DEveloping a Complex Intervention for DEteriorating Patients using Theoretical Modelling (DECIDE study)

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Declaration

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Statement of Originality

This work has not previously been submitted for a degree or diploma in any university. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

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Abstract

Background:

Patients who deteriorate without recognition and/or response are at risk of unplanned admission to intensive care, cardiac arrest, death (termed Serious Adverse Events (SAEs)). To mitigate SAEs, track-and-trigger tools are used internationally to prompt healthcare practitioners (typically nursing staff) to recognise physiological changes that signal deterioration, and to contact a practitioner with expertise in acute/critical illness. In the United Kingdom and parts of Europe, the National Early Warning Score (NEWS) (track-and-trigger tool) was developed and disseminated widely to standardise practice. Despite evidence track-and-trigger tools (like NEWS) improve patient outcomes, their translation into clinical practice is inconsistent. This is partly attributed to nursing staff failing to change their behaviour.

Aim:

To develop a theory-based, preliminary, behaviour change intervention, to enhance enablers and overcome barriers to Registered Nurses (RNs) and Healthcare Assistants (HCAs) enacting expected behaviours in recognising and responding to signs of patient deterioration.

Method:

A mixed methods design with three phases: **1.** Focused ethnography on two clinical floors in an acute hospital to compare directly observed behaviours (of RNs and HCAs) with those specified in policy. From directed content analysis of field notes, target behaviours were identified, specified, and shortlisted; **2.** Brief (not audio-recorded but recorded in field notes) interviews were conducted soon after direct observation of relevant behaviour. Some brief interview participants were recruited for an audio-recorded, semi-structured, interview informed by a Theoretical Domains Framework (TDF) topic guide. Interview data were analysed deductively (the 14 TDF domains were coding categories) and inductively to identify determinants (i.e. barriers and enablers) of target behaviours. TDF domains representing important determinants were identified using published criteria and linked to Behaviour Change Techniques (BCTs) from expert consensus literature; **3.** BCTs were shortlisted by the research team and presented to clinical stakeholders

alongside example applications (i.e. concrete strategies for operationalising BCTs). Using Nominal Group Technique, stakeholders ranked BCTs and their potential applications for acceptability and feasibility. Ranking data were used to inform the content of the preliminary intervention.

Results:

During 300 hours of fieldwork, 499 items of data (i.e. an episode of observation or a set of vital signs from chart review) were recorded; 289 (58%) associated with expected (i.e. policy-specified) behaviour; 210 (42%) associated with unexpected behaviour (i.e. alternative behaviour or no behaviour). Ten behaviours were identified as potential behaviours for change; shortlisted to seven target behaviours. Brief interviews were conducted with 39 RNs and 50 HCAs, and semi-structured interviews with 16 RNs and 16 HCAs. Quotes from interviews were linked to nine (for brief interviews) and 14 (for semi-structured interviews) TDF domains. Nine TDF domains were identified as being of high importance: *Knowledge, Social Professional Role and Identity, Beliefs about Consequences, Reinforcement, Intentions, Goals, Memory, Attention and Decision Processes, Environmental Context and Resources, Social Influences.* These domains were linked to 50 BCTs; shortlisted to 14. Ranking data from two nominal groups held with 19 stakeholders were used to shortlist further, resulting in a preliminary intervention that includes an educational package and 12 BCTs that will be delivered through workshops and on acute wards, using 18 applications.

Conclusion:

This research makes a unique contribution to the international body of evidence, as it is the first study where a theoretical framework of behaviour change has been used to model an intervention to improve responses to deteriorating patients by RNs and HCAs. The intervention is preliminary, as it is anticipated that it will be refined during a subsequent feasibility study (a programme of work planned for after this PhD).

List of abbreviations

AE/s	Adverse Event/s
AECOPD	Acute Exacerbation of Chronic Obstructive Pulmonary Disease
AUROC	Area Under the Receiver Operating Characteristic curve
AWTTS	Aggregate Weighted Track-and-Trigger System
BCT/s	Behaviour Change Technique/s
BPA/s	Best Practice Alert/s
BtF	'Between the Flags; track-and-trigger tool
CCOT	Critical Care Outreach Team
CH	Chronic Hypoxaemia
COPD	Chronic Obstructive Pulmonary Disease
COVID-19	Coronavirus 2 (SARS-CoV-2)
CPD	Continuing Professional Development
CPG	Clinical Practice Guideline
CQC	Care Quality Commission
CREWS	Chronic Respiratory Early Warning Score
DENWIS	Dutch-Early-Nurse-Worry-Indicator-Score
DI	Deterioration Index
EBP	Evidence Based Practice
eCART	Electronic Cardiac Arrest Triage
ED	Emergency Department
EHR	Electronic Health Record
EHRS	Electronic Health Record System
EWS	Early Warning Score
H-AKI	Hospital-acquired Acute Kidney Injury
HCA	Healthcare Assistant
HEI	Higher Education Institution
ICU	Intensive Care Unit
iEWS	Individualised Early Warning Score
LMTO	Limitations of Medical Treatment Orders
MET	Medical Emergency Team
NA	Nursing Associate
MEWS	Modified Early Warning Score
NEWS	National Early Warning Score (used as a generic term to describe both NEWS1 and/or NEWS2)
NEWS1	The first version of the National Early Warning Score (published 2012)
NEWS2	The second version of the National Early Warning Score (published 2017)

NEWSIG	National Early Warning Score Implementation Group
NGT	Nominal Group Technique
NHS	National Health Service
NIC	Nurse-In-Charge
OR	Odds Ratio
PA	Patient Advisor
PABAK	Prevalence And Bias Adjusted Kappa
PPIE	Patient and Public Involvement and Engagement
RN	Registered Nurse
RR	Risk Ratio
RRS/s	Rapid Response System/s
RRT	Rapid Response Team
RU	Research Utilisation
SAE/s	Serious Adverse Event/s
SBAR	Situation, Background, Assessment, Recommendation/s
SOS	Suspicion of Sepsis
$Sp0_2$	Peripheral Oxygen Saturations
SPTTS	Single Parameter Track-and-Trigger System
TDF	Theoretical Domains Framework
TIDieR	Template for Intervention Description and Replication
UCR	Urgent Clinical Review
UK	United Kingdom
USA	United States of America
ViEWS	VitalPAC® Early Warning Score

1 CHAPTER 1: INTRODUCTION

1.1 Introduction

Sub-optimal care of the deteriorating patient in the acute hospital setting is recognised as an enduring clinical problem (Healthcare Quality Improvement Partnership, 2018), despite a variety of different measures being used to address it. Reported strategies (targeting clinical staff) include: education, often incorporating manikin-based simulations (Connell et al., 2016); virtual-reality simulations (Liaw et al., 2014, 2015); online learning packages (Liaw et al., 2016); multi-modal interventions that incorporate combinations of the aforementioned components (Mitchell et al., 2010; Duff et al., 2018); and electronic early warning systems that use a variety of objective clinical data (e.g. vital signs, demographics, laboratory data) to identify patients vulnerable to further deterioration (Fu et al., 2020; Bartkowiak et al., 2019). Arguably, the most common strategy has been the international implementation of Rapid Response Systems (RRSs) (DeVita et al., 2006; Lyons, Edelson & Churpek, 2018; Haegdorens et al., 2018). Despite sub-optimal care receiving a high level of international focus for over two decades, evidence suggests that the problem persists (Healthcare Quality Improvement Partnership, 2018). Further, it remains unclear why staff behaviour in recognising and responding to deteriorating patients is inconsistent, and how staff could be supported to change their behaviour and sustain best practice (Al-Moteri et al., 2019). An overview of sub-optimal care and the RRS is provided in this chapter. Gaps in the literature related to staff recognising and responding to deteriorating patients will be identified. The aims and significance of this research are also outlined.

1.2 Background to sub-optimal care

Within the hospital environment, patient acuity has increased internationally (Needleman, 2013; Steventon et al., 2018; Burdeu et al., 2021). This increase has been attributed to an ageing and progressively co-morbid population with complex needs and multiple problems at the point of hospital admission (Steventon et al., 2018; National Institute of Health and Care Excellence (NICE), 2007; Hogan et al., 2019). In addition to having ‘sicker patients’ within the hospital context, rising pressure to release beds means that patients are often discharged sooner and have shorter

inpatient stays (Needleman, 2013; Steventon et al., 2018). Pressure on clinical staff to expedite investigation, treatment, and discharge potentially increases risk of clinical error and adverse events (Bagust, Place & Posnett, 1999; Kaier, Mutters & Frank, 2012). An adverse event (AE) is defined as: 'A *complication or un-intended injury that results in prolonged hospitalisation, new disability at the point of discharge, or death; caused by healthcare management rather than the patient's underlying disease process'* (De Vries *et al.*, 2008 p216). In the wider healthcare context, examples of AEs include (but are not limited to): complications associated with surgery or invasive procedures, medication related errors, and hospital acquired infections (Schwendimann et al., 2018; Donaldson, Panesar & Darzi, 2014; Alanazi, Sim & Lapkin, 2022).

From the international literature, it is reported that nearly 1 in 10 hospitalised patients experience an AE during their hospital admission (De Vries et al., 2008; Schwendimann et al., 2018). In a scoping review of international studies, a median of 36% of adverse events resulted in moderate or severe patient harm (Schwendimann et al., 2018). More specifically, a median of 21.2% of AEs resulted in the patient needing an additional recuperation period of 1-12 months (the outcome associated with 'moderate harm'), a median of 7.3% of AEs resulted in permanent disability, and a further 7.3% in death (both outcomes associated with 'severe harm') (Schwendimann et al., 2018). In addition, over 50% of all AEs were reported as preventable (Schwendimann et al., 2018). The high frequency of preventable AEs is corroborated by a prospective observational study conducted in the United Kingdom (UK) (Garry et al., 2014). From a sample of 280 patients admitted to ICU, 216 (77%) were reported to have experienced a preventable event (Garry et al., 2014). It has been estimated that preventable AEs cost the NHS approximately £1bn per annum (Vincent, Neale & Woloshynowych, 2001). This figure is from a source that is two decades old. Due to inflation alone, this figure would have increased by half a billion pounds by 2022 (calculated using: "Inflation Tool," n.d.). Given the increasing co-morbidity of hospitalised patients, complexity of clinician decision-making, and care required by these patients, it is plausible that the incidence of preventable adverse events and the associated financial burden will be even greater now.

Another specific phenomenon that may result in an AE is sub-optimal care of the deteriorating ward patient. In this work, deterioration is defined as a change in the condition of a patient from one clinical state to a worse clinical state, that accompanies an increased risk of morbidity or mortality (Jones et al., 2013). A ward is defined as an inpatient hospital setting where patients receive level 0 or level 1 care, but would not be expected to receive level 2 or level 3 care (i.e. high dependency or intensive care respectively) (Table 1.1) (The Intensive Care Society, 2009). Consequently, a ward patient is defined as a hospitalised individual who is being cared for in a ward environment. The concept of sub-optimal care of the deteriorating ward patient was first highlighted in the published literature over two decades ago (McQuillan et al., 1998). A prospective, confidential inquiry was conducted on patients (n=100) admitted to the Intensive Care Unit (ICU) in UK hospitals. The researchers reported that over half of patients (n=54) received sub-optimal ward-based care prior to ICU admission, and that sub-optimal care impacted on mortality, morbidity and resource consumption within the ICU (McQuillan et al., 1998). Specific deficits in clinical care that resulted in sub-optimal management were reported as: failure to recognise physiological abnormalities signalling patient deterioration, failure to deliver basic clinical interventions (e.g. oxygen therapy), and failure to seek advice from senior clinicians in response to signs of patient deterioration (McQuillan et al., 1998). This is considered a seminal paper in the area however several limitations are evident. First, the study had a small sample from only two hospitals limiting the generalisability of findings (Polit & Beck, 2018). Second, the methods led to a risk of cognitive bias (specifically outcome bias[1]) as members of the research team, who assessed the quality of clinical care, were aware that patients had deteriorated and had been admitted to the ICU. Third, the assessment of whether a patient had received sub-optimal care was based on the opinion of two intensive care clinicians. These clinicians were unable to reach agreement on the quality of care received by a quarter of patients sampled (McQuillan et al., 1998). Whilst reaching consensus in research can be challenging (Atkins et al., 2017), even amongst experts of the same discipline, no approaches to reconcile these differences were reported in the methods.

[1] Outcome bias is defined as an error made in evaluating the quality of a decision when the outcome of the decision is already known (Blackwell et al., 2016; Peecher & Piercey, 2008).

Table 1.1 – classification of ward-level care versus critical care with examples

Level of care (numerical label)	Level of care (description)	Typical location within which care is provided	Example of care provided in this environment
0	Ward based care	Ward	– Vital signs required less frequently than every 4 hours – Patients requiring intravenous therapy e.g. antibiotics
1	Ward based care	Ward	– Vital signs required at minimum every 4 hours – Patients requiring continuous supplemental oxygen therapy
2	High dependency care	Critical care unit	– Vital signs required at minimum every 1 hour – Patients requiring therapies to support **one** organ system e.g. drugs to support blood pressure
3	Intensive care	Critical care unit	– Patients requiring mechanical ventilation and/or support of **multiple** organ systems e.g. mechanical ventilation and drugs to support blood pressure

The Intensive Care Society, 2009

Despite the limitations of the work undertaken by McQuillan and colleagues (1998), more contemporary and methodologically robust research has yielded similar findings, suggesting that patients who deteriorate and receive sub-optimal care are at greater risk of unplanned admission to ICU, cardiac arrest or death (Tirkkonen et al., 2013; Trinkle & Flabouris, 2011). These specific outcomes have been labelled as Serious Adverse Events (SAEs) in the context of the deteriorating patient specifically (Alam et al., 2014; Petersen et al., 2014). All AE incident reports (n=2,010) submitted by healthcare staff to a national UK database over a 17-month period, were extracted and thematically analysed by two independent reviewers (Donaldson, Panesar & Darzi, 2014). Incidents related to ‘mismanagement’ of deteriorating patients was the single largest category (greater than healthcare associated infections and medication errors) and was linked to 705 (35%) of the reported deaths, highlighting the magnitude of the problem in the wider context (Donaldson, Panesar & Darzi, 2014). For those patients who survive, the medium to long term physical and

psychological harm from sub-optimal care is evident from patient stories available in the public domain (Health Service Journal Events, 2018).

Sub-optimal care of the deteriorating patient has emerged as a complex and multi-faceted concept. Within the wider literature, the term ‘failure to rescue’ has been used to describe what is broadly the same clinical problem (Griffiths, Jones & Bottle, 2013; Herron, 2018; Johnston et al., 2015; Jarvelainen, Cooper & Jones, 2018). The defining attributes of sub-optimal care have been reported as delays in diagnosis, treatment or referral, poor assessment, and/or inappropriate or inadequate treatment (Quirke, Coombs & McEldowney, 2011). Further, sub-optimal care may arise from deficiencies at the level of an individual clinician, at the level of the workforce (i.e. a group of clinicians), or at the level of the organisation (Quirke, Coombs & McEldowney, 2011). As such, a comprehensive and system-wide approach to mitigate sub-optimal care of the deteriorating patient is required (Angus & Black, 2004; DeVita et al., 2006).

