then, obviously you include your own gut feelings if you want to choose another colour, but then you always justify that, to explain to your colleagues what you have seen that makes you want the patient to have a higher colour and you need to check on them a little more often. . . As nurses, we never go down in colour. It is only a doctor who can to this. " (Interview 9. Nurse)

Therefore, nurses' clinical judgement played an important role in deciding if extra vital sign recordings were required or if the priority level needed to be raised. However, only doctors could make the decision to lower a priority level.

Theme 2. Documenting vital signs

This theme describes the documentation of vital signs in the ED. It had two categories: EHR and paper.

Category 1. Documentation in EHR. The EHR category had three sub-categories: journal, table and continuous monitoring

Sub-category 1. Journal

On admission, the vital signs were entered into the RETTS protocol in the EHR (figure 5.4). This field note shows what happened next:

After the priority level was calculated the results from RETTS were automatically transferred to the journal section of the EHR and were presented as a list. (Field note 6)

However, only the first vital signs were in the journal section of the EHR and were presented as a list (see the example in Table 5.4). The next sub-category explains what happened next.

Sub-category 2. Table

Subsequent vital signs were recorded in the table for measurements in the EHR, as seen in this interview excerpt:

"It is only the first vital signs that we write in the RETTS triage module which gives us these colours. After that when we write vital signs in the table for vital signs in the EHR, as is done in the rest of the hospital but there we don't get the same help- that the patient is given a colour depending on the vital signs." (Interview 9. Nurse)

Thus, the table did not provide decision support and it was also more difficult to use than the RETTS protocol.

> *"The triage module is easier to use, I think. For the table you have to keep double clicking and it is a longer way to come in to the table. Then I think it would be great if you could continue to get help when you write in the vital signs in the table. That you could get help with colour coding there too. That would be great." (Interview 9. Nurse)*

Clearly, this nurse saw the possibilities of having a more advanced electronic system that would recognise abnormal vital signs and alert nurses to possible deteriorating patients.

Sub-category 3. Continuous monitoring

Patients who had a red priority were usually monitored continuously. As the following interview excerpt indicates, this could affect the completeness of documentation in the EHR.

> *" Then we have a nurse who is at the bedside all the time. Here there can be a dilemma if the patient is connected (to a monitor), then the vital signs are not documented in the same way. Then you have a visual overview the whole time when they are connected (to the monitor) and then everything is not documented so well." (Interview 9. Nurse)*

This was also noted during the observational study; there was no clear routine for recording vital signs in the EHR when patients were continuously monitored and sometimes, during continuous monitoring, vital signs were not documented. Instead nurses would give this information verbally during the hand-over report when a patient was transferred to another part of the hospital.

An explanation for why documentation was not added to the EHR is given in the following quote:

> *"With patients who are monitored it would make things much easier if it could in some way go in to the EHR automatically. Documentation takes time. It's important but it takes time." (Interview 9. Nurse)*

This suggests that nurses see the possibilities that technology may have to offer to improve facilities for their work and patients. It seems that a problem was the time it took to add vital signs to the EHR and this nurse would have preferred an easier way to document these monitored vital signs. Patients who are continuously monitored are high risk patients requiring acute care so the attitude of nurses seemed to be that it was unnecessary to take time to document when there were other important things to do and they knew they could observe the patient constantly on the monitor. There was another view that when patients were being continuously monitored that vital signs were added regularly to the table suggesting some differences in practice from nurse to nurse. As there did not seem to be a specific routine for what do when patients were monitored continuously, it is likely that there were varied practices. This issue is discussed in greater detail in Chapter 6.

Category 2. Documentation on paper

There were two sub-categories in the category, paper-based records: paper charts and paper notes.

Sub-category 1. Paper chart

In the ED, there was one paper chart used (Appendix VIc). This chart included the following information: Patient name and ID number; date; time; reason for admission; if the patient was contagious; a box for rough notes; and a table for vital signs: blood pressure, respiratory rate, saturation, pulse and temperature.

When a patient was admitted the nurses added the vital signs to this paper chart. The chart was then put in a plastic folder and placed at the nurses' station where the doctor collected it when going to see a new patient. At interview, a nurse explained this:

> *"We write the vital signs on a paper first when we admit a patient . . .This is just so that we can have it for ourselves, to simplify, to be able to quickly hand over to the doctor so they don't have to go to the EHR. So that is it handy." (Interview 10. Nurse)*

This suggests that it was more convenient for doctors to have a paper chart with patient details, including initial vital signs, and may explain why they used these rather than the EHR.

Sub-category 2. Paper notes

When new vital signs were taken in rooms that were not immediately in front of the nurses' station, where the computers were located, nurses jotted these down on a paper note, walked back to the nurses' station and transferred the information to the EHR. Otherwise, nurses documented vital signs into the EHR directly. This indicates that it was necessary to use paper notes when patients were not close to a computer. If anything delayed this input, then the recording might be lost.

Theme: Retrieving vital signs

This theme is divided into three categories. Verbal retrieval, retrieval from paper and retrieval from the EHR.

Category 1. Verbal retrieval

During the observational study, several incidences of verbal reporting of vital signs were noted. For example, in this field note during an emergency admission of a priority red patient:

> *(Day shift. Doctor) The doctor is in the process of examining the patient. He asks the nurse what the patient's temperature is, then he asks for the blood pressure. (Field note 6)*

Naturally, it was useful for doctors to be able to ask the nurses for the latest vital signs in acute situations. In addition, ambulance staff related vital signs verbally when they gave a hand-over report to nurses on newly-admitted patients.

Another instance of verbal communication on vital signs was when a patient had been on continuous monitoring and vital signs had not been documented. Then, nurses from the ED would give a verbal report to ward nurses when the patient was transferred.

Category 2. Retrieval from paper charts

When a doctor came to the ED to see a patient, the first thing s/he did was to collect the plastic folder at the nurses' station, which contained the paper chart that the nurses had completed on admission (Appendix VIc).

As previously mentioned, this paper was accessible for the doctor and it meant that s/he did not have to go to the EHR to retrieve immediate essential information about the patient.

Category 3. Retrieval from EHR.

The first set of vital signs taken on a new patient were documented in RETTS and automatically transferred to the journal section of the EHR. Subsequent vital signs were entered into the table in another section of the EHR.

> *"Our triage vital signs can be seen in the journal part of the EHR . . . you must go in to the table to see what subsequent vital signs the patient has had". (Interview 9. Nurse)*

This implies that to retrieve vital signs and be able to compare admission values, users would have to look in two separate places in the EHR. To look in two separate places for admission recordings and subsequent recordings is not optimal, as admission recordings provide an important baseline for a patient's status and should be viewed together with subsequent recordings so that trends and changes can be easily observed (Hutson, 2009). This issue is discussed in greater depth in Chapter 6.

This concludes the findings from the observational and interview studies in the emergency department.

In the following section, the findings for the infection ward are presented.

5.5.4 Findings: Infection ward

This section presents the findings from the infection ward. Ten hours of observations and three interviews were performed in this setting. The analysis of data from observations and

interviews in the infection ward were merged and are presented in the following section according to the three main themes: measuring vital signs; documenting vital signs; and retrieval of vital signs. An overview of the analysis can be seen in Figure 5.7.

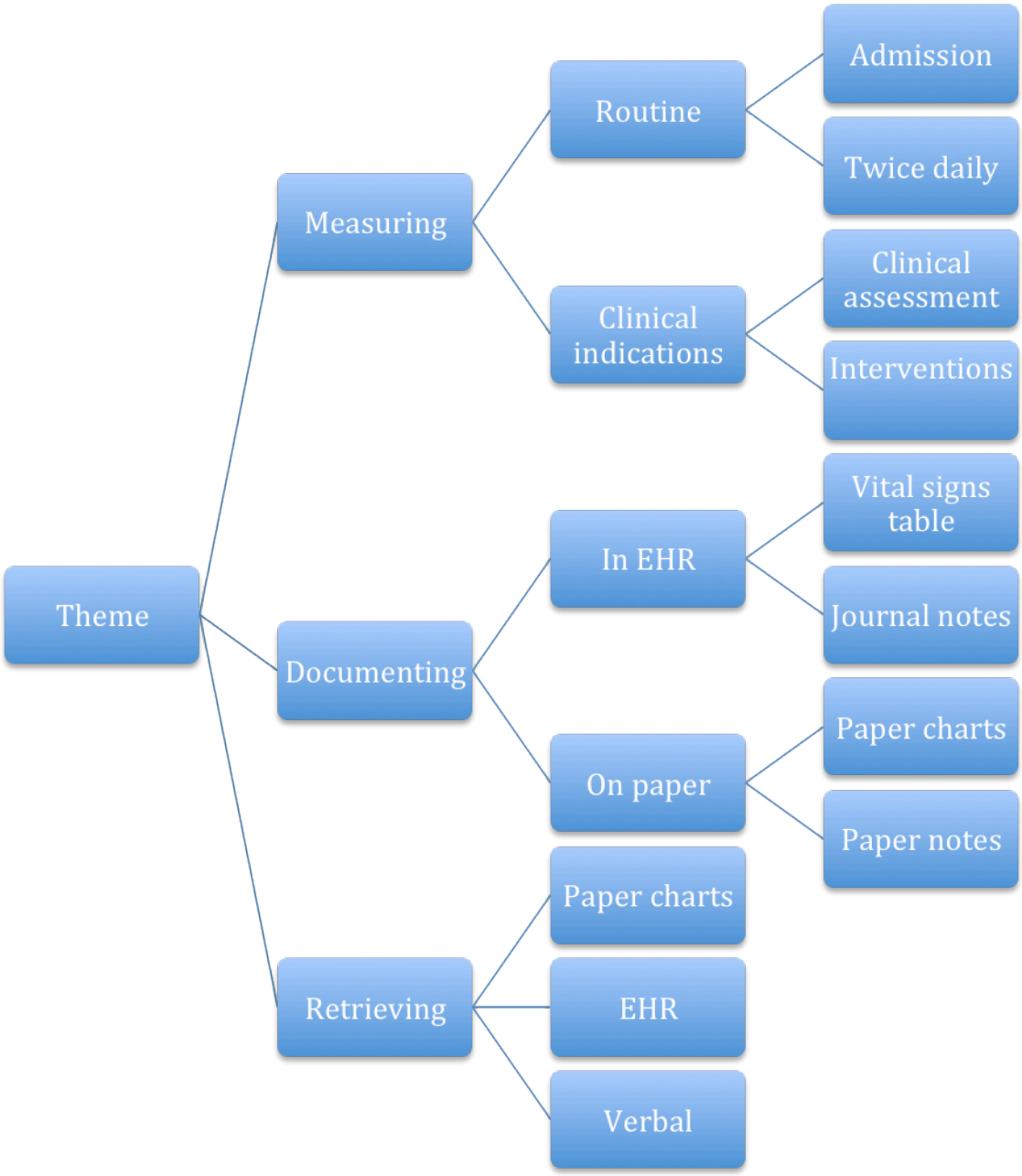


Figure 5.7 Analysis Infection Ward: themes, categories and sub-categories

Theme: Measuring vital signs

This theme describes measuring vital signs in the infection ward. It is divided into two categories 'Routine recordings' and Clinical indications'.

Category 1. Routine recordings

Routine recording of vital signs had two sub-categories: admission and twice daily recordings. The first sub-category, admission, is described in the next section.

Sub-category 1. Admission

There were specific rules regarding which vital signs should be recorded on admission.

> *"We have been using BAS at the hospital since 2007 and the rules are that they are recorded by ambulance crew, then in the ED and again on admission to the ward. After that it is according to the routines on the wards. We also take pulse and temp at the same time as BAS." (Interview 12. Nurse)*

This admission routine is demonstrated in the following examples from the field notes of the observation study.

> *On admission, an RN records a patient's TPR, BP and oxygen saturation. (Field note 10)*

However, in another observation, the assistant nurse omitted to take the respiratory rate on a patient who was having vital signs recorded on admission, perhaps suggesting that although there was a specific routine, it was not always followed and that there may even be some confusion about what the term, BAS.

Sub-category 2. Twice daily recording

The second sub-category, twice daily recordings, is described in the next section. Twice daily recordings focused on measuring patients' temperatures as shown in the following observation.

> *(Day shift. Nurse). The nurse relates that all patients should have their temperatures taken twice daily. Usually the morning temperature was taken at 06.00 hrs by the night nurse, but if the patient was asleep the nurse on the morning shift checked it when she went round the patients with medicines at 08.00 hrs. (Field note 10)*

During interviews, nurses confirmed this and that a patient's temperature was the most significant vital sign for the infection ward:

> *"We always record the temperature every morning and then at 14.00 hrs when the next shift starts." (Interview 11. Nurse)*
>
> *"With us, all patients have their temperature checked - that's what we are interested in." (Interview 12. Nurse)*

This indicates that only temperature was a compulsory recording in the infection ward. However, if there were clinical indications, additional vital signs were taken. The next section, and second category of the theme 'measurements', describes how decisions were reached on recording additional vital signs.

Category 2: Clinical indications for recording vital signs

This category is divided into two sub-categories, clinical assessment and interventions. Clinical assessment is described below.

Sub-category 1. Clinical assessment

Some patients also had BAS recordings taken at the same times as the temperature if there were clinical indications. During interview a nurse explained:

> *"We sometimes BAS the patients too."(Interview 12. Nurse)*

Examples of when this might happen are given below.

> *"If the doctor wants us to take it" (Interview 11. Nurse)*

> *"If we notice that a patient's condition worsens, then we decide ourselves as nurses if we should take it more often. Often it can be that we need to BAS four times a day." (Interview 11. Nurse)*

An example of selecting specific vital signs for some patients is also shown in the following field note:

> *(Day shift. Nurse). Of the six patients on the 'temp list', each patient had had temperature recorded, and for two patients BP Pulse and saturation had been added. These recordings have been made by the night nurse as she went round at 06.00 hrs. (Field note 10)*

Notably, respiratory rate was the one sign not taken in the two patients for whom the nurse had found it necessary to take additional vital signs. As noted earlier (section 5.1), BAS incorporates blood pressure, respiratory rate and oxygen saturation. However, during observations when the nurse related that some patients had had BAS recordings taken, the actual recordings taken were blood pressure, pulse, saturation and temperature. Respiratory rate was omitted. This shows some discrepancy between the use of the term BAS and what was actually measured. In the phase one study, respiratory rate was a vital sign that was often not documented and omissions of the nature just described could be one of the reasons.

During an interview, a newly qualified nurse related how MEWS (see literature review Chapter 2, section 2.5.1.4) had been used in her training hospital. She said she felt safer with MEWS.

"It is clearer because you have those different colours . . . You see it and can quickly read and understand, that now I have to do something. If it is green then everything is fine . . . I mean if you are put in an acute situation it's easier to see what you should do with various patient status. If you compare to BAS, there is no real, clear guidelines . . . I think its strange that they do not use the same thing all over the country." (Interview 11. Nurse)

This seems to suggest that a MEWS system gave more security when assessing patients, perhaps, in particular for less experienced nurses (Andrews & Waterman, 2005).

Sub-category 2. Interventions

The second sub-category, interventions, is shown in the following example. In this instance, a clinical indication for recording 'extra' vital signs led to an intervention. This is shown in the following field note:

(Day shift. Nurse): The nurse has been told at the handover report that one of the patients has a low saturation level. Therefore she checks the patients saturation. It is 87%, so she commences oxygen therapy via face mask at a rate of 0.5 litres. (Field note 10)

The action above illustrates a clinical judgement made by the nurse to treat the patient based on a vital sign measurement.

Theme 2. Documentation of vital signs

The documentation theme had two categories: documentation in electronic health record (EHR) and documentation on paper.

Category 1. Documentation in the EHR

This category was divided into two sub-categories: Vital signs table and the journal sections of the EHR.

Sub-category 1. Vital signs table

Similar to routines for documentation in the cardiology unit, the vital signs table was considered the correct place for the documentation of all vital signs. However, the nurses in the infection ward used a further function of the table in the EHR, as seen in the following field note.

(Day shift. Nurse): The nurse writes in the low oxygen saturation value in the table and then she makes an addendum to the table. This is done by double clicking on the box in the table where she has just entered the vital sign. A speech bubble appears and she writes in the intervention that she commenced oxygen therapy. The speech bubble is then closed but marked with an asterisk on the table to indicate that something is written there. (Field note 10)*

This demonstrates a function in the EHR used in this section of the hospital that was not used in the other three clinical areas in which this study took place. This could indicate that the education and training on EHR functions was not the same throughout the hospital or

that other departments did not consider this function as suitable for their needs. If the EHR is used in different ways in different parts of the hospital it could cause problems in communication and the flow of information, for example, if a patient were transferred from one part of the hospital to another.

Another example of different parts of the hospital not having the same routines for documentation became apparent during the observation study, when a patient was transferred from the intensive care unit (ICU) to the infection ward. In this instance there were no vital signs documented in the EHR from the 24 hours the patient had spent in the ICU. Instead, a paper print-out of BP and pulse came with the patient. It transpired that the ICU used a continuous monitoring system that could give an automatic print-out of these vital signs.

> *(Day shift. Nurse) An opportunistic question about this was put to the nurse who was admitting the patient to the infection ward. She was not sure if the printout was scanned into the EHR but she said, "It is poor that nothing is in the table for vital signs for all of today". (Field note 10)*

This is an important observation, as hand overs from ICU to normal wards have recently been reported as being a precarious period for patients (Häggström & Bäckström, 2014). This situation could imply further risks for patients if two systems of documentation impede the flow of information.

Sub-category 2. Documentation in the journal of the EHR

Sometimes vital signs were written in both the table and the journal notes. One nurse pointed out that she did this when a new patient was admitted:

> *"I probably write them in both when I admit a patient - in the table and I also write it in text form (in the journal)." (Interview 11. Nurse)*

Another nurse explained that writing in the journal notes also gave a means of providing a more complete picture of the patient.

> *"They [vital signs] are always written in the table but it can be that a summary is written in the journal notes . . . it is to do with how the patient has been. You don't have to write a summary but, sure, we are used to this and it is good to get the whole picture . . . then you don't have to go to so many places in the EHR; you can read what you need in the journal and not have to read so much". (Interview 12. Nurse)*

This suggests that sometimes nurses felt if was important to write more than just the patient's vital signs and writing a summary with the vital signs saved clicking around the EHR to get a complete picture of the patient's condition.

Another explanation for vital signs in the journal notes was when something had happened to a patient.

> *"Sometimes if there is an acute event with a patient who is very sick, it can happen that they write in text in the journal . . . Then I can understand that they maybe miss entering all the blood pressures they have taken during that time as it is so difficult in an acute situation to keep track of exactly when some vital signs are taken". (Interview 13. Doctor)*

This shows that when a patient was very sick, nurses sometime wrote in the journal to report on a special event. This suggests that it was more efficient to report an acute situation by writing in free text.

Category 2. Documentation on paper

The second category, 'paper-based records' was divided into two sub-categories: pre-printed paper charts and paper notes.

Sub-category 1. Pre-printed paper charts

In the infection ward, there were four pre-printed paper charts (shown in Appendix VId). The first of these was similar to the observation chart in the cardiology ward, for patients requiring frequent vital sign recordings, because their condition was unstable, or if they were very ill. This was called the 'checklist' or 'BAS list' (Appendix VId). The following interview excerpts highlight this.

> *"If we have a sepsis patient who is unstable in the ward, then there is a paper chart which is left in the room with the patient." (Interview13. Doctor)*
>
> *"If we have someone who needs BAS checked more often . . . then we have the BAS list" (Appendix VId) (Interview 11. Nurse)*
>
> *" Because there are patients on whom we take vital signs more often . . . there is a paper for this" (Interview 12. Nurse)*

There were additional reasons for having a paper observation chart. Firstly, it could be kept beside the patient:

> *"You don't need to run back and forth between the computer and the patient . . . in or out or take the laptop, instead you have a paper that is there all the time." (Interview 13. Doctor)*

This suggests that a paper in proximity to the patient was appreciated by nursing and medical staff to allow both to have easy entry and easy retrieval of vital signs. Furthermore, if the patient was being barrier nursed the laptop could not be taken into the room. In this ward, several patients were barrier nursed in special rooms, each of which had an ante-room between the patient room and the corridor. This was where nurses could wash their hands and don a plastic apron and gloves. This made it impossible to wheel the trolley into the room because of the risk of cross infection.

Secondly, it was quicker to document on paper than in the EHR as a nurse pointed out during an interview:

> *"There is a paper for this - you just write it in quickly. We don't have time to go to the EHR every time. . . Because, I think there are very many clicks before you can get anywhere. Masses of clicks . . . if there were less clicks it would be easier.*
>
> *Researcher: "Maybe there will be easier technology in the future, like touch screens and tablets."*
>
> *Nurse: "Yes, if there were tablets you could have with you, then you would not have to run to the computer all the time. I've seen it on films from the USA (laughs) that they seem to have tablets to take round with them for the EHR. That would be something. " (Interview 12. Nurse)*

This suggests a usability issue. A frequent comment was the number of clicks it took to enter vital signs so that when patients required vital signs to be monitored frequently, it would have been too time consuming to write in the EHR every time. Time use is a usability issue noted previously (Stevenson and Nilsson 2012). Furthermore, the nurse was aware that having technology at the bedside could benefit her work.

Thirdly, nurses found that writing frequent vital signs, perhaps every 15 minutes, would fill up the table in the EHR and make it too long:

> *"There would be an awful lot if we wrote all the recordings every time in the table." (Interview 12. Nurse)*

This suggests that the table in the EHR could not accommodate frequent vital sign recordings. Generally, there was a sense that the EHR did not fit in with work routines, suggesting reasons for the need for paper chart:

> *". . . it [documentation] has to fit in with how we work. . . go smoothly. We can't have it that we stand at the computer the whole time and only write things. It's more important that we look after the patients, then document when we have time. Sure, we must document, but <u>when</u> we document is not the most important, just that everything is documented." (underline added for emphasis) (Interview 12. Nurse)*

This suggests that official documentation in the EHR was considered something that just had to be done, whilst paper workarounds were included in the actual process of care. The issue of an EHR not fitting in with work routines is frequently documented in the literature, with the explanation that system designers have poor understanding of the needs of end-users (Darbyshire, 2003; Goorman & Berg, 2000; Nemeth, Nunnally, O'Connor, Klock, & Cook, 2005).

Not all recordings were added to the EHR:

> *"We would write some recordings in the EHR, for example, when we finish a shift. . . maybe add the highest sign and the lowest sign . . . so you can see how it has been." (Interview 12. Nurse)*

Because not all vital signs were documented in the EHR, this could be an explanation for why phase one study found a lack of vital signs documentation in the EHR. It appears that many vital signs were taken but not documented.

The second paper chart used in the Infection Ward was primarily for recording temperatures, a 'temp list'. It acted as a sort of checklist to ensure all patients had their temperature taken (Appendix VId). The routine temperatures at 06.00 and 14.00 were written on a paper called a 'temp list' and added to the EHR afterwards. In the mornings the day nurse would refer to this when she went round the patients on the morning shift. She could then take vital signs on any patients who had been asleep at 06.00 or who had had unstable results earlier. This is seen in the following field note:

> *(Day shift. Nurse). At 07.30, the 'temp list' is on the trolley, along with a laptop which is being used for administering medications. The nurse checks the oxygen saturation of a patient which the night nurse had said was labile. She adds the measurement of the oxygen saturation to the paper 'temp list'. After she has been round all the patients, she sits down at the EHR and transfers the new information she has added to the paper 'temp list' to the EHR. (Field note 10)*

Thus, the paper 'temp list' was used so that the nurse could add any further recordings that would be later entered to the EHR. Although called a 'temp list' other vital signs were also noted here if necessary. The following interview excerpts describe how and why a 'temp list' was considered necessary.

> *The RN points to a temperature list. (VId). "With us, all patients have their temperature checked . . . and then we BAS the patients too [means to check blood pressure, respiratory rate and oxygen saturation], then write it on that temp list too in the first place. So if we have BASed a patient we write it like this" (the RN points to more vital signs which have been added in small handwriting at the side of the temperature slot, in the same slot as the patient's name - small because there is no actual slot for this). (Interview 12. Nurse)*

The 'temp list' only had a slot for temperature and when other vital signs were squeezed in beside the patient's name it could be hard to read, compromising effective communication.

> *"We have the list so that we have it when we go round [the patients]. You don't always have time to stand at the computer. We write it in later. It's easier to write it on a paper and then put it in the EHR when you have time. We have a routine that it is written in the EHR before we go home." (Interview 12. Nurse)*

As with the paper observation chart for frequent observations, the 'temp list' was considered quicker and easier to use as it accompanied the nurse as she went from patient

to patient. Similarly, there may have been a time delay from the time vital signs were written on the paper and when they were added to the EHR.

There were two further paper forms which had been especially created by the infection ward personnel. These were used during admission. One of these was a blue form, called a 'worksheet', which was filled in for all patients on admission (Appendix VId). It was mainly to assist the ward secretary with administration and contained information about blood tests etc., as well as vital signs - temperature, pulse, blood pressure, respiratory rate, oxygen saturation - taken on admission. This is illustrated in an example from the field notes:

> *Day shift. RN. On admission the nurse uses the blue 'worksheet' form to note the vital signs at the bedside. She says it is convenient to use this form as it must be filled in anyway. Afterwards, the nurse goes to the nurses' station and enters vital signs to the table in EHR. (Field note 10)*

In this instance, the worksheet was used as a means of noting vital signs before entering these into the EHR. The second form was a paper checklist, which was sometimes used by nurses, especially if they were new to the ward or newly qualified, to remind them of what to ask patients on admission, and included vital signs: temperature, pulse, blood pressure, respiratory rate, oxygen saturation and oxygen therapy (Appendix VId). The following interview excerpt describes this:

> *" . . . that's a checklist we use when a patient is admitted, because of the new nurses . . . so that they can tick off what needs to be done." (Interview 12. Nurse)*

Sub-category 2. Paper notes

The following field note is an example of how a paper note was used on admission.

> *Day shift. Assistant nurse: An assistant nurse checks a patient's vital signs and writes them down on a paper notepad. Back at the nurses' station, he writes these vital signs on a blue 'admission paper'. He then adds the vital signs to the table of the EHR. (Field note 10)*

In this case the vital signs were documented twice on paper before being entered into the EHR. This could imply a risk for error during transcription.

Theme 3. Retrieval of vital signs

This theme had three categories: paper charts, EHR and verbal communication. These are described below:

Category 1: Paper charts

In order to check previous vital signs, nurses often used the paper 'temp list'. This chart was kept on the trolley which the nurses used as they went round the patients. At other

times, the trolley was at the nurses' station and during the observation study on the ward it was noted that the 'temp list' remained on the trolley at all times. When a new 'temp list' was made at 06.00 and 14.00, the previous list was discarded.