1.3 The Rapid Response System (RRS)

Deteriorating patients frequently have physiological changes that may be detected by clinical staff through the routine monitoring of vital signs, including respiratory rate, heart rate, blood pressure, temperature, peripheral oxygen saturations and conscious level. Sixty to 80% of ward-based patients who deteriorate have changes in these vital signs preceding a SAE (Sprogis et al., 2017; Kause et al., 2004; Goldhill & McNarry, 2004). These premonitory signs provide an opportunity for vulnerable patients to be ‘rescued’ through clinical staff recognising the deterioration and triggering an appropriate response. To facilitate a timely and clinically appropriate response to patient deterioration, Rapid Response Systems (RRSs) have been implemented in healthcare organisations internationally including acute hospitals in the UK, Europe, North America and Australasia (Lyons, Edelson & Churpek, 2018; DeVita et al., 2006; Johnstone, Rattray & Myers, 2007; Langkjaer et al., 2021). Despite differences in how these services have been operationalised, the characteristics are often similar. RRSs frequently have an afferent (recognition) and an efferent (response) limb (DeVita et al., 2006) (Figure 1.1). In this context, ‘limb’ refers to a sequence of actions performed by clinical staff within a specified timeframe (Smith

et al., 2019). Expected afferent limb behaviours include monitoring a patient's vital signs at specified intervals, recognising abnormality (which signals deterioration), and informing a more senior or expert clinician (termed escalation) within a specified timeframe (DeVita et al., 2006; Smith, 2010; Smith et al., 2019). Modes of notification will depend on the context, but could include any combination of face-to-face communication, telephone communication, and use of technology, e.g. a hospital pager system (DeVita et al., 2006; Johnston et al., 2014; Alvarez & Coiera, 2006). These monitoring and escalation behaviours are typically performed by nursing staff (Smith and Aitken, 2016).

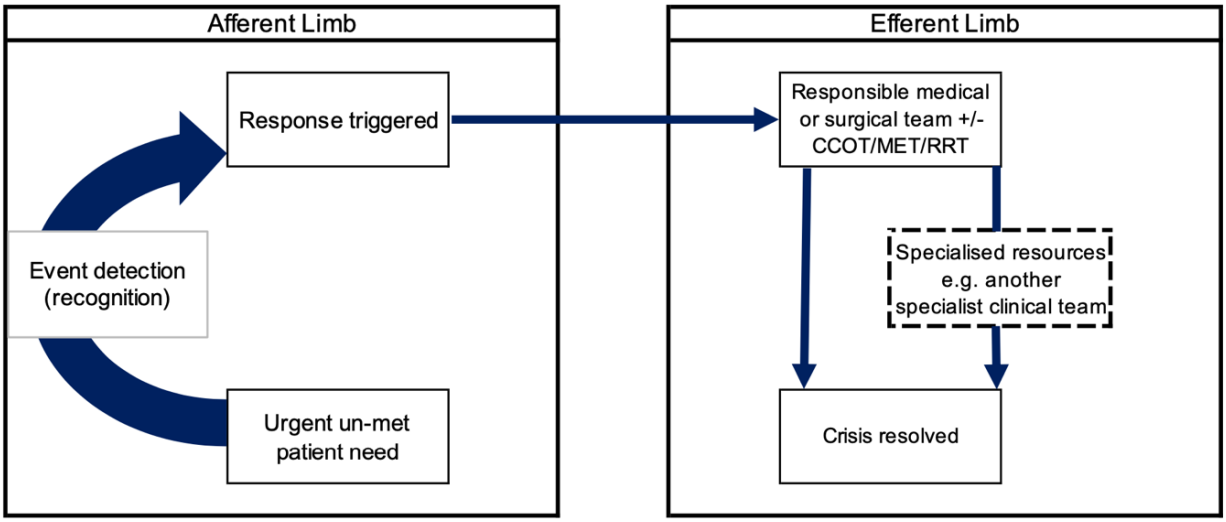

Figure 1.1 – conceptual model of the Rapid Response System (RRS)

Adapted from: DeVita et al., 2006, p.2464, fig. 1.

The efferent limb of the RRS includes all actions that follow escalation performed by the responder/s (DeVita et al., 2006). Efferent limb responders may include personnel from the responsible medical team and/or members of a designated, often peripatetic, clinical team e.g. a Rapid Response Team (RRT) or equivalent (Rihari-Thomas et al., 2017; Lyons, Edelson & Churpek, 2018). Efferent limb behaviours include performing additional patient assessment, initiating treatment or stabilising interventions, and facilitating a transfer of the patient to a higher-care setting e.g. ICU (DeVita et al., 2006; Bannard-Smith et al., 2016). Appropriate activation of the efferent limb for a deteriorating patient has been shown to reduce patient mortality and the frequency of cardiac arrest (Maharaj, Raffaele & Wendon, 2015; Rocha et al., 2018; Jung et al., 2016). However, for patients to benefit from the expertise of the efferent limb responders,

appropriate afferent limb behaviours must first be enacted (i.e. the deterioration recognised, and a response triggered). If these monitoring and escalation behaviours are not enacted, or not enacted effectively, then the risk of sub-optimal care persists.

1.4 Afferent Limb Failure (ALF)

Despite the inception of RRS, there is evidence that nursing staff are failing to change their behaviour by increasing monitoring or escalating care in response to relevant criteria being met (Credland, Dyson & Johnson, 2018). This is described in the literature as afferent limb failure (ALF) (Trinkle & Flabouris, 2011; Johnston et al., 2014; Sundararajan et al., 2021).

The scale of this problem across the UK was reported in a confidential inquiry carried out in NHS hospitals (Findlay et al., 2012). One objective was to report the care that patients received before, during, and after a cardiorespiratory arrest. Whilst 739 cases met inclusion criteria for review, the denominator used in analysis varied across the report according to the different sources of information available (e.g. clinical questionnaires and/or expert reviewer analysis of case notes). From cases where sufficient data were available for analysis, 64% (289/454) of cardiac arrests were reported as ‘predictable’ (i.e. could have been anticipated) and 38% (156/413) were reported as ‘avoidable’ (i.e. could have been prevented). Seventy five percent (344/462) of patients were reported as having physiological ‘warning signs’ of deterioration; 62% (213/344) had these signs for longer than 6 hours prior to cardiac arrest. Expert multidisciplinary reviewers concluded that recognition of deterioration and escalation was carried out ‘poorly’ in 1 in 4 of the cases reviewed (Findlay et al., 2012). These findings suggest that sub-optimal care of the deteriorating patient and ALF persists despite it being a priority area for clinicians, academics, and policymakers. Given that stories related to sub-optimal care of the deteriorating patient have emerged in popular media (Paduano, 2019), there is likelihood of broader societal engagement with this issue and a possible span of interest that extends beyond the professional community.

Despite this broad level of focus, many of the ‘themes’ of sub-optimal care reported over two decades ago (McQuillan et al., 1998) continue to be highlighted as problematic. In particular,

contemporary reports suggest that ALF occurs in the context of deficiencies in 'basic' patient monitoring and clinical care, failure to appreciate the clinical urgency of a situation, failure to seek advice, delayed responses, and poor communication between clinicians (Healthcare Quality Improvement Partnership, 2018). ALF is increasingly recognised as a problem arising from inconsistent staff behaviour (Massey, Chaboyer & Anderson, 2017; Treacy & Stayt, 2019) and typifies a wider challenge of effectively translating clinical guidelines into practice; which is recognised as an often complex and time consuming process (Grol et al., 2007; Grimshaw et al., 2004). These broader challenges of translating evidence into 'real world' practice resulted in the emergence of implementation science. The original definition of implementation science from published sources (Foy, Eccles & Grimshaw, 2001; Eccles et al., 2005) has been recently elaborated resulting in the definition as follows: '*the scientific study of methods that promote the systematic uptake of research findings, and other evidence-based practices, into routine practice hence improving the quality and effectiveness of health services'* (Presseau et al., 2021 p3). The field of implementation science includes the study of the determinants[2] of healthcare practitioners' behaviour and methods that enable them to use research findings more effectively (Eccles et al., 2005). Given the persistent nature of ALF, there is an argument for the use of more structured and systematic approaches to develop a replicable implementation intervention that can be tested empirically. In this context, an implementation intervention is defined as an intervention with the broad aim of translating evidence-based practice into routine clinical practice by changing the behaviour/s of one or more healthcare practitioners (Presseau et al., 2019). Use of theory during intervention development is advocated as a means to improve the effectiveness of implementation approaches, increase uptake of evidence based guidelines, and facilitate necessary clinical staff behaviour change (Taylor et al., 2013, 2016; Patton et al., 2018; Craig et al., 2008).

The barriers to nursing staff enacting best practice behaviours of the afferent limb have been broadly described in several published review papers (Treacy & Stayt, 2019; Wood,

[2] A determinant is defined as a factor which influences or affects behaviour in either direction (i.e. the behavioural effect may be desirable or undesirable) (Sam, 2013) and includes barriers, obstacles, enablers and facilitators (Baker et al., 2015).

Chaboyer & Carr, 2019; Olsen et al., 2019). Reported barriers include unclear deteriorating patient protocols; lack of staff and equipment; excessive workloads; inter-professional conflict and hierarchy; fear of reprimand from senior colleagues; lack of education and/or knowledge; and a lack of clinical skills. All these cited review papers included studies where qualitative methods were used, often underpinned by grounded theory methodology, to broadly describe the barriers to afferent limb behaviour. Despite the acknowledgement that ALF is a problem characterised by inconsistent staff behaviour (Credland, Dyson & Johnson, 2018; Ede et al., 2019), only one publication from Australia was identified where the use of a theoretical framework of behaviour change had been applied systematically to explore possible determinants of behaviour (i.e. barriers and enablers) (Walker et al., 2021). Further, from the modest body of literature reporting interventions to address ALF (Duff et al., 2018; Liaw et al., 2016; Mitchell et al., 2010; Bucknall et al., 2017; Connell et al., 2016) only a single protocol paper from an Australian group (Bucknall et al., 2017) was identified where the use of theory for intervention development was proposed. As such, it is plausible that the remaining interventions were developed pragmatically (i.e. using common sense[3] or intuition[4]) rather than using an explicit theory-based approach. The noteworthy lack of theory in the development of interventions for ALF is consistent with findings from the broader implementation literature where reports of the explicit use of theory to elucidate barriers and to populate interventions with content are scarce (Davies, Walker & Grimshaw, 2010; Prestwich et al., 2014).

1.5 Developing interventions using theory

Several review papers have reported positive associations between use of theory during intervention development and successful behaviour change (Noar, Benac & Harris, 2007; Webb et al., 2010; Albada et al., 2009; Albarracín et al., 2005; Taylor, Conner & Lawton, 2012; Glanz & Bishop, 2010). However, there is some contradictory literature that suggests an absence of effect from the use of theory during intervention design (Gardner et al., 2011; Roe et al., 1997;

[3] Common sense is defined as the implicit knowledge that a group hold about a phenomenon which is informal and may be un-codable (Fletcher, 1984; Nilsen, 2015).
[4] Intuition is defined as an instinctive understanding without conscious reasoning (Oxford University Press, 2022).

Stephenson, Imrie & Sutton, 2000). The equivocal evidence base underpinning the efficacy of theory-based interventions may be in part explained by the considerable variance regarding how theory has been used and reported within the literature (Michie et al., 2014). Findings of empirical work suggest that the reporting of theory use is often poor and its application across the implementation process inconsistent (Timlin et al., 2020; Prestwich et al., 2014; Birken et al., 2017). These findings support the assertions of Michie and Prestwich (2010) who posit that theory is often used only as a 'loose framework' rather than being embedded within the research process. It is plausible that the tendency towards poor reporting and superficial application of theory may have hampered the accumulation of evidence. To permit the accumulation of more robust evidence related to the efficacy of theory-based interventions, clearer selection, application and reporting of theory-use spanning the implementation process is required (Timlin et al., 2020; Bhattacharyya et al., 2006; Craig et al., 2008).

The systematic application of theory permits the explicit reporting of the causal mechanisms of behaviour change, intervention content, and modes of delivery (i.e. how content is operationalised) (Patton et al., 2018). This may permit more efficient replication of interventions in different settings and with different populations (Little, Presseau & Eccles, 2015; Michie et al., 2008), to an extent that may not be achievable with pragmatic or non-theoretical alternatives (Eccles et al., 2007; Craig et al., 2017; Haskell et al., 2021). Further, as pragmatic interventions may be developed from clinician or researcher intuition, they are potentially more susceptible to cognitive bias (Nisbett & Wilson, 1977; Bargh et al., 2001) and attribution error (i.e. where the presumed influences of behaviour as perceived by the researcher/clinician do not align with the *actual* influences) (Dyson & Cowdell, 2021). The systematic application of theory may help to mitigate cognitive bias and enable more accurate attribution.

From a more practical perspective, the use of theory may improve communication between groups and disciplines due to the provision of a 'common language' (Michie et al., 2014). Likewise, use of theory may help researchers approach questions more methodically and therefore has the potential to improve the efficiency of the research process (Michie et al., 2014). Whilst a number of

different approaches for developing theory-based implementation interventions are reported (O'Cathain et al., 2019), this research was broadly situated within a process modelled on the Medical Research Council's guidance for developing and evaluating complex interventions (Skivington et al., 2021; Craig et al., 2008). More specifically, the structure was informed by the process for developing theory-based interventions proposed by French et al (2012) which is guided by four questions. In this research, the first three questions will be answered:

1. Who needs to do what differently?
2. Using a theoretical framework, which barriers and enablers need to be addressed?
3. Which intervention components could overcome modifiable barriers and enhance the enablers?

In keeping with this process, determinants of best practice afferent limb behaviours were assessed, and precise change strategies directed towards these *specific* barriers and enablers. Each step of this process was underpinned by a specified theoretical framework of behaviour change (French *et al.*, 2012).

Theories of behaviour change attempt to explain the context of behaviour change (or lack of behaviour change) as well as mechanisms of action and moderators of change along various causal pathways (Michie et al., 2016). There are numerous theories of behaviour and behaviour change available (Davis et al., 2015) making the selection of a suitable theory challenging for non-specialists (Francis, O'Connor & Curran, 2012; Michie et al., 2005). The Theoretical Domains Framework (TDF) was developed to overcome this challenge by identifying a parsimonious set of broad theoretical domains drawn from behavioural theories (Cane, O'Connor & Michie, 2012; Michie et al., 2005). The TDF (version 2) specifies 14 theoretical domains (e.g. Knowledge; Skills; Beliefs about Consequences; Social Influences; Environmental Context and Resources) (Table 1.2) that each represent between three and 11 conceptually related constructs (e.g. the theoretical domain of Knowledge includes three constructs: Knowledge of the health condition, Procedural knowledge, and Knowledge of the task environment). The 84 constructs of the TDF were obtained from 33 different behaviour change theories (Atkins et al., 2017; Holdsworth et al., 2015). In

addition to its comprehensive theoretical underpinning, the TDF is adequately flexible for delivery using a range of methods (e.g. interviews, focus groups, questionnaire), and can be applied to different behavioural problems where health behaviour or healthcare practitioner behaviour change is required (Atkins et al., 2017; French et al., 2012; Cane, O'Connor & Michie, 2012; Phillips et al., 2015; Dyson & Cowdell, 2021). Findings from existing empirical work suggest that nursing staff' afferent limb behaviour may be influenced by a range of mediators and moderators (Wood, Chaboyer & Carr, 2019; Treacy & Stayt, 2019). Consequently, the TDF enabled expansive inquiry and reporting of determinants across all potential domains of behaviour change (Michie, van Stralen & West, 2011).