> *"We have the list so that we have it when we go round. You don't always have time to stand at the computer." (Interview 12. Nurse)*

Thus, the paper 'temp list' was used so that the nurse had the most recent record for retrieval of information on vital signs at her fingertips. In this way, a suitable workaround had been created to ensure that the information they needed for caring for patients was at hand.

Category 2: EHR

Vital signs were also retrieved from the table in the EHR.

> *"If I want to see how it has changed over time, then I go in to the page with the measurements [the table] in the EHR to find out how it has been during a period of time, for both this admission and earlier to see how it has been with blood pressure and saturation, how it has been earlier. Now you can see it horizontally and you can compare the blood pressure and saturation over time. It is much simpler . . . this page [with table] is what I use several times per day when I am on the wards". (Interview 13. Doctor)*

This indicates that the doctor was satisfied with retrieving vital signs in the table. He also compared it to a previous system that had been used, i.e., when vital signs in the infection ward had been documented in the journal section of the EHR.

> *"It is a very new file, one or two years old. Since this was introduced it has become much easier. Earlier, it was written in the journal notes". (Interview 13. Doctor)*

This indicates an improvement in the method of documenting vital signs. In the phase one study, vital signs were often found in the journal notes. This may have been because the part of the EHR previously recommended for the documentation of vital signs (the template, Fig. 4.2) at that time, was more complicated for both entering and retrieving information.

Category 3: Verbal communication

An example of verbal communication as a means of knowing about a patient's vital signs was at handover report between a night and day shift. It is shown in this field note.

> *(Night shift. Nurse) handing over to day shift: Day nurse receiving report from night nurse. The night nurse reports that one patient has a high pulse and high BP. She also reports that another patient's saturation is labile. (Field note 10)*

This suggests that verbal communication was used to inform other nurses of patients who may require extra vigilance because of the risk of deterioration. Thus, nurses were

concerned with the patient's safety and well-being. By keeping each other informed verbally they may have felt they had more control over potentially worsening situations.

As mentioned, there could be a time lapse before vital signs were transcribed from a paper chart to the EHR. This could be problematic for a doctor who was checking the vital signs remotely in the EHR and hence, doctors asked nurses verbally for the latest vital signs.

> *"First I ask the nurse for the latest vital signs. They can often be given verbally." (Interview 13. Doctor)*

This suggests that all personnel were aware that they could not rely upon the latest vital signs being in the EHR. There were two possible reasons for this. The first was that they could be on a paper chart and not yet added to the EHR and the second was that only some of the vital signs were added to the EHR when vital signs were measured frequently. Consequently, doctors had devised a convenient workaround to ensure they knew the latest vital signs on their patients: by contacting nurses directly and receiving the information through verbal communication.

This concludes the findings from the infection ward. The final clinical area to be investigated was a surgical ward and the findings from this clinical area are presented in the next section.

5.5.5 Findings: Surgical ward

This section describes the results of the observational and interview studies from a general surgical ward in the surgical division of the hospital. Eight hours of observation and one interview were performed in this setting. The results of the analysis of the two data sets were merged and are presented in the following section according to three main themes: measuring vital signs; documenting vital signs; and retrieval of vital signs. An overview of the themes can be seen in Figure 5.8.

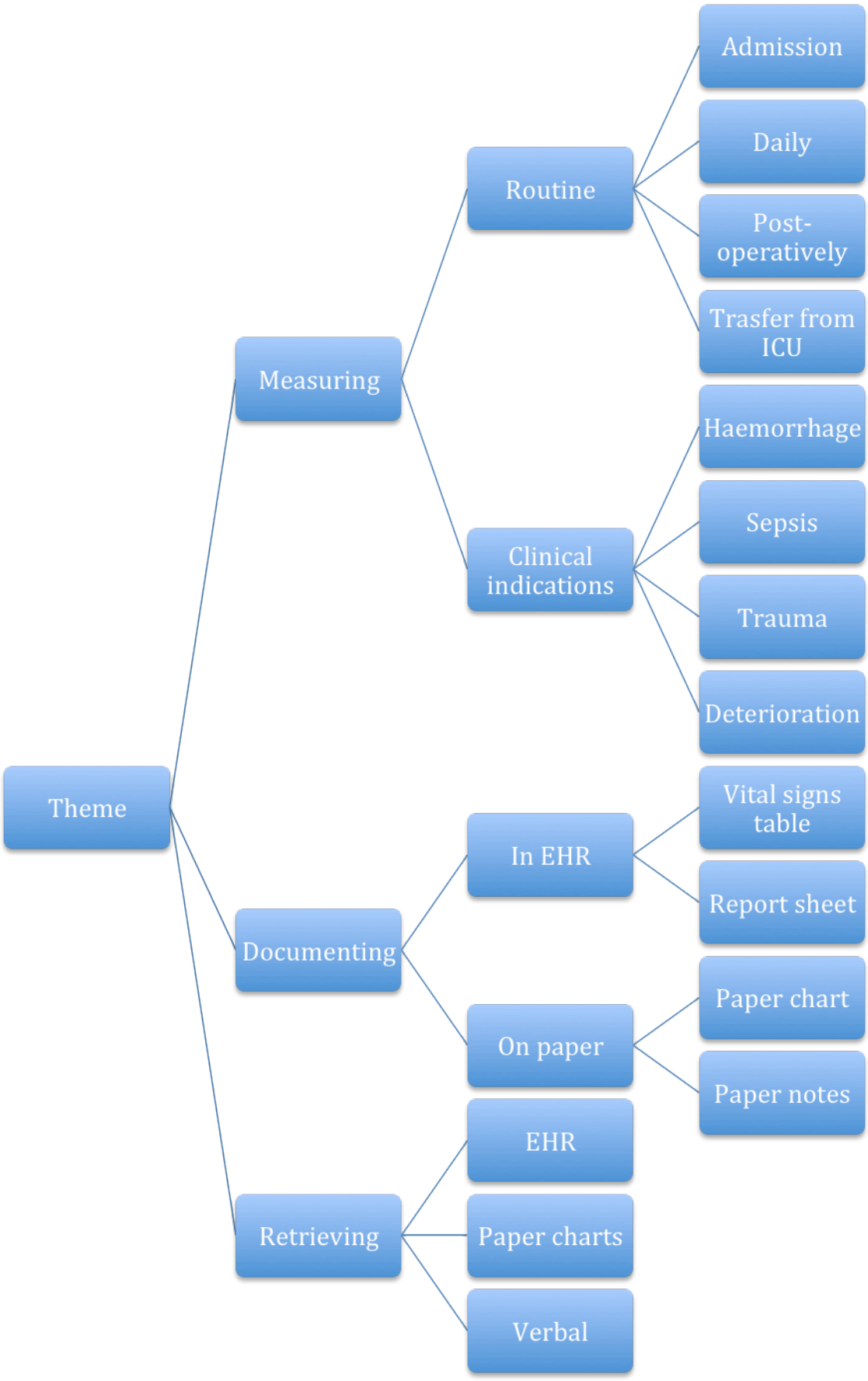


Figure 5.8 Analysis Surgical Ward: themes, categories and sub-categories

Figure 5.8 Analysis Surgical Ward: themes, categories, and sub-categories

The data collection involved one eight-hour observation session and one interview with a registered nurse (RN) on a separate occasion. At the beginning of observational study, the researcher was introduced to the staff, at the start of the 14.00 shift. Both morning and evening nursing staff were present and were interested to know more about the study. When this was described briefly, they were keen to relate that they used BAS and that it was used in all the surgical wards. They had guidelines for how it was used and a paper copy was quickly procured and given to the researcher. BAS recordings included 'blood pressure, respiratory rate, saturation, pulse and temperature'. As the author of these guidelines later pointed out during interview, "these vital signs are the same as those in MEWS - we just don't call it MEWS!" This BAS guidelines document is shown in its original Swedish form with an English translation in Appendix VIe. This guideline document was the basis for the measurement and documentation of vital signs in the surgical wards and is referred to frequently in the following account of the findings.

5.5.5.1 Theme 1. Measuring vital signs

This theme describes measuring vital signs in the surgical ward. It is divided into two categories 'Routine recordings' and Clinical indications'.

Category 1. Routine recordings

Routine recording of vital signs had four sub-categories: admission, once per day, post-operatively and patients transferred from ICU. The first sub-category, admission, is described in the next section.

Sub-category 1. Admission

BAS was always recorded on admission, following the surgical division's checklist/guidelines. The vital signs recorded were temperature, pulse, respiratory rate, blood pressure and oxygen saturation. This was confirmed during observations.

> *"All patients are BASed on admission." (Field note 12)*

Having the guidelines provided a routine that ensured that complete sets of vital signs were recorded on admission. The second sub-category, daily recordings, is described in the next section.

Sub-category 2. Once per day.

As stated in the guidelines, BAS should be checked once per day (Appendix VIe). During an interview, a nurse confirmed that vital signs were recorded daily on all patients.

> *"On all patients, it's once per day." (Interview 14. Nurse)*

When asked about her views on the current recording of vitals signs, she added,

> *" I think it has improved. Checking sick patients is something we have always done. But that we check <u>all</u> patients is new, we didn't do that before. You thought that as long as they were up and about, then everything was fine [laughs]. . . We sometimes detect things like atrial fibrillation, and other things. [underlined for emphasis] (Interview 14. Nurse)*

This suggests that since the introduction of the guidelines, the recording of regular vital signs had detected abnormalities which otherwise may have remained undetected. This implies that surveillance of patients had improved and may have had an impact on patient safety.

The nurse was asked how long these guidelines had been in use.

> *" . . . it was me who wrote it so I should remember [laughs heartily] eh, what can it be, two years maybe, something like that." (Interview 14. Nurse)*

In addition, it seemed that these relatively new guidelines for recording of vital signs provided a routine that ensured all patients in this surgical area had five vital signs checked at least once per day. This is in line with current research that suggests the regular measurement of core vital signs on all patients. However, the consensus of such research suggests that the minimum frequency should be at least twice per day (DeVita et al 2010).

During the observation study, the nurse said that it was useful to do BAS recordings at the start of the day shift as it gave information about patient status which was also useful for morning doctors' rounds. She said:

> *(Day shift. Nurse) "Usually we take them [vital signs] during the morning at around 08.00. If we don't have time or the patient is out of the ward, then the afternoon staff do it". (Field note 12)*
>
> *The nurse who was interviewed was less specific and said that vital signs were taken "sometime during the forenoon." (Interview 14. Nurse)*

Occasionally, the daily vital signs were taken at other times. For example, one patient had been taken to the theatre before BAS was taken. During a hand-over report, the morning nurse said:

> *"He has not been BASed - you can do that when he comes back." (Field note 12)*

This suggests patients had BAS recorded at least once per day and that nurses were careful to ensure the routine was followed. The patient referred to in the last statement would have BAS checked on return from theatre, as post-operatively was another routine time for BAS recordings according to the guidelines. This is described in the next section.

Sub-category 3. Post-operative patients.

According to the guidelines, all post-operative patients should be BASed three times per day on the first day and twice per day for the next two days. This was confirmed at interview:

> *". . . on newly operated patients it's three times a day." (Interview 14. Nurse)*

During the field study a patient was fetched from theatre. When the patient was back in the ward, the nurse said that the vital signs did not need to be taken straight away:

> *"He looks well and the operation was so minor that the surgeon had said after the operation that he could almost go home." (Field note 12)*

Therefore, vital signs were checked two hours after the patient returned. Because he was alert, talking and looked well, the nurse made the decision that vital sign recordings could wait till later. This indicates that the nurse used her clinical judgement and decided that the patient did not require vital signs to be taken immediately. Although the guidelines state that patients should have vital signs measured post-operatively, they do not indicate that this should be done immediately on return to the ward. However, according to accepted normal procedures, vital signs should be measured directly on return to the ward from theatre or the recovery room (Hutson & Millar, 2009).

Sub-category 4. Patients transferred from ICU.

The routine according to the guidelines was that all patients transferred from ICU should have BAS checked twice daily after transfer.

Category 2: Clinical indications for recording vital signs

This category is divided into four sub-categories, suspected haemorrhage, suspected or actual sepsis, trauma patients and patients who show any sign of deterioration. These are described below.

Sub-category 1. Suspected haemorrhage

According to the guidelines, BAS recordings should be done more often if there was any suspicion of haemorrhage, if there were specific orders from a doctor, or if there were indications according to the patient's status if. For example, at interview, a nurse said:

> *"If they have had an investigation where there might be a risk of bleeding . . . we would take them then too." (Interview 14. Nurse)*

Sub-category 2. Suspected or actual sepsis

Another directive of the guidelines was regarding patients with suspected sepsis who should have had BAS recordings taken more frequently. This was apparent during the field study:

> *(Evening shift. Nurse) A patient had been diagnosed with sepsis as the result of a urinary tract infection. All vital signs had been checked at 08.00, but in addition her temperature had been checked at 05.00 and 12.00. This shows that sometimes isolated vital signs were taken with the nurse using clinical judgement to decide that temperature was most important. On the evening shift, the nurse recorded a full set of vital signs at 19.00 thus following the BAS guidelines which said that patients with sepsis should have BAS recorded more frequently. (Field note 12)*

Sub-category 3. Trauma patients

The BAS guidelines also indicated that all trauma patients required BAS recordings more frequently- this according to doctors' orders or patient status.

Sub-category 4. Deterioration

The BAS guidelines (Appendix VIe) state "Furthermore, new recordings should be taken directly if a patients shows any sign of deterioration (vertigo, decrease in conscious level, poor colour, poor appetite, etc.,) and then more frequently until the patient is stable." As the nurse during interview stated:

> *"If they are poorly, of course we take them". (Interview 14. Nurse)*

This suggests that clinical judgement is important in decisions about taking vital signs.

During the field study, there were several incidences of patients having vital signs measured more frequently than once daily:

> *A patient who had an oxygen saturation of 86% at the 08.00 recordings had oxygen saturation and pulse checked in the afternoon. The nurse said that it was the oxygen saturation which was of interest so did not take a full set of vital signs. Here, the nurse is using clinical judgement in deciding not to record all the BAS vital signs. (Field note 12)*

However, according to the current consensus, full sets of vital signs should always be taken, rather than just one or two vital signs in isolation (DeVita 2010)

Patients who were very ill were continuously monitored to measure the vital signs, that is, the patient was connected to a monitor that measured blood pressure, pulse and respiratory rate. The nurse related:

> *"They are connected to a monitor . . . we have two of these monitors. As there is so little room in ICU we can have really sick patients in the ward in a way that we maybe did not used to have before." (Interview 14. Nurse)*

This indicates that patients who were very sick or unstable were closely monitored but it also suggests an awareness that patients in general wards were more at risk of deterioration then than they were in previous years.

Theme 2. Documentation of vital signs

The documentation theme had two categories: documentation in electronic health record (EHR) and documentation on paper.

Category 1. Documentation in the EHR

This category was divided into two sub-categories: Vital signs table and the report sheet in the EHR.

Sub-category 1. Vital signs table

Similar to routines for documentation in other clinical areas in this study, the vital signs table was considered the correct place for the documentation of all vital signs. Vital signs were entered into the table one at a time. No graph was used. During observations, the nurse mentioned that there were many clicks to carry out this procedure.

Sometimes extra vital signs were taken outside the routine daily measurement. These were noted on paper first and then added to the table in the EHR. During observations it could be seen in the table in the EHR that sometimes these were complete sets of vital signs and at other times, only an isolated vital sign such as a temperature or oxygen saturation were recorded.

The nurse who was interviewed pointed out one situation in which there could be a lack of documentation was when patients were on continuous monitoring.

> *"Then there can be gaps [laughs]. Because there we can often take the blood pressure, say at least half hourly and then we don't stand and write all of these BPs in Cosmic. It would be impossible. On the other hand, it is saved in that computer if you should want to go back and*

see - in the monitor it is saved - if you should want to go back and look. But we don't write it in our EHR as it would quite simply take too much time. Instead we might document 3 sets of vital signs over the day." (Interview 14. Nurse)

This suggests that the EHR did not accommodate documentation of frequent vital sign recordings. It also clarifies reasons for some of the lack of vital signs in the EHR as revealed by the phase one study.

Sub-category 2. Report sheet

The second sub-category was 'report sheet'. The report sheet is another section of the EHR where any documentation is in the form of free text. This section is used by nurses only. The report sheet was used for the documentation of vital signs if there were abnormal recordings, for example, it was noted in the report sheet that a patient had a temperature of 39°C and was breathless. This type of recording is also described by a nurse during the field study.

"I would write in the report sheet as there I can report the abnormality, the action taken and the evaluation. For example, a patient with fever, that I gave paracetomol, then check the temp later and write in the new temp. For a patient with low sats, and that I gave oxygen, evaluated the effect and wrote in the new saturation." (Field note 12)

At interview, the need to report abnormal vital signs and actions taken in the report sheet was confirmed:

"Yes, if you do something. If you take some action. Yes, if you notice something like a patient not feeling well. He's shivering, check temperature, and then if you have taken some action too. Maybe given Frusemide or an extra Xylocaine . . . There it would be written that the patient is poorly and that we have connected her to the monitor. Often a doctor has said what the target values should be - that they should have a systolic pressure over 90 or something. And then you try to achieve these parameters. And then we have standing orders for starting Ringer's lactate." (Interview 14. Nurse).

This indicates the use of the report sheet to report nursing diagnoses, actions taken and evaluating the actions by writing in subsequent results. This is an important part of the nursing process so it is perhaps not surprising that the nurses have the need to write this up in this way. It may attract the label 'double-documentation' but for most nurses, this is an essential part of their job and they need to be able to document their observations and actions in a way that makes sense to those reading the report.

Category 2. Documentation on paper

This category had two sub-categories: pre-printed paper charts and paper notes.

Sub-category 1. Pre-printed paper charts

In the surgical ward there was one pre-printed paper chart. This was a paper chart in the form of a table where the 'once daily' routine recording were first written (Appendix VIf) before being added to the EHR. This chart was in the form of a table with room numbers in the left hand column and the vital signs in a row along the top. It included TPR, BP, SaO_2, VAS and blood sugar. At interview, a nurse described how the paper chart was used:

> *"We take one of those lists so that we see that it is done on everyone [vital signs]. Then we see if one is not done then we go in and take them. The paper is like a checklist." (Interview 14. Nurse)*

The nurse said that these vital signs were added to the measurements table in the EHR during the morning. The nurse said she would write the time of 08.00 in the EHR table as this would show the time the signs had been taken, although it might be later in the morning before these were entered into the EHR. The paper chart was thrown away after the vital signs were entered into the EHR.

During an interview, a nurse said that vital signs were usually written in soon after they were taken, adding:

> *" . . . and those isolated ones we take, not the routine ones, those we write in straight away if the patient is poorly." (Interview 14. Nurse)*

The paper chart was considered quicker and easier to use as it was taken from patient to patient during morning rounds. Similar to the cardiology department and infection ward, there may be a time delay from when the vital signs were written on the paper to when they were added to the EHR.

Sub-category 2: Paper notes

When vital signs were recorded at additional times to the daily recordings, nurses jotted down vital signs in a notepad that they kept in their pockets. They would then go to the nearest computer and enter the vital signs into the table in the EHR, as can be seen in this field note.

> *A patient who had returned from theatre had a full set of vital signs recorded. Initially this was written on a paper note. Then the nurse transferred the recordings into the EHR which was on a laptop in the corridor along from the patient's room. (Field note 12)*

If they were doing a medicine round they had a laptop on a trolley in the corridor. At other times the computers were at the nurses' station. When asked about paper notes at interview, the nurse confirmed that it was usual practice to write vital signs on a paper note

when the recordings were taken at times other than the once daily recordings, before adding these to the EHR. Interestingly, she added:

> *"They have started to talk about that we could have small hand held computers, but we have not come that far yet. But it is in the plans for down the line. Instead of a notebook in your pocket there will be a hand held computer. That you can write in directly." (Interview 14. Nurse)*

This statement implies that technological solutions have been considered.

Theme 3. Retrieval of vital signs

This theme had three categories: EHR, paper charts and verbal communication. These are described below:

Category 1: EHR

At the start of each shift, nurses in the surgical ward sat down at the EHR and read through the records of patients for whom they would be caring on that shift. They had a set routine for this. First they would read the journal pages where doctors notes were written. Then they went to the table for vital signs to assess latest recordings. Whilst doing this they made notes in their pocket books. The field note describes this:

> *(Day shift. Nurse). As the nurse systematically went through each patient's records, she always looked at the vital signs table. (Field note 12)*

During interview, the nurse said that they had become very used to the table and that nowadays she did not miss not having the information on a graphical chart:

> *"We are so used to it. You have a row with all the vital signs and you can look in the history. And if there is anything, then they are there." (Interview 14. Nurse)*

Thus, information on vital signs were retrieved from the table in the EHR at the same time as they read about their patients. During an interview, it was pointed out that the main method of receiving reports was by reading the EHR. Only supplementary information was added at short follow-up verbal reports.

Category 2: Paper charts

In the immediate post-operative period, patients were observed in the recovery room, where vital signs were monitored and documented in a direct system into the computer. However, the computer programme was not linked to the patient's EHR. Therefore, when a patient was transferred back to the surgical ward, the vital signs taken during the immediate post-operative period in the recovery room were printed out on a computer

print-out paper, i.e., they were not available in the EHR. This meant that nurses on the ward retrieved vital signs from the paper print-out.

During interview, the nurse said that the recovery room system was a separate computer programme to which they did not currently have access. However, it was planned that the ward nurses would eventually have 'reading rights' for the recovery room system.

> *"It's so new, this system. We will have 'reading rights' for that system but we have not got it yet. But it's on the way. We shall be able to read it. Before, the recovery room had a paper journal and it was scanned in to our computer system. But now they have their own computer system." (Interview 14. Nurse)*

The interviewer asked about the flow of information.

> *"Just now, it does not work optimally, but as soon as we get reading rights it will be OK." (Interview 14. Nurse)*

This suggests that the flow of information on vital signs could have been variable. This is also an example of how different computer programmes within the same hospital did not communicate with each other. In fact, there were several computer programmes used in this hospital. For example, the blood bank, X-ray and surgical operation records had separate systems some of which required a different 'log in' from the EHR.

> *"Despite our EHR being so big, we still have about eight parallel systems. . . it means we have to hop out of the EHR a lot . . . there are many codes . . . the blood bank, you have to log in every time, but the operation programme, we don't have to log in to that, and not the X-ray programme either; we can go from our own system without needing to log in again." (Interview 14. Nurse)*

The lack of interoperability between computer systems may upset the flow of information with subsequent risks to patient safety.

Category 3: Verbal communication

An example of verbal communication as a means of knowing about a patient's vital signs was between a morning and evening shift. (NB This was a very brief verbal report received as required to follow up the reading report). An example is shown in this field note:

> *(Morning shift handing over to evening shift. Two nurses): The morning nurse reports that one patient has not been BASed today. As he is now in theatre undergoing an operation, the morning nurse says "so you can BAS him this evening". During the verbal report the morning nurse also mentions that a patient had an oxygen saturation of 86% so could she check this again in the evening. A patient who had a high temperature was also mentioned at the report (Field note 12)*

This suggests that verbal communication is used to inform nurses of patients who may require extra vigilance because of the risk of deterioration. This implies that nurses are

concerned with the patient's safety and well-being. By keeping each other informed verbally they may feel they have more control over potentially worsening situations.

> *(Day shift. Doctor) Another situation in which verbal communication occurred was when a doctor came to visit a patient who had an infection. The nurse informed the doctor of the latest temperature recording and that the patient was a little breathless. This meant that the doctor did not have to check for this information in the EHR and thereby saved time as well as ensuring up-to-date information. (Field note 12)*

At interview, the nurse was asked about how doctors retrieved information on vital signs.

> *"It is a little up to the person. If it is one of our older consultants, then he asks us. If it is one of the newer doctors, they go in and read in the table. So it is a bit of a generation question." (Interview 14. Nurse)*

This suggests that verbal communication for information on vital signs was used by some doctors, particularly if they were of an older generation. This concludes the findings from the surgical ward. The next section presents a summary of the findings.

5.6 Summary of key findings

This section provides a summary of the key findings from the qualitative study and brings together the findings from the different hospital areas. It is presented in three parts following the same themes as those of the findings: measurement, documentation and retrieval of vital signs. A detailed discussion of these findings is presented in Chapter 6 in which the studies from both phases of this research are interpreted.

5.6.1 Measurement of vital signs

There was a policy related to measuring vital signs in the study hospital. This policy referred to a system called BAS. BAS is an acronym which stands for B - blodtryck (blood pressure), A - andningsfrekvens (respiratory rate) and S - saturation (oxygen saturation). The system was introduced to the study hospital in 2007, primarily as a tool for detecting sepsis in patients. However, the policy for using BAS appeared to be somewhat vague. For example, whilst conducting the quantitative study of this research, the researchers were informed that BAS should be recorded once per day on all patients. However, when the current qualitative study was conducted the researcher was informed that BAS should be measured on admission and after that 'as required', or as directed in each of the clinical areas.

An interesting observation was that the acronym, BAS, was used liberally when speaking about recording vital signs in all four clinical areas. For example, the acronym had

developed verb forms, e.g., "shall I BAS that patient", "the patient has been BASed" and "we BAS all patients on admission". However, perhaps somewhat surprisingly, to say that a patient was 'BASed' did not necessarily mean that all of the BAS vital signs had been taken. Although BAS meant measuring blood pressure, respiratory rate and oxygen saturation, the findings showed that the term was used rather loosely and could refer to varying combinations of vital signs. For example, there were many instances of nurses saying they checked BAS recordings when in fact the recordings they measured were blood pressure, pulse and oxygen saturation and, in other instances, 'BAS' could mean measuring blood pressure, respiratory rate, temperature, pulse and oxygen saturation. Therefore, it appeared that 'BAS' had become a term used to indicate that some/any combination of vital signs had been taken. This might be explained in the following discussion about variations between the clinical areas in the study.

Examination of the measurement of vital signs in the four clinical areas produced a wide range of findings. From these findings it was possible to gain an insight into routines and decision making processes which led to vital signs being measured or not. The findings revealed that the stricter and clearer the routine used in individual areas, the more complete was the measurement of vital signs. For example, the routine for measurement of vital signs in the ED was very clear. This was most likely because the triage instrument, RETTS was used, and dictated that all vital signs in the RETTS system (temperature, pulse, respiratory rate, blood pressure, oxygen saturation and conscious level) must be measured and entered into the system in order for the triage priority to be calculated.

Similarly, in the surgical ward there were clear guidelines, which had been drawn up within the previous two years, and were in place when the data was collected for this study. The nurses on the surgical ward related that they used BAS as their guideline for observations. However, the guideline did not only include the BAS parameters but two further vital signs, pulse and temperature. As the nurse who wrote the guidelines pointed out, the new guidelines were actually more similar to the parameters measured in MEWS systems than BAS. The frequency for measuring these vital signs in the surgical ward was at least once daily. Additional times were on admission, after transfer from ICU or recovery room, and post-operatively. The guidelines also indicated that any patient who showed signs of deterioration should have vital signs checked. These guidelines provided a clear routine which appeared to be strictly followed by nursing staff, according to the findings of the observations and interviews. Hence, the measurement of vital signs in both the ED and the surgical ward usually included recording complete sets of vital signs. However, in both the

ED and the surgical wards, there were incidences of isolated vital signs being checked. For example, a nurse might check a temperature outside routine times if a patient showed signs of fever or take an extra blood pressure if the patient felt or looked poorly. Checking isolated vital signs was considered 'extra' recordings to double check if something was 'going on with the patient'. The current literature, however, recommends that complete sets of vital signs should be recorded (DeVita et al., 2010).

In the cardiology department and the infection ward, the findings were somewhat more complex. Guidelines or specific systems, such as those used in the surgical ward or the ED respectively, were not apparent in these clinical areas. This lack of strict guidelines may have contributed to the variability of recordings in cardiology and infection.

For example, in the cardiology ward there was consensual agreement that vital signs were routinely measured three times per day, once during each of the three nursing shifts. However, the choice of 'which' vital signs measured during these routine times varied substantially, and depended almost entirely on individual decisions by nurses. Most nurses agreed that they would always check the blood pressure and pulse and maybe oxygen saturation. They explained that because it was a cardiology ward the blood pressure and pulse were the most important. Nurses used their clinical judgement to decide whether additional vital signs to those mentioned above were necessary when the three times daily recordings were measured.

The routine on the infection ward was to record vital signs on admission, and at least twice per day, on all patients. However, the twice-daily recordings only included temperature as a standard recording. This can be seen on the paper chart that was used during these twice daily recordings (Appendix VId). There was a general opinion that temperature was the most important vital sign. According to the ward routine, it was only temperature that had to be measured twice daily. This meant that the selection of additional vital signs measured was decided upon by individual nurses according to their clinical judgement. There was a general opinion that BAS was also important. A senior nurse in the ward explained that the overall hospital policy was that BAS should be measured on admission, but, after admission, individual wards had their own routines on when they should measure BAS. This ward did not have any written guidelines and therefore nurses measured BAS when they thought it was necessary. This could explain why the table for measurements in the EHR of the infection ward displayed isolated and rather sporadic recordings of vital signs.

It was demonstrated during observations and interviews that nurses made decisions about which vital signs to measure according to a variety of reasons, e.g., checking the temperature of a patient who had had a surgical procedure and checking oxygen saturation if a patient complained of breathlessness. Nurses were obviously aware of the need to observe patients and reacted to clinical indications and events as they unfolded by using their clinical judgement.

Data from observations and interviews revealed that the vital signs that seemed to receive least attention in cardiology and the infection ward were respiratory rate and conscious level. Respiratory rate was often overlooked and nurses gave several explanations for this, for example, that they were "careless with respiratory rate", sometimes forgot to take it, claimed it was difficult to measure if patients were talking, or said that it was easy to see if a patient was breathless and therefore there was no need to stand and count it. Conscious level was rarely mentioned in cardiology or the infection ward. This vital sign was explicitly articulated in the ED where it was one of the six parameters in RETTS, and in the surgical ward where it was cited in the written guidelines (Appendix VIe).

The findings suggest that clear guidelines of the type used in surgical wards, or the RETTS tool such as that used in the ED, had observable benefits. Staff recorded vital signs as a routine and not only when there was a clinical indication. The findings from the cardiology department and the infection ward suggest that not having clearly expressed guidelines may have led to greater variability in the recordings of vital signs. Thus, the findings indicate a relationship between clear guidelines and the thoroughness of vital sign recordings. In fact, in this qualitative study, it can be reasoned that the stricter the guidelines for recording vital signs, the more complete were the vital sign recordings. The relationship between explicit routines for recording specific vital signs have been demonstrated in several studies (McBride et al., 2005; McCormick, 2005). For example, with EWS systems, where guidelines are very clear, staff know what should be recorded and how often, with clear instructions for escalating the frequency of observations in the event of abnormal recordings. In turn, this has resulted in improvement in detecting critical deterioration and a reduction in the incidence of cardiac arrest (Bunkenborg, Samuelsson, Poulsen, Ladelund, & Åkeson, 2013).

5.6.2 Documentation

Documentation of vital signs in EHRs has received little attention in the literature. Nevertheless, good documentation is crucial in the detection of critical illness and has been

examined regarding documentation on paper charts (Horswill et al., 2010). The findings of the current study elucidated many aspects of documenting vital signs in the EHR and a summary of these findings is given in this section.

Nurses documented vital signs in three parts of the EHR but the most common section, and where nurses agreed that they should be recorded, was in the vital signs table. A screen shot of a typical table is shown in Figure 5.3. There was general agreement that the table they currently used was a considerable improvement on the previous facility used for vital signs in the EHR (See Figure 4.2).

There were several comments related to usability when documenting vital signs. As seen in the findings, many found the table awkward to use as it involved many clicks in order to enter the vital signs. This was found to be time-consuming especially when frequent recordings were required. As suggested by the name, the table was in a table format. Having the table format and not a graphical format may have been related to the awkward process involved in creating a graph and, in fact, it seemed that most nurses were unaware that creating a graph was even possible. One nurse described how it was possible to make a graph from the table but, as it was difficult to create in the EHR, it was never used. There were varied opinions among nurses about whether they would prefer to see the vital signs in graphical format or not. Some thought they got a good overview from the table while others mentioned that they would have preferred to see the vital signs in graphical format in order to get a better overview and be able to follow trends. Many of the younger nurses had never used a graphical chart, as these had already been replaced with electronic systems by the time they began their nursing careers. However, according to recent research on the presentation of vital signs, graphical format makes it easier to identify clinical deterioration (Horswill et al., 2010).

The report sheet in the EHR was another location for documenting vital signs. There were specific reasons for recording vital signs in this section. The main reason noted during the study was that it was to record abnormal vital signs or give extra information related to vital signs. In cardiology and the surgical ward, the report sheet was frequently used for documenting vital signs. For instance, abnormal vital signs were noted in the report sheet to draw attention to any abnormal recordings. In addition, if there was an intervention because of abnormal vital signs, it was also written in the report sheet. Nurses felt that by writing in the report sheet, they could tell the 'whole story' of what had happened to the patient. In a way, this could be a means of describing the process of nursing care.

Moreover, some nurses found that it was quicker to write the vital signs in the report sheet if they were very busy. This could be related to usability issues, as many nurses found that entering vital signs in the table involved an excessive number of clicks. Some nurses expresses a wish for more suitable technological solutions and suggested that mobile appliances such as tablets or mobile phones would be more fitting for their work processes.

The journal was the third area in which vital signs were sometimes documented. In the ED, the first set of vital signs went automatically to the journal as this is where the triage system RETTS documented those. Subsequently, nurses documented vital signs in the table, the table which was also used in the remaining clinical areas in this study. In the infection ward, nurses used the journal rather than the report sheet to record abnormal vital signs and to write narratives relating to interventions and outcomes.

However, documentation of vital signs was not restricted to the EHR as could be seen from the many paper documents for vital signs found during this study. The most common reason for using paper charts was when frequent vital sign recordings were taken, for example, if a patient's condition was unstable or if they were receiving a new treatment. When frequent vital signs were recorded, the table in the EHR was found to be unsuitable for such frequent documentation. To begin with, frequent entries of vital signs made the table too long and quickly filled the width of a computer screen in the EHR. Then personnel would have to scroll horizontally to see previous vital signs. Another problem was that when many vital signs were taken, the lengthy process involved in entering each vital sign was too time-consuming. In addition, nurses felt that they got a better overview of a patient's condition and could see all the vital signs at a glance on a paper chart. Another advantage of the paper chart was that it was more mobile than a computer and could easily be kept beside the patient. Thus, paper charts served a useful purpose when frequent vital signs were required.

Nevertheless, there were some problems associated with paper chart use. First, when paper charts were used, only a selection of the vital signs recorded were added to the EHR making the electronic record incomplete. Second, no reference was made in the EHR that a paper chart existed or was being used. This could make it difficult for doctors who wanted to view vital signs remotely, as no vital signs would be documented in the EHR, and it might even look as though vital signs had not been taken. Third, although these paper charts were scanned in at a later date to the EHR, there was no reference in the EHR to say that these scanned charts were available in an archive section of the EHR.

Further types of paper used, were notepads and temporary paper checklists. These were used to note vital signs when the computer was not beside the patient's bed. This was often the case as computers with the EHR were either in the corridor adjacent to the patient rooms or at the nurses' station; therefore, these notes and paper checklists were used to jot down vital signs until they could later be documented in the EHR. This was either done fairly promptly after the recordings were made or it could be delayed until the end of a shift. These actions suggest that the EHR did not fit in well with work processes, but it seems that when paper was used it was easily aligned within work processes. Furthermore, there was a sense in some cases that documentation in the EHR was just something that had to be done.

5.6.3 Retrieval of vital signs

In this section, there is a brief summary of how medical and nursing staff were informed about patients' vital signs. As there was some variation between medical and nursing staff, the summary first presents retrieval by nursing staff and is followed by retrieval by medical staff.

For nursing staff, the most common method of finding vital signs in the EHR was to look in the table, although there were some variations from ward to ward. The infection ward nurses checked the table and the journal sections. The cardiology ward nurses seemed to vary their choices on where retrieval took place and most nurses in this unit had their own way of going about this. Often this meant that three different parts of the EHR were checked. In both cardiology and infection, nurses would mention deviations in vital signs at the verbal handover report. In the surgical ward, at the start of each shift, each nurse coming on duty sat down at a computer in a quiet room to read the report on patients for whom s/he would be responsible for during the shift. In this way, a silent report took place and verbal reporting was kept to a minimum. Information on vital signs in the EHR was found by looking at the table and by checking the report sheet for further information. In the ED the triage vital signs were documented in the journal and all subsequent vital signs were in the table. This meant that to see baseline vital signs in comparison with the additional vital signs, the staff had to look in two separate places, potentially wasting time.

Two of the doctors interviewed were very irritated and frustrated about the difficulty in retrieving vital signs from the EHR. They claimed that it was difficult to locate the correct section of the EHR, that the procedure was time-consuming and that it took too many clicks. Moreover, these doctors said that when they found the information, it was not

presented in a way in which it could be easily interpreted, stating that lack of graphical representation and not being able to view trends made it difficult to assess patient status. They also said that they could not be sure that the latest vital signs measured had been documented. Because of this, they often resorted to asking nurses verbally for the latest vital signs. Another doctor was reasonably satisfied with the table format in the EHR although he found it necessary to check verbally with nurses to ensure he had the latest vital signs. In addition, he appreciated that a paper chart with vital signs was available at the bedside of very sick patients, allowing easy access to latest recordings.

This section has provided a brief summary of the main findings from the qualitative study. The next chapter, Chapter 6, provides an integrated, interpretive discussion of the studies carried out in this mixed methods research.

Summary of key findings from phase two study

Measurement of vital signs

- there were varied routines for the frequency of vital signs recording in each clinical area
- there were varied routines for which vital signs were recorded in each clinical area
- clear guidelines would make it easier for staff to know when and which vital signs to record

Documentation of vital signs

- there were usability issues - e.g., a need for easy entry of data
- paper charts may serve a useful purpose
- there is a need for standardisation of paper charts

Retrieval of vital signs

- there were varied routines for retrieving vital signs from the EHR, e.g., to look through three sections
- clinical information could not easily be seen at a glance
- it is difficult to assess clinical status of a patient easily
- there is a need for verbal communication

Chapter 6 Integration

6.1 Introduction

Chapters 4 and 5 presented the quantitative study from phase one and the qualitative study from phase two, and provided conclusions to each individual study. In this chapter, Chapter 6, the results from the quantitative and qualitative phases are combined to integrate both sets of findings, to develop meta-inferences, and to provide a holistic perspective to the entire research. This chapter begins with a brief overview of the design, analysis and integration pertaining to this mixed methods research (Sections 6.1.1-6.1.3). Section 6.2 presents an integration of the findings from the quantitative study of phase one and the qualitative study of phase two. Section 6.3 discusses the meta-inferences and deeper implications of the research. Finally, trustworthiness, and strengths and limitations of the research are presented (Section 6.4). The discussions in this chapter contribute to research on the documentation of vital signs in electronic health record (EHR) systems.

6.1.1 Sequential explanatory design

As described in Chapter 3, the design strategy within the mixed methods approach for the current research was a sequential explanatory design. The quantitative data were collected and analysed first. This was phase one of the research (Chapter 4). This phase informed the research questions for the qualitative phase of the study. The qualitative data could then be collected and analysed to develop a deeper understanding of the results of the phase one study. The phase two study provided useful explanations to the findings of the phase one study as it illuminated practices, routines and attitudes toward the documentation of vital signs. In addition, this design worked well when there was only one researcher; it was practical to collect the data sequentially; to collect data concurrently would have been too complex.

6.1.2 Mixed Methods Data Analysis

In this research, the quantitative and qualitative strands had equal weighting which means that neither were dominant as is often the case in mixed methods research (Creswell & Plano Clark, 2007). The data analysis for both strands of the research were rigorously performed so that credible inferences could be made. When credible inferences are available from both studies, the quality of meta-inferences will be high.

6.1.3 Integration during the mixed methods research process

As described in section 3.3.1, there are several possibilities for integrating the two phases of a mixed methods study and it is important to identify when this happens to indicate the value of doing a mixed methods study (Ivankova, 2014). In this mixed methods study, there were several points of integration between the quantitative and qualitative phases of the research. An early point of contact between the two study phases was during the data collection stage of the quantitative study. For example, when collecting data from the existing records in the EHR, it was noted that it was difficult to find data on vital signs because they was scattered throughout three sections of the EHR. Therefore, seeds of questions about 'why' it was like this were already sown, and enhanced the planning of the second phase. The descriptive statistics revealed that there were gaps in documentation and thus the question 'why' was formulated. It was these ideas that laid the ground for the development of research questions for phase two and therefore a second point of connection was made between phases one and two. Thus, the explanatory sequential design allowed building on and developing initial findings (Feilzer, 2010) at the intermediate stage of the overall study.

Another example of how the data were integrated arose within the qualitative study. In this phase, two methods of data collection were used, observations and semi-structured interviews. The observations were carried out first. The field notes from the observations were analysed using an inductive approach to gain knowledge of the phenomenon, i.e., there were no previously assigned themes (Graneheim & Lundman, 2004). Themes created from this inductive approach were then used to prepare the questions for the semi-structured interviews. In this way, the semi-structured interviews were conducted with the benefit of previous knowledge, and therefore the second method of data collection and data analysis within the qualitative study used a deductive approach. In this way, the interview part of the qualitative study built on previous data from the observational part of the study (Feilzer, 2010). When multiple methods are used within the same approach, in this case, the qualitative approach, it is known as multi-method research and should not be confused with mixed methods research, which involves two approaches, collecting both quantitative and qualitative data, and then integrating both forms of data (Creswell, 2013b). Multi-method research is a strategy used in construct validation (Johnson et al., 2007) which is discussed later in this chapter.

The final stage of mixing methods was when the quantitative and qualitative findings were integrated during the discussion of the outcomes of the entire study (Ivankova et al., 2006; Venkatesh et al., 2013). At this stage, inferences from both phases of the research were combined. 'Inferences' are defined as "a researcher's construction of the relationships among people, events, and variables, as well as his or her constructions of respondents' perceptions, behaviours and feelings and how these relate to each other in a coherent and systematic manner" (Teddlie & Tashakkori, 2010, p. 27). After substantial inferences have been made from the quantitative and qualitative studies, a meta-inference pathway can be established. In explanatory sequential design, the pathway begins with the quantitative findings, is followed by the qualitative findings and ends with the meta-inferences (Venkatesh et al., 2013)(See Figure 6.1).

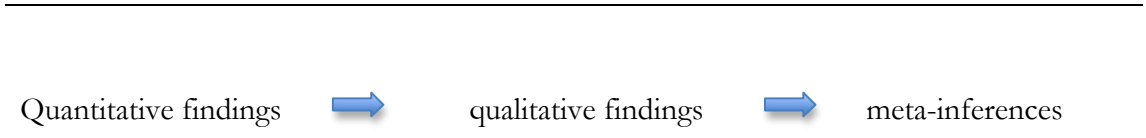


Figure 6.1 Meta-inference analysis pathway (adapted from Venkatesh et al.)

Inferences from both phases of the research were combined to interpret the results and develop meta-inferences. Meta-inferences are described in section 3.8.3.

6.2 Integration of the findings from phase one and phase two

In this section, the results of the phase one study have been integrated with the findings of the phase two study. The phase two study set out to explain the results of the phase one study. The phase one quantitative study began with the overall aim of examining the documentation of vital signs in the EHR of patients who subsequently suffered a cardiac arrest. Following the pilot study, the objectives were refined to include:

- Identify the extent to which vital signs were recorded in the EHR in the final 24 hours prior to cardiac arrest;
- Establish the location of vital sign recordings within the EHR, and how they were documented;

- Examine whether documented vital signs could reveal information about a patient's risk of deterioration by aligning these to two track and trigger systems (TTS) (BAS and ViEWS);

Briefly, there were four main findings from the phase one study:

1. there were three sections of the EHR in which vital signs were documented
2. vital signs in general were missing from the EHR documentation
3. there was uneven documentation of the various vital signs, i.e., some signs were recorded frequently and some were seldom recorded
4. more patients were identified for physiological deterioration by ViEWS than by using BAS

These four findings from the phase one study have been integrated with the findings from the qualitative study in the discussion that follows. This section begins with explanations of why vital signs were found in three sections of the EHR. This is followed by explanations for the lack of vital sign documentation and the reasons for vital sign documentation being uneven for various vital signs. Finally, ViEWS and BAS are compared. Thus, this section provides a description and discussion of how the qualitative findings in phase two explained the quantitative results from phase one (Ivankova et al., 2006).

6.2.1 Why were vital signs found in three sections of the EHR?

During the first phase study, it had been identified that there were three different sections in the EHR in which vital signs could be documented and were found: the journal, the template and the report sheet. The qualitative study provided some explanations for this diversity which included both usability issues and issues related to practice and routines.

First, it is important to highlight that there had been some changes made in the EHR between the time of data collection for the phase one study (2011) and the phase two study (2014). In the first phase, the designated location for vital signs was a 'template' (shown in Figure 4.2). By the time data were collected for the phase two study, the template had been replaced by a table (shown in Figure 5.3). In the phase two study, there was general agreement among the interviewees that the 'correct' place to document vital signs was in the table. The table used in the phase two study showed significant improvement when compared to the template of the phase one study. For example, in the table it was possible to see approximately six sets of vital signs in relation to each other which was not possible

in the template used previously. It is possible that the findings of the phase one study may have had some impact which led to the improvements; results of the phase one study were presented to hospital staff during several seminars and this may have been implemented in updates to the system. (Further possible effects of this research are discussed in Chapter 7, section 7.6.) The improvements between the template and the table were mentioned several times by both nurses and doctors during the phase two study. Although these improvements were appreciated, it was evident that the table was still not an optimal tool for documenting vital signs and did not meet the requirements for documenting vital signs, as explained below. This was one of the reasons that the nursing staff still found it necessary to document vital signs in two further sections of the EHR: the report sheet and the journal.

6.2.1.1 Quicker and easier

The nurses explained that when they were busy, it was quicker and easier to enter vital signs in the report sheet section of the EHR than in the table. For instance, many nurses complained about the amount of time it took to reach the table in the EHR and the number of clicks it took to enter the vital signs. They said they would have liked a more user-friendly system. The issue of systems not being user-friendly regarding time consumption and awkwardness have been mentioned in previous studies (Darbyshire, 2003; Robert Wood Johnson Foundation, 2010; Timmons, 2003).

6.2.1.2 Tell the whole story

Further reasons for vital signs to be entered into the report sheet were to highlight a change in the patient's condition, such as deterioration, to document the process of care, for example, interventions and outcomes, and to tell the whole story about a patient's progress. This suggests that it was very important from a nursing care perspective to have a place in the EHR in which to narrate and record various aspects of a patient's care and progress, where they could write about their patients in their own words (Eason & Waterson, 2014). However, the nurses in the infection ward used the journal section for this type of information.

The fact that nursing staff were using both the journal and the report sheet for this purpose within the same hospital implies an inconsistency in how this EHR was used on one site. Moreover, it suggests varied preferences about where to document certain aspects of care and may have led to confusion for staff working in different parts of the hospital, such as doctors on rotation or nurses in training. Furthermore, sometimes vital signs were entered

in these sections only, i.e., not in the table. This could mean that it would be difficult to get an overview of all vital signs in the table and this could impede the flow of information about patients' vital signs.

6.2.1.3 Triage tool

A further example of the journal section being used for vital signs was in the ED. In the ED, the journal was the point of documentation for the baseline vital signs of all patients admitted through the ED. This was because all patients were triaged using RETTS and the results of the RETTS vital signs were automatically transferred to the journal section of the EHR. However, subsequent recordings were documented in the table section. This meant that baseline recordings were in a separate location from subsequent recordings. Baseline recordings are essential because they provide a baseline of vital sign values with which future vital signs can be compared, indicating improvement or deterioration in a patient's condition (Jackson, 2011). Clearly, if baseline recordings are in a different location to future recordings, it would be difficult to make comparisons between these. This implies a barrier to the flow of crucial information. A similar problem was recognised in another study regarding the flow of vital information in EHRs (Dowding, Turley, & Garrido, 2014).

In this section, the findings of the qualitative study have explained why vital signs were scattered throughout three sections of the EHR, the result found in the quantitative study. These results imply that a more user-friendly method of documenting vital signs than the currently used table is still required. Research into human-computer interaction emphasises the need for designing systems that will facilitate and augment decision-making and the importance of "gaining a better understanding of the interaction between health care information systems and end users in conducting day-to day tasks" (Kushniruk & Patel, 2004, p. 57). A well-designed system could encourage the documentation of all vital signs in one section of the EHR to allow a good overview of this vital information.

Furthermore, the problem of baseline vital signs in the ED being separate from subsequent vital signs could be resolved to improve patient safety (Jackson, 2011) if a more appropriate system were available. Although narratives as a supplement to vital signs may be necessary, and these were recorded elsewhere than the table, it important that a bespoke section of the EHR for vital signs is accessible and complete to ensure safe patient care.

As well as the practical reasons described above, writing in the report sheet and the journal section allowed nurses to demonstrate their contribution to patient care. A positive aspect of nurses writing in the journal section was that this was where other health care

professionals carried out their documentation about the patient. The report sheet was considered the appropriate place for nursing documentation, i.e., separate from the other professionals. It is interesting to note that despite health care being promoted as a team effort with multi-disciplinary health professionals contributing to patient care, nursing aspects were in a separate section of the EHR. This was the case in three out of the four areas in which this study was conducted and could imply that it was difficult to see the contribution that nurses made to the healthcare team (Manojlovich, 2007)

6.2.2 Why were many vital signs missing in the EHR?

In the quantitative study, it was found that vital signs were missing from the EHR. Two reasons were found for this in the qualitative study: either vital signs had been measured and not documented, or vital signs had not been measured. This section begins by describing the former situation, 'measured but not documented' and continues to relate the latter situation, 'not measured'.

6.2.2.1 Measured, not documented

The qualitative study revealed that when a patient required vital signs to be recorded frequently, vital signs were measured but were often not documented in the EHR. This happened frequently if a patient was very ill or unstable and it was necessary to monitor the patient closely to detect any changes in vital signs. The patients either had vital signs measured continuously by being connected to an electronic monitor or manually by the nurses.

The nurses in the study gave several reasons why patients on continuous monitoring on an electronic monitor did not have vital signs documented in the EHR. One view was that the vital signs could be seen on the monitor so did not need to be written down. The nurses also implied that when there was a lot to do, they did not have time to document the vital signs in the EHR. However, some nurses made regular entries in the EHR summarising the results on the monitor frequently. This demonstrates varying practices among individual nurses and that there was not a strict policy for documenting vital signs in patients who were being continuously monitored.

Essentially, even if vital signs are continuously monitored, it is still important that they are documented regularly (Hands et al., 2013). Not documenting vital signs because the patient is being continuously monitored may lead to several problems. First, it means that the

patient's record on vital signs would be incomplete. Second, it means that trends cannot be viewed over time and third, it may mean lack of pertinent information for a nurse taking over the care of the patient, or for a doctor who comes to assess a patient. Perhaps if the EHR were more user-friendly, documentation could be easier, encouraging documentation even if nurses were busy. Moreover, set guidelines for documentation could diminish the variation in practice.

Nurses in two clinical areas mentioned that printouts from monitoring equipment would become available in the future, but currently this was not the case. However, if printouts were available, this would not necessarily lead to an improvement in documentation in the EHR, as these would be paper printouts and a further decision would be required regarding how these could be included in the flow of communication.

Similarly, frequent vital signs that were measured manually were not always documented in the EHR. These vital signs were, instead, documented on various paper charts. The reason for using paper charts was that the EHR did not support frequent documentation of vital signs. First, it took too long to enter all of the vital signs into the EHR. Second, the table for vital signs became extensively long horizontally if, for example, half hourly or hourly vital signs were entered over a period of time. Third, paper charts could easily be kept beside the patient's bed and documentation could take place at the point of care. Finally, a health care professional assessing the patient had direct access to the latest vital signs at the point of care. For these reasons, paper charting was the method of choice for frequent documentation of vital signs. The use of paper charts is an example of a workaround and is discussed in section 6.3.

A further issue, which the qualitative study revealed, was that these paper charts were usually scanned and deposited in an archive section of the EHR. However, there was no reference made to these archived scanned documents in the sections of the EHR that were used regularly, when the patient was discharged. This meant that the scanned files would not be apparent to any retrospective study carried out in the EHR, whether doing research or scrutinising the EHR for legal/audit reasons. Consequently, the second reason for missing vital signs was that although they had been measured they were not documented in any of the three sections of the EHR. This suggests that facilities and functions available for the documentation of vital signs in the EHR may not have met the needs of practice when patients required more frequent observations. In essence, the two examples above

illustrate that many of the vital signs noted as missing in the EHR in the phase one study had most probably been measured but had not been documented.