To enable precision and specificity when reporting intervention content, a taxonomy of Behaviour Change Techniques (BCTs) was developed by a group of experts using a Delphi-type method (Michie et al., 2013). BCTs are the observable and irreducible components of an intervention that bring about the change in behaviour (e.g. Feedback on Behaviour, Material Reward, Comparative Imagining of Future Outcomes, Action Planning, Modelling or Demonstrating the Behaviour) (Michie, Atkins & West, 2014; Abraham et al., 2015). In order to populate an intervention with appropriate BCTs from the taxonomy, linkages (derived from expert consensus processes) from the published literature (Cane et al., 2015; Michie et al., 2008) may be used to map theoretically informed determinants (i.e. TDF domains representing barriers and enablers) to specific intervention content. The behaviour change literature distinguishes between BCTs and the strategies used to operationalise them (Michie et al., 2008). The mechanisms through which BCTs are delivered to recipients have been labelled as modes of delivery (Michie, Atkins & West, 2014). The mode of delivery may encompass the proximity of the intervention deliverer to the recipient (e.g. face-to-face, remote), the number of individuals targeted by the intervention on a single occasion (e.g. individual, dyad, group), and the medium through which BCTs are sent to intended recipients (e.g. radio, poster, mobile phone application) (Michie et al., 2013; Michie, Atkins & West, 2014). Reporting the operational components of an intervention in sufficient detail to be replicable requires descriptions of intervention content (what was delivered); provider (who delivered it); setting (where it was delivered); recipient (to whom it was delivered); intensity (over how many

contacts it was delivered), and fidelity (the extent to which it was delivered as intended) (Michie, Atkins & West, 2014; Davidson et al., 2003). In this work, the terms BCT and mode of delivery will be used in accordance with the definitions from published literature. The more concrete strategies used to operationalise BCTs will be labelled as applications.

1.6 Preparatory work preceding this PhD research to report expected behaviours of the afferent limb

The first stage in the process proposed by French et al (2012) for developing implementation interventions to change behaviour, is to specify 'who needs to do what differently' (i.e. specify who needs to change their behaviour). To do this requires clear reporting of the evidence-practice or policy-practice gaps (Grimshaw *et al.*, 2012; French *et al.*, 2012); that is, where discrepancies exist between the evidence-based 'desirable' behaviours and those that are enacted in the 'real world' setting (Presseau et al., 2021). In the context of recognising and responding to deteriorating patients, desirable behaviours are typically reported in local policy documents and protocols which are customised according to local context but informed by national guidelines. Here, local is defined as Trust or organisation level. However, no published literature was identified reporting how national guidance related to the recognition and response to deteriorating ward patients had been translated into local policies, and what level of specificity in behavioural instruction was provided for clinicians required to enact behaviours of the afferent limb. It was anticipated that using structured methods to analyse national guidelines and local deteriorating patient policies could address this knowledge gap, whilst also providing a more detailed understanding of the expected behaviours of the afferent limb. Through identifying the expected (policy specified) behaviours (preparatory work), direct comparisons could then be made with those behaviours enacted in the 'real world' clinical setting (as part of this PhD research) enabling implementation gaps to be clearly reported.

A purposive sample (a range of acute NHS hospitals and locations) of local deteriorating patient policies was obtained from across the UK for documentary analysis;

the procedure for which was broadly informed by reported methods from the published literature (Murray, 2013; McGraw & Drennan, 2015; Gould et al., 2014). Deductive content analysis (Elo et al., 2014) was carried out on national guidelines and each of the local policy documents using the five elements of a published behaviour specification framework (action, actor, context, target, time – AACTT) as the coding categories (Presseau et al., 2019). A full description of the methods employed and the results of this documentary analysis have been published (Smith et al., 2019). The broader findings of this work are also incorporated within the background chapter of this thesis as they form part of the wider picture of ALF (see section 2.4.4.1).

Findings of this targeted documentary analysis were used to populate research materials (used in this PhD research) with expected behaviours of the afferent limb specified in accordance with the aforementioned AACTT framework (Presseau et al., 2019). This specific application of the preparatory work to this PhD research is reported in the methods chapter (see section 4.5.1.1).

Table 1.2 – the domains of the Theoretical Domains Framework (TDF) and the content of each domain

TDF domain	Content of the domain
Knowledge	An awareness of the existence of something
Skills	An ability or proficiency acquired through practice
Social, Professional Role & Identity	A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting
Beliefs about Capabilities	Acceptance of the truth, reality or validity about an ability, talent, or facility that a person can put to constructive use
Optimism	The confidence that things will happen for the best or that desired goals will be attained
Beliefs about Consequences	Acceptance of the truth, reality, or validity about outcomes of a behaviour in each situation
Reinforcement	Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus
Intentions	A conscious decision to perform a behaviour or a resolve to act in a certain way
Goals	Mental representations of outcomes or end states that an individual wants to achieve
Memory, Attention & Decision Processes	The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives
Environmental Context & Resources	Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence, and adaptive behaviour
Social Influences	Those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviour
Emotion	A complex reaction pattern, involving experiential, behavioural, and physiological elements, by which the individual attempts to deal with a personally significant matter or event
Behavioural Regulation	Anything aimed at managing or changing objectively observed or measured actions

Cane et al., 2012, p.13-14 and Atkins et al., 2017, p.4-5.

1.7 Research aims

The aim of this multi-phase, mixed methods study was to develop a theory-based preliminary complex intervention (targeting nursing staff) to enhance enablers and overcome barriers to performing expected afferent limb behaviour. To identify where ALF is occurring, expected afferent limb behaviours were reported and compared to the behaviours observed on hospital wards (phase 1). Using a theoretical framework, determinants of desired afferent limb behaviours (target behaviours) were identified, and precise techniques selected to ameliorate barriers and/or enhance enablers (phase 2). The acceptability and feasibility of intervention components and potential applications were assessed, and a preliminary intervention was developed (phase 3). It is acknowledged that interventions are rarely static entities and typically evolve or 'shift' in response to the context within which they are delivered (Cotterill et al., 2018 p5). Consequently, interventions may be developed and refined through an iterative process that typically includes formal piloting and may incorporate a concurrent process evaluation (O'Cathain et al., 2019; Downey et al., 2018; Skivington et al., 2021). The decision to term the output of this research as a 'preliminary' intervention reflects the likelihood of further revisions being made during subsequent feasibility testing (a separate study).

1.8 Potential importance of the proposed research

This is the first UK study to use a specific theoretical framework of behaviour change to theorise and model the causal pathway to ALF. The systematic application of the framework allowed specific intervention components to be developed aimed at modifying staff behaviours that are proximal antecedents to ALF. Theorising the evidence-practice gap, and the causal pathway to ALF, has led to the development of a preliminary theory-based intervention which is more likely to result in behaviour change and can be tested empirically in future research.

1.9 Summary

RRS have been implemented to address the persistent clinical problem of sub-optimal care. Despite the RRS, staff behaviour in recognising and responding to deteriorating patients remains

inconsistent leading to ALF. Whilst the noteworthy advantages of using theory to develop interventions have been identified, no research from a UK context was found reporting the systematic application of theory to elucidate determinants or to select intervention components to address this pervasive clinical problem. Further, whilst ALF has been identified as a behavioural problem, no published research was found where behaviour change theory, or a theoretical framework, had been systematically applied to develop an intervention. To address this knowledge gap, a theoretical framework of behaviour change (the TDF), and a taxonomy of behaviour change techniques, were used to theorise the causal pathway to ALF and to develop a preliminary complex intervention.

The background chapter that follows provides a more detailed narrative synthesis of the existing evidence related to the RRS and ALF. In chapter three, this research is situated within the wider context of implementation science, and the theoretical framework of behaviour change that underpins the study (the TDF) is evaluated, and its use justified. The methods employed including the procedure for recruitment and sampling, the development of research materials, data collection and analysis, and ethical considerations, are presented in chapter four. Care of the deteriorating patient is a rapidly evolving area in both the clinical and academic contexts. To ensure that dissemination activities were suitably aligned to the progressive nature of this area of practice, results were published in peer reviewed journals throughout this research. Three key publications summarising the main results from each phase of the research are embedded within chapter five. In the final chapter, the overall findings and significance of the research are explained. Recommendations for education, research and policy and practice are made and research conclusions are outlined.

2 CHAPTER 2: BACKGROUND

2.1 Introduction

Failure to recognise or respond appropriately to a deteriorating patient can result in a Serious Adverse Event (SAE) including unplanned Intensive Care Unit (ICU) admission, cardiac arrest, or death (Tirkkonen et al., 2016). Patients who deteriorate frequently have changes in measurable physiological parameters (Sprogis et al., 2017). These premonitory signs provide an opportunity for staff to intervene as part of the Rapid Response System (RRS). Despite implementation of the RRS, there is evidence that nurses do not consistently enact expected afferent limb behaviours (e.g. recognising the deterioration and calling for help) leaving patients vulnerable to ongoing deterioration and SAE (Trinkle & Flabouris, 2011). Whilst the problem of Afferent Limb Failure (ALF) is well reported in the literature, it is less clear why the problem persists despite wide implementation of the RRS, over 2 decades of research, and a strong focus in clinical practice (Massey, Chaboyer & Anderson, 2017). In this chapter, a narrative review and synthesis of primary and secondary research related to the RRS, and ALF, will be presented. To establish the context in which the RRS is activated, literature related to the prevalence of physiological antecedents in deteriorating patients will be reviewed. Subsequently, research underpinning the afferent (recognition) limb of the RRS will be synthesised. This will include a review of track-and-triggers tools used internationally, the role of 'nurse worry' in the afferent limb, the evidence underpinning the National Early Warning Score (NEWS), and the literature reporting ALF. Whilst the focus of this PhD is the afferent limb of the RRS, to situate this work within the broader system, research related to the efferent (response) limb of the RRS will also be presented and evaluated. Finally, international literature reporting existing interventions to mitigate sub-optimal care of deteriorating patients and, specifically, reduce the likelihood of ALF will be synthesised and used to identify knowledge gaps in the existing body of evidence.

2.2 Antecedents to Serious Adverse Events

Hospitalised patients who deteriorate without intervention (receive sub-optimal care) are at risk of experiencing a SAE defined in the literature as unplanned ICU admission, cardiac arrest, or

death (Tirkkonen et al., 2013; Trinkle & Flabouris, 2011; DeVita et al., 2006). There is evidence that a proportion of patients who reach SAEs have antecedent signs of deterioration that are potentially detectable and treatable by clinical staff (Hillman et al., 2001; Jacques et al., 2006). To assess the frequency of physiological antecedents preceding SAE, a multi-centre prospective observational study was conducted in the United Kingdom (UK) (n=69) and Australasia (n=21) (Kause et al., 2004). Over a 3-day period, a total of 638 SAEs were reported of which 383 (60%) had antecedent signs. Specific reported antecedents included changes in respiratory rate, pulse rate, systolic blood pressure, and conscious level. This was the first international study to report the relative high frequency of changes in routinely measured vital signs preceding a SAE (Kause et al., 2004). Whilst the methods reported for obtaining the data were sufficiently rigorous, collecting data from clinical records has inherent limitations. In particular, the completeness of the research data is contingent on the quality of the records maintained in clinical practice (i.e. the accuracy of the vital sign charts and clinical documentation). The authors noted that variations between countries in the quality of these data may have affected the analysis and accuracy of results (Kause et al., 2004).

A *post-hoc* multi-variable analysis of registry data from the United States of America (USA) was carried out to report the prevalence of ‘abnormal’ and ‘severely abnormal’ vital signs, preceding cardiac arrest (Andersen et al., 2016). From the 7,851 patients included, 59.4% had at least one abnormal vital sign recorded in the 4 hours preceding cardiac arrest. In patients with a ‘severely abnormal’ vital sign, post cardiac arrest mortality was only mildly increased when compared to those with an ‘abnormal’ vital sign. However, the authors describe a dose-dependent relationship between the number of different vital signs deranged (i.e. outside of acceptable parameters) and mortality following cardiac arrest (Andersen et al., 2016). Broadly, the findings here are consistent with other research (Hillman et al., 2001; Kause et al., 2004), suggesting that more than half of patients whose clinical endpoint is a SAE have prior observable changes in their vital signs. In addition, these findings suggest that patients with multi-parameter vital sign abnormalities are more at risk of SAE than those with a single parameter abnormality, even when

the single vital sign is severely deranged (Andersen et al., 2016; Spångfors, Molt & Samuelson, 2020).

2.3 Overview of the Rapid Response System

To address sub-optimal care of deteriorating patients, RRSs have been established in the UK, Europe, North America and Australasia (Lyons, Edelson & Churpek, 2018). Despite shared goals, the nuances of the RRS vary between organisations nationally and internationally (Rocha et al., 2018). In order to reach a level of agreement about the core characteristics of the RRS, an international group of clinical and academic experts in patient safety and critical care was convened, with the aim of reviewing existing evidence and reaching consensus on the basic requirements of a RRS (DeVita et al., 2006). It was agreed that all RRS should have a 'detection arm' to enable bedside clinical staff to track patients' progress and to identify those with unmet clinical needs. The detection of deterioration is typically identified through the routine measurement of vital signs, and the use of track-and-trigger tools that highlight when the vital signs are outside of acceptable parameters (Lyons, Edelson & Churpek, 2018). Having identified deterioration, mechanisms are required to enable staff to 'raise the alarm' and trigger a response (DeVita et al., 2006; Lyons, Edelson & Churpek, 2018). These behaviours, often performed in sequence by nursing staff, form what was described as the afferent limb of the RRS (DeVita et al., 2006).

Once the alarm has been raised, to ensure that a patient's unmet needs are addressed, an organised response is required. This response, termed the efferent limb of the RRS (DeVita et al., 2006), results in clinicians with enhanced knowledge and expertise being mobilised to the patient's location and/or the patient being transferred to a higher-care setting e.g. ICU (Lyons, Edelson & Churpek, 2018; DeVita et al., 2006). In addition to the RRS having an afferent (activation) limb and an efferent (response) limb, the original consensus group agreed the importance of governance processes to monitor and evaluate the RRS, and to ensure those responsible for enacting afferent and/or efferent limb behaviours receive appropriate education (DeVita et al., 2006). The need for more effective integration of personnel working within operational (e.g. the clinical responders) and governance (e.g. those providing resources, training and leading quality improvement) roles within

the RRS has been recommended (Olsen et al., 2019). This is reflected in an updated conceptual model of the RRS (Olsen et al., 2019, p76, fig.1) (Figure 2.1).