6.2.2.2 Not measured

Further reasons for the lack of documented vital signs in the EHR noted in the quantitative study were revealed in the phase two qualitative study: that some vital signs were not measured. This was related to practices and routines for the documentation of vital signs. These practices and routines overlap to explain uneven documentation of specific vital signs, described in the next section.

6.2.3 Why was there uneven documentation of specific vitals signs?

The results of the quantitative study in phase one exposed variability in the documentation of individual vital signs. The qualitative study identified several reasons for these results, mainly connected to practices and routines for recording vital signs.

6.2.3.1 Guidelines

To begin with, the policy in the hospital for measuring vital signs was vague. During the phase one study, it was stated that BAS should be measured once per day (personal communication). However, by the time the data were collected for the second study, the policy was to measure BAS on admission and after that, 'as required' and according to routines or guidelines decided at the level of each department (Interview 13). The phase two study revealed several interpretations of what 'as required' could mean. For example, the surgical ward had drawn up their own guidelines, which were also used in the other surgical wards of the study hospital.

Advantages had been observed by nursing staff in relation to measuring vital signs routinely. Nurses in the surgical wards remarked upon the fact that measuring all vital signs routinely had 'picked up' unexpected conditions that would not have been noted previously when the rule of thumb was "if they look OK and were walking around there was no need to measure vital signs" (Interview 14). The ED had a triage system, RETTS, which provided their guidelines. One nurse in the ED commented that since they had started using BAS it had "opened their eyes to recording all vital signs and not just checking the blood pressure" (Interview 10). These comments suggest that nurses are open to introducing new routines that can ultimately enhance patient care.

Clear guidelines may have supported vital sign measurement and documentation and could be seen by combining results from both strands of this research. For instance, an important

result in the descriptive analysis of the phase one study was the poor rate at which respiratory rate was recorded, a frequency of 29%. In the qualitative study, it was revealed that respiratory rate was a vital sign that was often forgotten or missed. This could then account for the relatively low frequency of documentation of respiratory rate noted in the phase one study. A Chi-squared test revealed that patients in the ED were the most likely to have the respiratory rated recorded compared with other clinical areas (Section 4.7.7.3). The phase two study found that RETTS in the ED included the recording of respiratory rate; this could explain why the rate of respiratory rate recordings was higher in the ED.

6.2.3.2 Clinical judgement

Conversely, the clinical areas in which firm guidelines were not available were less likely to measure and record all vital signs. For example, although cardiology had a routine to record vital signs three times per day and the infection ward had a routine for twice daily, there was a great deal of variability in the selection of vital signs to be taken and recorded. In these clinical areas, the choice of vital signs was based on what individual nurses considered to be appropriate according to their clinical judgement, a practice noted in a previous study (Bunkenborg et al., 2013). When nurses are required to make decisions about which vital signs to take, based on what they individually consider appropriate, it places a great deal of responsibility on their shoulders. For experienced practitioners, this may not be such a problem, but for novice nurses, this could be stressful, as their ability to judge patients clinically by simply looking at them may not be as finely honed as those of experienced and skilled practitioners. For example, during the data collection, one novice nurse explained how she missed using an early warning score (EWS) system, which she had been taught to use in her training hospital, because with EWS it was easy to know which vital signs to take, how often to take them, and how to react if values were outside normal limits. Furthermore, decisions on taking only isolated or selected vital signs rather than complete sets may become a habit without much thought into which vital signs are necessary. Subsequently, it can be determined that stricter guidelines regarding which vital signs to record could improve measurement and documentation.

Moreover, decisions on taking vital signs according to individual clinical judgement is not optimal, primarily because of the nature of clinical judgement. While it is recognised that bedside nurses have the closest proximity to the patient and can react to subtle changes in a patient's condition (Manojlovich, 2007), clinical judgement can vary greatly. It is based on an individual's perception, his/her sensory impression of a situation. Therefore, a clinical

judgement/perception may be different from the objective reality as it can vary depending on time, setting and the social situation (Zarabzadeh et al., 2013). This earlier study showed that healthcare providers perceptions vary in patient assessment (ibid). This implies that there can be variations in clinical judgements and decisions made from one occasion to another, and could mean that nurses making decisions on whether to record individual vital signs may vary greatly. Furthermore, another previous study indicated that clinical judgement has low sensitivity compared to physiological vital signs in detecting critical deterioration (Fullerton et al., 2012).

6.2.3.3 Sub-culture

However, a further interesting feature was that the vital signs selected for measurement may have revealed a kind of subculture in relation to the clinical area. For instance, in the infection ward, a paper checklist used twice daily was called a 'temperature list', presumably because of the relationship between infection and fever. In the cardiology unit, observation charts also reflected that specific vital signs were considered more important than others, e.g., blood pressure was the focus in the post-angiography chart. Furthermore, several nurses in the phase two study who worked in the cardiology department indicated that they thought that the most important vital signs were blood pressure and pulse. This was also reflected in the results of the Chi-squared test when testing for associations of specific vital signs with department when it was shown that the most likely department for documentation of blood pressure and pulse was cardiology. It is not unusual for there to be a range of observation charts within the same hospital, as mentioned in the literature review (Section 2.7.3). However, having several charts for similar purposes suggests an unnecessary waste of resources.

6.2.3.4 Qualitative findings explaining logistic regression analysis

The findings of the qualitative study in phase two may shed further light on the results of the logistic regression analyses from the quantitative study. As described in section 4.6.8, logistic regression analysis was undertaken on the quantitative data after Chi-squared tests had revealed significant associations between several variables. These analyses revealed some interesting, if somewhat confounding, results. For example, the result from the logistic regression analysis to assess the impact of the total number of vital signs recorded on survival, was that the greater the frequency of the total number of vital signs recorded in the 24 hours prior to cardiac arrest, the lower were the chances of surviving the resuscitation procedure (p=0.002) or surviving to discharge (p<0.001). The findings from

the qualitative study may suggest a reason for this result. The qualitative study demonstrated that a deciding factor on whether to take vital signs or not was if the patient looked unwell or showed signs of deterioration: thus patients who were more sick may have had more vital signs recorded indicating closer observation, but these patients were also less likely to survive because of their poorer health. However, as already shown, it was rare for complete sets of vital signs to be recorded so this result probably means that more recordings were made of selected vital signs, e.g., blood pressure, pulse and oxygen saturation, but not of others, e.g., respiratory rate and conscious level.

This result is interesting from the perspective of cardiac arrest prevention, in that if sicker patients had more vital signs recorded, it was possibly too late to prevent cardiac arrest and mortality. Earlier documentation of changing vital signs, i.e., before more obvious deterioration took place, may have allowed interventions that would have prevented cardiac arrest. As previously noted, overt deterioration is often preceded by physiological instability (Offner et al., 2007). This means that it would be better to record vital signs before a patient 'looks poorly' and this is why TTS recommend regular recordings of vital signs (DeVita et al., 2006). Vital signs should be monitored whether the patient is critically ill or not, albeit that the sicker the patient, the greater the frequency of the vital signs.

There is also the possibility that despite the increase in frequency of vital sign recordings, appropriate action was not taken, or not taken in time to prevent a cardiac arrest. This study does not have evidence related to whether these patients with more frequently recorded vital signs were referred for medical assessment or actively treated. As seen in the qualitative study, nurses often initiated interventions such as oxygen therapy and medications in line with what they were 'allowed to do' but, apart from the guideline for a patient with a positive BAS recording, there were no specific thresholds for when a patient required medical assessment. It is, therefore, possible that patients had irreversible deterioration before appropriate management could be initiated. On the other hand, the situation may have been that a patient was noted to be ailing and therefore more vital signs were recorded, but that despite the patient was not a good candidate for resuscitation, no decision was made regarding a 'not for resuscitation' (NFR) order.

A second interesting result from the logistic regression analysis to assess the impact of combined vital signs on survival, was that the more often a patient had their temperature recorded, the less likely they were to survive the resuscitation procedure ($p<0.001$) or survive to discharge ($p=0.004$). This result is somewhat confounding as the vital signs

which were recorded in the highest frequency overall were blood pressure, pulse and oxygen saturation, respectively. Tentatively, the qualitative findings from the infection ward may elucidate the reason for this result. The most frequently recorded vital sign in the infection ward was temperature (noted in the qualitative study, section 5.5.5) and patients with sepsis may have temperature checked more frequently to monitor the underlying infection and response to treatment. In addition, patients with sepsis have a low chance of survival from cardiac arrest (Ebell, Becker, Barry, & Hagen, 1998). Another possible reason might be that when nurses were recording more frequent vital signs on critically ill patients, they included recordings of temperature. A further suggestion to clarify why temperature may have been significant is that lower than normal temperatures (hypothermia <35°C) is an important variable in detecting patient deterioration (as described in section 2.5.1.7 of the literature review of this thesis) (Duckitt et al., 2007).

The third interesting result from the logistic regression analysis was that the type of clinical area in which a patient who had a cardiac arrest was least likely to survive the resuscitation procedure (p=0.004) or survive to discharge (p=0.006) was a general ward. This is not at all surprising, as this is the level of care with the lowest nurse-to-patient ratio where it is more difficult for a nurse to identify patients' problems at an early stage (Hunt, 2009). Hospitals today have seen an increase in the number of acutely ill patients, partly due to an elderly population with complex problems and partly because of shorter hospital stays. The resulting increase in patient acuity has not been matched by an increase in the numbers of qualified staff on general wards (James et al., 2010; NPSA, 2007).

The examples above provide some possible explanations of why vital signs were unevenly represented in the EHR; there was a lack of strict routines and decisions on taking vital signs were related to the clinical judgements made within clinical areas and by individual nurses.

Practices for observing patients and documenting observations may also have had an effect on the completeness of vital sign documentation in the EHR. For instance, it was noted that nurses sometimes wrote in the report sheet that a patient had been breathless or dyspnoeic but did not count the respiratory rate or add this as a vital sign to the table. As respiratory rate is often the first sign to change in a deteriorating patient the significance of measuring this vital sign is emphasised (National Institute for Clinical Excellence (NICE), 2007; NPSA, 2007). The importance of respiratory rate is also discussed in the literature

review to this research (Sections 2.4 and 2.5.1.3). This may indicate the need for further education regarding the importance of measuring respiratory rate.

6.2.4 How important is it that physiological deterioration was identified in more patients by ViEWS than by BAS?

When comparing ViEWS to BAS, ViEWS was found to be more likely to detect deterioration than BAS. Although vital signs were largely incomplete in relation to both ViEWS and BAS, each had the potential to detect clinical deterioration, with ViEWS demonstrating greater predictive ability than BAS. However, this finding should be viewed with caution because of the moderate sample size (n=228).Furthermore, discussion regarding the advantages and disadvantages of single parameter systems in comparison to aggregated weighting score systems is on-going (Hunt, 2009; Jarvis et al., 2015). Further discussion on sensitivity and specificity is available in Chapter 2, Section 2.5.1.5.

This section has interpreted four of the main results from the quantitative study in phase one in relation to the findings of the qualitative study in phase two. It has given an account of the integrated findings of both the quantitative and qualitative studies. Drawing on inferences from both phases, the quantitative results were explained by the qualitative findings. The process of interpretation has enabled the findings from the qualitative study to explicate the statistical results from the quantitative study (Ivankova et al., 2006). From this integrated analysis, two dominant themes were generated. The first theme was *facilities and functions in the EHR*. The second was *practices and routines for measuring vital signs*. A summary of these integrated findings are presented in Table 6.1.

Table 6.1 Summary of the integrated findings of the two phases of research

Quantitative results	Qualitative findings	
	Facilities and functions in EHR	Practice and routines for measuring vital signs
Vital signs in three locations in EHR	No clear policy of where to document	Varied practice from ward to ward
	Quicker and easier to write in one section than another	Varied routines from ward to ward
	In RETTS - first set of vital signs in journal. Subsequent vital signs in table	
Lack of documented vital signs in EHR	Usability issues - excessive clicking	Variability in which vital signs were measured
	Not suitable for frequent vital signs:	(Not measured)
	Documented on paper	
	Continuous monitoring	
	(Measured but not documented)	
Uneven documentation of various vital signs		Policy guidelines vague on which vital signs to measure
		Decisions on routines for measurement of vital signs made at ward level or left to clinical decisions of individual nurses

6.3 Meta-inferences

This section discusses the deeper implications and meta-inferences of the previous analysis in relation to the two dominant themes: *facilities and functions in the EHR*, *practices and routines for measuring vital signs* (Table 6.2), and the relevant literature. Meta-inferences have been generated to give a holistic perspective to the current research. This section begins with *facilities and functions in the EHR* and is followed by *practices and routines for measuring vital signs.*

6.3.1 Facilities and functions in the EHR

Usability issues for end-users included that:

- it was not possible to obtain an adequate visual picture to enhance the processing of information and facilitate informed decision making
- it was difficult to document and retrieve vital signs on very sick or unstable patients as the EHR did not accommodate frequent vital signs
- to enter and access vital sign information involved too much clicking and was time consuming
- the point of documentation was often too far from the patient

In this section, these usability issues are discussed in relation to vital signs. Effective record keeping is essential to good healthcare and, in the context of this thesis, effective records on vital signs are essential to patient safety. Three key features of record keeping are: to make continuity of care easier; to support effective clinical judgements and decisions; and to help to identify risks and enable detection of complications (NMC, 2007). The way in which vital signs are presented can have a direct impact on clinical decision making (see Section 4.1.1). Clinical decision-making involves integrating and interpreting several pieces of patient information and combining this with clinical knowledge (Armijo, McDonnel, & Werner, 2009). Effective displays with good visual impact using colours and graphs improve the ability of clinicians to identify trends and to recognise patient deterioration (Chatterjee et al., 2005; Horswill et al., 2010).

6.3.1.1 Tables versus graphs

In the EHR of this study, vital signs were presented in tables and not graphs, as recommended in recent research (Horswill et al., 2010; Preece et al., 2010). Examining the

distinctive properties of tables and graphs can give an indication of their uses. Graphs are more illustrative for indicating trends and for making broad comparisons or showing relationships. Graphs are more efficient at presenting views that promote understanding (Dickenson, 2009). Tables, on the other hand, provide an effective means for presenting numeric information and giving exact values (Statistical Services Centre, 2000). Because determining trends is a key feature for detecting changes in a patient's condition, it is perhaps somewhat surprising to find the use of tables in this EHR, as these were not an optimal means of viewing vital signs and detecting clinical deterioration in patients. Thus, the table in the EHR did not possess the recommended features for charting vital signs. Although it was possible to create a graph in the EHR, this process was so difficult and time-consuming that graphs were never used. It is possible that the lack of automatic graphs may have had a profound impact on the ability of staff to recognise patient deterioration. If information is incomplete or inconsistent, clinical decisions may be inappropriate and therefore patient safety can be compromised. In addition to the problem of inadequate displays of the records in this study, the table for vital signs was difficult to access and took many clicks to reach, thereby, making it ineffective.

6.3.1.2 Paper observation charts

To circumvent these difficulties, a selection of paper observation charts had been created in the individual clinical areas. These paper charts were also designed in table formats, therefore, similar to the table in the EHR, they were not in accordance with current thinking on how vital signs ought to be presented to promote interpretation (Horswill et al., 2010; Preece et al., 2010). Thus, neither the EHR nor the paper charts were optimal, despite the fact that the way in which information is displayed has a direct impact on decision making, whether it is presented on a paper table or in an electronic table (Armijo et al., 2009).

It is not clear why tables were created in the paper charts. Possibly, it was because they were designed by staff members at ward level and designing tables was easier than creating a graphical chart. These paper charts showed initiative and resourcefulness on the part of clinical staff, as they strove to ensure safe patient care despite an inappropriate EHR system. However, despite these attempts, early recognition of clinical deterioration may still have been hindered because an optimal visual summary was not available and the paper charts were not in line with current evidence on observation charts. It could be important

that high quality paper charts be used if maximum benefit is to be gained from these workarounds.

Among the staff observed and interviewed in this study, there was some variation in opinions on whether graphs or tables were the best way to view vital signs. Several doctors and nurses indicated that it would be easier to follow patient progress and see trends if graphs were available. This accords with current research (Horswill et al., 2010; Preece et al., 2010) and indicates the need for graphical presentation of vital signs whether in the EHR or on paper charts. Interestingly, some of the more junior nurses had never seen documentation of vital signs other than the one currently in use and were therefore unaware of previous use of graphs.

6.3.1.3 Time and ease of paper observation charts

These paper observation charts may have had the wrong format regarding interpreting vital signs and promoting decision making, but they may have been an appropriate workaround (Russ et al., 2010) regarding usability issues of time and ease. The nurses found it quicker and easier to enter the vital signs on paper so the process of recording vital signs when frequent recording of vital signs was necessary was more efficient.

There were additional paper workarounds in the form of paper checklists and paper notes. Paper checklists were often used for routine recordings and staff had these checklists with them when they attended to their patients. The nurses said that if they used a checklist, they could see at a glance the patients whose vital signs had been recorded. In addition, they could easily see if there were vital signs that were outside the normal limits. In this way, they had details of the vital signs at hand, allowing greater control of vital sign surveillance and documentation. Nurses often preferred to write down the vital signs on the paper checklist and then document the vital signs in the EHR later. The reason for this was that entering the vital signs in the EHR directly took too much time when additional patient care activities were also being undertaken. In this instance, it can be posited that the EHR was too cumbersome to fit in with routines and nurses felt that it was quicker to do this later when essential work with the patients had been completed. Documenting in the EHR could happen at various times, from a few minutes after measurement, up to several hours, or be delayed till the end of a shift, depending on the workload. Nurses documented the times that the vital signs had been taken and not the time they were documented. This practice has been noted previously (Dowding et al., 2014). A problem with delay in

documenting vital signs is that someone reviewing vital signs from a remote computer, for example, a doctor checking patients, would not be able to see the latest vital signs.

6.3.1.4 Point of care documentation

An advantage of paper observation charts was that documentation could take place at the point of care as the paper could be kept beside the patient's bed. This also meant that a doctor assessing the patient would have easy access to the patient's latest vital signs at the bedside. Thus, paper charts used at the bedside had several advantages for those caring for the patient.

In the same way, paper notes were often used for initial recording of vital signs, e.g., a piece of note paper, a notebook or even a paper towel. Similar to paper observation charts, an important reason for using paper notes and checklists was for documenting vital signs at the point of care, that is, at the bedside, when it was difficult or impossible to take the EHR into the room beside the patient.

Despite observation charts, checklists and notes being useful for documenting at the point of care, they may have incurred some disadvantages. For example, this practice may have increased the workload of nurses as it meant double documentation and, in turn, there could be the associated risk of error during transcription.

6.3.1.5 Verbal reporting

A third type of workaround was verbal reporting. In particular, doctors preferred verbal reporting for two reasons. First, they found that it was difficult to locate vital signs in the EHR because of usability issues, and second, if they did view vital signs in the EHR, they could not be sure that these were the most recent.

6.3.1.6 Workarounds

Paper charts, paper notes and verbal communication such as those noted during the qualitative study are examples of 'workarounds'. Workarounds can be defined as non-standard methods for accomplishing work blocked by dysfunctional processes (Tucker, 2009) and are common in complex environments such as healthcare settings. Dealing with unexpected situations is common practice for health care professionals and thus they are often masters at workarounds (Zhou, Ackerman, & Zheng, 2011). The introduction of EHR in the study setting and subsequent usability problems most probably led to the development of these workarounds (Zhou et al., 2011).

6.3.1.7 Usability

Usability is central in the field of human computer interaction and has evolved from referring to a property of the software to meaning the relationship between software and its context of use (Svanaes, Das, & Alsos, 2008). To be successful in health care settings, interactive user interfaces should be streamlined to the working patterns of the end-users and be highly usable (Peute et al., 2008). Usability in context is the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context (Svanaes et al., 2008). Kushniruk and Patel (2004, p. 56) claimed that usability is "the capacity of a system to allow users to carry out their tasks safely, effectively, efficiently and enjoyably" and Peute et al. (2008) added the vital attribute of patient safety to its definition. Clearly, there were problems with usability in this EHR when related to these qualities. More specifically, vital signs could not be documented:

- effectively - it was difficult to enter and to retrieve vital signs,
- efficiently - it took too many clicks and took too much time,
- safely - frequently measured vital signs could not be accommodated, and
- enjoyably - not enjoyable due to problems with effectiveness, efficiency and safety.

6.3.1.8 User friendliness

User-friendliness implies that an EHR should facilitate clinical work and be easily modified (Ovretveit, Scott, Rundall, Shortell, & Brommels, 2007). Facilitating clinical work requires a system to take account of work routines so that it seamlessly fits in with the working patterns of clinical staff. For this to happen, clinical staff should be involved in the design of EHR. As nurses pointed out in a previous study, no-one had asked them what might be required for documentation (Stevenson & Nilsson, 2012). In addition, an EHR should be easily navigable and patient information should be available at a glance; this was not evident in this EHR. The EHR in this study is an example of how developers need insight into everyday work patterns before attempting to design a system for which they lack understanding (Goorman & Berg, 2000). Lack of consultation with clinical staff may have led to poor facilities for the documentation of vital signs. Moreover, following implementation, pleas by nursing staff to improve facilities for documentation were perceived to have little effect (Stevenson & Nilsson, 2012) or lead to only partial solutions. For example, although the 'measurements table' was a big improvement on the 'template'

found in the phase one study, it still did not meet the requirements of vital sign documentation. Consequently, the design of this EHR may have been inadequate and may have inadvertently had a negative impact on patient safety. Thus, front-line users attempted to mitigate inadequate design by developing workarounds. The qualitative study confirmed the frequent use of workarounds to circumvent system problems.

6.3.1.9 Persistence of workarounds

Although workarounds may provide solutions to urgent problems, they may not be ideal in the longer term. Workarounds, by nature, carry the risk of becoming embedded as routines and the reason they were needed in the first place may then be forgotten. This can mean that organisations do not learn from or solve inadequacies, which, in the longer term, can be inefficient and expensive (Tucker, 2004).

One example from this study was that nursing staff were forced to overcome the usability problem of the EHR not accommodating frequent vital signs. They had to find an efficient means of documenting vital signs quickly and easily and therefore produced paper charts for the purpose. This meant that ward staff were more contented as they had found a solution to the immediate problem. Because of this, the usability problem no longer existed at ward level and, thus, not at an organisational level either. Consequently, the final outcome was a lack of evidence-based facilities for the documentation of vital signs in either the EHR or on paper.

In the study hospital, it may be that the best solution for vital sign recording in the meantime was on paper observation charts. Just as Coiera (1997, p. 64) proposed "it is possible for a well-designed set of paper forms to be far more effective in improving the quality of a medical record than a poorly designed computer-based one". However, paper observation charts should be designed from an evidence base to ensure optimal patient surveillance and patient safety. The question remains regarding who is responsible for patient safety: whether it is the nurses on individual wards or the organisation. Ultimately, organisations have a responsibility to guarantee patient safety and should not depend on frontline workers to solve problems created by inadequate technological design.

6.3.1.10 Why does the EHR not meet the needs of front line staff?

There are several possible reasons for the design of this EHR being inappropriate to these frontline users. i.e., doctors and nurses. One reason is that EHRs have many different functions. As well as being the main tool for documenting and planning treatment and

care, the EHR may be used for administrative procedures, archiving information, ordering tests, management information and audit information (Eason & Waterson, 2014). This means that there are other stakeholders who are interested in the design features of an EHR. A basic requirement in EHRs is that they are 'fit for purpose', but when there are many different purposes, it may not be possible to meet the demands of all the different stakeholders. If all demands cannot be met, some stakeholders may be privileged over others (Eason & Waterson, 2014). In the context of healthcare, it might be assumed that patients and patient safety would be central to the design of EHRs and thus the requirements of frontline staff given the highest priority. However, a recent study has shown that the needs of frontline staff may not be prioritised (Eason & Waterson, 2014). Instead, it is the needs of management, that is, the more powerful group of users, which can receive the highest priority. This 'top down' approach where the needs of frontline staff are not the main focus is problematic because they are then obliged to use a system that for them is not 'fit for purpose'. Thus, EHR systems often serve the needs of strategic and managerial users who may not be so concerned with meeting the needs of frontline workers (Eason & Waterson, 2014).

This section has discussed the integrated findings of both strands of this research in relation to the *facilities and functions* available for the documentation of vital signs in the EHR. Usability issues and resultant workarounds have been discussed with reference to current research on how vital signs should be presented to aid decision making and early detection of deterioration. The second dominant topic was *practices and routines* for measuring vital signs. This is described in section 6.3.2.

6.3.2 Practices and routines for measuring vital signs

As discussed in the literature review (Section 2.8), there is widespread agreement that monitoring vital signs to detect clinical deterioration can reduce the incidence of cardiac arrest, unplanned admissions to intensive care units and death (DeVita et al., 2010; Smith et al., 2006). Track and trigger systems (TTS) have been developed to guide vital signs monitoring. These TTS are examples of Clinical Decision Support Systems (CDSS). These include single parameter systems such as BAS, and aggregated weighted scoring systems, such as ViEWS. ViEWS can be considered as a gold standard among early warning score systems, because it was adopted as the standardised national early warning score, NEWS, in both England and Ireland (Royal College of Physicians, 2012; Royal College of Physicians of Ireland, 2012). ViEWS was used in this research as a model with which to compare

monitoring of vital signs in the study hospital. Using ViEWS implies recording six vital signs twice daily as the minimum for hospital patients (Prytherch et al., 2010). From the information obtained in the qualitative study, the routines for the documentation of minimum vital signs in each clinical area have been derived. These are presented in table 6.2 and are compared in this table to the gold standard, ViEWS.

Table 6.2 The frequency and exact vital signs recorded in relation to the gold standard, ViEWS

	Gold standard (ViEWS)	ED	Surgical	Cardiology	Infection
Frequency x daily	2	Admission and then according to RETTS	1	3	2
Temperature	Yes	Yes	Yes	As required	Yes
Pulse	Yes	Yes	Yes	Yes	As required
Respiratory rate	Yes	Yes	Yes	As required	As required
Blood pressure	Yes	Yes	Yes	Yes	As required
Oxygen saturation	Yes	Yes	Yes	As required	As required
Conscious level	Yes	Yes	As required	As required	As required
Total	6	6	5	2	1

The department which came closest to achieving the gold standard was the ED, as it recorded all of the 'gold standard' vital signs and had set routines for how often subsequent vital signs should be recorded in relation to the patient's degree of risk. The surgical ward recorded 5 of the 6 recommended vital signs but only once per day in comparison to the minimum recommendation of twice daily. The remaining two areas, although

demonstrating good frequency at three times or twice daily, were deficient in the range of vital signs which they recorded, indicating that complete sets of vital signs were not always recorded. Recording incomplete sets of vital signs or only isolated vital signs is not congruent with current evidence on how patients in hospitals should be monitored to detect early signs of clinical deterioration (DeVita et al., 2006; DeVita et al., 2010; Smith et al., 2006).