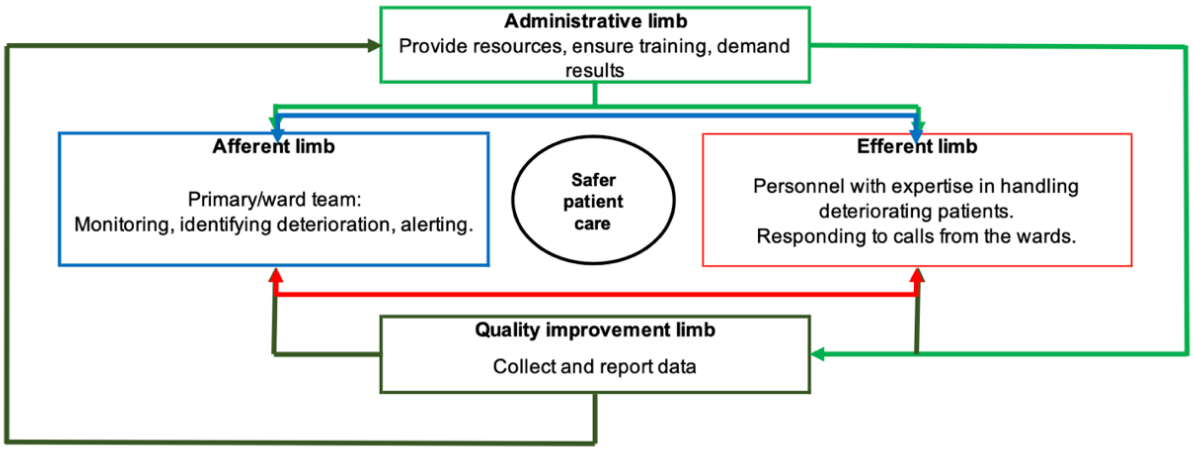

Figure 2.1 – updated conceptual model of the Rapid Response System (RRS)

Olsen et al., 2019, p76, fig.1

To consolidate the governance arm of the RRS, and to create a degree of international consistency in how the quality of these systems is measured, a consensus exercise was conducted using a modified Delphi approach (Subbe et al., 2019). Participants were service users and clinicians of different disciplines from five continents. Ten quality metrics that can be used to assess the quality of RRS were agreed. As part of this output, the group recommended that RRS should also incorporate a mechanism for patients and their relatives to raise the alarm if deterioration is not obviously recognised by clinical staff (Subbe et al., 2019). Currently, there is paucity of evidence to support patient and family activated RRS in the adult patient population (Albutt et al., 2017; Gill, Leslie & Marshall, 2016; Al-Moteri et al., 2019). Despite the lack of evidence, some authors have suggested that inclusion of a patient and family activation pathway could strengthen the afferent limb of RRS, without over-burdening those who respond to deteriorating patients (Odell, Gerber & Gager, 2010; Subbe et al., 2019; Albutt et al., 2017).

2.4 The Afferent Limb of the Rapid Response System

2.4.1 Overview of Track-and-Trigger tools

Given the prevalence of physiological antecedents to cardiac arrest, there is international consensus that healthcare organisations implement objective, pre-determined 'calling criteria' to facilitate the recognition of deranged vital signs and to identify patients with emergent, un-met clinical needs (DeVita et al., 2006). To implement these criteria, and strengthen the afferent limb of the RRS, the use of track-and-trigger tools is recommended in national guidelines from the UK (National Institute for Health & Care Excellence, 2007), Australia (Australian Commission on Safety and Quality in Health Care, 2021) and by the Institute for Healthcare Improvement in the USA (Institute for Healthcare Improvement, 2022). In the UK context, the prominence of these tools is underscored by recent introduction of financial penalties for organisations who do not demonstrate consistent compliance with their use (Chiu et al., 2020). Broadly, track-and-trigger is a universal term describing a tool (either paper-based or electronic) upon which vital signs are recorded (the tracking). The tool provides a signal to clinical staff when the vital signs fall outside of acceptable parameters, so that appropriate behaviours such as calling for help from a more senior colleague or a different clinical discipline (the triggering) can be enacted (Grant, 2018).

One of the greatest challenges related to the implementation and utilisation of track-and-trigger tools over the last two decades, has been a lack of scientific evidence regarding the thresholds that should trigger clinical staff to call for further assistance. This lack of clear evidence has led to the adoption of different tools with different calling criteria on an international scale, often informed by expert consensus rather than data driven processes that have been robustly validated (Green et al., 2018; Gerry et al., 2020). Track-and-trigger tools can be described as either Single Parameter Track-and-Trigger Systems (SPTTS), or Aggregate Weighted Track-and-Trigger Systems (AWTTS). SPTTS require that only one vital sign falls outside of pre-determined parameters to trigger a response. Aggregate weighting track-and-trigger charts (AWTTS) utilise a combined scoring approach to reach calling criteria. Abnormalities in each discrete measured vital sign give rise to a score (the more abnormal the greater the score), which are then aggregated.

The total score reflects the degree of abnormality across vital signs and signals when calling criteria have been met and action is required (Grant, 2018). The term Early Warning Scoring (EWS) system is also frequently used in the literature to describe these particular types of multi-parameter track-and-trigger tools (Grant, 2018; Lyons, Edelson & Churpek, 2018).

A systematic review of the international literature identified 39 different SPTTS with unique calling criteria (Smith et al., 2008b). The same authors used a database of vital signs, collected from patients in a UK-based acute medical setting, to evaluate the performance of SPTTS identified from the literature (n=30). In this evaluation, Smith *et al* (2008) reported considerable variation in the calling criteria included, and in the performance of the various tools in predicting mortality. The SPTTS examined in this evaluation were found to have low sensitivity. Sensitivity is defined as the ability of the SPTTS to correctly identify patients at risk of a SAE (i.e. its propensity to give a 'true positive') (Smith et al., 2008b).

In Australia, a SPTTS was implemented state-wide (Hughes et al., 2014). This tool, known as the 'Between the Flags' (BtF) system, is based on the premise of beach safety and the idea that swimming in the ocean between the flags ensures relative safety compared to swimming outside of the flags (Hughes et al., 2014). The concept of a 'safe zone' and a 'danger zone' were translated onto a vital signs chart, with white (safe), yellow (caution) and red (triggering) regions visually representing the degree of abnormality in the vital signs. Following the state-wide implementation of the BtF system, an interrupted time-series study was conducted to examine changes in patient outcomes, before and after implementation of the BtF in 232 public hospitals (Chen et al., 2016). A downward trend in overall mortality, incidence of cardiac arrest, and mortality following cardiac arrest, prior to the Btf implementation, were reported. This downward trend continued at a similar rate after implementation of the BtF tool (Chen et al., 2016) suggesting the incidence of cardiac arrest did not change with the implementation of the BtF system. These equivocal findings on the impact of a SPTTS may be explained by an increasing awareness of RRS in the state prior to BtF implementation, leading to favourable changes in pre-implementation staff behaviour (Chen et al., 2016). Results from a more recent prospective observational study suggest potential benefits of

implementing a BtF system (Bhonagiri et al., 2021). To evaluate the impact of implementing the BtF system across 35 hospitals with an ICU in a single state in Australia (the same state as the earlier work by Chen et al., (2016)), the researchers measured the rate of cardiac arrest (the primary outcome) on hospital wards during and after implementation. Patient data were collected prospectively from a cardiac arrest database over a period of six years (Bhonagiri et al., 2021). Noteworthy findings were a reduction in the incidence of cardiac arrest from 0.91 per 1000 hospital admissions (during implementation) to 0.70 per 1000 hospital admissions (post implementation); with an estimated 912 cases (911.5, 95% CI 738.3 – 1075.0) of cardiac arrest averted due to BtF implementation. This effect was observed across sites which included metropolitan and rural hospitals (Bhonagiri et al., 2021). In this work, the researchers acknowledge that they did not collect data on the number of hospitals that had existing RRS in place before the Btf was implemented, nor on the characteristics of any pre-existing systems. It is possible that a renewed focus on the RRS from BtF implementation and the standardisation of practice (i.e. use of a single tool) within and across participating organisations may have contributed to the favourable results (Bhonagiri et al., 2021).

A wide sample of AWTTS (n=33) was identified from a systematic search of the international literature, and their performance at predicting mortality tested on medical patients' vital signs (n=9,987) (Smith et al., 2008a). Like the findings for SPTTS, the authors reported considerable variation between the different AWTTS in relation to the included parameters, and the thresholds for assigning different scores. They also reported generally weak performance in the tools' ability to predict patient mortality, with only 12 tools (36%) discriminating reasonably well (Smith et al., 2008a). The AWTTS with more favourable predictive value incorporated scoring for abnormalities in temperature and peripheral oxygen saturations ($Sp0_2$), alongside the traditionally measured parameters of pulse rate, respiratory rate, blood pressure and conscious level (Smith et al., 2008a). Whilst this study yielded predominantly weak findings regarding the predictive value of AWTTS, it did provide an early signal of modifications to existing EWS tools that could improve their ability to discriminate patients at risk of SAE.

More recently, a systematic review and synthesis of the literature was carried out to examine the ability of EWS tools to improve patient outcomes (Credland, Dyson & Johnson, 2020). Only five international studies were included within the review representing data from over 74,000 patients, despite the burgeoning body of international literature on the topic. The small number of papers included is explained by the exclusion of papers where the patient population included children, obstetric patients, and patients receiving care in the pre-hospital setting. Studies were also excluded if they did not explicitly report the impact of EWS on patient outcomes (cardiac arrest, ICU admission, mortality, length of hospital stay) or if they used qualitative methods (Credland, Dyson & Johnson, 2020). Whilst results were varied, the authors reported positive associations between the use of EWS protocol and patient outcomes including reduced SAE and hospital length of stay (Credland, Dyson & Johnson, 2020). Broadly, these favourable findings are consistent with those of a preceding systematic review that was conducted to report the ability of EWS tools to predict patients' risk of clinical deterioration (Beth Smith et al., 2014). A small sample (n=8) of observational studies from North America, UK, and East Africa (6 prospective cohort; 2 case control) met inclusion criteria. The authors concluded that, across the studies, the discriminative performance of the EWS tools were generally high in relation to predicting patient mortality within 24 and 48 hours of an elevated score (Beth Smith et al., 2014). However, in one Canadian study, a high proportion of patients (89%) who met calling criteria, with significant vital sign abnormalities, did not have a negative outcome i.e. survived the event (Kellett & Kim, 2012). Whilst this may have been due to a modification of the patient's clinical outcome, by appropriate recognition of deterioration and therapeutic interventions, it does highlight the potential for false positives when using a more sensitive EWS tool (Beth Smith et al., 2014).

False positives in this context could negatively impact on staff response through 'alarm fatigue' and increase the unnecessary deployment of resources across already over-burdened healthcare organisations (Smith & Aitken, 2016; Connolly et al., 2017; Olsen et al., 2019). Alarm fatigue occurs when healthcare practitioners are exposed to an environment with excessive alarms. Such exposure can be overwhelming and can contribute to individual healthcare practitioners becoming desensitised and/or not taking action in response to an alarm (Harris et al.,

2011). Whilst traditionally alarm fatigue has been associated with audible alarms (e.g. from patient monitoring equipment), this term is also used more broadly to describe desensitisation to other 'alarms' such as signals from a track-and-trigger tool when vital signs are abnormal (Shiloh et al., 2016). The authors of this review also acknowledged overarching limitations of the included studies which were broadly flawed by lack of randomisation and the associated risk of systemic bias (Beth Smith et al., 2014; Polit & Beck, 2018).

Despite the wide implementation of track-and-trigger tools, there is a noteworthy lack of published literature reporting the cost of operationalising these tools and the cost effectiveness of their ongoing use. A systematic review was conducted to identify and report economic evaluations of EWS tools used for adult patients (Murphy et al., 2018). The authors of the review reported a noteworthy lack of full evaluations (i.e. conducted across an organisation) but identified a small sample of partial evaluations (i.e. involving a sub-set of patients or a particular clinical setting). From the findings of these partial evaluations, it was reported that the implementation of an EWS tool could result in a 29% reduction in average patient length of stay within general wards, and a 40.3% reduction in average patient length of stay within ICU (Murphy et al., 2018). Given the high demand for acute hospital beds, particularly those in ICU (Prin & Wunsch, 2012), it is likely that these length of stay reductions would translate into increased efficiency within the system (i.e. bed utilisation) rather than direct monetary savings (there will always be a patient waiting to occupy a bed within the ICU) (Murphy et al., 2018). Notwithstanding the limitations from a lack of evidence in this area, information from partial economic evaluations suggests that EWS tools may be cost effective by increasing efficiency and bed utilisation. However, these gains will likely be contingent on the EWS tools being used effectively in clinical practice.

2.4.2 The contribution of 'nurse worry' to the afferent limb of the RRS

Alongside the objective calling criteria provided by a specific track-and-trigger tool, many of the tools implemented in practice incorporate a 'worry criterion' to legitimise nurses calling for help if they are concerned, even when there are no objective physiological signs of deterioration (Douw et al., 2017). In organisations that have implemented RRS, approximately a quarter of RRS

triggers occur in the context of ‘nurse worry’ (Chen *et al.*, 2010). The degree of accuracy associated with a nurse’s subjective view of their patient’s level of risk has been debated (DeVita et al., 2006). In order to elucidate the concept of ‘nurse worry’, a group of researchers from the Netherlands conducted a systematic review which included 18 papers with various study designs (5 quantitative; 9 qualitative; 4 mixed-methods) (Douw et al., 2015). Thirty-seven different signs and symptoms emerged from the data and were summarised as 10 general indictors of worry (e.g. ‘change in circulation’, ‘change in breathing’, ‘unexpected trajectory’) (Douw et al., 2015). The same researchers used these objective worry indictors to synthesise a new clinical assessment tool: the Dutch-Early-Nurse-Worry-Indicator-Score (DENWIS).

A prospective cohort study was later carried out to determine the significance of nurses’ worry in predicting unplanned ICU admission or unexpected mortality in a cohort of surgical ward-based patients (n=3,522) (Douw et al., 2016). Using the DENWIS, nurses (n=96) were required to routinely score their level of worry for each patient, once per shift, and at any other ‘moments of worry’. One hundred and two (2.9%) patients had an unplanned admission to ICU; 5 died unexpectedly. In 85% of cases where the patient reached an adverse endpoint (the event group), nurses reported being worried. In 70% of cases, nurses reported worry when EWS calling criteria were not met. Most frequent DENWIS indictors in the event group were: ‘change in circulation’ (57.8%); ‘change in breathing’ (45.1%); and ‘no clinical progress’ (42.2%). Most important DENWIS indictors of a patient being admitted to ICU were: ‘changes in breathing’ (OR 15.2); ‘subjective nurse observation’ (OR 14.6); ‘change in circulation’ (OR 12.4) (Douw et al., 2016). The combination of DENWIS and an elevated EWS was the strongest predictor of SAE (Douw et al., 2016).

It is particularly noteworthy that a high proportion of patients who reached an adverse endpoint met DENWIS ‘worry criteria’, but did not trigger the standard EWS calling criteria (Douw et al., 2016). This research highlighted the potential importance of nurse worry in the early identification of deteriorating patients. However, the wider application of findings is limited by the single centre design and the sampling which included only surgical ward nurses. Findings of this

work are corroborated by the findings of a study conducted in the USA, where nurses from both surgical and medical ward areas were recruited (Romero-Brufau et al., 2019). Here, the researchers used focus groups to synthesise a worry factor score (WFS) ranging from 0 (no worry) to 4 (extreme concern). Nurses recorded a WFS at the start of a shift, or whenever a patient's condition changed. True deterioration events (i.e. where an adverse event occurred) were identified from the health records and confirmed by independent expert review. In 77% of cases where the WFS was elevated, the event was considered a true deterioration by an expert reviewer. Where the WFS was ≥3, patients were 40 times more likely to require ICU admission within 24 hours (Romero-Brufau et al., 2019). Whilst the WFS score performed well when utilised by the cohort with whom it was developed, the external validity of this scoring system was neither tested nor reported. As such, the potential for wider application is unclear (Oglesby, Sterne & Gibbison, 2020). As the EWS was not included in the data analysis, further research is required to identify if there is a relationship between the WFS and EWS, and what weight the WFS should be given in relation to the EWS (Romero-Brufau et al., 2019).

Findings from existing empirical work suggest that there may be merit to the inclusion of a worry criterion within track-and-trigger systems. However, the most effective way to incorporate this component remains unclear. Further, it remains unclear if nurse worry in this context is a consequence of slower, deliberative and reflective thought processes (i.e. based on information processing and clinical decision-making) (Levett-Jones et al., 2010; Petersen, Rasmussen & Rydahl-Hansen, 2017), or faster, automatic and less effortful processes (i.e. pattern recognition) (Romero-Brufau et al., 2019; Presseau et al., 2014b; Odell, Victor & Oliver, 2009). A group of Danish researchers have published a protocol for a multi-centre, cluster randomised, crossover, non-inferiority study that may address some of these reported knowledge gaps (Nielsen et al., 2020). In their protocol, the researchers hypothesise that an individualised EWS (iEWS) will not be inferior to NEWS at predicting patient mortality but will result in fewer inappropriate escalations of care (i.e. those resulting from false positive triggers). The iEWS is derived from vital signs plus an additional clinical assessment by nursing staff, the findings of which may be used by the nurse to

modify the iEWS upwards (maximum 6 points can be added) or downwards (maximum 4 points can be subtracted) at their discretion. From the associated feasibility study published alongside Nielson et al's (2020) protocol, 4585 iEWS were analysed; 992 of which were adjusted by nursing staff based on further clinical assessment. A higher frequency of these adjustments involved score deflation (876 (19.6%)) compared to inflation (116 (2.6%). Historically, the worry criterion has been applied to permit nursing staff to inflate scores and raise the alarm for patients whose EWS alone would not meet criteria for escalating care (Douw et al., 2016). Whilst just an early signal, these findings suggest that nurses make more complex cognitive adjustments in both directions when interpreting EWS data. Providing a mechanism for nurses to incorporate clinical assessment findings into the EWS could help to reconcile the dissatisfaction that some nurses have expressed related to the inflexible and restrictive nature of the protocols that accompany track-and-trigger tools (Minyaev, Harrington & King, 2021).

2.4.3 National Early Warning Score (NEWS)

2.4.3.1 Background to NEWS

By the end of the last decade, there were several hundred different tools to assess patient deterioration being used within and between different hospitals and healthcare organisations around the world (Jansen & Cuthbertson, 2010; Shiloh et al., 2016). In addition to creating confusion in clinical practice, this lack of consistency was recognised as a significant barrier to the design of high-quality multi-centre research (Royal College of Physicians, 2012). To standardise practice across the UK, a National Early Warning Score Implementation Group (NEWSIG) was convened consisting of clinical experts, patient safety professionals, and service user representatives. The overarching objective of NEWSIG was to synthesise a National Early Warning Score (NEWS) tool from the existing evidence, that could be implemented across the UK to address inconsistencies. Subsequently, the Royal College of Physicians (2012) published the first iteration of a paper-based NEWS tool (see volume 2, appendix 1 for a copy of the paper chart) and an implementation guideline to support adoption. The content of the original NEWS tool (i.e. the vital signs parameters and scoring thresholds) was informed by an electronic EWS system

(VitalPAC® EWS) that was found to predict in-hospital patient mortality more effectively than 33 alternate EWS tools (Prytherch et al., 2010). NEWS signals patient risk based on the total score (total score range 0-20) aggregated from individual scores assigned to the six routinely recorded vital signs plus a score uplift for supplemental oxygen (Table 2.1). The patient's level of risk is then stratified according to the aggregate NEWS as either low risk (aggregate score range 0-4), medium risk (aggregate score range 5-6 or 3 in a single parameter) or high risk (aggregate score ≥7) respectively (Royal College of Physicians, 2012).

Table 2.1 - the vital signs parameters measured for NEWS, and the individual scores assigned for each parameter according to the degree of abnormality

Individual score →							
Physiological parameters (units of measurement) ↓	**3**	**2**	**1**	**0**	**1**	**2**	**3**
Respiratory rate (breaths per minute)	<8		9-11	12-20		21-24	≥ 25
Peripheral oxygen saturations - $Sp0_2$ (%)	≤ 91	92-93	94-95	≥ 96			
Air or supplemental oxygen?		Oxygen		Air			
Temperature (° C)	≤ 35		35.1-36.0	36.1-38.0	38.1-39.0	≥ 39.1	
Systolic blood pressure (mmHg)	≤ 90	91-100	101-110	111-219			≥ 220
Heart rate (beats per minute)	≤ 40		41-50	51-90	91-110	111-130	≥ 131
Conscious level using AVPU				A			V, P or U
AVPU abbreviates **A**lert; responsive to **V**oice; responsive to **P**ain; **U**nresponsive							

Adapted from: Royal College of Physicians, 2012, p.14, chart 1.

There is some preliminary evidence that older patients with an elevated EWS have higher mortality than younger patients with equivalent scores (Smith et al., 2008c). This finding is consistent with research from South Korea, that focused specifically on the efficacy of NEWS (Lee et al., 2018b). Based on the findings from this single centre retrospective study, it was concluded that the addition of age to the NEWS resulted in more accurate predictions of mortality. Despite these findings, age has not yet been incorporated into the NEWS tool. The decision to exclude age

was justified by the lack of high-quality evidence, and a more pragmatic rationale that many of the organisations implementing NEWS would have been doing so initially using a paper-based approach. As such, the need to adjust the aggregate score according to the patient's age could further increase the complexity of the tool, undermining the desire for it to be simple and accessible for all clinical users (Royal College of Physicians, 2012; Smith et al., 2008c; Haegdorens et al., 2020).

2.4.3.2 Comparisons between NEWS and other track-and-trigger tools used internationally

Following the release of NEWS within the public domain, the tool was tested on the same large database of vital signs as the electronic system (VitalPAC®) upon which it was developed. NEWS demonstrated a similarly strong ability to discriminate patients at risk of dying within 24 hours of an elevated score (Smith et al., 2013). The finding that NEWS is most effective at predicting mortality over shorter time periods (i.e. within 24 hours of the score being recorded) was also reported from a recent systematic review (Holland & Kellett, 2021). Smith *et al* (2013) also tested the discriminatory ability of NEWS to identify patients at risk of unplanned ICU admission within 24 hours of an elevated score. For this outcome, NEWS also demonstrated superior discriminatory performance when compared to the 33 other EWS tools (Smith et al., 2013). This finding may be of greater significance in relation to the potential of NEWS to strengthen the afferent limb of the RRS. The ability to predict unplanned ICU admission is a more modifiable outcome than absolute mortality, providing clinical staff with an opportunity to change their behaviour, interrupt deterioration, and potentially 'rescue' the patient (Smith et al., 2013).

Following the inception of NEWS, researchers from Scandinavia conducted a prospective point prevalence study to evaluate the ability of an existing dichotomous SPTTS and NEWS to discriminate patients at risk of reaching a SAE (Tirkkonen et al., 2014). After adjusting for confounding factors, the conventional SPTTS criteria were not associated with patient outcome. By comparison, the two score thresholds for NEWS that were tested (aggregate score ≥ 5 or ≥ 7) were independently associated with worse patient outcomes (Tirkkonen et al., 2014). Further, an

aggregate NEWS of 7-8 was associated with a 25-fold increase in 30-day mortality, and an aggregate NEWS of 9-10 was associated with a 45-fold increase in the same endpoint. Whilst the study was limited by its single-centre design, the results favour the use of NEWS over an alternative dichotomous SPTTS (Tirkkonen et al., 2014). To reach a high-risk threshold (aggregate NEWS $\geq$ 7) requires a minimum of two vital signs to be deranged (Royal College of Physicians, 2012). From the wider literature, it is clear that discrete changes across the entire set of vital signs is a stronger signal of impending collapse than even a significant deviation in one isolated parameter (Andersen et al., 2016; Jarvis et al., 2015). This may explain why the higher aggregate NEWS accompanied such a large increase in 30-day mortality.

Further evidence of the favourable predictive performance of NEWS, compared to alternative track-and-trigger tools, is provided in a more recent study where a large data set of vital signs (>4 million) from 107,868 patients across five hospitals in the USA, were mined from an Electronic Health Record (EHR) (Green et al., 2018). An EHR is defined as a 'systematic electronic collection of health information about patients which may include medical history, medication orders, vital signs, laboratory results, radiology reports, and notes from various clinicians' (Campanella *et al.*, 2016 p60). The primary objective of the study was to compare the predictive performance of NEWS, the BtF SPTTS, an alternative modified EWS (MEWS), and an electronic Cardiac Arrest Triage (eCART) score (a computer-generated individualised score based on a patient's demographics, vital signs, and laboratory values). Whilst limited by its retrospective design, the researchers reported that NEWS demonstrated higher performance in identifying patients at risk of SAE, within 24 hours of calling criteria being met, when compared to the BtF and MEWS (Green et al., 2018). Whilst the performance of NEWS exceeded the performance of the alternative paper-based systems, the eCART tool outperformed NEWS. These results are consistent with findings from other research where the effectiveness of eCART in predicting SAE has been reported (Churpek et al., 2019; Bartkowiak et al., 2019) and a study where NEWS combined with additional clinical data (oxygen flow rate, laboratory values) was superior to NEWS alone at predicting SAE in patients with severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2) (hereafter referred to as COVID-19) (Carr et al., 2021). Collectively, these findings highlight the possible benefits of

electronic systems, where computer modelling is used to generate individualised scores based on a wider profile of objective clinical data extracted from the EHR (Churpek et al., 2014, 2019; Hogan et al., 2020; Bell et al., 2021). The potential of these systems is likely to become of greater interest as an increasing number of healthcare organisations transition from paper-based charts to EHR.

2.4.3.3 The validation of NEWS in different clinical contexts and with different patient cohorts

Alongside research comparing NEWS to other track-and-trigger tools, a contemporary body of research has emerged reporting the predictive performance of NEWS in specific clinical contexts and with different cohorts of patients. In a Danish sample of patients from Emergency Departments (ED), medical wards and surgical wards, a medium and high-risk NEWS resulted in a two-fold and three-fold increase in odds of in-hospital mortality compared to low risk scores (Spångfors et al., 2019). The findings here are consistent with other research (Kovacs et al., 2016; Klepstad et al., 2019; Luís & Nunes, 2018; Skov et al., 2020) suggesting that NEWS retains its predictive performance when used on ward-based patients across medical and surgical disciplines as well as in the ED setting. A single centre retrospective study was conducted in South Korea to examine the ability of NEWS to predict mortality in a sample of patients >65 years of age (median age 75 years), admitted to the ED for any reason (Kim et al., 2020). A significant correlation was reported between NEWS and in-hospital mortality. The risk of in-hospital death for patients with a NEWS ≥7 (high risk) was 30.3% compared to 2.7% for patients with a NEWS 2-4 (low risk). These findings suggest that NEWS maintains its predictive performance in older patients with a range of diagnoses (Kim et al., 2020). Whilst age and comorbidity can affect a patient's physiological response to acute illness, it has been reported that an elevated NEWS in the ED should be acted upon irrespective of age and comorbid state (Kivipuro et al., 2018). This conclusion was informed by a prospective cohort study conducted in an ED in Finland, where NEWS was found to retain adequate discriminatory performance following statistical adjustments for age and cumulative co-morbidity index (Kivipuro et al., 2018).

In the ED and acute admissions context, NEWS has been found to perform better than other general and illness-specific screening tools. In a narrative review of the literature, NEWS outperformed other tools (total included n=23) in predicting short-term mortality and ICU admission in the general patient population and in those diagnosed with community acquired pneumonia (Nannan Panday et al., 2017). In a sample of ED patients with infection and likely sepsis (n=8,204), NEWS demonstrated superior discriminatory performance for outcomes of 10-day and 30-day mortality, when compared to 2 other sepsis-specific tools (Brink et al., 2019). Similar findings were reported from a retrospective study conducted in an ED in Thailand (Ruangsomboon et al., 2021). Here, NEWS also outperformed 2 sepsis-specific tools in predicting all-cause in-hospital mortality in patients with a provisional diagnosis of sepsis (Ruangsomboon et al., 2021). There is also some evidence that NEWS can accurately discriminate risk of SAE in patients with liver cirrhosis (Hydes et al., 2018) and in patients with COVID-19 infection (Kostakis et al., 2021; Aliberti et al., 2021; Pugazhvannan et al., 2021)

It has been posited that any successes associated with NEWS, are likely a consequence of the standardisation of practice and the ‘common language’ that it provides for clinical staff about patient acuity and rate of deterioration (Oglesby, Sterne & Gibbison, 2020; Pullyblank et al., 2020). On this basis, a network of professionals and stakeholders from the South West of England delivered a large quality improvement project that involved the implementation of NEWS across an entire healthcare system (including all ambulance, community and hospital settings) (Pullyblank et al., 2020). The group used quality improvement methodology to both deliver the intervention and to measure its effect over a 4-year period, with a particular focus on outcomes in patients with Suspicion Of Sepsis (SOS). The mortality of patients with SOS fell in the implementation region compared to the rest of England (Pullyblank et al., 2020). Given the complexity of the systems being studied, and the number of potential confounders, causality cannot be proven (Polit & Beck, 2018). However, these findings broadly highlight the potential benefit of standardising practice across the continuum of healthcare. Concerns have been reported regarding the implementation of NEWS within primary care, and in the pre-hospital setting. Specifically, it has been posited that NEWS could cause an increase in inappropriate hospital admissions due to patients having

chronically disturbed physiology and a persistently elevated baseline NEWS in the community (Scott et al., 2019). The findings of this work refute this perception, as the number of hospital admissions did not increase disproportionately to the rest of England when NEWS was implemented (Pullyblank et al., 2020; Scott et al., 2019). The potential benefits of NEWS in the pre-hospital context is further evidenced by cohort studies conducted in the UK (Abbott et al., 2018; Scott et al., 2020; Shaw et al., 2017) and Finland (Hoikka, Silfvast & Ala-Kokko, 2018), where pre-hospital NEWS was found to be effective at predicting subsequent in-hospital mortality.

The aggregate NEWS is generated from vital signs obtained at a single time point (i.e. a 'snapshot' approach). Based on this single value, nursing staff are prompted to act (Royal College of Physicians, 2017). It has been argued that this feature of the tool is at odds with how clinicians interpret physiological data, which typically involves some level of scrutiny for changes over time (i.e. a consideration of trend) (Churpek, Adhikari & Edelson, 2016; Chiu et al., 2020). The importance of reviewing a series of vital signs, is highlighted by the findings of a multi-centre study conducted in the Netherlands (Latten et al., 2021). From a cohort of patients (n=1743) with suspicion of sepsis, vital signs data (maximum of 4 complete sets per patient) were prospectively collected in the ED and used to generate several illness-severity scores, including NEWS. Forty-six percent of patients sampled experienced alternations in vital signs, with 55% of alterations representing improvement and 45% representing deterioration in the patient's condition (in accordance with the illness severity scores) (Latten et al., 2021). These findings confirm the tendency of vital signs to fluctuate (even within a relatively short period of time) and highlight the importance of trend when assessing a patient's risk of deterioration. Two publications were identified (Zhu et al., 2020; Bell et al., 2021) with the broad aim of examining the impact of incorporating trend into a computer modelled EWS. In both studies, the computer modelled trend based EWS had superior predictive performance when compared to traditional 'snapshot' track-and-trigger tools (including NEWS and the BtF tool) (Zhu et al., 2020; Bell et al., 2021).