6.3.2.1 Education

In addition to the identified need for clear policies and routines regarding the practice of measuring and documenting vital signs, there may also be a need for acute illness training of nursing staff (Jones et al., 2011). The aim of the training would be to enhance the ability of nurses to detect and recognise physiological instability in patients. For example, the importance of recording complete sets of vital signs and accurately interpreting values would need to be emphasised (Chua, Mackey, Ng, & Liaw, 2013). If a more robust TTS were to be introduced, training in the use of the new system could be coupled with training for treating/managing acute illness. This could produce additional benefits as it has been shown that teaching nursing staff how to use EWS systems can improve the prevalence of respiratory rate recording (McBride et al., 2005).

6.3.2.2 Patient surveillance

Current evidence-based practice promotes the use of TTS such as ViEWS and those described in the literature review of this thesis (Chapter 2). These systems have been shown to enable early recognition of the deteriorating patient and early treatment to prevent adverse outcomes (DeVita et al., 2006; DeVita et al., 2010; Smith, 2010; Smith et al., 2006). Included in the advantages of these systems is that they provide clear guidelines on the frequency and extent of vital sign recordings and direct the escalation of care as required. Furthermore, studies have shown that the strict guidelines and routines inherent in early warning systems such as ViEWS, increase the frequency of vital sign observation (Bunkenborg et al., 2013; Chen et al., 2009; Hammond et al., 2013; Zarabzadeh et al., 2013). This confirms the need for practices regarding patient surveillance to include the regular recording of vital signs. The use of track and trigger, early warning systems in hospitals helps to ensure routine documentation of all vital signs. Specifically, one study demonstrated that a clinical intervention which introduced systematic monitoring of vital signs three times daily, an early warning score system, an observation chart and an

algorithm for bedside management may reduce unexpected mortality in hospital (Bunkenborg et al., 2013).

As described in this research, the practice and routines for recording vital signs was variable in the study hospital, therefore, it is possible that early signs of clinical deterioration may have been missed. The nurses in this study were adept at using their clinical judgement in deciding which vital signs to record. However, as described in section 6.2.3, clinical judgement is not an exact science and can vary greatly from one individual to the next. Related to current evidence, clinical judgement is important and it is recognised that nurses often take an intuitive approach to clinical decision making (Thompson, 1999). Thus 'worried about the patient' is a parameter included in many TTS (Bellomo et al., 2004; DeVita et al., 2006) but should not substitute the regular and routine recording of vital signs (Cuthbertson & Smith, 2007). Further discussion on this subject was presented in the literature review, section 2.5.1.6.

Studies have demonstrated that changes in vital signs indicate early signs of deterioration (Goldhill & McNarry, 2004; Offner et al., 2007; Schein et al., 1990). Thus, the use of track and trigger systems is robust compared with decisions by individual nurses about which vital sign recordings they consider necessary. The results of the current study also indicate that variances between completeness of documentation in clinical areas were related to the firmness of the guidelines for the measurement of vital signs. Consequently, this could suggest the need for a hospital wide policy to standardise the documentation of vital signs with the aim of improving patient surveillance (Smith et al., 2006).

However, identifying clinical deterioration is only the first step in avoiding adverse events. An important aspect of saving patients from further deterioration is related to how effectively clinical staff respond to abnormal physiological vital signs so that patients receive appropriate and early intervention (DeVita et al., 2004). When deterioration is identified, the correct responses must be made regarding escalation of care. This could be as simple as increasing the frequency of vital sign recordings to calling for expert help. Currently, a medical emergency team (MET) or rapid response team (RRT) is not available in the study hospital. If a track and trigger system were to be introduced, some kind of rapid response team would be required (Chapter 2, Section 2.6).

As suggested in the literature review (Section 2.6.8), track and trigger systems and early recognition of deterioration may have additional benefits related to timely decisions on patients for whom resuscitation would not be appropriate. Subsequently, 'do not attempt

resuscitation' (DNAR) orders could be issued and futile attempts at resuscitation could be avoided (Kenward, Caste, Hodgetts, & Shaikh, 2004; McKeown, 2004). This is described in the literature review (Section 2.6.8). However, it is beyond the scope of the current research to discuss this issue in depth.

This concludes the meta-inferences made in regard to practices and routines. The integrated findings of both strands of this research in relation to the *practices and routines* for measuring vital signs have been discussed. The findings in phase one of the research indicated that there were variations in practice and routines between and within the clinical areas in the study. In light of current recommendations for patient surveillance, this suggests that all hospitals could benefit from policies that could standardise practices and routines.

6.3.3 Summary

In this discussion, two key themes have been identified: facilities and functions in the EHR and practices and routines for documenting vital signs. In the phase one study, the results pointed clearly to problems in usability in the EHR. However, as seen in the findings of the phase two study, this was only part of the reason for variable and sparse documentation in the EHR. There were also issues with routines and practices at ward level. The key themes are summarised below:

Facilities and functions in EHR

- Documentation of vital signs should enhance clinical decision-making (6.3.1)
- Graphical formats are required to illustrate trends, make comparisons and show relationships (6.3.1.1)
- Paper charts were created as workarounds (6.3.1.2 & 6.3.1.6)
- Paper charts were in table form, i.e., not optimal format for vital signs (6.3.1.2 & 6.3.1.9)
- Paper charts allowed for documentation at point of care (6.3.1.4)
- Verbal reporting of vital signs was often preferred by doctors (6.3.1.5)
- Usability: streamline user interfaces to working patterns of end-users (6.3.1.7)
- User-friendliness: EHRs should take account of work routines. End-users should be involved ain design (6.3.1.8)

Practice and routines for measuring vital signs

- Complete sets of vital signs are not recorded in some clinical areas when compared to a universally agreed gold standard (Table 6.2)
- Introduction of track and trigger system is recommended (6.3.2.2)
- Introduction of rapid response team is recommended (6.3.2.2)
- Education is required for staff regarding detecting and recognising physiological instability (6.3.2.1)

6.4 Trustworthiness of the research

As discussed in the Methodology chapter (Chapter 3), the validity of the data and results are a vital component of good research (Creswell & Plano Clark, 2007). When validating mixed methods research, there is general agreement that traditional principles of validation should be applied to both quantitative and qualitative phases of the research, therefore, separate procedures are required to assess the quantitative and qualitative studies (Ivankova, 2014; O'Cathain, 2010; Venkatesh et al., 2013). In addition to validation of the separate quantitative and qualitative phases, validation of the quality of the integrated conclusions or meta-analysis is required (Venkatesh et al., 2013). There is no shortage of descriptions for carrying out quality assessments on quantitative and qualitative studies (Bryman, 2012). However, guidelines on conducting quality assessment on the integrative stage of mixed methods research are still quite limited (Venkatesh et al., 2013). Likewise, the nomenclature used for 'validation' in mixed methods research is not, as yet, established. Teddlie and Tashikorri (2010) favoured the term 'inference quality' to distinguish validation from the standard use of validity in quantitative and qualitative research. Conversely, Creswell (2007) argued that a new term is not necessary. Nevertheless, in this research, the term 'inference quality' is used when discussing validation of the interpretation phase. This choice was based on the fact that the terms 'inferences' and 'meta-inferences' were used to discuss interpretations and conclusions of the mixed methods research.

Creswell and Plano Clark (2007) offered some general pointers for validating mixed methods research. The first was to give an account of the validity of quantitative and qualitative studies using thorough and traditional approaches and then to proceed with validation of the integrated results. Similarly, Venkatesh et al (2013) suggested that rigorous

validation of quantitative and qualitative phases should be followed by validation of the meta-inferences.

Ivankova (2014) suggested a three-step process to ensure the quality of meta-inferences for sequential mixed methods design where a quantitative study is followed by a qualitative study. The first two steps were to separately evaluate the quality of the quantitative and qualitative phases of the study respectively. The next step was to assess the credibility of the meta-inferences that had been drawn from the integration of the inferences made in the quantitative and qualitative phases of the study. The three steps and strategies used in this research have been adapted from Ivankova's method (Ivankova, 2014) and were influenced by Creswell and Plano Clark (2007). These steps are summarised in table 6.3.

Table 6.3 Steps in validation of mixed methods research (inspired by Ivankova 2014)

Section of study	Procedures
Quantitative study	Assess reliability and validity of data and results
Qualitative study	Assess credibility and trustworthiness of data and findings
Meta-inferences/integrated conclusions	Assess credibility of meta-inferences Strategies: • systematic procedure for selection of participants for follow up study • choosing appropriate results from quantitative study to follow up in qualitative study • integrate and interpret the results of quantitative and qualitative study phases

A discussion on validity of this research is presented here according to Ivankova's three step procedure. First, there is a description of the reliability and validity of the quantitative

data. Second, a description of the credibility and trustworthiness of the qualitative study is given. Finally, the credibility of the integrated conclusions/meta-inferences are discussed.

6.4.1 Reliability and validity of quantitative data and results

The type of design of the quantitative phase in mixed methods research must match the research question so that the data collection will glean reliable and valid results (Creswell & Plano Clark, 2007). Therefore, careful consideration was given to the research question regarding the description of vital signs in the EHR and the means of data collection. To guarantee internal validity, a data collection tool was created by the researcher for the collection of the quantitative data. Content validity (Bowling, 2009) of the instrument was gained by obtaining expert advice from both clinical and academic colleagues. The instrument was tested in a pilot study, in which 20 cases were examined from the Swedish Register for In-hospital Cardiac Arrest and the EHR. The custom-built data collection tool ensured that the same data were collected for each case. This helped to guarantee internal validity as the instrument enabled consistency in the data collection and supported measuring the variables for which it was designed to measure. A range of statistical analyses were performed, including univariate, bivariate and logistic regression analyses. The sample size of 228 cases was considered sufficient to yield reliable results and therefore ensure statistical conclusion validity.

The question of external validity, i.e., whether it is possible to generalise the results to a wider setting, is difficult. On one hand, the results were from just one EHR system in one hospital setting, so, in essence, the results were only about one case. On the other hand, a case study may be potentially valid to other cases (Punch, 2005). Although external validity can not be guaranteed, it is possible that the results of this study could be transferred to similar settings and, therefore, an organisation planning to implement an EHR would benefit from the findings of this study.

6.4.2 Credibility and trustworthiness of qualitative data and findings

Three main strategies were employed to verify the validity of the qualitative data and findings: triangulation, member checking and a 'thick' description. Three kinds of triangulation were employed (Patton, 2002). The first, was 'triangulation of data sources', a process of checking and comparing data collected at different times and in different ways. The observational data were compared with the interview data. Further, the interview data were used to corroborate the findings from the observations and vice versa. This ensured

consistency of the findings in the qualitative study. This is also known as within-methods triangulation, which exists when multiple qualitative approaches are used within the same study (Johnson et al., 2007). The second type of triangulation was 'analyst triangulation' which means to engage more than one analyst in the analysis process (Patton, 2002). To enhance the accuracy of the data analysis, a second analyst reviewed the interview translations and transcripts and found these to be accurate. However, further assistance with the analysis was not available. 'Perspective triangulation' is when several perspectives are used to analyse the data. This was achieved by drawing on the work of Braun and Clark (2006), and Granheim and Lundman (2004), as well as some additional steps created by the researcher to ensure thorough analysis of the data.

The second strategy was 'member checking' to assess the credibility of the presentation of participants' views. This was conducted by inviting key participants from each of the four clinical areas to read a written summary of the findings from the study. Participants were asked to verify that the findings reflected an accurate account of their views (Creswell & Plano Clark, 2007). Each key participant was in agreement that the findings were correct and true, ensuring accuracy of the qualitative data. The summaries of the findings from the respective clinical areas, which were checked by key respondents, are available in Appendix VII).

The third strategy was to provide 'thick' description by including authentic citations from interviews and quotes noted during fieldwork. These quotes were included in the findings from the qualitative study in Chapter 5. Direct quotations can provide a rich illustration of the views of participants to increase the trustworthiness of the findings (Patton, 2002).

6.4.3 Credibility of integrated conclusions/meta-inferences

Several strategies were employed to ensure the quality of the integrated conclusions/ meta-inferences. A systematic procedure adapted from Ivankova (2014) was followed. Ivankova suggested that inference quality was dependent upon 1) careful selection of participants for the follow-up qualitative study, 2) explaining quantitative results from the qualitative findings, and 3) integrating the two phases of the study. Inference quality will be enhanced if potential threats to quality are identified and addressed (Creswell & Plano Clark, 2007). Thus, threats to quality were addressed and are described in the next section.

6.4.3.1 Selection of participants for qualitative study

In sequential explanatory design, one threat to quality is the selection of inappropriate individuals for data collection. Therefore, steps were taken to minimise this threat. The participants selected for the follow-up qualitative study were people who used the EHR for the documentation and retrieval of vital signs. Creswell (2007) recommended that the same individuals should be used in the second phase as those of the first phase. Although no actual respondents were directly involved in phase one (the data collection was from existing patient records), the selected respondents in phase two were users of the EHR system from which the data on vital signs were collected in phase one. Because of this, the respondents represented end-users who frequently documented and retrieved vital signs from the EHR. Therefore, selecting respondents from within the case study boundaries provided an appropriate sample to explain the quantitative results. As explained in Chapter 5, a convenience sample of respondents was found within the study hospital.

6.4.3.2 Choosing which qualitative findings to follow up

The second threat to inference quality in mixed methods research is that weak quantitative results are chosen for qualitative follow-up (Creswell, 2013b). If the quantitative results are weak there is a possibility that the subsequent follow-up findings will also be less important. To minimise this threat, key results were identified for follow-up in the qualitative phase. For example, in the quantitative phase, missing vital signs, particularly some vital signs such as respiratory rate, and the inconsistency of documentation in three sections of the EHR were all important results. Hence, the follow-up qualitative study was designed to explain and give an in-depth understanding of these results.

6.4.3.3 Integrating the two phases of the study

When the results of both phases of mixed methods research using exploratory sequential design are integrated, the aim is to develop high quality meta-inferences. Venkatesh et al. (2013) proposed an integrative framework to incorporate the process of mixed methods research and inference quality in information systems (IS) research. There were three criteria for validation of meta-inferences within the framework: integrative efficacy (refers to the blending of findings); integrative correspondence (refers to both strands of research being consistent with the overall aim); and inference transferability (refers to the extent to which meta-inferences can be applied to other contexts). These criteria have been summarised in table 6.4.

Table 6.4 Quality criteria for meta-inferences (adapted from Venkatesh et al., 2013)

Key criterion	Explanation
Integrative efficacy	inferences are effectively integrated into a theoretically consistent meta-inference (refers to the blending of findings)
Integrative correspondence	meta-inferences satisfy the initial purpose of performing a mixed methods study (is consistent with the overall aim of the research)
Inference transferability	meta-inferences are generalizable to one context and setting (the extent to which the meta-inferences can be applied to other contexts)

Integrative efficacy

The quality of the explanations depends on the results from phase one and the findings from phase two being effectively integrated. This is the stage at which the findings are blended together (Venkatesh et al., 2013). The integration of the findings should be explained and discussed, and clearly demonstrate the effectiveness of explanatory sequential design. In the current research, the results of the quantitative study had revealed deficiencies in the documentation of vital signs. The findings from the qualitative study were compared, contrasted and linked to the results of the quantitative study, to explain its results and blend the findings together. In this way, tiers of information were integrated to form a complete picture gradually. For example, the result that vital sign documentation was so variable could be explained by the observations and interviews carried out in the qualitative study, in which it could be seen that the selection of vital signs measured depended largely on the opinions of individual nurses.

Integrative correspondence

A high degree of integrative correspondence will be ensured if both quantitative and qualitative studies have the same overarching research objectives. Therefore, both the qualitative and quantitative studies were carried out with the same focus and the overall aim

of both phases was to investigate the documentation of vital signs in the electronic health record system. This aim was the focus of the entire research and, therefore, the meta-inferences that were developed were in line with this aim, contributing to a high quality of meta-inferences.

Inference transferability

Another measure of quality of the meta-inferences is the extent to which they are generalisable and transferable to other contexts or settings. By conducting this research as a case study within the boundaries of one medium-sized hospital and on one electronic record system in Sweden, the hope is that the results of this research could be transferred to similar settings in Sweden and beyond. Since little was known about the documentation of vital signs in EHRs, it is feasible that the results of this study will contribute to knowledge in this field and could be applied to settings in which an EHR has been, or is about to be, implemented.

6.4.4 Limitations and strengths

There were several benefits to carrying out mixed methods research in the current investigation. These are in line with those listed by (Doyle, Brady, & Byrne, 2009), i.e., triangulation, completeness, offset weaknesses, answering different research questions, explanation of findings and illustration of data. There was corroboration between quantitative and qualitative data (triangulation). Completeness was achieved by providing a more complete picture of vital signs documentation, the phenomenon under investigation. By building on the strengths of both approaches, strong inferences could be deduced, thus offsetting the weaknesses of individual studies. Some questions could not be answered by using one approach so mixed methods facilitated answering different questions. A quantitative study followed by a qualitative study helped to explain the findings of the former study. Finally, the findings of the quantitative study could be illustrated more thoroughly by the qualitative study.

A limitation of mixed methods research with a sequential design is the length of time taken to carry out the two distinct phases (Doyle et al., 2009), particularly as the research was carried out on a part-time basis. In the current study, a problem was noticed in relation to the length of time that lapsed between the data collection in phase one and two. The problem was that in phase one it was noted that there was a potential usability problem in the EHR related to the section in the EHR designated for vital signs which was in the form

of a 'template' (see Figure 4.2). By the time data were collected for the phase two study this problem had been addressed to some extent by replacing the 'template' with a more functional 'table' (see Figure 5.3). This meant that during the phase two study, the participants were being observed in the field and responding in the interviews to a slightly altered EHR system. Nonetheless, although attitudes towards the table may have been more favourable than they might have been towards the template, the table was not considered an optimal solution for the documentation and representation of vital signs according to data in the phase two study. In addition, the researcher was pleased to see that some steps had been taken to improve the EHR for those using it.

A strength of the quantitative study was that each of the patients whose records were examined had suffered a cardiac arrest and therefore may have deteriorated in the 24 hours prior to arrest. The fact that they had had a cardiac arrest indicated that they belonged to an at-risk group and therefore it might be presumed that they may have been under close monitoring, have additional vital signs documented and, thus, provide rich data about vital signs in the EHR. A limitation of the study is that it is unclear whether documentation would have been more complete if paper charts had been used as there was not a previous study with which to compare documentation before the implementation of the EHR. The study was also limited in that it only included one medium-sized hospital and a relatively small cohort of 228 patients. Further, the study only investigated the use of one EHR system so the results could not be generalised to all EHRs. Strengths of the qualitative study included that it was performed in four clinical areas of the study hospital and gave a broad selection of data. A limitation of the qualitative study was that a convenience sample was used. This implies that the sample was not randomly selected and could mean that the sample was not representative of the wider population. However, as noted in Section 3.6, researchers may have to use whatever sample is available. A limitation of qualitative studies in which members of staff are observed is that they may behave differently when they know that they are being observed. However, this limitation may have been offset by the researcher wearing a nurse uniform and blending in with the surroundings.

6.5 Conclusion

This chapter has presented an integration of the findings from this mixed methods study, and discussed the meta-inferences of the findings. This was followed by a discussion of the trustworthiness of this research and concluded with the strengths and limitations. In the next chapter, Chapter 7, the conclusion to this study is presented.

Chapter 7 Conclusion

7.1 Introduction

This is the concluding chapter of this thesis. First, the key findings of the study are presented (7.2). The following section presents the novel contribution of this research to current knowledge (7.3) Next, the implications for practice and policies are discussed (7.4) and areas of possible future research are described (7.5). The benefits as a result of this research are presented in Section 7.6 and, finally, there is a conclusion (7.7).

7.2 Findings of this research

This section summarises the literature review and the findings from the two phases of this this mixed methods study. It then highlights the key meta-inferences from the interpretation of the two phases as described in the discussion in section 6.3.

7.2.1 Literature review

The literature review in this study emphasised that monitoring, i.e., measuring and documenting, vital signs is essential for detecting any deterioration in a hospital patient's physiological condition. In relation to this, the literature review explained that the level of severity of illness (acuity) of patients in general wards has risen. This implies an increase in patients who are at risk of deterioration and underlines the importance of accurate monitoring in hospital wards today. It also described the concept of sub-optimal care and how signs of deterioration in patients in general wards had often not been recognised nor acted upon. The review described the development of track and trigger systems to detect signs of deterioration at an early stage so that an appropriate response could be initiated to save patients from serious outcomes such as cardiac arrest, death and unanticipated admission to intensive care. The literature review emphasised effective monitoring, observation and documentation of vital signs, as well as early detection of deterioration so that timely management could save patients. Rapid response systems have been implemented to a large extent in the western world and clear visual representation of vital signs enabled clinicians to interpret values and identify deteriorating patients. The literature review also identified gaps in information about documenting vital signs in EHRs. Despite EHRs being used for documentation of vital signs, little was known about the impact this might have on the flow of information and patient safety; it appeared that the

documentation of vital signs had received little attention. Three main questions therefore arose from the literature review:

- How complete is documentation of vital signs in the EHR?
- Are there any actual or potential problems in documenting vital signs in the EHR?
- Can documented vital signs reveal anything about a patient's risk of deterioration?

These were used as the focus for the phase one study.

7.2.2 Phase one - Quantitative study

The overall aim of this study was to examine the documentation of vital signs in the EHR of patients who subsequently had a cardiac arrest. The objectives were to:

- Identify the extent to which vital signs were recorded in the EHR in the final 24 hours prior to cardiac arrest in an acute hospital
- Establish the location of the vital sign recordings within the EHR, and how they were documented
- Examine whether documented vital signs could reveal information about a patient's risk of deterioration by aligning these to two track and trigger systems (BAS and ViEWS).

The key findings were as follows:

- With regard to the extent to which vital signs were recorded there were many gaps in the documentation of vital signs and there was uneven documentation of the various vital signs.
- The investigation of the location of vital signs within the EHR showed that there were three sections of the EHR in which vital signs were documented. In relation to documented vital signs revealing information about a patient's risk of deterioration, ViEWS had better predictive ability than BAS to identify physiological deterioration.
- Furthermore, it was found that the more vital signs were recorded, the less the chances were of surviving.

7.2.3 Phase two - Qualitative study

The qualitative study was the second phase of the mixed methods research. In phase one of this research, the results of the study revealed that there was a noticeable lack completeness of documentation and that vital signs were inconsistently documented in three different sections of the EHR. Although the quantitative study provided information about how

vital signs were represented in the EHR, a limitation of the research was that it could not give reasons for the lack of completeness, and fragmented representation of vital signs. Thus, phase two set out to explain the results of the quantitative study.

The aim of this study was to investigate how medical and nursing staff measured, reported and retrieved vital signs. The research questions were:

a) What are the routines for measuring vital signs - when, which, why and how often?
b) What are the routines/procedures within the workflow that medical and nursing staff use to document vital signs?
c) What are the routines/procedures within the workflow that medical and nursing staff use to retrieve information on vital signs?
d) How do medical and nursing staff experience incorporating the EHR into their workflow when documenting vital signs and reviewing patient status?
e) To what extent does the EHR support documentation of vital signs?

The key findings in relation to the research questions are presented below:

a) Regarding routines, the measurement of vital signs was very variable especially in those clinical areas that did not have a strict routine for vital sign monitoring. It could be seen that the stricter the ward routine, the more complete was the monitoring of vital signs. Vital signs were often recorded according to the clinical decisions made by nurses.
b) Regarding documenting vital signs, usability issues in the EHR presented several challenges. There were three different locations in which vital signs could be located within the EHR. To enter information to the table for vital signs was awkward and time-consuming. This was particularly problematic when a patient required frequent vital signs.
c) Retrieving vital signs was also awkward and time-consuming. It was sometimes necessary to browse through three sections of the EHR to find vital signs. Lack of functional graphs made it was difficult to get an overview of all vital signs. As documentation was often delayed, a person retrieving vital signs could not be sure that they were viewing the most current information.
d) To overcome workflow problems, workarounds in the form of paper charts had been created to circumvent these difficulties. Verbal workarounds were also used to improve the flow of information.

e) Although there was a location in the EHR for vital signs, it did not provide optimal facilities for this type of documentation because it was difficult to enter and retrieve vital signs.

7.2.4 Integration of phase one and two findings

The integrated findings of the two study phases presented two key themes: facilities and functions in the EHR, and practices and routines for documenting vital signs. In the first phase study, the results pointed clearly to problems related to usability in the EHR. However, as shown in the findings of the phase two study, this was only part of the reason for the variable and sparse documentation of vital signs in the EHR; there were also issues with routines and practices at ward level. Clearly, current practices in the clinical areas in which this study was performed, failed to meet the requirements of universally accepted standards for patient surveillance.

7.3 Contribution to current knowledge

This thesis makes a number of novel contributions to current knowledge about electronic health record systems in relation to vital signs.

7.3.1 Implications for patient safety

Although, prior to this research, it was known that nursing documentation in the EHR could be awkward and time-consuming (Stevenson & Nilsson, 2012) it was not clear that the documentation of vital signs in the EHR could have a direct impact on patient safety. The implications of the findings in this thesis indicate that current facilities for the documentation of vital signs in the EHR could impose a high risk that deterioration in a patient's condition would not be recognised, or recognised in time. Not only was it difficult to enter vital signs into the EHR, when the vital signs were documented they were difficult to access. Moreover, when the vital signs were accessed, they were not presented in a format that could be easily interpreted, or in which trends could not be viewed at a glance. In a situation in which every minute can be critical for patient survival, this could pose a serious risk for the safety of the patient, for instance, if deterioration is not clearly evident from the documentation. Furthermore, because vital sign documentation in the EHR rarely took place directly at the bedside, vital signs documented in the EHR were seldom up-to-date. Therefore, the findings of this thesis provides evidence that there are problems

related to vital sign documentation in the EHR. This is important as it could imply a direct impact on patient safety.

7.3.2 Benefits for end-users and designers

This thesis makes another important contribution to knowledge. There is substantial indication in the literature that designers do not have a good understanding of the work processes for which they design electronic systems (Darbyshire, 2003; Goorman & Berg, 2000; Nemeth et al., 2005), and, because of this, many recommendations have been made indicating the need for end-users to be consulted regarding design. Although the opinions of end-users are obviously important, this thesis found that sometimes the end-users may not have had sufficient knowledge about vital sign monitoring to make appropriate evidence-based recommendations for design. For example, sometimes, as shown in section 5.6.1, routines were not in line with universal standards and there was a lack of awareness of evidence-based recommendations as to how vital signs could be documented efficiently. This could mean that if end-users were consulted about their design needs, they may not know exactly what they should ask for. This may indicate the need to consult current research on optimal methods for measuring and documenting vital signs to guide both end-users and designers towards the best solutions. This is an example of how important it is for research to be disseminated back to its source, in this case clinical areas, so that practice can benefit from the findings of the research. In this way the 'theory-practice' gap can be narrowed. For example, this thesis makes several recommendations (see section 7.5.1) for existing technological solutions that could enhance patient surveillance and, subsequently, patient safety, as well as recommending the use of evidence-based paper charts when necessary. Therefore, the findings of this thesis provides new knowledge which could benefit end-users and designers, as well as those responsible for procuring EHR systems to hospitals.

7.3.3 Hospital policy

In addition, this research provides important insights into the actual practice of monitoring and recording patients' vital signs, a subject which has received little attention before the development of rapid response systems (RRS), despite it being a key action in acute hospitals (DeVita, Hillman, & Smith, 2014). This research has also shown how the introduction of clear and firm routines can improve monitoring of vital signs. Moreover, when hospital policy is not in line with universal recommendations for patient surveillance

and early identification of deteriorating patients, this thesis could provide crucial information for, e.g., policy makers.

7.3.4 Mixed methods research

Another novel aspect of this thesis is the contribution it makes to mixed methods research. It demonstrates how mixed methods design allowed issues related to vital sign documentation in the EHR to be examined from several perspectives, and enhances current knowledge of how mixed methods research can provide a deep understanding of research which addresses information systems. Furthermore, it adds new insights into how to integrate the quantitative and qualitative phases of mixed methods research. For instance, it adapts integration recommendations from two authors (Ivankova, 2014; Venkatesh et al., 2013) and develops these to create a novel method of integration for this type of research.

7.4 Implications for practice and policy

There were three main implications for practice and policy: improve documentation of vital signs by development of user-friendly technology, whilst simultaneously improving the ability to capture abnormal vital signs; improve routines and policies for measuring vital signs; and educational initiatives. These are discussed in detail below.

7.4.1 Technology

Clearly, facilities and functions in the EHR influence the documentation of vital signs and, thereby, patient safety. To improve patient safety, digital solutions are required that are simple to use, that fit into ward routines and the working patterns of nurses, and that enable records to be kept so that they are current and available (Russ et al., 2010). Documentation of vital signs could be more effective and efficient if undertaken at the point of care and in real time, and any electronic system should be simple to use so that vital signs can be entered easily and quickly.

Currently, available technology may offer some solutions. For example, there are mobile devices such as personal digital assistants (PDAs), smartphones or tablets. An example of a PDA used for the documentation of vital signs is VitalPAC (The Learning Clinic Ltd, 2012) (see literature review, section 2.5.1.7). Hand-held PDAs can run the VitalPAC software. ViEWS and its escalation plan are embedded into VitalPAC. Complete sets of vital signs can be entered at the bedside and VitalPAC can automatically calculate the

ViEWS values to measure for any physiological abnormality. If there are any abnormalities, decision support is immediately displayed indicating when the next set of vital signs should be taken or if further action is required (Hands et al., 2013). This system has some similarities to the triage system (RETTS) in the study hospital, which assigns a severity of illness code and indicates the required frequency of vital signs recordings. The difference between RETTS and VitalPAC is that RETTS does this automatically only for the first set of vital signs. After that, nurses have to consult a paper chart to calculate the severity of illness. One of the emergency department (ED) nurses expressed that it would be beneficial if RETTS continued to allocate severity of illness automatically (see section 5.5.4.1). Therefore, technological solutions are not only possible but might actually be desired by nursing staff.

Smartphones are also becoming increasingly popular for documentation of vital signs. For example, Chelsea and Westminster hospitals in London, England have started using 'ThinkVitals' for faster detection of deteriorating patients (McBeth, 2015). Another example is to use a tablet, for example an i-Pad, with features based on an early warning system (Engineering and Physical Sciences Research Council (EPSRC), 2013). These systems work in a similar way to VitalPAC.

There are several advantages to these mobile devices. They can be used for documentation at the point of care, which would relieve the issue of trailing cumbersome trolleys with laptops around. They are user-friendly using touch screen technology and allow immediate documentation at the bedside and could, therefore, diminish the need for paper charts, checklists and notes. These mobile devices could be directly connected to the EHR so that information is automatically transferred into the mainstream EHR or onto an electronic whiteboard. In addition, these systems can evaluate a patient's vital signs by calculating early warning scores. Instant displays of evaluations of vital signs can alert staff to any deterioration in a patient's clinical condition and be automatically relayed to senior staff responsible for the patient. Implementing bedside electronic solutions in direct relation to acute illness training for nurses can maximise efficiency of such new initiatives (Jones et al., 2011). A further advantage of this type of system is that it can give an indication of individual patient severity of illness and indicate to hospital managers the units in the hospital which are particularly busy (DeVita et al., 2010). However, in the event that technological solutions are not pursued and paper observation charts are still used, it is recommended that standardised evidence-based observation charts be utilised.

7.4.2 Routines and policies

The benefits of rapid response systems (RRS) are clear and that is why they have been implemented widely in the western world, e.g., in Australia, New Zealand, United Kingdom, the Netherlands and Scandinavia (DeVita et al., 2014). However, to date, the Scandinavian hospital in this study has not adopted an RRS. It is hoped that the evidence in this study would be enough to persuade hospital managers and those in policy making positions that there is a need for an RRS. The findings from this research demonstrate the necessity of introducing an RRS so that there are clear guidelines on how to prevent all adverse events, and not just sepsis, which is the focus of the current track and trigger system used in the study hospital, BAS (blood pressure, respiratory rate and oxygen saturation). The implementation of an RRS would improve the quality of care and patient safety, and align the study hospital to current practice in much of the developed world. All hospitals should aspire to deliver the best quality of care possible. This entails implementing the recommendations of current research, e.g., on RRS, and ensuring evidence-based practice.

In the study hospital, there are two possible ways forward for the implementation of an RRS. The first would be to build on the system, BAS, which is already in use. An advantage of further developing the current system is that it is already known to the hospital staff and it may be easier to build onto a system with which they are familiar. After all, to some extent, there was evidence of this already happening; the surgical ward in this study had written new guidelines extending BAS to include further vital signs to improve patient surveillance (Section 5.5.6). This initiative aimed to detect any type of physiological deterioration. In addition, in the event of using a single parameter system, technology that supports point of care documentation, and alerts to abnormal vital signs, could be developed.

However, from this research it was apparent that attitudes and beliefs about using BAS were mainly restricted to it being considered a tool for detecting sepsis, rather than a tool for detecting deterioration in general. This is probably because BAS had been created as a tool to detect sepsis and that is how it was introduced to the study hospital. Therefore, further development of BAS to include all the criteria in established single parameter systems would require to be coupled with education in acute illness.

The second possibility for an RRS at the study hospital would be an aggregate weighted track and trigger system (AWTTS). These systems are more sensitive and specific than

single parameter systems, and they encourage the measurement of full sets of vital signs (Smith, 2013b). A disadvantage of EWS systems is that they are more complex and there are frequent errors made when the EWS is calculated by hand (Mohammed et al., 2009; Prytherch et al., 2006). However, if used in combination with appropriate technology, the calculations would be automatic. For example, ViEWS is a validated EWS and is also suitable for bedside electronic documentation (Jones et al., 2011). Subsequently, the problem of miscalculation associated with hand-written EWS is diminished. This makes it very attractive as a TTS. A disadvantage of implementing this system is that it does not relate directly to the currently used BAS system, and would therefore require more comprehensive education and implementation.

Furthermore, introducing a more robust track and trigger system is not enough on its own. Having an RRS does not only mean to detect and recognise patient deterioration, there is also the need for an emergency response team to manage these patients at an early stage of deterioration. Many hospitals have extended the role of the cardiac arrest team to become the emergency response team. As the study hospital has a cardiac arrest team, this could be one possibility for developing a rapid response team (RRT). Anecdotally, senior staff at the study hospital seemed reluctant to consider this option due to the financial burden it might impose. However, there may be financial gains to be made if there were, for example, fewer adverse events, shorter hospital stays, fewer unplanned admissions to ICU, or futile resuscitation attempts on patients who would have benefitted from the timely issue of 'do not attempt resuscitation' (DNAR) orders. In one study, adverse events were estimated to cost an additional 18.6% of a total in-patient hospital budget (Ehsani, Jackson, & Duckett, 2006).

7.4.3 Education

The need for educational initiatives emerged as a key meta-inference and was also identified in the literature review (Sections 2.4.2 and 2.6.5) and in section 6.3.2 of this thesis. In particular the term 'Chain of Prevention', coined by Smith, is useful and relevant to provide comprehensive education in preventing cardiac arrest (Smith, 2010). For example, it has been recognised that junior doctors have poor knowledge of acute care and its identification and management. Attending an acute care course such as ALERT can be significantly beneficial (Smith et al., 2002). Moreover, several studies have emphasised the importance of on-going education for qualified staff (Bright et al., 2004; Deakin et al., 2010; Smith, 2010).

In addition, it has been suggested that newly-qualified nurses do not hold the decision-making skills necessary for managing deteriorating patients (Cooper et al., 2010). One study, by nurse educators (McCallum, Duffy, Hastie, Ness, & Price, 2013), suggested that this lack of skills might be due to EWS, claiming that EWS did not emphasise the importance of certain concepts, such as knowing individual patients, recognising other signs of deterioration or interpreting vital signs. As it is generally understood that EWS is merely a tool to assist in the identification of deterioration, these claims are somewhat surprising and provoke the question of why EWS have become necessary in the first place. It also raises the question as to whether there has been a deskilling of nurses which has led to EWS being necessary to identify deteriorating patients. It is also possible that the problem of poorly skilled, newly-qualified nurses is related to the quality of the education or training that they have received. One suggestion from the nurse educators who wrote the paper was that maybe the mentors needed support to develop their own skills.

It is important to note that nurse education has undergone some significant changes in the last two decades. One major change is that nurse education moved into higher education. As a result of this, nursing students have spent much less time in clinical areas during their education than they did previously. In fact, many may have spent only a fraction of that time in acute clinical areas, thus reducing the extent to which they gain expertise through apprenticeship (Bright et al., 2004). This would also apply to many mentors who have been educated in the last two decades. Thus, the question is raised as to whether it is time to re-examine nurse education to ensure it prepares nurses for the role they have in acute care and address the issue of bridging the theory-practice gap (Corlett, 2000).

In the event of unqualified HCAs recording vital signs, using EWS can simply enhance the detection of deteriorating patients, provided that the HCAs are sufficiently educated to inform a qualified member of staff when a EWS threshold is reached. In the case of qualified staff, EWS has been found to be beneficial for reporting deterioration to medical staff in that it provides a number to specify the level of deterioration. Nonetheless, qualified staff should be educated to an adequate level to ensure they have the knowledge base to make correct decisions in dealing with deteriorating patients. Therefore, nurse education should focus on the importance of monitoring and interpreting vital signs and ensuring newly qualified nurses possess these skills (Chua et al., 2013).

7.5 Suggestions for future research

In light of current evidence it is highly recommended that an RRS be implemented in hospitals that do not currently utilise these systems. Were such a system to be implemented in the study hospital, future research should focus on an intervention study. The current research could become a pre-intervention study and the proposed research would become a post-intervention study. The type of TTS would require discussion with leading nursing and medical staff. The implementation would require an inter-professional team to include educators, technological experts and communication and collaboration experts (Bunkenborg et al., 2013).

Two positive developments at the study hospital imply that there might be the possibility to develop an electronically based TTS. One is that one ward at the hospital is piloting the use of i-Pads and electronic whiteboards for documentation, including the documentation of vital signs. The second development has been that surgical wards have written new guidelines which include most ViEWS measurements. The aim of the study would be that nursing staff would record complete sets of vital signs according to a pre-determined protocol, that vital signs would be recorded in real time at the point of care, that severity of illness would be calculated automatically, that observed abnormalities would be dealt with according to a pre-determined algorithm and that an emergency response team would be available if and when necessary. Outcome measurements would be calculated by the number of cardiac arrests for given periods before and after the study. Following these interventions, future research could evaluate the outcomes.

7.6 Benefits of this study

Despite advances in resuscitation procedures, the survival rate from cardiac arrest has not improved for many years (DeVita et al., 2014). Because of this, the focus has shifted to the period prior to cardiac arrest with the aim of arrest prevention. There is convincing evidence that potentially reversible abnormal vital signs may be present for many hours before a patient has a cardiac arrest (Goldhill, Worthington, et al., 1999; McQuillan et al., 1998; Schein et al., 1990). Sub-optimal care in general wards has been identified indicating the need for closer surveillance of vital signs. A range of track and trigger systems and emergency response teams evolved with the aim to prevent cardiac arrest (and other adverse events). This concept gradually became known as rapid response systems (RRS). Studies to evaluate these systems have shown impressive results in reducing the number of

cardiac arrests. However, the results of a major randomised controlled study, MERIT, were disappointing in that the results did not demonstrate any improvement in survival rates (Hillman et al., 2005). Later, valid explanations could be offered for why results have not been more positive. (McDonnell et al., 2007). A particularly interesting reflection was that it may not be possible to evaluate RRS in the same way that new drugs and procedures are evaluated, and suggested that "successful implementation of an RRS requires a large Hawthorne effect" (DeVita et al., 2014, p. 2). (The Hawthorne effect is described in chapter 3.5.) This could explain the impressive results of before and after studies (ibid). This suggests that the act of being in a clinical area and being proactive in implementing systems to improve patient surveillance, whilst simultaneously evaluating those, can lead to a positive change. There have been a few instances of small accomplishments at the study hospital which may or may not have occurred in relation to the current research, similar to the Hawthorne effect described above.

For example, after the first study, the researcher was invited to be involved in in-service education at the study hospital during two meetings in August/September 2012. This included presenting the results of the phase one study to instructors of cardio-pulmonary resuscitation (CPR). The intention was that the instructors would further disseminate information about the study to medical and nursing personnel, at the same time as they carried out CPR training. Information about the importance of recording respiratory rate was one of the points emphasised in these talks. Subsequently, all CPR instructors should now emphasise the importance of doing BAS vital signs on all patients and point out that these recordings may also detect other conditions and not just infection/sepsis which was the initial aim of introducing BAS at the hospital. This has been an important benefit arising from this project.

Anecdotal feedback has indicated other positive outcomes. For example, a nurse known to the researcher related how when visiting a patient at home and contemplating whether or not the patient should be admitted, that he remembered what had been said about respiratory rate. On checking the patient's vital signs he found that the respiratory rate was over 30. This gave him the evidence he needed that the patient should be admitted to hospital. He said that there was no problem when he rang the ambulance as the patient had a positive BAS result. Furthermore, in discussion with one of the consultant cardiologists, he mentioned how BAS was useful when making decisions about patients' status and how it could even indicate whether a patient was fit for discharge or not. These incidences seem to demonstrate that the talks had revitalised the importance of measuring BAS vital signs.

Another instance was when the researcher was admitted to hospital for surgery following an accident. When the healthcare assistant checked the vital signs, she said "don't talk now as I have to count your respiratory rate". (This was not best practice as patients should be unaware that their respirations are being counted, but at least she was recording it.) Notably, the respiratory rate was recorded with each set of vital signs and nurses even mentioned how it was important to record respiratory rate. This was not the usual practice observed during data collection for the qualitative study. It is possible that word had got around that "she's the one that talks about respiratory rate".

Another occasion was when the researcher made a return visit to the infection ward to meet with a senior nurse to carry out 'member checking' for the qualitative study. The nurse confirmed that the findings gave an accurate description of vital signs monitoring in the infection ward "as it was when you were here". She went on to show the researcher a new paper checklist of vital signs that had replaced the one that had been used during the time of data collection for the qualitative study. It showed considerable improvements, e.g., space for more vital signs than just temperature. New guidelines for how frequently vital signs should be measured had also been drawn up. Of course, it is possible that this would have happened anyway but it just might be that it was influenced by someone coming around examining routines for recording vital signs. These examples perhaps illustrate small steps to increasing awareness on the importance of patient surveillance.

During the time that this thesis was being drawn to a conclusion, there was another interesting development at the study hospital. The researcher had been asked to present this research at a staff open day at the clinical training centre. After the results had been presented, an enthusiastic discussion ensued in which it transpired that an update of the currently used EHR was to include the National Early Warning Score (NEWS) system. The format of the system was not known. However, the concern of an anaesthetist who took part in the discussion was that the hospital management team would have to be persuaded of the importance of NEWS so that this particular early warning score system could be implemented at the hospital. It transpired that he wanted to use the results of the current studies as a lever to persuade management to change from using BAS to NEWS. The contact between the anaesthetist and the researcher was on-going at the time of publication of this thesis.

7.7 Summary of thesis and recommendations

Tables 7.1 and 7.2 provide a summary of this thesis with regard to the main issues and recommendations, and the rationale guiding these recommendations.

Table 7.1 Issues to inform computer system designs and adaptations to EHR to fit with clinical processes and demands of vital sign documentation

Issue (reference)	Recommendation	Rationale
Point of documentation must be at bedside (Section 7.4.1)	Implementation of hand-held devices or tablets for bedside use that are automatically linked to central EHR system	Save time wasted in double documentation; minimise risk of error during transcription; documentation made at time of measurement giving an up-to-date record
Entry of vital signs data to EHR (Section 7.4.1).	Facilitate ease of use with user-friendly entry, should be possible to access each patient's vital sign chart with one click	Save time; documentation made at time of measurement; staff provided with a usable system that is fit for purpose
Presentation of vital signs (Section 4.8.6)	Graphical presentation of vital signs	View vital information at a glance to allow interpretation of patient condition; immediate view of trends and changes
Early warning score system (Section 7.4.1)	Abnormal vital signs should be captured and immediately identify any deterioration	Early detection of deterioration; efficient, practical decision-support system
Utilise current research to inform design (Section 7.3.2)	Research, e.g., current thesis, on needs of design should be consulted, in addition to consulting end-users.	End-users may have varied opinions so beneficial to consult research that has an overview of design requirements

Table 7.2 Issues to inform routines, practice and policies to improve patient safety

Issue (reference)	Recommendation	Rationale
Introduction of early warning system (Sections 4.3.4.2 & 7.4.2)	Set guidelines for vital signs recordings of all hospital patients; set routines of minimum recordings; full sets of vital signs two times daily	Patient receives right care at right time
Introduction of escalation of care (in line with early warning system) (Section 2.5.1.3 & 7.4.2)	Set guidelines for required action if patient has abnormal vital signs	Patient receives right care at right time
Introduction of rapid response team (Sections 2.6.7 & 7.4.2)	Create a clinical team that can be called to assess and manage a deteriorating patient	Patient receives right care at right time
Education (Section 7.4.3)	Staff education and training to improve recognition and management of deteriorating patient	Staff feel secure and are competent in care of unstable patients
Education (Section 2.7.6)	Staff education and training in use of proposed new clinical documentation system for vital signs	Staff feel secure using system to document vital signs efficiently. Diminish the need for paper notes and charts
Inform staff of reasons for changes (Section 7.4.2)	Provide information to staff on current evidence on patient surveillance	Staff understand the need to improve patient surveillance and therefore comply with change process
Paper charts (Sections 2.7.4 & 6.3.1.9)	Provide standardised paper charts to facilitate good and safe documentation of vital signs	Until EHR is made fit for purpose in documenting vital signs, it may be necessary to upgrade and standardise paper charts

These tables (7.1 and 7.2) summarise the main findings and recommendations of this thesis.

7.8 Conclusion

This PhD study has explored an area in which little previous research has been undertaken. It has identified issues related to patient surveillance and documentation of vital signs in an EHR. The findings could be useful for hospital managers who want to improve patient surveillance and monitoring of vital signs and ensure that hospital policy is in line with universal standards. Policy makers at a national level may also find the evidence in this study useful if deciding on a national standard for patient surveillance. Designers of information systems in health care could also benefit from the evidence in this study regarding end-user and patient safety perspectives.

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Appendices

Caveat

Please accept apologies for the quality of some of the appendices for this thesis. Some of these have been made from photocopied charts and documents of varying quality, mostly received directly from clinical areas. Every effort has been made to ensure readability. Most have been translated into English. Some of the clinical charts have had only relevant sections translated, i.e., those related to vital signs.

Appendix Ia Copy of Ethical Approval letter Central Ethical Review Board

Närvarande:

Ledamöter: Claes Lindgren, kammarrättsråd, ordförande, ersättare för Lars Dahlstedt
John Carstensen, professor *(epidemiologi&biostatistik)*
Charlotta Dabrosin, professor *(tumörsjukdomar, obstetrik/gyn),* vetenskaplig sekr
Oliver Gimm, professor *(kirurgi)*, ersättare för Kristina Söderlind Rutberg
Johnny Ludvigsson, professor *(barnmedicin)*
Jan Marcusson, professor *(geriatrik),* deltog punkt 1 - 22
Ina Marteinsdottir, docent *(psykiatri)* deltog punkt 3, 10, 19, 11 - 28
Bo Nordenskjöld, professor *(tumörsjukdomar)*
Eva Nylander, professor *(klinisk fysiologi)* deltog punkt 11 – 18, 20 - 28
Curt Peterson, professor *(klinisk farmakologi)*, ersättare för Staffan Hägg
Gunilla Sydsjö, professor (*klinisk psykologi*)

Ledamöter som företräder allmänna intressen:
Berit Sjöö, barnmorska
Anja Uvenberg, studerande deltog punkt 3 - 28
Rolf Wilhelmsson, landstingsledamot

Övriga: Anna Alexandersson, adm sekr

PUNKT	ÄRENDE	BESLUT

7. Ansökan om etikprövning
Forskningshuvudman: Linnéuniversitetet
Forskare: Göran Petersson, eHälsoinstitutet, Linnéuniversitetet, Kalmar.
Projekt: Dokumentation av vitalparametrar i elektronisk journal hos patienter som drabbats av hjärtstopp på sjukhus – en fråga om patientsäkerhet. Projektnr/id: 1
Versionnr: 1 Dnr **2010/351-31**
Föredragande: John Carstensen

Nämnden beslöt godkänna ansökan. Behandlingen av personuppgifter, som den beskrivs i ansökan, godkänns.

Uppgift om vetenskaplig frågeställning saknas och ska anges i ansökan.

Vid protokollet Justeras:

Anna Alexandersson Charlotta Dabrosin Claes Lindgren

Att utdraget överensstämmer med originalet intygar:

Anna Alexandersson
Administrativ sekreterare

Adress:
Regionala etikprövningsnämnden i Linköping
c/o Hälsouniversitetets kansli
Sandbäcksgatan 7
581 83 LINKÖPING
www.epn.se

Kontaktpersoner: Telefon:
Adm sekr Anna Alexandersson 010 - 103 70 30
E-post: anna.alexandersson@linkoping.epn.se
Adm sekr Ewa Westny 010 – 103 41 42
E-post: ewa.westny@linkoping.epn.se

Appendix Ib Copy of Ethical Approval letter (English translation)

English translation of the letter of ethical approval

EPN	Central Ethical Review Board, Linkoping, Sweden.	Extract from Agenda.
	Department for approval of medical research.	Date of meeting: 15 December 2010

Present:
Members:

Claes Lindgrean	Chairman of the Board, substitute for Lars Dahlstedt
John Carstensen	Professor *(epidemiology, biostatistics)*
Charlotta Dabrosin	Professor *(obstetrics, gynaecology)* Research secretary
Oliver Gimm	Professor *(surgery)* substitute for Kristina Soderlind Rutberg
Johnny Ludvigsson	Professor *(paediatric medicine)*
Jan Marcusson	Professor *(geriatrics)*
Ina Marteinsdottir	Professor *(psychiatry)*
Bo Nordenskjold	Professor *(oncology)*
Eva Nylander	Professor *(clinical physiology)*
Curt Peterson	Professor *(clinical pharmacology)* substitute for Staffan Hagg
Gunilla Sydsjo	Professor *(clinical psychology)*

Members representing the public interest:

Berit Sjoo	Midwife
Anja Ulvberg	Student
Rolf Wilhelmsson	Member of Health Board

Other: Anna Alexandersson Administrative Secretary

ITEM	ERRAND	DECISION

7. Application for ethical approval
Linnaeus University is the responsible organisation.
Professor Göran Petersson is responsible for the research.
Project "Document of vital signs in electronic health records in patients who have suffered in-hospital cardiac arrest - a question for patient safety". Project no. ID: 1
Version no: 1 Entry no. **2010/351-31**

Presenter: John Carstensen

The board decided to approve the application. Managing personal information, as described in the application, is approved.

Information about the research questions is missing and should be provided in the application.

Agenda approved		Seconded
Anna Alexandersson	Charlotta Dabrosin	Claes Lindgren

That the document is in agreement with the original document is certified by:

Signature
Anna Alexandersson
Administrative secretary

Appendix Ic Copy of email from Research and Innovations Services

Email from Lindsaty Unwin, Research and Innovations Department, stating that no additional ethical approval was required from the University of Sheffield

From: **Lindsay Victoria Unwin** <L.V.Unwin@sheffield.ac.uk>
Date: 20 January 2011 at 16:57
Subject: Re: Research ethics approval
To: Peter Bath <p.a.bath@sheffield.ac.uk>
Dear Peter,

Further to your email below and our earlier conversation, I have been able to find an English translation of the details I need on the relevant website, and I am happy that the ethics review process conducted in Sweden is sufficiently robust.

Please can you arrange for the School's Ethics Administrator to receive copies of the application form and the approval letter so a record can be kept?

Many thanks
Lindsay

Peter Bath wrote:
Dear Lindsay,

I hope you are well. I am supervising a PhD student, Jean Stevenson-Agren, who is based in Sweden and is doing a study looking at the recording of "vital signs" in electronic records. This is being undertaken in collaboration with a local hospital and with two academic colleagues at the eHealth Institute at Linnaeus University.

Jean has applied to the Swedish health service and has been granted ethics approval for her study. I am attaching the application and approval letter, but this is in Swedish and a translation is not available. I am satisfied that this process etc. is a robust as the University's system, and am confident that Jean and the hospital colleague and the two academic colleagues/supervisors will have covered the necessary details, even though I do not have a translation. Will this suffice for her research ethics approval from our University's viewpoint? I would very much appreciate your advice on this.