Early iterations of NEWS were developed primarily to be operationalised in paper-based healthcare systems (Royal College of Physicians, 2012, 2017). As more organisations transition

towards EHRs, future iterations of NEWS should be developed with the digital context in mind; harnessing computer modelling to factor an individual patient's trend in vital signs into the score (Zhu et al., 2020; Chiu et al., 2020). Existing evidence suggests that the inclusion of trend may further increase the performance of tools like NEWS in detecting true events, whilst also reducing 'false alarms' where the tool delivers a signal of risk but the patient comes to no harm (Churpek, Adhikari & Edelson, 2016; Zhu et al., 2020; Bell et al., 2021). These findings are particularly noteworthy given the wider evidence that a NEWS may under detect or over detect SAE in certain cohorts of patients.

From data derived prospectively from a cohort of medical patients (n=2,677) in Italy, it was reported that 114 patients from the sample had an unplanned transfer from the ward to an ICU setting within 72 hours of admission, due to an acute cardiac event (Spagnolli et al., 2017). More than half of the patients in this sub-group had a NEWS commensurate with low or medium level of risk on admission, suggesting that false negatives may occur in this clinical cohort (Spagnolli et al., 2017). By comparison, from the patients who did not experience a SAE (n=2,395), almost half were diagnosed with chronic respiratory disease (n=1114). From this sub-group, 525 (21.9%) had a high risk NEWS and 436 (18.2%) had a medium risk NEWS on admission, suggesting that false positives may occur in this group (Spagnolli et al., 2017). This is the largest prospective study to be published to date adding weight to the findings, which are broadly in-keeping with findings from older studies and more contemporary but retrospective research (Haegdorens et al., 2020; Fernando et al., 2019). Specifically, the adequacy of the overall predictive performance of NEWS is emphasised albeit with limitations related to the tendency for NEWS to provide false positive and false negative signals in some groups of patients (Spagnolli et al., 2017; Chiu et al., 2020; Fernando et al., 2019; Haegdorens et al., 2020).

Patients with long-term respiratory diseases and chronic hypoxaemia (CH) reflect one sub-group of patients where inflated scores and excessive triggering may occur, predominantly from low baseline peripheral oxygen saturations ($Sp0_2$) (Kane et al., 2012; Bilben, Grandal & Søvik, 2016). Eccles *et al* (2014) conducted a prospective cohort study on a small sample of patients

(n=196) admitted to general medical wards in two UK hospitals. The sample included patients with and without CH and was designed to develop and test a tool with high sensitivity and specificity in patients with CH (a Chronic Respiratory Early Warning Score – CREWS) (Eccles et al., 2014). At discharge, 8% of patients without CH had a NEWS >6; 32% of patients with CH had a NEWS >6. When the newly developed CREWS parameters were applied retrospectively to the same dataset, the proportion of NEWS >6 at discharge was 14%. Twenty-three patients (including 12 with CH) died within 30-days of admission. All patients with CH who died triggered a high score (>6) on NEWS and CREWS (Eccles et al., 2014). Whilst limited by a very small sample size, it is possible that modifying pulse oximetry parameters on the NEWS tool for patients with CH (i.e. adopting CREWS parameters) could reduce false positive high scoring during periods of clinical stability, whilst preserving sensitivity in predicting mortality (Eccles et al., 2014).

The modification of NEWS to incorporate CREWS parameters has since been contested. In a UK-based retrospective cohort study, a sample of patients with Acute Exacerbations of Chronic Obstructive Pulmonary Disease (AECOPD) (n=942) were compared with other acutely unwell medical patients (n=20,415) (Hodgson et al., 2017). A high-risk NEWS was found to have a sensitivity of 60% and a specificity of 80% for predicting inpatient mortality. By comparison, a high-risk CREWS was found to have a 13% sensitivity and a 96% specificity for predicting the same endpoint. These results suggest there is insufficient evidence of benefit to modify NEWS for patients with COPD, as the improvement in specificity is outweighed by the loss of sensitivity (Hodgson et al., 2017). The same authors also highlight that the original derivation cohort of medical patients, upon which NEWS was validated, included patients with COPD, explaining its high performance in predicting mortality within this group (Hodgson et al., 2017). These findings overlap with those of a retrospective cohort study conducted in Denmark, where patients whose scores were downgraded (i.e. moved from a higher to a lower risk range) due to the application of modified parameters (including CREWS), more frequently had a SAE within 48 hours compared to patients whose scores were unmodified (Pedersen et al., 2018b).

2.4.3.4 National Early Warning Score version 2 (NEWS2)

Despite the equivocal evidence for incorporating chronic respiratory parameters into NEWS, a second iteration of the NEWS tool (NEWS2) has since been published by the NEWSIG (Royal College of Physicians, 2017) (see volume 2, appendix 2 for a copy of the paper chart). Broadly, the measured vital sign parameters and the scoring criteria remain the same as NEWS with two adjustments. NEWS2 incorporates different scales for $Sp0_2$ (Table 2.2). The NEWSIG recommend that the admitting doctor decide on the most appropriate scale based on the patient's history (Royal College of Physicians, 2017). $Sp0_2$ scale 2 ranges have been adjusted for patients with CH, more specifically those patients predisposed to hyperoxygenation induced hypercapnia (Royal College of Physicians, 2017). In this sub-group of COPD patients, there is a risk that increasing oxygen concentrations (even to a level considered 'normal' in healthy individuals) may result in an accumulation of carbon dioxide which can adversely affect homeostasis and have deleterious consequences (Adam, Osborne & Welch, 2017; Abdo & Heunks, 2012). Consequently, the scale 2 parameters were added to protect this group of patients from the potentially adverse effects of excessive supplemental oxygen, and to reduce spurious score inflation and excessive triggering in the context of chronically disturbed physiology (Royal College of Physicians, 2017). In practical terms, this means that chronic respiratory patients with an 'acceptable' level of hypoxaemia would not accrue a score for the $Sp0_2$ parameter unless it was severely deranged. $Sp0_2$ scale 1 reflects the score ranges included within the original NEWS chart and is intended for all other patients (i.e. those deemed to be not at risk of hyperoxygenation induced hypercapnia).

Following the publication of NEWS2, Hodgson *et al* (2018) retrospectively applied the revised NEWS2 $Sp0_2$ scale 2 criteria to the same data-set used in an earlier study to validate NEWS (Hodgson et al., 2017). Specifically, they assessed the number of patients whose risk group was downgraded by application of NEWS2 scale 2 parameters. Sixty-two patients who died had an admission NEWS $\geq$7; rescoring using NEWS2 would have resulted in a down-scaling of the risk level in 44% of these cases, suggesting a reduction in sensitivity for the modified NEWS2 parameters (Hodgson et al., 2018). The suggestion that the application of NEWS2 $Sp0_2$ scale 2

parameters offers no predictive advantage and/or reduces sensitivity is corroborated by findings from retrospective observational studies conducted in the UK (Pimentel et al., 2019) and Finland (Tirkkonen, Karlsson & Skrifvars, 2019).

Table 2.2 - the vital signs parameters measured for NEWS2, and the individual scores assigned for each parameter according to the degree of abnormality

Individual score →							
Physiological parameters (units of measurement) ↓	**3**	**2**	**1**	**0**	**1**	**2**	**3**
Respiratory rate (breaths per minute)	<8		9-11	12-20		21-24	≥25
Peripheral oxygen saturations - $Sp0_2$ (%) Scale 1	≤91	92-93	94-95	≥96			
Peripheral oxygen saturations - $Sp0_2$ (%) Scale 2	≤83	84-85	86-87	88-92 or ≥93 on air	93-94 on oxygen	95-96 on oxygen	≥ 97 on oxygen
Air or supplemental oxygen?		Oxygen		Air			
Temperature (° C)	≤ 35		35.1-36.0	36.1-38.0	38.1-39.0	≥39.1	
Systolic blood pressure (mmHg)	≤ 90	91-100	101-110	111-219			≥220
Heart rate (beats per minute)	≤ 40		41-50	51-90	91-110	111-130	≥131
Conscious level using AVPUC				A			V, P, U or C
AVPUC abbreviates **A**lert; responsive to **V**oice; responsive to **P**ain; **U**nresponsive; evidence of new **C**onfusion							

Adapted from: Royal College of Physicians, 2017, p.29, chart 1.

The finding that NEWS2 is weaker at discriminating patient mortality than NEWS is contested by findings of an alternate publication where the vital signs of patients (n=2,645) admitted with AECOPD were collected on admission to six UK hospitals (Echevarria, Steer & Bourke, 2019). Patients sampled all had the diagnosis of COPD confirmed by pulmonary function tests prior to their acute admission. Findings of this study are in opposition to other work, as NEWS2 showed superior discriminatory performance for mortality than NEWS. Here, the researchers also challenged the recommendation from the NEWSIG (Royal College of Physicians, 2017) that the use of scale 2 $Sp0_2$ parameters should be limited to patients deemed at risk of

hyperoxygenation induced hypercapnia; arguing that there is potential for harm from excessive supplemental oxygen in all patients with a COPD diagnosis (Echevarria, Steer & Bourke, 2019).

In both NEWS and the updated NEWS2, additional points are added to the aggregate NEWS for patients receiving supplemental oxygen therapy (see tables 2.1 and 2.2) (Royal College of Physicians, 2017, 2012). Delivering supplemental oxygen to an acutely unwell patient can normalise other physiological parameters and may mask the severity of the underlying condition (Skov et al., 2020). This reasoning justifies the addition of 2 points to the aggregate NEWS for any patient receiving any concentration of supplemental oxygen via any delivery device (e.g. facemask, nasal cannula). A cohort of patients (n=83, 304) prescribed supplemental oxygen on admission to UK hospitals, was used to model a modified NEWS whereby the score added for supplemental oxygen was determined by the concentration of oxygen being delivered to the patient, rather than a fixed score of 2 being applied (Malycha et al., 2019). The researchers examined the ability of the modified NEWS to predict SAE and compared the performance to standard NEWS; concluding that the modified NEWS would have correctly identified a further 173 patients from the derivation cohort who went on to have a SAE compared to standard tool (Malycha et al., 2019). Applying a weighted score adjustment to a computer modelled EWS, based on a patient's requirement for supplemental oxygen, was also reported to improve predictive performance of the EWS when tested on a sample of post-operative patients following cardiac surgery (Chiu et al., 2020). This small body of research provides an early signal of potential modifications that might further improve the performance of NEWS, particularly in relation to a patient's requirement for supplemental oxygen. Given the computer modelling needed to generate an adjusted EWS, these modifications may be part of the direction of travel for NEWS as more organisations adopt EHRs.

In addition to the changes to $Sp0_2$ parameters, the conscious level criteria have been modified subtly in NEWS2 to include a score uplift for patients with acute confusion (Table 2.2). This modification is based on the rationale that deteriorating patients will often have changes in cerebration resulting in acute delirium (Royal College of Physicians, 2017; Spångfors et al., 2016). Early evidence from a retrospective cohort study suggests that this 'new confusion' score uplift

could increase the number of patients meeting calling criteria at medium and high risk scores, therefore increasing workload of those responsible for responding to deteriorating patients (Mohammed et al., 2019). However, at present there is limited evidence that this inclusion will improve the discriminatory performance of NEWS2 (Mohammed et al., 2019).

There is paucity of evidence for the specific inclusion of modified $Sp0_2$ parameters and the new confusion criterion in NEWS2. However, in the wider context there is a reasonably compelling evidence base for the role of NEWS in strengthening the afferent limb of the RRS. In several cohort studies (both retrospective and prospective) NEWS demonstrated good performance in predicting patients at risk of SAE in both medical and surgical settings.

2.4.4 Afferent Limb Failure (ALF)

In addition to a paper-based chart or electronic equivalent for recording vital signs, track-and-trigger tools provide guidance for clinical staff on what specific behaviours should be enacted in response to calling criteria being met (Lyons, Edelson & Churpek, 2018). Typically, having recognised abnormality within the vital signs and/or the EWS, staff are prompted to contact a more senior or expert clinician (escalation of care) within a specified timeframe (DeVita *et al*., 2006; Smith, 2010) using an appropriate mode of notification depending on the context e.g. a hospital pager system (DeVita et al., 2006; Johnston et al., 2014). To ensure that the level of the response is congruent with the patient's level of risk, some track-and-trigger systems incorporate a graded or tiered response protocol (Smith et al., 2019; Sprogis et al., 2017). In practical terms, this means that local responders (i.e. clinicians from the ward team) are contacted by bedside nursing staff when mild to moderate abnormalities in vital signs are detected, whilst external personnel (i.e. clinical specialists from outside of the ward) are targeted for those patients with significantly deranged vital signs (Lyons, Edelson & Churpek, 2018; Smith, 2010). For NEWS, the graded response aligns to the patient's level of risk which, as previously described, is determined by the aggregate score (Royal College of Physicians, 2017). Specifically, when a patient's NEWS reaches medium or high risk (NEWS$\geq$5) nursing staff are prompted to change their behaviour, increase frequency of monitoring, and escalate care to an appropriate clinician (Royal College of

Physicians, 2017). Despite international implementation of track-and-trigger systems over the past two decades, and a growing body of research supporting the predictive performance of NEWS, there is evidence that staff do not consistently change their behaviour when criteria are met (Credland, Dyson & Johnson, 2018; Sprogis et al., 2021b). Within the wider body of international literature this has been termed 'Afferent Limb Failure' (ALF) (Johnston et al., 2014; Trinkle & Flabouris, 2011; Sundararajan et al., 2021).

To report the impact of delayed RRS activation on patient mortality and morbidity, a cohort study was conducted in the USA (Barwise et al., 2016). All adult patients meeting calling criteria and triggering the RRS were included (n=1,725). Vital signs of patients who met calling criteria were reviewed for evidence of delay (defined as >1 hour between calling criteria being met and a call being placed). Outcomes were compared for patients with and without a delayed activation. Forty-three percent of the cohort had a timely RRS activation (n=748); 57% had a delayed activation (n=977). Delay in activation was independently associated with an increase in 30-day mortality, hospital mortality and hospital length of stay. In addition, those transferred to ICU following a delayed activation had higher ICU mortality, higher vasopressor requirements, and a trend towards increased ICU length of stay (Barwise et al., 2016). These findings are supported by more recent work conducted in the UK, where data were collected from patients with a persistent NEWS $\geq$ 7 (n=632) admitted to critical care from a ward (Whebell et al., 2021). The researchers concluded that a longer time interval between the elevated NEWS being recorded on the ward, and the patient's arrival in critical care (termed the 'score to door' time) was associated with an increase in critical care mortality (the primary outcome) (Whebell et al., 2021). Whilst limited by its retrospective single centre design, the findings here are consistent with earlier research (Boniatti et al., 2014; Calzavacca et al., 2010; Chen et al., 2009; Trinkle & Flabouris, 2011) broadly suggesting that ALF persists and is associated with poor outcomes for patients despite the introduction of track-and-trigger systems and objective calling criteria.