Thank you,
Best regards,

Peter

Peter Bath, PhD
Reader in Health Informatics
Information School
University of Sheffield
Regent Court
211 Portobello Street
Sheffield S1 4DP UK
--

Lindsay Unwin (née Cooper)
Quality Support and Regulations Officer
Quality and Governance Team

Research and Innovation Services
Academic Services
The University of Sheffield
New Spring House
231 Glossop Road
Sheffield
S10 2GW

Appendix 4.1

Data collection tool

Data collection from Swedish national register for cardiac arrest

Date of data collection	**Case no.**
Date of SCA:	**Time of SCA:**
Department pre arrest	
Age	
Gender	M F
Initial rhythm	
Cause of arrest	
Witnessed cardiac arrest Y/N	
Time to treatment in minutes	
Intubation during resuscitation procedure	
Medication during resuscitation procedure. If yes, which?	
Return of spontaneous circulation (ROSC) Y/N If Y, time	
Survival after resuscitation Y/N	
Survival at discharge Y/N	
Survival at 30 days	
Cerebral performance category score (CPC)- admission	
Cerebral performance category score (CPC)- discharge	

Data collection in electronic patient record (EPR)

Electrocardiogram (ECG) (last taken before SCA)	**Date**	
Signs of ischaemia /ST changes	ST elevation	
	ST depression	
	Inverted T- wave	
Signs of bundle branch block. QS >0.12		

Prescribed medication prior to arrest			
Name of medication		**Yes/No**	**Date and time of last administration**
Thrombocyte inhibitor ASA	Trombyl		
Thrombocyte inhibitor	Clopidogrel, Plavix		
Thrombocyte inhibitor other	Fragmin, Klexane, Arixtra, Aggrasat.		
Beta blocker	Seloken, Metoprolol, Bisoprolol		

Appendix II (cont)

Physiological status													
Case no.	**Date of SCA:**							**Time of SCA:**					
Date of data collection:	Last vitals in 24 hours prior to SCA date and time: from earliest (left) to latest (right)											Latest record	BAS or MEWS
Date													
Time													
Respiratory rate													
Where documented													
Heart rate													
Where documented													
Systolic blood pressure													
Where documented													
Temperature°C													
Where documented													
CNS (AVPU)													
Where documented													
Urinary output (hourly)													
Where documented													
Oxygen saturation %													
Where documented													
BAS alert													
EWS alert													

Appendix II (cont)

Interventions										
Date										
Time										
Oxygen therapy Y/N										
Where recorded										
IV fluids commenced										
Where recorded										
Medication administered Y/N Antibiotics A/Diuretic D										Yes/No A/D
Where recorded										
Increased frequency of vital sign obs Y/N										Yes/ No
Where recorded										
Check arterial blood gases (ABG) Y/N										Yes/No
Where recorded										
Key: J-journal, R- report sheet, T-template, G- graph used	AVPU: Alert, Voice, Pain, Unresponsive SCA: sudden cardiac arrest									
Notes:										

Appendix IIIa Copy of Ethical Approval letter Central Ethical Review Board

Regionala etikprövningsnämnden i Linköping
Avdelningen för prövning av medicinsk forskning

PROTOKOLLsutdrag
Sammanträdesdatum
2013-11-13

Närvarande:

Ledamöter: Lars Dahlstedt, lagman, ordförande
John Carstensen, professor *(epidemiologi&biostatistik)*
Charlotta Dabrosin, professor *(tumörsjukdomar, obstetrik/gyn)*, vetenskaplig sekr
Staffan Hägg, professor *(klinisk farmakologi, psykiatri)*, vetenskaplig sekr
Johnny Ludvigsson, professor em *(barnmedicin)*
Jan Marcusson, professor *(geriatrik)*
Ina Marteinsdottir, univ. lektor *(psykiatri)*, deltog ej vid punkt 6
Bo Nordenskjöld, professor em *(tumörsjukdomar)*
Eva Nylander, professor *(klinisk fysiologi)*
Gunilla Sydsjö, professor (*klinisk psykologi*), deltog ej vid punkt 5
Kristina Söderlind Rutberg, överläkare *(anestesi&intensivvård)*

Ledamöter som företräder allmänna intressen:
Lisbeth Rydefjärd, f.d. landstingsråd
Berit Sjöö, barnmorska
Martin Tollén, landstingsledamot
Rolf Wilhelmsson, landstingsledamot

Övriga: Anna Alexandersson, adm sekr

PUNKT	ÄRENDE	BESLUT

15. Ansökan om etikprövning
Forskningshuvudman: Linnéuniversitetet, eHälsoinstitutet
Forskare: Göran Petersson, eHälsoinstitutet, Linnéuniversitetet, Kalmar
Projekt: Dokumentation för vitalparametrar i elektronisk journal.
Dnr **2013/415-31**
Föredragande: Eva Nylander

Nämnden beslutade att godkänna ansökan. Behandlingen av personuppgifter, såsom den beskrivs i ansökan, godkänns.

Nämnden anser att forskaren bör överväga att utöka antal forskningspersoner som utväljs för intervju.
Forskningspersonsinformationen ska genomgå en språklig översyn.

Vid protokollet: Anna Alexandersson
Justeras: Charlotta Dabrosin, Lars Dahlstedt

Att utdraget överensstämmer med originalet intygar:

Anna Alexandersson
Administrativ sekreterare

Beslutet expedierat till behörig företrädare och forskare

Besöks- och postadress: c/o Hälsouniversitetets kansli, Sandbäcksgatan 7, 581 83 LINKÖPING
Telefon: 010 – 103 70 30, 010 – 103 41 42
Fax: 013 – 10 44 95
E-post: registrator@linkoping.epn.se
Hemsida: www.epn.se

Appendix IIIb **Copy of Ethical Approval letter (English translation)**

EPN	Central Ethical Review Board, Linkoping	Extract from Agenda.
	Department for approval of medical research.	Date of meeting: 13 November 2013

Present:
Members:

Claes Lindgrean	Lars Dahlstedt, Chairman of the Board
John Carstensen	Professor *(epidemiology, biostatistics)*
Charlotta Dabrosin	Professor *(obstetrics, gynaecology)* Research secretary
Staffan Hagg	Professor *(clinical pharmacology, psychiatry)* Research secretary
Johnny Ludvigsson	Professor *(paediatric medicine)*
Jan Marcusson	Professor *(geriatrics)*
Ina Marteinsdottir	Professor *(psychiatry)*
Bo Nordenskjold	Professor *(oncology)*
Eva Nylander	Professor *(clinical physiology)*
Gunilla Sydsjo	Professor *(clinical psychology)*
Kristina Soderlind Rutberg	Consultant *(anaesthetics and intensive care)*

Members representing the public interest:

Lisbeth Rydefjard	former member of the Health Board
Berit Sjoo	Midwife
Martin Tollen	Member of Health Board
Rolf Wilhelmsson	Member of Health Board

Others: Anna Alexandersson, Administrative Secretary

ITEM	ERRAND	DECISION

15. Application for ethical approval
Linnaeus University is the responsible organisation.
Professor Göran Petersson is responsible for the research.
Project "Document of vital signs in electronic health records ".
Entry no. **2013/415-31**

Presenter: Eva Nylander

The board decided to approve the application. Managing personal information, as described in the application, is approved.

The board thinks that the researchers should consider increasing the number of participants selected for interview.
The researchers should review use of language.

Agenda approved		Seconded
Anna Alexandersson	Charlotta Dabrosin	Lars Dahlstedt

That the document is in agreement with the original document is certified by:

Signature
Anna Alexandersson
Administrative secretary

Appendix IIIc Copy of email from Research and Innovation Services

Email from Lindsaty Unwin, stating that no additional ethical approval was required from the University of Sheffield

On 20 November 2013 15:24, Lindsay V Unwin wrote:
Hi Peter

Yes, I can confirm that the organisation's ethics review procedure was approved as sufficiently robust in comparison to our own, and there do not appear to have been any significant changes, so it's fine for ethics approval to be obtained through this organisation instead of the University.

Many thanks
Lindsay

Mrs Lindsay Unwin

Team Leader, Quality and Governance Team Quality and Skills Team

On 19 November 2013 10:44, Peter A Bath wrote:

Hi Lindsay,

You may remember that in 2011 you kindly confirmed that one of the PhD students I supervise, Jean Stevenson-Agren, did not need research ethics approval from the University because she was obtaining ethics approval in Sweden (please see below). Jean is now applying for research ethics approval from the same organisation for her second study. Please could you again confirm that she will not need University approval as well.

Thank you very much,
Best regards,

Peter

Appendix IIId Application to include additional clinical areas (Swedish)

Kalmar 2014-09-10

Regionala Etikprövningsnämnden i Linköping

Ansökan om komplettering till projektet 'Dokumentation av vitalparametrar i elektronisk journal'. Dnr 2013/415-31

Forskningshuvudman: Linnéuniversitetet, eHälsoinstitutet

Forskare: Göran Petersson, eHälsoinstitutet, Linnéuniversitetet, Kalmar

Som framgår av etikprövningsnämden har vi utökat antalet forskningspersoner som utväljs till intervju. I och med detta har vi bett cheferna till de utökade klinikerna att ge sitt medgivande till studien.

Härmed inskickas tre medgivanden från klinikchefer på Länssjukhuset i Kalmar.

Vänliga hälsningar

Namn

Titel

Appendix IIIe Application to include additional clinical areas (English translation)

Kalmar 10 September 2014

Central Ethical Review Board,
Linkoping

Application for additions to the project
'Document of vital signs in electronic health records'.
Entry no. 2013/415-31

Linnaeus University is the responsible organisation.
Professor Göran Petersson is responsible for the research.

As suggested by the Central Ethical Review Board, Linkoping, we have increased the number of participants to be selected for interview for the above study. In addition, we have asked the managers from the additional clinical areas for consent to carry out this study.

We hereby submit the consent forms received from the managers of the additional clinical areas.

Best regards,

Name
Title

Appendix IIIf Approval granted - additional clinical areas (Swedish)

Regionala etikprövningsnämnden i Linköping
Avdelningen för prövning av medicinsk forskning

BESLUT

2014-11-05

Göran Petersson
eHälsoinstitutet
Linnéuniversitetet
391 82 KALMAR

Ansökan: Dokumentation av vitalparametrar i elektronisk journal. (dnr 2013/415-31)
Sökande forskningshuvudman: Linnéuniversitetet
Dnr **2014/351-32**

EPN har erhållit ansökan om ändring av tidigare godkänd ansökan. Ändringen består i att öka antalet forskningspersoner som utväljs till intervju enligt brev daterat 2014-09-10. I ansökan beskrivs dock inte antalet. Ansökan godkänns förutsatt att inte fler än 20 forskningspersoner intervjuas i studien.

På nämndens vägnar

Staffan Hägg, professor
Vetenskaplig sekreterare

Beslutet expedierat till behörig företrädare och forskare

Postadress:
c/o Hälsouniversitetets kansli
Sandbäcksgatan 7
581 83 LINKÖPING

Telefon:
013 – 28 27 76, 013 – 28 27 77

E-post:
registrator@linkoping.epn.se

Hemsida
www.epn.se

Appendix IIIg Approval granted - additional clinical areas (English translation)

EPN Central Ethical Review Board, Linkoping
Department for approval of medical research.

Decision
5 November 2014

Goran Petersson
eHealth Institute
Linnaeus Universty
391 82 Kalmar

Application: Documentation of vital signs in electronic health records
Applicant: Linnaeus University
Entry no. 2014/351-32

The Central Ethical Review Board, Linkoping, has received an application for changes to an earlier approved application. The changes imply that an increased number of participants will be selected for interview according to a letter dated 10 September 2014. However, it does not state how many additional participants in this application. The application is approved provided that not more than 20 participants are interviewed in the study.

For the board

Signature
Staffan Hagg, professor
Research secretary

The decision has been sent to authorised representatives and researchers

Appendix IV Fieldwork materials Phase II

Appendix IVa Information to clinical managers (Swedish)

Kalmar 2013-05-12 Verksamhetschef medicinkliniken

Vitalparametrar i elektroniska patientjournaler

Jag arbetar på eHälsoinstitutet, Linnéuniversitetet i Kalmar som doktorand.

Vi har genomfört en studie där vi undersökt hur vitalparametrar fanns representerade i elektroniska patientjournaler (accepted). De viktigaste resultaten påvisade att det fanns en brist på dokumentation av vitalparametrar, samt att dokumentationen av vitalparametrar var splittrad och inkonsekvent.

I vår nya studie planerar vi att undersöka bakomliggande orsaker till tidigare resultat i syfte att förbättra möjligheter för dokumentation av vitalparametrar i den elektroniska patientjournalen. Detta kan leda till enklare och mer fullständig dokumentation av vitalparametrar, en minskad arbetsbörda för sjuksköterskor och läkare, samt ökad patientsäkerhet.

Studien kräver två metoder. För att se arbetsprocessen behöver vi först observera sjuksköterskor och läkare när de mäter, dokumenterar och inhämtar information om vitalparametrar. Därefter behöver vi intervjua sjuksköterskor och läkare för att undersöka deras uppfattningar om information/dokumentation av vitalparametrar.

Deltagandet i studien är helt anonymt och inga namn kan kopplas till deltagare.

Regionala Etikprövningsnämnden i Linköping har godkänt studien (Dnr 2013/415-31). Medicinska Kliniken har gett sitt medgivande. Eftersom studien utvidgas till Kirurgiska Kliniken och Akut Kliniken behöver vi även ert medgivande.

Om Du har några frågor eller vill veta mer, ring eller skriv gärna till mig eller min handledare.

Med vänliga hälsningar,

Jean Stevenson-Ågren och Gunilla Nilsson (handledare)

Jean Stevenson-Ågren leg. ssk doktorand
Tel:0480-497181
E-post: jean.stevenson.agren@lnu.se
eHälsoinstitutet
Fakulteten för hälso- och livsvetenskap
Linnéuniversitetet i Kalmar

Gunilla Nilsson leg.skk docent
Tel:0480-446042
E-post: gunilla.c.nilsson@lnu.se
eHälsoinstitutet
Fakulteten för hälso- och livsvetenskap
Linnéuniversitetet i Kalmar

Appendix IVb Information to clinical managers (English translation)

Kalmar 2014-05-12 Departmental Managers

Vital signs in electronic health records

I am a PhD student at the eHealth Institute, Linnaeus University.

We have carried out a study in which we investigated how vital signs were represented in electronic patient records (Stevenson et al). The key findings included that there was a lack of completeness of vital sign documentation, and that vital signs were fragmented and inconsistent in the electronic patient record.

In our new study we plan to investigate the underlying reasons for these results with the aim of improving facilities and possibilities to document vital signs in the electronic patient record. This could lead to easier and more complete documentation of vital signs and a reduced workload for nursing and medical staff, as well as an improvement in patient safety.

To investigate this we plan to use two approaches. First, in order to understand work processes, we would like to observe doctors and nurses as they measure, document and retrieve vital signs After this, we would like to interview doctors and nurses to ask about their understanding of information/documentation of vital signs.

Participation in the study is completely anonymous and no names will be linked to the people in the study.

The Central Ethical Review Board, Linkoping have approved the study (Dnr 2013/415-31). We require your permission to conduct the study in your department.

If you have any questions or would like more information about the study, please do not hesitate to call or write to me or my supervisor.

Yours faithfully

Jean Stevenson-Ågren and Gunilla Nilsson (supervisor)

Appendix IVc Consent from clinical managers (Swedish)

Vitalparametrar i elektroniska patientjournaler

Intyg från verksamhetschef

Härmed intygas att vid Medicinkliniken, Länssjukhuset, Kalmar finns resurser som garanterar forskningspersonernas säkerhet vid genomförandet av projektet "Dokumentation av vitalparametrar i elektroniskjournal: en undersökning om hur läkare och sjuksköterskor hantera vitalparametrar".

Signatur .....

Namn förtydligande .....

Kalmar den .....

Appendix IVd Consent from clinical managers (English translation)

Vital signs in electronic health records

Certification form for clinical manager

It is hereby certified that the Emergency Department/Surgical Department/ Medical Department/ Infection Department at County Hospital, Kalmar has resources which guarantees the safety of research participants during the implementation of the project "Documentation of vital sign in electronic health records: an investigation of how doctors and nurses manage vital signs".

Signature.....

Name in print .....

Date and location.....

Appendix IVe Information to participants (Swedish)

Information om vår forskningsstudie: Vitalparametrar i elektroniska patientjournaler

Denna studie ska undersöka arbetsprocesser och informationsflöden vid mätning, samt dokumentation och inhämtning av vitalparametrar i datorjournalen och undersöka i vilken utsträckning en datoriserad journal stödjer dokumentation av vitalparametrar.

Du tillfrågas härmed om deltagande i vår forskningsstudie. Vi ska undersöka hur läkare och sjuksköterskor, (och eventuellt undersköterskor), mäter vitalparametrar samt upplever användning av datorjournal för rapportering och hämtning av information om vitalparameter i elektronisk journal.

Vi har genomfört en studie där vi undersökt hur vitalparametrar fanns representerade i elektroniska patientjournaler (ref.). De viktigaste resultaten påvisade att det fanns en brist på dokumentation av vitalparametrar, samt att dokumentationen av vitalparametrar var splittrad och inkonsekvent.

I vår nya studie planerar vi att undersöka bakomliggande orsaker till tidigare resultat i syfte att förbättra möjligheter för dokumentation av vitalparametrar i den elektroniska patientjournalen. Detta kan leda till enklare och mer fullständig dokumentation av vitalparametrar, en minskad arbetsbörda för sjuksköterskor och läkare, samt ökad patientsäkerhet.

Studien kräver två metoder. För att se arbetsprocessen behöver vi först observera sjuksköterskor och läkare när de mäter, dokumenterar och inhämtar information om vitalparametrar. Därefter behöver vi intervjua sjuksköterskor och läkare för att undersöka deras uppfattningar om information/dokumentation av vitalparametrar.

Deltagandet i studien är helt anonymt och inga namn kan kopplas till deltagare.

Ditt deltagande i studien är helt frivilligt. Du kan när som helst avbryta ditt deltagande utan att motivera varför. Det kommer inte att få några negativa konsekvenser för Dig.

Har Du några frågor var god och kontakta någon av nedanstående:

Jean Stevenson-Ågren leg.ssk.,
doktorand
Tel:0480-446473/447181
E-post: jean.stevenson.agren@lnu.se
eHälsoinstitutet
Fakulteten för hälso- och livsvetenskap
Linnéuniversitet Kalmar

Appendix IVf Information to participants (English translation)

Information on our research study: Vital signs in electronic health records.

This study will investigate the work processes and flow of information when measuring, documenting and retrieving vital signs in the electronic health record, and examine the degree to which an electronic health record supports the documentation of vital signs.

You are hereby invited to participate in this research study. We are going to carry out a study in which we examine how doctors and nurses experience using electronic health records for reporting and retrieval of information on vital signs.

We have carried out a study where we investigated how vital signs were represented in electronic patient records. The key findings were that there was a lack of completeness of vital sign documentation, and that vital signs were fragmented and inconsistent in the electronic patient record.

In our new study we plan to investigate the underlying reasons for these results with the aim of improving facilities and possibilities to document vital signs in the electronic patient record. This could lead to easier and more complete documentation of vital signs and a reduced workload for nursing and medical staff, as well as an improvement in patient safety.

To investigate this we plan to use two approaches. First, we want to observe doctors and nurses as you work with information on vital signs, that is, measuring, documenting and retrieving information on vital signs. Second, we want to interview doctors and nurses and ask about documenting vital signs in electronic records. Your participation is extremely important for this study.

Participation in the study is completely anonymous and no names will be linked to the people in the study.

Your participation in this study is completely voluntary. You can cancel your participation at any time without motivating why. There will not be any negative consequences for you.

If you have any questions, please do not hesitate to contact us.

Jean Stevenson-Ågren

PhD student
Tel:0480-446473/447181
Email: jean.stevenson.agren@lnu.se
eHealth Institute
Fakulteten för health and life sciences
Linnaeus University,
Kalmar

Appendix Va Observation protocol

Observation protocol- from measuring vital signs to data entry

		Descriptive notes	Reflective notes
Subject *Doctor or nurse and designation*			
Date			
Time			
Measured vital signs- which (TPR BP CNS. Sats. O_2)			
Describe the exact chain of events from when the VS was measured until it was recorded in the EHR	Was the EHR beside the patient, e.g. COW? If not beside patient, where?		
	Did the subject have to walk from patient to EHR, how far?		
	Did the subject record the VS in any other way (eg paper) before entering it into the EHR?		
	How long was the time interval between when a VS was recorded and being entered into the EHR?		
Where and what was recorded?			
Opportunistic questions and answers /subject comments			
Observer comments			

Observation protocol - recording vital signs

Recording information		
	Descriptive notes	Reflective notes
Subject *Doctor or nurse and designation*		
Date		
Time		
How was the EHR accessed? e.g. number of clicks, screen changes etc		
Which information is being recorded? TPR BP CNS. Sats O_2		
Where was it recorded? Section of EHR		
Which format was used? Prose or numbers.		
Can a graph be made of vital signs?		
Note any recordings on BAS		
Opportunistic questions and answers /subject comments		
Observer comments		

Observation protocol- retrieving vital signs

Retrieving information		
	Descriptive notes	Reflective notes
Subject *Doctor or nurse and designation*		
Date		
Time		
How was the vital sign (VS) accessed from the EHR? e.g. number of clicks, screen changes etc		
Which information is being retrieved? TPR BP CNS. Sats O_2	T P R BP CNS Sats O_2 (tick)	
Where did the subject retrieve the VS? Section of EHR.		
In which format was it found? Prose or numbers.		
Can vital signs be viewed in graphical format?		
Were vital signs retrieved in any other way, e.g., verbally, from paper?		
Opportunistic questions and answers /subject comments		
Observer comments		

Appendix Vb Interview protocol (nurses)

Arranging the interview- time and place.
Recording the interview. Device- Olympus Dictaphone. Extra batteries. Back up device- second Dictaphone. Note taking.

Profession:
Years in job:
Age (optional):
Gender:

Rapport - build up a rapport with the interviewee. Thank the interviewee for agreeing to the meeting. Assure them that I understand their profession by informing them that my background is in nursing etc.
Explain to interviewee purpose of research.
Assure the interviewee that the interview is anonymous.
Give written information.

Questions

A. Semi-structured questions - measuring

1. How often do you check a patients vital signs routinely?
2. Which vital signs do you measure?
3. Apart from routinely, when else would you check a patient's vital signs? (to try to find instances of when extra checks taken)
4. If you observe abnormalities in vital signs, what do you do?
5. In what circumstances would you report deviations to a doctor?

B. Semi structured questions - documenting.

1. What is the procedure you use for documenting vital signs?
2. Where in the EPR do you document vital signs, e.g., patient journal, table, report sheet?
3. Do you document these directly into the EHR after you have taken them?

4. Where does the documentation take place ,e.g., at the bedside, outside pt room, at nurse station?
5. If so, when might you write vital signs in a notebook?
6. Are they then added to the EHR?
7. If so, when might you write vital signs down paper chart?
8. Are they then added to the EHR?

C. Semi-structured questions - retrieving

1. When you want to know a patient's vital signs, what do you do. Prompt: Do you:

a) ask the nurse in charge of the patient?
b) measure the vital signs yourself?
c) look in the EHR? and

i. if so, where in the EHR do you look?
ii. is it easy/difficult to find the information you need?

D. Semi-structured questions - general

1. How important are vital signs? (If difficult to answer, prompt, on a scale of 1-10)
2. Which vital signs do you consider as most important?
3. What about respiratory rate? (if not mentioned)
4. Are there any circumstances where you think respiratory rate might be important.

E. Unstructured open- ended question

1. I am interested in any views you have on measuring vital signs, and on documenting and retrieving vital signs from the EPR. Is there anything you would like to add?

Appendix Vc Interview protocol (doctors)

1. If you have a patient and you want to know the vital signs, what do you do? Ask the nurse? Look in the EHR?
2. If you look in the EHR, where exactly do you look?
3. Do you think information on vital signs is accessible?
4. Which vital signs do you consider to be most important?
5. What about respiratory rate?
6. On a scale of 1-10, how important are vital signs?
7. If a patient has abnormal vital signs, do you get this information in good time?
8. Is there anything else you would like to add?