2.4.4.1 Lack of clear guidance for staff regarding what specific behaviours of the afferent limb should be enacted

For NEWS, the suggested behaviours that should be enacted in response to the aggregate score, and the associated degree of patient risk, were first reported in a strategic working party report by the National Early Warning Score Implementation Group (NEWIG) (Royal College of Physicians, 2012). This document, which was published to guide the roll out of NEWS across the UK, was subsequently updated when NEWS2 was released (Royal College of Physicians, 2017). Following its inception, NHS Trusts within the UK have used the content of the NEWSIG documents to populate their own local (i.e. Trust level) policy documents and protocols to direct staff afferent limb behaviour (Smith et al., 2019; Freathy et al., 2019). Two structured content analyses of local deteriorating patient policy documents from UK hospitals were conducted to elucidate how NEWSIG guidance had translated into local policy documents, and to report themes from documents purposively selected from different organisations (Smith et al., 2019; Freathy et al., 2019). Broadly, a high level of variation between local policies was reported even when organisations were using the same EWS tool. Further, the documents included within the analyses were often convoluted with frequent use of vague or ambiguous language (Smith et al., 2019; Freathy et al., 2019). More specific themes from across both publications were a lack of clear information regarding the specific timescale within which behaviours of the afferent limb should be enacted (Freathy et al., 2019; Smith et al., 2019), a lack of clarity regarding who should enact the different behaviours (e.g. RN or HCA) (Smith et al., 2019), and a lack of direction about the actions that RNs might perform between activating the efferent limb and the responder arriving (Freathy et al., 2019). An Australian group conducted an in-depth documentary analysis of all clinical documents and educational materials, from one health service, that related to the Urgent Clinical Review protocol for deteriorating patients (Sprogis et al., 2021a). Like findings from the UK work, the authors concluded that the instructions for staff were often vague and, at times, contradictory. They also reported that the documents did not accurately reflect the range of different practitioners who might respond to a deteriorating patient, nor provide guidance on who should adjust the calling criteria for patients with chronically disturbed physiology (Sprogis et al., 2021a).

Notwithstanding the paucity of literature, findings of this international work suggest that the quality of documentary guidance for staff regarding the precise afferent limb behaviours that they should enact is inconsistent and frequently non-specific. To increase the likelihood that these local policies and protocols lead to appropriate actions, the clinical behaviours recommended within these materials should be defined using language that is specific, concrete and actionable (Michie & Johnston, 2004; Grol et al., 1998; Michie & Lester, 2005; Freathy et al., 2019). Consequently, it is plausible that a lack of clear guidance for staff may be contributing to ALF. However, further empirical work is required to support this assertion.

2.4.4.2 Lack of staff compliance with EWS protocols

Having acknowledged ALF as a threat to patient safety, a body of literature has emerged with the broad aim of increasing understanding of where specifically within the sequence of staff behaviour ALF is occurring. A narrative review of the literature was published to report patterns of compliance with EWS tools and the associated escalation protocol (Credland, Dyson & Johnson, 2018). Due to heterogeneity of the existing evidence (both methodological and clinical), a meta-analysis of findings was not possible. The authors synthesised findings from seven studies conducted in the UK or Europe and identified three overarching themes related to EWS compliance 1.) *EWS calculation accuracy;* 2.) *Monitoring frequency;* 3.) *Clinical response* (Credland, Dyson & Johnson, 2018).

Regarding the theme *EWS calculation accuracy*, where paper EWS charts were used, aggregate scores were not consistently recorded and where the score had been calculated, inaccuracies were found due to missing vital signs data (Credland, Dyson & Johnson, 2018). In a more recent Danish study involving a large dataset (almost 3 million) of vital signs, 10% of NEWS records were found to have missing data (Pedersen et al., 2018a) further supporting the findings of this review. From one study included within the systematic review, an inverse correlation was found between high EWS and the accuracy of the aggregate score recorded on the chart, suggesting that higher scores are more likely to be calculated and/or recorded incorrectly (Kolic et al., 2015). These findings are broadly consistent with those of a Swedish study, where a sample of

patients' (n=598) vital signs and NEWS were reviewed for accuracy (Friman et al., 2019). In 134 cases, the NEWS was calculated incorrectly with nearly all of the incorrect scores being under-recorded (i.e. the NEWS being recorded as lower than it was) (Friman et al., 2019). Broadly, the problem of missing or inaccurately recorded vital signs has been reported as a global problem irrespective of variations in context (Al-Moteri et al., 2019; Pedersen et al., 2018a).

In relation to the theme *monitoring frequency*, it was found that a higher EWS did not consistently result in a decrease in time before the next set of vital signs were measured, suggesting that staff do not always follow EWS protocol and increase frequency of monitoring when the EWS is elevated (Credland, Dyson & Johnson, 2018). In one included paper, this delay in repeat monitoring of vital signs was reported as particularly noteworthy during the night (Hands et al., 2013). Omissions in the monitoring of vital signs were also reported from more recent research conducted in a neurological unit in Germany (Saar et al., 2021). In this single-site study, researchers conducted a structured retrospective chart review on a small sample of patients (n=100), with the broad aim of reporting the characteristics and frequencies of omitted nursing care activities. To identify omissions, researchers developed a list of expected care activities for each patient before crosschecking the care documented (i.e. appearing on EHR), with expected care. Across the sample, 1885 expected care activities were identified; 971(52%) of these were partially or fully omitted. In relation to the monitoring of vital signs, from 342 expected episodes of monitoring, 181 (53%) were omitted (Saar et al., 2021). The authors of this work acknowledge several limitations. Their study was dependent on the structure and quality of the clinical documentation, and on the skills of the single reviewer carrying out the chart reviews. The authors also acknowledge the limitations of extracting information from an EHR where the nuances of clinical care may not be fully reflected (Saar et al., 2021). Notwithstanding these limitations, the findings of this study overlap with those of Credland, Dyson and Johnson (2018), suggesting that vital signs are often not measured at the required frequency.

The *clinical response* theme related to escalation of care in response to the EWS. Delays were reported in escalation of care when the EWS was elevated, with some evidence of 'weekend

effect' (i.e. poorer responses on a Saturday and/or Sunday compared to a weekday) (Kolic et al., 2015). Like the theme of EWS calculation accuracy, there was a signal of the existence of a possible inverse relationship between an elevated EWS and the clinical response, implying that compliance with escalation protocols may reduce when the EWS is higher (Petersen et al., 2014). The conclusion that ALF involves failure to escalate as well as failure to monitor vital signs, is consistent with older research conducted in different healthcare systems (Odell, 2015; Tirkkonen et al., 2013; Shearer et al., 2012). It is also corroborated by more recent international work with retrospective study designs. A group of Australian researchers retrospectively analysed the vital signs of ward patients who had triggered RRS activation (n=200) (Sprogis et al., 2017). The hospital within which the study was conducted operated a two-tier efferent limb response. For patients with more minor abnormalities in vital signs, protocol dictated that staff should trigger an Urgent Clinical Review (UCR), whilst severe (and potentially more life-threatening) abnormalities prompted staff to call the Medical Emergency Team (MET) (Sprogis et al., 2017). A high proportion of patients (78.5%) met the lower threshold UCR criteria in the 24 hours preceding MET activation; 80.9% breeched multiple times. The medical records of 110 patients attending an ED in Australia were audited over a 2-week period (Connell, Endacott & Cooper, 2021). In 52 (47%) patients with deranged vital signs, escalation of care did not occur despite calling criteria being met. Escalation of care in the ED setting was not significantly impacted by workload, staffing, or patient complaint (Connell, Endacott and Cooper, 2021). Notwithstanding the limitations of small samples and retrospective designs, findings from these studies suggest that whilst staff have multiple opportunities to summon help for a patient with deranged vital signs, they do not consistently escalate in accordance with protocols.

2.4.4.3 The impact of Electronic Health Records on compliance with EWS protocols

The impact of EHR on compliance with EWS was reported as a sub-theme in a narrative review (Credland, Dyson & Johnson, 2018). Broadly, the EHR was found to improve compliance with EWS calculation accuracy, compared to paper-based charts, due to the automated nature of the systems (Credland, Dyson & Johnson, 2020). However, the use of EHR was not associated with consistent improvements in compliance with monitoring frequency or the clinical response to

an elevated EWS (Credland, Dyson & Johnson, 2018). This mixed picture of potential benefit from EHR in improving staff compliance with EWS is reflected in the wider literature. A retrospective population-based study was conducted on all patients (n=228) suffering a cardiac arrest in a single hospital in Sweden, in the 4-years that followed EHR implementation (Stevenson et al., 2016). The researchers identified shortfalls in the recording of vital signs which were 'fragmented' through various sections of the system and did not consistently align to how staff operate in clinical practice (Stevenson et al., 2016). This finding was supported by a qualitative study that aimed to explore the barriers to using an EHR for the recording of vital signs. Observation and semi-structured interviews were carried out with nursing (n=11) and medical (n=3) staff (Stevenson et al., 2018). Reported barriers were: lack of clear guidance for staff regarding how to record vital signs, display of vital signs in a clinically unhelpful format, and lack of adequate facilities leading staff to record vital signs on paper (using paper 'workarounds') rather than directly into the EHR (Stevenson et al., 2018).

To prompt nursing staff to enact the appropriate behaviour when a patient's vital signs are deranged or the EWS elevated, EHR systems may incorporate Best Practice Alerts (BPAs). Practically, these may be delivered in the form of an on screen 'pop up' that prompts staff to take a course of action when specific conditions are met. For example, in the context of NEWS, a pop up might appear prompting staff to call the RRT if a patient's aggregate score reaches 7 (Bedoya et al., 2019). A multi-site retrospective study with a pre-post design was carried out to examine the impact of the implementation of an EHR embedded NEWS and BPAs aligned to the NEWS graded response algorithm (Bedoya et al., 2019). In addition to reporting unplanned ICU admission and patient mortality, the researchers also examined whether nurses accepted or ignored the BPA when it appeared (i.e. confirmed in the EHR that they had taken the action prompted or not). No significant differences were identified in patient outcomes after the implementation of NEWS. Across both sites, over 175,000 BPA 'pop ups' were delivered by the EHR; these were ignored by nurses 86% of the time. In situations where the BPA was accepted, the patient was more likely to have a SAE (Bedoya et al., 2019). These findings suggest that nurses may be exposed to a high frequency of BPAs when using NEWS embedded within an EHR workflow, increasing the risk of

staff desensitisation and ‘alarm fatigue’ (Olsen et al., 2019). In this study, a nurse electing to ignore a BPA was considered an indicator that they did not deem the prompted action necessary. The association between an accepted BPA and an adverse patient outcome, implies that nurses may have been using the BPA as part of a broader decision-making process. However, the design of this study did not permit a deeper exploration of this. Further research with a qualitative design, could expand the body of knowledge regarding how BPAs are perceived by nurses and whether they impact on decision making and behaviour.

To explore further the potential of bedside systems that both measure vital signs automatically and upload the data into the EHR, a retrospective before-and-after study was conducted on a cohort of patients admitted to a surgical high dependency unit in the Netherlands (Mestrom et al., 2019). During the control period, nursing staff measured patients’ vital signs and entered them manually into an EWS embedded within an EHR; whilst during the intervention period a fully automated system that both measured and recorded all vital signs and calculated the EWS was used. The reported outcomes were both operational (e.g. accuracy and completeness of vital signs and EWS records, and compliance with EWS monitoring frequency protocol) and clinical (e.g. ICU re-admission and 28-day mortality). Significant improvements were reported during the intervention period in the operational outcomes including fewer missing vital signs within the EWS, more consistent recording of respiratory rate and conscious level, and greater compliance with EWS monitoring frequency protocol (Mestrom et al., 2019). However, no statistically significant differences in patient outcomes were reported between the control and intervention periods. In addition to the risk of missing data from the retrospective design, the study was also under powered for the outcome of patient mortality making this finding equivocal. The study was also conducted in high dependency area with a small number of beds, making it unclear if these findings could be generalised to a larger general ward setting.

Whilst fully automated measurement and recording of vital signs may improve completeness of EWS records and compliance with monitoring frequency protocols, less is known about the role of automated escalation (i.e. computer-generated efferent limb activation when

threshold criteria are met rather than typical staff-led activation). A single centre service evaluation was conducted in the USA in an organisation where staff-led escalation was the current practice, but an automated activation system was being considered for implementation (Fagan et al., 2012). A large dataset of vital signs (n=545,773) from a sample of hospitalised adult patients (n=3,843) were reviewed. There were 120 (staff led) RRT activations, of which 114 (95%) met threshold criteria. There were 1,111 occasions where threshold criteria were met, when the RRT was not called by staff but would have been activated by an automated system; 2612 patients did not meet threshold criteria or trigger RRT activation. Overall, 4.2% of patients had a SAE. The patients triggering RRT activation had the highest frequencies of SAE; patients not meeting threshold criteria or having RRT activation had the lowest. Whilst this study was not conducted in the UK where NEWS is used, it does highlight the importance of bedside staff using clinical judgement alongside calling criteria, when determining the need for escalation to the RRT. Excessive automated escalations in patients who come to no harm has the potential to undermine the system, overwhelm responders and increase 'alarm fatigue' (Fagan et al., 2012).

Published review papers suggest that ALF is multi-factorial and may be the consequence of human error and deviations in staff behaviour across the continuum of afferent limb behaviour (Credland, Dyson & Johnson, 2018; Downey et al., 2017), irrespective of whether the EWS in use is paper-based or embedded within an EHR. Despite the potential of EHR to enhance the RRS and strengthen the afferent limb (Wilson & Khansa, 2018), existing evidence suggests that transferring EWS tools from paper into an EHR platform is not straightforward. Similarly, fully automated escalation accompanies a risk of overwhelming responders with referrals, creating alarm fatigue and potentially 'blunting' the response to the most vulnerable patients (Olsen et al., 2019). Further research is required, particularly in the UK context, to understand how EHR influence nursing staff working in ward settings when they are enacting behaviours of the afferent limb.

2.4.4.4 Inaccuracies in the measurement and recording of respiratory rate

It has been noted in the literature, that vital signs are frequently measured using mobile electronic monitoring devices (Ede et al., 2019; Smith & Aitken, 2016; Baig et al., 2021). Such

devices may be used to obtain intermittent measurements of vital signs required for NEWS including blood pressure, pulse rate, and peripheral oxygen saturations. However, these devices do not typically measure a patient's respiratory rate or conscious level (Woodley Equipment Company Ltd, n.d.). As such, these parameters must be measured visually (i.e. 'manually') by the healthcare practitioner during episodes of patient monitoring (Badawy et al., 2017; Mohammed et al., 2019). In adult patients hospitalised for a range of clinical diagnoses, respiratory rate was found to be an independent predictor of adverse events (Fine et al., 1997; Escobar et al., 2012; Fieselmann et al., 1993). Despite the evidence of the importance of respiratory rate in detecting patients who are potentially deteriorating, there are numerous reports of respiratory rate measurements being inaccurate with a tendency towards under recording (Badawy et al., 2017; Lafonte, Cai & Lissauer, 2019; Rimbi et al., 2019). A systematic review was conducted to elucidate further the potential sources of inaccuracy in the manual measurements of respiratory rate in adult patients (Kallioinen et al., 2020). The review included 49 studies from 16 different countries. Broadly, sources of inaccuracy were reported at the point of measurement (e.g. counting the respiratory rate over 15 seconds rather than for a full minute) and at the point of recording, where staff were susceptible to bias from previously recorded measurements (so called value bias) (Kallioinen et al., 2020). Authors of this review concluded that some nursing staff may have gaps in their knowledge regarding the correct procedure for measuring respiratory rate, and that education may be part of the solution. However, they also acknowledge that the barriers to nursing staff correctly measuring and recording respiratory rate are likely to exceed gaps in knowledge alone, and that any interventions targeting these behaviours should be tailored to the local organisational and cultural context (Kallioinen et al., 2020).