Appendix VIa Paper charts-cardiology

Patient-id

Datum

Övervakningslista

		BAS 90-30-90					Anmärkning
kl	Puls	**Bltr**	**Andn frekv**	**SpO2 %**	Diures ml/h	Diures totalt	Läkemedel, åtgärd etc

Appendix VIa **Cardiology - English translation**

Date Observation chart Patient-id

		BAS 90-30-90					Notes
Time	Pulse	BP	RR	SpO2%	Urine output ml/hr	Urine output total	Medicine/treatment

BP=blood pressure; RR=respiratory rate; SpO2=saturation of peripheral oxygen

Nitroglycerin 1 mg/ml

FASS

Försiktighet vid: Hypotension. Cerebrovaskulär sjukdom. Aortastenos, mitralisstenos och hypertrofisk obstruktiv kardiomyopati, anemi, hypoxemi, hypotyreoidism
Biverkningar: Huvudvärk, yrsel, takykardi, hypotoni, flush.
Dosering: efter kroppsvikt
Hantering: färdigblandad infusionslösning som ges i sprutpump

Vikt	Startdos	"Slutdos" enligt generella direktiv
50-70 kg	0,5 ml/h	7,5 ml/h
70-90 kg	0,7 ml/h	10 ml/h

Ordination enligt generella direktiv
Öka infusionstakten var 5:e min. till symtomlindring eller tecken på hemodynamisk påverkan i form av blodtrycksfall > 10% och eller frekvensökning >10 slag/min. Blodtrycksfall p.g.a. smärtlindring beaktas ej. Vid blodtrycksfall, sänk huvudändan och minska dosen, ev. stäng infusionen. Är patienten symtomfri trappas dosen upp till minst medeldos eller symtom på hemodynamisk påverkan

Datum Kl	Puls	Bltr	Diures ml/h	Diures totalt	Dosering ml/h	O2 liter	SpO2 %	Anmärkning	Sign

Övervakning angio/PCI

Hjärtsektionen I Kalmar

Datum:_____

Patient id

Id kontroll utförd
Anhörig uppgift finns
Patientinfo given
Premed given kl___
Sign:_____

Längd:_____ Vikt:_____ Bltr:_____

EKG taget Distala pulsar ja nej

Preop. rakning utförd Alléns test ok ej ok

PVK satt

Överkänslighet:_____ Allergiprofylax:_____

Diabetes:_____ B-glukos:_____mmol/l

Metformin: ja nej Utsatt från:_____

Waran: ja nej Utsatt från:_____

Datum lab.värde:_____ Kreatinin:_____(µmol/l)

Introducer in kl:_____ Punktionsställe:_____

Hjärtrytm:_____ Bltr:_____

Tid										
Instick-ställe										
Distala pulsar										
BT										
Femo-stop										
TR-band										
OBS!										
Sign										

ACT kl:_____sek_____

Introducer ut kl:_____ TR-band satt kl:___ml_____

Etiketter för ballonger och stentar

Appendix VIb RETTS protocol with English translation

Vitalparametrar för vuxna

Vitalparametrar för vuxna RETTS

	Akut	Akut		
A	Ofri luftväg Stridor			-
B	SpO_2 < 90 % med O_2 AF >30 eller < 8	SpO_2 < 90 % utan O_2 AF >25	SpO_2 90 - 95% utan O_2	SpO_2 ≥ 95 % utan O_2 AF 8 - 25
C	SR > 130 el OR > 150 SBT < 90 mmHg	Puls > 120 eller < 40	Puls > 110 eller < 50	Puls 50 - 110
D	Medvetslös Krampanfall	Somnolent / RLS 2 - 3	Akut oklar/desorientering	Alert/Vaken
E		Temp > 41°C Temp < 35°C	Temp > 38,5°C	Temp 35° - 38,5°C

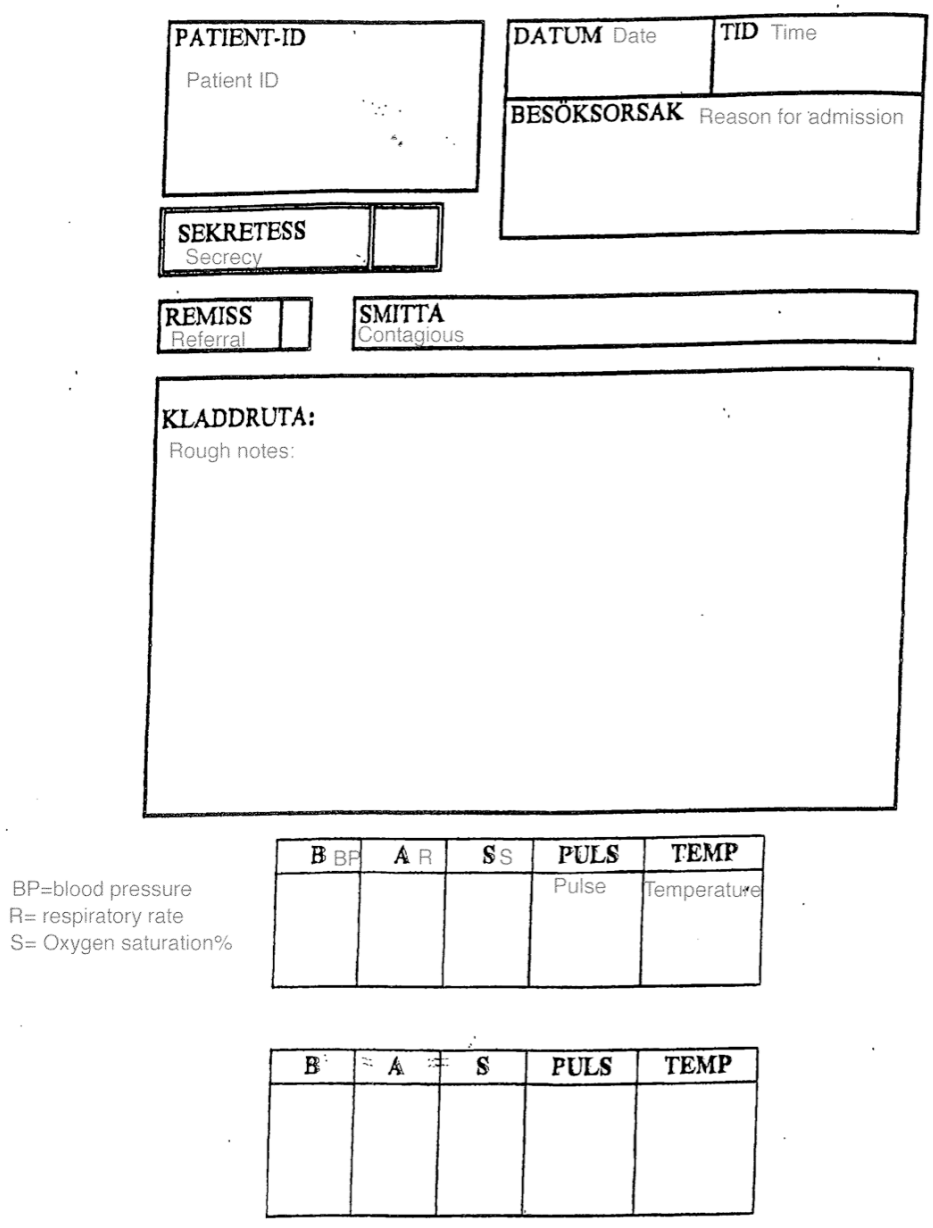
RETTS. English translation

Vital signs for adults RETTS

	Acute	Acute		
A	Obstructed airway Stridor			
B	SpO_2 <90% with O_2 RR >30 or < 8	SpO_2 < 90% without O_2 RR > 225	SpO_2 < 90% without O_2	SpO_2 < 90% without O_2
C	Pulse>130 or >150 SBP < 90	Pulse > 120 or < 40	Pulse > 110 or < 50	Pulse 50-110
D	Unconscious Seizure	Drowsy /RLS 2-3	Acute confusion	Alert/Awake
E		Temp >41°C Temp< 35° C	Temp >38.5°C	Temp 35° - 38.5°C

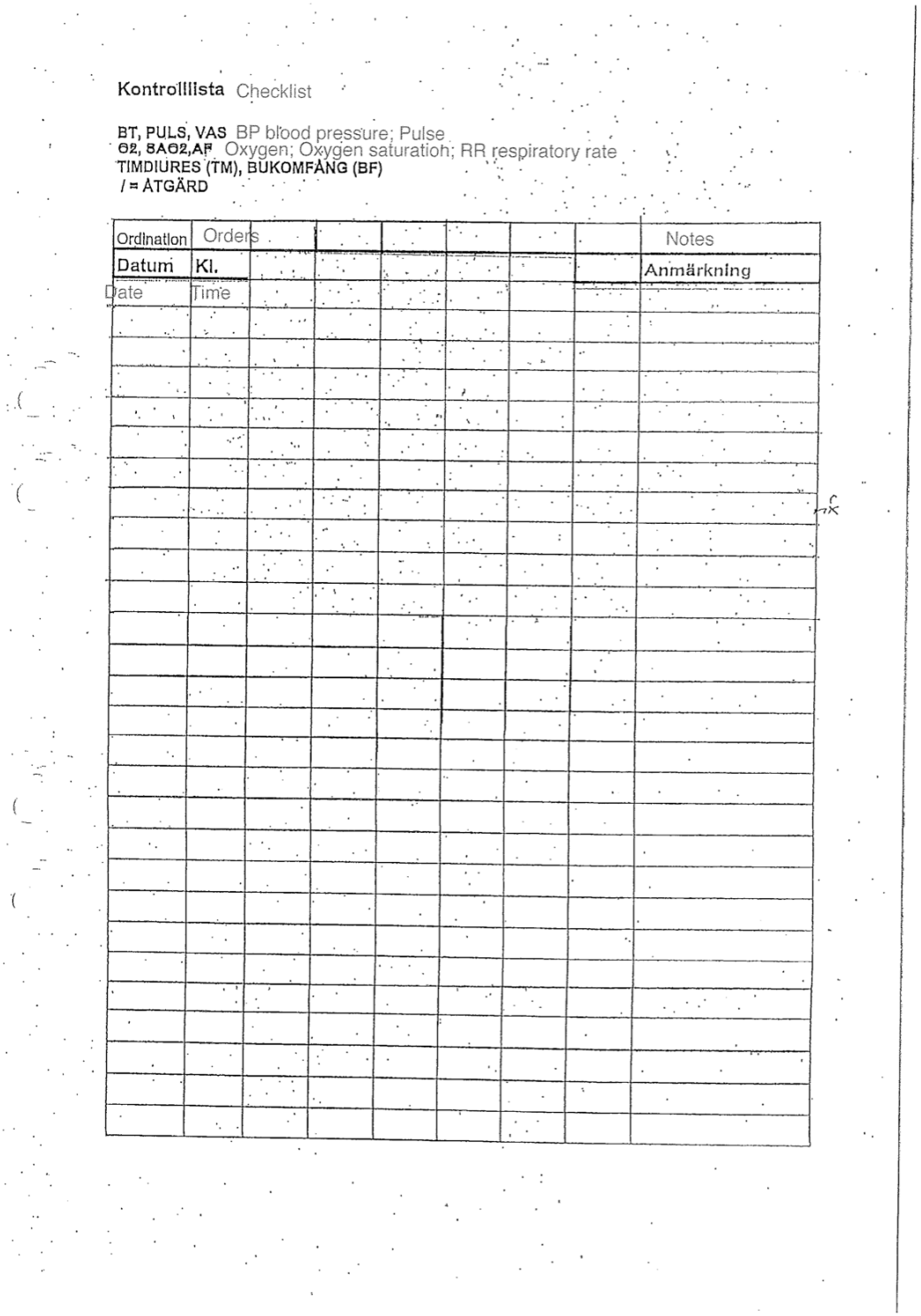
SpO_2=saturation of peripheral oxygen; O_2=oxygen; RR=respiratory rate; SBP=systolic blood pressure; Temp=temperature

Appendix VIc **Paper chart - ED**



BP=blood pressure
R= respiratory rate
S= Oxygen saturation%

Appendix VId Paper charts - infection ward (BAS list)



Kontrolllista Checklist

BT, PULS, VAS BP blood pressure; Pulse
~~O2, SAO2,AF~~ Oxygen; Oxygen saturation; RR respiratory rate
TIMDIURES (TM), BUKOMFÅNG (BF)
/ = ÅTGÄRD

Ordination Orders							Notes
Datum	Kl.						Anmärkning
Date	Time						

Appendix VId **Infection ward (Twice daily temperature list)**

AVD 39 B TEMPLISTA DEN /

Sal	Patient	FM	EM
6			
7			
8			
9			
10			
11:1			
11:2			
12:1			
12:2			

Appendix VId Infection ward (Blue worksheet)

Arbetsblad Infektionskliniken/ÖNH-kliniken

Worksheet Infection ward

Datum	Tid	Rum	Patient-ID
Sekretess	Nej	Ja	
MRSA/VRE	Nej	Ja	
Blodsmitta	Nej	Ja	
ESBL	Nej	Ja	
Observanda	Nej	Ja	Doktor:
Närstående i Cosmic	Nej	Ja	Visat ID Nej Ja
Anhöriga meddelade	Nej	Ja	Pappersjournal Nej Ja

BAS Blood pressure RR SaO2

Kl.	Blodtryck	AF	SaO2

Andra kontroller Other checks

Kl.	Temp Temp	Puls Pulse	Övrigt Other

Klinisk kemi		☐ Akuta prover!
☐ CRP ☐ Kap-CRP:_____ ☐ Blodstatus inkl diff ☐ Leverstatus (ASAT, ALAT, LD, bil, ALP) ☐ Elstatus (Na, K, krea, alb)	☐ SR ☐ PK ☐ P-glukos ☐ Cystor & maskägg x ☐ Bastest ☐ Blodgruppering ☐ AFP alfafetoprotein	☐ Paket "inkomststatus" ☐ Paket "sepsis" ☐ Paket "lumbalpunktion" ☐ Paket "ledpunktion" ☐ Elfores ☐ Urinsticka ☐ U-Pneumokock-ag ☐ U-Legionella-ag

Mikrobiologi			
☐ Urin ☐ NPH ☐ Svalg ☐ Sputum	☐ Blod x ☐ Sårodling, lokal: _____ ☐ Faeces x	☐ VRE-screen ☐ MRSA-screen ☐ Quantiferon	☐ ☐ ☐ ☐

Hepatit B	Hepatit C	Övrigt
☐ HBsAg ☐ Anti-HBs ☐ Anti-HBc ☐ HBV DNA	☐ HCV ☐ HCV RNA påvisning och kvantifiering ☐ HCV RNA typning	☐ HIV-serologi ☐ HIV-RNA ☐ CD4/CD8 ☐ HAV IgG

Urinsticka

Glukos: Leukocyter: Protein: Blod: Nitrit: Blåstid:

Planering

Arbetsbladet tillhör Infektions- och ÖNH-klinikerna och skall aldrig lämna klinikerna. Skall ej scannas in!

Appendix VId Infection ward (White admission list)

Aid for admitting patients

Hjälpmedel vid inskrivning av patienter

Aktuellt hälsoproblem.....
.....
.....

Tidigare sjukdomar.....
.....

Andning: Breathing SaO2..... AF.RR.. O2.Oxygen

Cirkulation: Bltr.BP..... P.Pulse... Temp.Temperature

Kommunikation: Orienterad Desortienterad
Glasögon Hörapparat

Socialt: Särskilt boende Lägenhet Villa
Ensamboende Make/maka

Kommunkontakt: Larm
Hemtjänst x.....
Kommunssk

Aktivitet: Uppegående Rullstolsburen Sängliggande

Nutrition: A-kost D-kost Annan.....

Elimination: Blöja KAD

Smärta: VAS(1-10) ..... Abbey Pain Scale (0-3)...

Hud: Hel hudkostym Sår.....

Id-band?

Sekretess?

Känd allergi?

Senior Alert?

Närmast anhörig.....

1

Appendix VIe Guidelines- surgical ward (Swedish)

Landstinget i Kalmar län	Gäller från och med: 2015-01-21	Gäller till och med: 2017-01-20	Version: 2	Sida: 1
Dokumenttyp: PM	Förvaltning Kirurgkliniken LSK			
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Kontroller enligt BAS 90-30-90 på Kirurgkliniken

Ett korrekt handläggande av patienter med septiska sjukdomstillstånd kräver, precis som vid akut hjärtinfarkt, trauma och cerebrala katastrofer att vi agerar snabbt och systematiskt. En förutsättning är att vi tidigt identifierar patienter med sepsis, svår sepsis och septisk chock.

Syftet med BAS 90-30-90 är att hjälpa oss att inte missa dem som uppvisar fysiologiska tecken på att ha en svår bakteriell infektion, men som vi kanske primärt inte uppfattar som så svårt sjuka. BAS 90-30-90 syftar också till att tidigt ge adekvat behandling med tydliga målvärden.

Alla ska "BASAS" **MINST 1 ggr/ dygn + vid ankomsten till avdelningen. BAS kontroller innebär: blodtryck, andning, saturation samt hos oss även pulskontroll och temp.**

På följande patienter ska BAS-kontroller tas oftare enl ordination eller utifrån patientens status:
Vid misstänkt blödning.
Alla med misstänkt eller pågående sepsis, akut sjukdom eller allmän påverkan.
Patienter som vårdats på IVA bör BAS tas minst 2 ggr/dygn efter överflytt.
Alla traumapatienter.
Postoperativt (till dygn 3), första dygnet 3 ggr/dag och därefter 2 ggr/dygn om patienten mår väl.

Vidare ska förnyade kontroller tas direkt vid all försämring (yr, nedsatt RLS, grådaskig, dålig aptit mm) och då med tätare intervall tills patienten är stabil.

Registreringen görs av undersköterska/ sjuksköterska i journaltabell mätvärden – OBS undvik dubbeldokumentation i rapportblad.

Utbildningsmaterial återfinns på nedanstående länk;
http://navet.lkl.ltkalmar.se/Global/Dokument/Om%20landstinget/Organisation/F%c3%b6rvaltningar/H%c3%a4lso%20och%20sjukv%c3%a5rdsf%c3%b6rvaltningen/L%c3%a4nssjukhuset%20i%20Kalmar/Sjukhusledning/Kvalitet%20och%20utveckling/2011-11-14%20Utbildningsmtrl_BAS%2090-30-90%20lsk%20hsf.pdf

Kriterier för undantagsfall

• Ansvarig läkare och övrig vårdpersonal tar ställning och beslutar när BAS-bedömning enligt rutin ej längre är nödvändigt (t ex patienter som är medicinskt färdigbehandlade och väntar på annat boende etc)
• Palliativa patienter som nått brytpunkt i palliativ vård och övergått till vård i livets slutskede ska inte BAS-bedömas enligt rutin.

Appendix VIe Guidelines- surgical ward (English translation)

Translation of checklist for BAS surgical division

Recordings according to BAS 90-30-90 in surgical wards

Correct management of patients with sepsis requires that we act quickly and systematically, just as we would for acute myocardial infarction, trauma and cerebral disasters. It is essential that we identify patients with sepsis and septic shock at an early stage.

The purpose of the BAS 90-30-90 is to help us to not miss those who show physiological signs of a serious bacterial infection, who we initially do not think of as seriously ill. BAS 90-30-90 also aims at providing suitable treatment with clear goals.

Everyone should be **"BASed" AT LEAST once per day + on admission to the ward. BAS recordings imply: Blood pressure, respiratory rate, saturation and with us also pulse and temperature."**

In the following patients BAS recordings should be taken more often according to orders or based on the patient's status:
With suspected haemorrhage.
All who have suspected or currently have sepsis, acute illness or are generally unwell.
Patients who have been cared for in ICU should have BAS taken at least twice daily after transfer.
All trauma patients.
Post-operative (for 3 days), first day 3 times/day and thereafter 2 times/day if the patient feels well.

Furthermore, new recordings should be taken immediately if deterioration (vertigo, poor colour, poor appetite etc.) and then at frequent intervals until the patient is stable.

Documentation is carried out by the assistant nurse/registered nurse in the table of the EHR - NB avoid double documentation in the report sheet.

Educational material is available on the link below:
http://navet.lkl.ltkalmar.se/Global/Dokument/Om%20landstinget/Organisation/F%3%b6rvaltningar/J%3%a4lso%20och%sjukv%3%a5rdsf%3b6rvaltningen/L%3%4nssjukhuset%20i%20Kalmar/Sjukhusledning/Kvalitet%20och%utveckling/2011-11-14%20Utbildningsmtrl_BAS%2090-30-90%20lsk%20hsf.pdf

Criteria for exceptions

The doctor on duty and other healthcare professionals consider and decide when BAS recordings according to the routines are not longer necessary (e.g., patients who have finished their treatment and are awaiting transfer to another home)

Palliative patients who have reached the end point of palliative care and have gone over to terminal care should not have BAS recordings according the routines.

Appendix VIf **Paper chart- surgical ward**

SAL	BLTR	AF	SaO2	PULS	TEMP	VAS	VIKT	B-GL
1.1								
1.2								
2.1								
2.2								
2.3								
6.1								
6.2								

SAL	BLTR	AF	SaO2	PULS	TEMP	VAS	VIKT	B-GL
3.1								
3.2								
3.3								
4								
5.1								
5.2								
7								

Appendix VIf English translation

Chart for vital signs used in surgical ward

ROOM	BP	RR	SaO_2	Pulse	Temp	VAS	Weight	BS
1.1								
1.2								
2.1								
2.2								
2.3								
6.1								
6.2								

ROOM	BP	RR	SaO_2	Pulse	Temp	VAS	Weight	BS
3.1								
3.2								
3.3								
4								
5.1								
5.2								
7								

KEY:

BP	blood pressure
RR	respiratory rate
SaO_2	Oxygen saturation
Temp	temperature
VAS	Visual analogue scale (pain scale)
BS	blood sugar

Appendix VII Member checking

Appendix VIIa Cardiology

Summary of findings from observations and interviews

- Vital signs are always recorded when a new patient was admitted.
- Vital signs recorded on admission are BAS, i.e., blood pressure (BP), respiratory rate and oxygen saturation, with the addition of pulse and temperature.
- In CICU the BP, pulse and oxygen saturation sensor is measured continuously. The ECG monitor also measures the respiratory rate.
- In the cardiology wards, vital signs were taken routinely three times per day, at the end of the night shift, 06.00, during the day shift, 14.00, and in the evening, 20.00.
- Nurses decided which vital signs should be measured according to the type of patients they were caring for.
- Most nurses thought that blood pressure and pulse were most important, with saturation being the next choice.
- There were added routines for recording patients' vital signs after some procedures, such as cardio-angiography.
- Another reason for measuring vital signs was if a patient was commenced on a new medication, such as nitroglycerin.
- Vital sign recordings were initiated in relation to nurses' clinical assessments, e.g., if a patient deteriorated or was unstable.
- Vital sign recordings were often interpreted and interventions taken, e.g., if a high fever, then paracetomol might be given.
- The vital signs table was considered the correct place for documenting vital signs.
- Nurses thought that it was good to have a table specifically for vital signs.
- Many nurses mentioned that documenting vital signs took "many clicks".
- The report sheet was used for reporting any deterioration, abnormal vital signs, the interventions taken to alleviate these and the outcomes of the interventions.
- Continuous monitoring gave a constant overview of vital signs in the CICU.
- Paper charts were used when patients required more frequent observations, e.g., patients who were very ill or unstable and required frequent vital sign recordings, a patient newly commenced on a medication such as nitroglycerine intravenously .
- The table in the EHR would become too long if all frequent vital signs were added.
- Paper note pads, post-its and sometimes paper towels were used for noting vital signs e.g. when the EHR was not at the patient's bedside when vital signs had been taken.
- Vital signs were retrieved by looking at the table first, the report sheet or the journal. Verbal reporting was also mentioned.

Appendix VIIb Emergency Department

Summary of the findings from the accident and emergency department (ED).

- A triage system 'rapid emergency triage and treatment system' (RETTS), is used in the ED.
- All patients admitted to the ED are triaged. A triage system aims to safely prioritise patients so that the most serious and urgent cases are treated first.
- The RETTS software has been integrated into Cosmic, the EHR system, used in the ED.
- It is a decision support system indicating how often patients should be monitored.
- It selects a monitoring frequency according to the priority level into which the patient is allotted.
- When the vital signs have been entered in the appropriate spaces, the priority calculator (Beräkna prioritet) is clicked and the patient is allocated one of six categories of severity of illness: red, amber, yellow, green, blue or gray, with red being the most severe.
- In the ED, vital signs are measured on admission according to the RETTS protocol which requires temperature, pulse, respiratory rate, blood pressure, oxygen saturation and conscious level.

- The thresholds in the RETTS system had similarities to the BAS system, for example, the highest priority (red) thresholds in RETTS for blood pressure, respiratory rate and oxygen saturation was the same as the thresholds in BAS 90-30-90.
- 'Red patients' are continuously monitored so that vital signs can be viewed on the monitor at all times.
- For an 'orange patient', the vital signs should be taken every hour
- There's a clock that does a countdown so that one knows when it is time to take the next vital signs. When the patients are yellow or green, then the vital signs are taken two hourly.

- Nurses' clinical judgement plays an important role in deciding if extra vital signs are required or if the priority level needs to be raised.
- After the priority level is calculated, the results from RETTS are automatically transferred to the journal section of the EHR and presented as a list.
- Subsequent vital signs are recorded in the table for measurements in the EHR.
- There was a paper chart/checklist used on admission: it included a table for vital signs, blood pressure, respiratory rate, saturation, pulse and temperature.
- The chart was then put in a plastic folder and placed at the nurses' station where the doctor collected it when going to see a new patient.
- When there was no EHR beside the patient, vital signs were written on a paper note first, and transferred to the EHR. Otherwise, nurses documented vital signs into the EHR directly.
- Retrieval of vital signs was from the journal section for admission vital signs (RETTS) and from the table in the EHR for subsequent vital signs.

Appendix VII c Infection Ward

Summary of the findings from observations and interviews results

- On admission to the ward, BAS is checked as well as pulse and temperature.
- All patients have their temperatures taken twice daily. Temperature is taken at 06.00 by the night nurse and at 14.00 when the next shift starts.
- BAS recordings are taken at the same times as the temperature if there are clinical indications, e.g., if a patient's condition worsens.
- The vital signs table was considered the right place for the documentation of all vital signs.
- Sometimes additional information is added to a speech bubble marked with an asterisk* on the table to indicate that something is written there.
- Sometimes vital signs were written in both the table and the journal notes, e.g. when a new patient was admitted.
- Writing in the journal notes also gave a means of providing a more complete picture of the patient when something had happened to a patient, e.g., became acutely ill.
- A paper chart was used for patients requiring frequent vital sign recordings if their condition was unstable or if they were very ill. This was called the 'check list' or 'BAS list'.
- If there was a sepsis patient who was unstable in the ward, then there is a paper chart which is left in the room with the patient
- On a paper chart vital signs could be written more quickly than clicking often in the EHR,
- The table in the EHR became it too long if all recordings were written there. The highest sign and lowest sign were added to the EHR.
- With very sick patients, the EHR did not fit in with the work process when many vital signs were necessary
- The routine temperatures at 06.00 and 14.00 were written on a paper called a 'temp list' and added to the EHR afterwards.
- Vital signs were retrieved from the table in the EHR.
- Also vital signs could be checked on the paper 'temp list'.
- Verbal information about vital signs was sometimes given at handover report and with doctors.

Appendix VIId Surgical ward

Summary of the findings from observations and interviews

- Guidelines for BAS recordings used. (a PM). BAS was always recorded on admission, following the PM guidelines.
- The vital signs recorded were temperature, pulse, respiratory rate, blood pressure and oxygen saturation.
- As stated in the guidelines BAS (five vital signs as noted above) was measured once per day.
- Vital signs were usually measured around 08.00 or during the forenoon.
- All post-operative patients were BASed three times per day on the first day and twice per day for the next two days.
- Patients transferred from ICU had BAS checked twice daily after transfer.
- BAS recordings were done more often if there was any suspicion of haemorrhage, if there were specific orders from a doctor, or if there were indications according to the patient's status.
- Patients with suspected sepsis should have BAS recordings done more frequently.
- Trauma patients required BAS recordings more frequently- this according to doctors' orders or patient status.
- New recordings should be taken directly if a patient shows any sign of deterioration (vertigo, decrease in conscious level, poor colour, poor appetite, etc.,) and then more frequently until the patient is stable.
- Patients who were very ill were continuously monitored to measure the vital signs, that is, the patient was connected to a monitor which measured blood pressure, pulse and respiratory rate.
- The vital signs table was considered the correct place for the documentation of all vital signs.
- If extra vital signs were taken outside the routine daily measurement. These were noted on a paper first and then added to the table in the EHR.
- The report sheet was used to report abnormal vital signs and actions taken.
- There was a pre-printed paper checklist for daily recordings, added to EHR later.
- Paper notes were used sometimes if EHR not nearby.