2.4.4.5 Barriers to nursing staff' compliance with EWS

A considerable number of primary research and review papers have been published with the broad aim of improving understanding of how nurses use EWS tools to monitor patients and escalate care, and to report potential barriers to EWS compliance. Reported barriers to EWS compliance in the existing literature are: poor knowledge of patient assessment and/or poor understanding of clinical deterioration (Treacy & Stayt, 2019; Massey, Chaboyer & Anderson,

2017); poor staffing levels and/or excessive workloads (McGaughey et al., 2017; Padilla, Urden & Stacy, 2018); a lack of continuity of care (i.e. nursing staff not having the opportunity to care for the same cohort of patients over an extended period) (Ede et al., 2021); difficult and convoluted inter and intra-professional communication pathways (Wood, Chaboyer & Carr, 2019; Chua et al., 2019a, 2021a); and conflicting clinical priorities (e.g. balancing a patient's need for sleep against the requirement for vital signs monitoring at night) (Hope et al., 2018). In comparison, education about the RRS, and clinical experience are reported as important enablers for staff in the context of recognising and responding to deteriorating patients (Olsen et al., 2019; Chua et al., 2021b).

Escalation frequently occurs late in the patient's trajectory of deterioration, and only once significant aberrations in vital signs are evident (Treacy & Stayt, 2019). Potential barriers that may explain these specific escalation delays have been reported as perceived hierarchy within and between professional groups (Allen, Elliott & Jackson, 2017; Ede et al., 2021; Currey, Allen & Jones, 2018); lack of self-confidence amongst nursing staff to raise the alarm (Wood, Chaboyer & Carr, 2019; McGaughey et al., 2017; Chua et al., 2017); negative past-experiences of escalation (Padilla, Urden & Stacy, 2018; Petersen, Rasmussen & Rydahl-Hansen, 2017); and concerns about a lack of permission from the primary medical team to escalate care to other responders (Olsen et al., 2019; Azimirad et al., 2021). Chua *et al* (2017) elaborate, describing how staff 'stall' escalation by spending considerable time justifying their decisions to escalate, communicating with colleagues, and seeking affirmation from more senior nurses. Communication between staff and patients has also been highlighted as a potential barrier, particularly where patients are unable to express new symptoms, or subjective feelings of deterioration, due to cognitive impairment (Treacy & Stayt, 2019).

All review papers cited included studies where qualitative methods were used, often underpinned by grounded theory methodology, to broadly describe the barriers to nursing staff enacting behaviours of the afferent limb. Afferent limb failure is increasingly reported to be associated with inconsistent behaviour of nursing staff (Treacy & Stayt, 2019; Padilla, Urden & Stacy, 2018). Consequently, in order to optimise the afferent limb and to drive more consistent

responses to deteriorating patients, there is a requirement for nursing staff to change their behaviour (Foley & Dowling, 2019; Al-Moteri et al., 2019; Oglesby, Sterne & Gibbison, 2020). A single publication was identified from Australia where a theoretical framework of behaviour change (the Theoretical Domains Framework (TDF)) was applied to explore barriers and enablers of recognition and response to patient deterioration (Walker et al., 2021). Seven themes (representing barriers/enablers) were synthesised and linked to ten of the 14 TDF domains: *Social Professional Role and Identity; Knowledge; Memory, Attention and Decision Processes; Environmental Context and Resources; Social Influences; Beliefs about Capabilities; Beliefs about Consequences; Reinforcement; Skills; Emotion* (Walker et al., 2021). This research provides methodological precedent for using theory to systematically examine determinants of afferent limb behaviour. The healthcare practitioners sampled were RNs, doctors, and allied health professionals (e.g. physiotherapists). No un-registered staff from the nursing workforce (e.g. healthcare assistants (HCAs)) participated. Given the central role of HCAs in enacting behaviours of the afferent limb in the UK context (Mackintosh, Humphrey & Sandall, 2014; Smith & Aitken, 2016; Ede et al., 2019), the absence of HCAs (or equivalent) within the sample potentially limits transferability of findings. Whilst the application of the chosen theoretical frameworks is clearly reported, the precise behaviours of interest have not been specified. Consequently, the reported TDF domains reflect broad barriers and enablers to the recognition and response to deteriorating patients rather than the determinants of *specific* behaviours of the afferent limb. Should this work progress to intervention development and evaluation, the poor specification of target behaviours could impose challenges related to the selection of suitable intervention content, and the measurement of behaviour and behaviour change (Presseau et al., 2019).

2.5 The Efferent Limb of the Rapid Response System

Once deterioration has been detected and escalation has taken place, an organised response is required to address the mismatch between the patient's needs and the care available in their existing setting (Lyons, Edelson & Churpek, 2018). This 'response arm' is represented in the conceptual model of the RRS as the efferent limb (Figure 1.1) (DeVita et al., 2006). As previously described, the clinicians targeted by bedside staff to respond as part of the efferent limb

may vary depending on the patient's level of risk (a so-called graded response). Examples of this graded response include the low, medium and high-risk response prompted by the NEWS escalation algorithm (Royal College of Physicians, 2017) or the two-tier UCR versus MET review criteria, used to guide the efferent limb response in Australia (Sprogis et al., 2017). In practice, the efferent limb response typically involves members of the primary medical team and/or a designated peripatetic team of clinicians with specific expertise in management of acute/critical illness (Lyons, Edelson & Churpek, 2018; Rihari-Thomas et al., 2017). Internationally, there is a degree of variation in both the composition of these teams and nomenclature (DeVita et al., 2006; Johnstone, Rattray & Myers, 2007). Use of terms Rapid Response Team; Medical Emergency Team; Critical Care Outreach Team, and ICU liaison team are reported within the international literature (Churpek et al., 2017; DeVita et al., 2006; Smith & Aitken, 2016; McIntyre et al., 2019). Team membership can include registered nurses, physiotherapists (typically in the UK), pharmacists, respiratory therapists (in North America) and doctors of varying degrees of seniority (Lyons, Edelson & Churpek, 2018; DeVita et al., 2006; Rihari-Thomas et al., 2017). In the UK, the first line response is typically nurse-led and delivered by a Critical Care Outreach Team (CCOT). The inception of CCOT was driven largely by a Government white paper, published over two decades ago, which prompted re-organisation of critical care services to ensure that patients across acute hospitals benefit from critical care expertise (Department of Health, 2000).

Given the level of international variability in the delivery of the efferent limb of the RRS, a prospective, cohort study was conducted to benchmark the activities of these teams operating in acute hospitals (n=51) across Europe, UK, USA and Australia (Bannard-Smith et al., 2016). The researchers studied the features, management, and immediate outcomes (i.e. within 24 hours) of patients (n=1,188) who were escalated to the local efferent response team (hereafter referred to as RRT but also including MET and CCOT). Broadly, 1 patient in 10 referred to RRT died within 24 hours; 1 patient in 4 had new limitations of therapy put in place (e.g. had a 'do not attempt resuscitation' decision made); 1 patient in 4 were transferred to the ICU (Bannard-Smith et al., 2016). The finding that approximately 25% of patients seen by RRT were transferred to ICU, was consistent with results from a systematic review of the literature (Tirkkonen, Tamminen & Skrifvars,

2017). In the UK centres, the process of transferring and admitting a patient to the ICU took four times longer than other centres (Bannard-Smith et al., 2016). This delay in admission may be explained by the nurse led CCOT model, which typically requires the CCOT nurse to liaise with a senior ICU doctor, before a decision to admit is made. In comparison, where the team is medically-led the decision to admit could be immediate (Bannard-Smith et al., 2016). Reduced ICU bed availability is an alternative explanation for this finding. From pooled data, it has been estimated that there are 3.5-7.4 ICU beds per 100,000 people in the UK (Prin & Wunsch, 2012). In all other countries included within this benchmarking work, more ICU beds were reported with the same denominator (20.0-31.7 in the USA; 8.0-8.9 in Australia and 6.7-8.9 in Denmark) (Prin & Wunsch, 2012). As such, it is plausible that delays in ICU admission within the UK context relate to the scarcity of ICU beds rather than the team composition.

2.5.1 The impact of Rapid Response Teams

Despite the pragmatic appeal of RRT in delivering the efferent limb of the RRS, the evidence underpinning the impact of these teams on patient outcomes is contradictory. Hillman *et al* (2005) conducted a prospective cluster-randomised trial (The MERIT study) to report the impact of RRT implementation on cardiac arrest, unexpected death, or unplanned ICU admission in the six months following RRT implementation. Twenty-three Australian hospitals from urban, suburban, and rural areas were enrolled. In intervention hospitals (n=12), medical and nursing staff received education on RRT calling criteria before the team were activated. In control hospitals (n=11), the 'usual care' emergency response remained as an alert for cardiac arrest but with no specific calling criteria or response for deteriorating patients. No statistically significant differences between intervention and control hospitals for the incidence of cardiac arrest (p=0.306), unplanned ICU admission (p=0.899), or unexpected death (p=0.564) was found, although there was an overall reduction in the frequency of SAE in both intervention and control hospitals during the study period. Whilst control hospitals received no formal education about RRT, it is acknowledged that information about the RRS had become available in the public domain (Hillman et al., 2005), potentially leading to contamination of staff behaviour in control hospitals. Despite limitations, the findings of MERIT study reflect general themes across a very small body of randomised studies.

Research in this field has predominantly been observational, retrospective, and single-centre limiting the wider generalisability of findings (Polit & Beck, 2018).

The lack of high-quality randomised studies in the area was reflected in a Cochrane systematic review that aimed to report the impact of RRT on hospital mortality (primary outcome), ICU admission, and hospital length of stay (secondary outcomes) (McGaughey et al., 2007). The authors identified a limited amount of research in this area and highlighted that the studies available (n=2) were methodologically weak. In addition, the research included within the review had contradictory findings. One (UK-based) study identified reduced mortality in the intervention (RRT) arm compared to the control (Priestley et al., 2004); whilst the second (Australian) study identified no such benefit (Hillman et al., 2005). Due to the methodological flaws and contradictory findings, the authors of the Cochrane review concluded the benefit of RRT to be unproven (McGaughey et al., 2007). These equivocal conclusions regarding the benefit of RRT were supported by the findings of a meta-analysis published in 2010. Chan *et al* (2010) included studies (n=18) that used randomisation, or a prospective design, and reported that whilst RRT implementation significantly reduced the number of adult cardiac arrests it did not have a significant impact on patient mortality (Chan et al., 2010).

Benefits of RRT have been identified in two recent systematic reviews and meta-analyses. Specifically, a reduction in hospital mortality (RR 0.87) ($p<0.001$) and cardiac arrests (RR 0.65) ($p<0.001$) in the adult patient population was reported (Maharaj, Raffaele & Wendon, 2015). Further, RRT implementation had a 'protective effect' for outcomes of mortality (Risk Ratio 0.85; 95% CI 0.76-0.94) and cardiac arrest (Risk Ratio 0.65; 95% CI 0.49-0.87) (Rocha et al., 2018). Despite these positive findings, the authors highlighted the ongoing limitations of the evidence base which is broadly of low quality, with high risk of bias and considerable heterogeneity in both the RRTs examined and the methods used to report their effect (Rocha et al., 2018). As such, they suggest that RRT implementation should be a level B or 'moderate-level' recommendation in clinical guidelines (Guyatt et al., 2008).

Recent data suggests that the RRT may reduce mortality and/or cardiac arrest (Rocha et al., 2018; Maharaj, Raffaele & Wendon, 2015; Jung et al., 2016). However, patients will only benefit from these specialist teams if they are activated and mobilised to the patient's location (Lyons, Edelson & Churpek, 2018). As such, this potential benefit is contingent on more proximal behaviours (i.e. those of the afferent limb) being enacted as expected.

Given the reported limitations of a 'reactive RRS' model (i.e. where efferent limb responders attend in response to a call from ward staff), a group of researchers hypothesised that a 'proactive RRS' model (i.e. where efferent limb responders screen for patients with elevated EWS and proactively attend) could reduce adverse events (Danesh et al., 2019). A controlled before and after study was conducted to report the effect of novel proactive RRT rounding on unplanned admissions to ICU. During the control period, nursing staff were required to place a call for the RRT, via the hospital pager system, when a patient met pre-existing calling criteria (termed traditional or manual activations). Subsequently, an EWS embedded within the EHR was implemented as part of the intervention. During the intervention period, an RRT nurse screened EWS trends in all patients outside of ICU for evidence of deterioration. Using these data, the RRT nurse generated a rounding list, and conducted proactive rounds, initiated interventions, and liaised with ward-based staff. The RRT nurse also responded to any manual RRT activations. During the intervention period, a 40% reduction in unexpected ICU admissions was reported compared to the control period, suggesting that proactive rounding of RRT staff may impact positively on patient outcomes (Danesh et al., 2019). Similar positive findings associated with proactive RRT rounding were reported from an alternate study where ward-based cardiac arrests decreased by 65% following initiation of proactive rounding by a RRT nurse (Winterbottom & Webre, 2021). Despite promising findings, both studies were single centre and conducted in the USA. In the wider international context, there is paucity of literature in this area. Further research is required to support the generalisability of findings and to evaluate the organisational and economic implications of re-structuring the RRS in this way.

2.5.1.1 Outcomes for patients for whom the Rapid Response Team is activated

An additional body of literature has emerged reporting the characteristics and broader outcomes of patients who trigger the RRT whilst in hospital. A group of reserchers from Finland and Australia conducted a systematic review to report outcomes of patients reviewed by RRTs, with a specific focus on the initiation of Limitation of Medical Treatment Orders (LMTO), transfer to ICU, and mortality (in ICU, in hospital, at 30 days, and at 180 days) (Tirkkonen, Tamminen & Skrifvars, 2017). Studies eligible for inclusion (n=29) were conducted in the UK, the USA, Australia, Europe, and the United Arab Emirates, and included a total of 157,383 RRT activations (a median of 16 activations per 1000 hospital admissions). On average, 1 in 12 patients had a new LMTO initiated; 1 in 4 were transferred to the ICU, and a third of the patients transferred to ICU died there. The median hospital mortality rate for patients triggering the RRT was 26% (with a broad range, 12-60%) (Tirkkonen, Tamminen & Skrifvars, 2017). This figure is broadly consistent with the findings of a more recently published retrospective single centre study conducted in Australia, where the mortality of older (≥ 75 years) patients, triggering RRT review, was reported to be 30% (Wijesundera et al., 2021). Findings of a Finnish study, imply that older patients (≥ 75 years) who trigger the RRS may have higher mortality than younger patients (≤ 75 years) (Tirkkonen, Setälä & Hoppu, 2017). From the cohort of patients (n=1372) who were attended by the RRT, 449 (33%) were older than 75 years. Older patients had higher mortality than younger patients at 30 days (33% versus 21%, $p<0.001$), 180 days (46% versus 31%, $p<0.001$), and at 1 year (54% versus 35%, $p<0.001$). Older patients were also more likely to have a LMTO initiated than younger patients (13% versus 4.7%, $p<0.001$), and less likely to be transferred to ICU (15% versus 29%, $p<0.001$) (Tirkkonen, Setälä & Hoppu, 2017). Findings from this prospective study, support findings of a systematic review (Tirkkonen, Tamminen & Skrifvars, 2017) which highlights the relative vulnerability of all patients for whom the RRT is activated. However, there is evidence that older patients may have even higher mortality than younger patients.

Another potentially vulnerable cohort of patients, identified from the literature, are those with haematologic malignancy (e.g. leukaemia, myeloma, lymphoma). The outcomes of a sample

of patients (n=401) who received treatment in a Canadian hospital for haematologic malignancy, over a 4-year period, who required RRT input, were examined (Gershkovich et al., 2019). The researchers here reported an in-hospital mortality of 42%, compared to 30% in patients without haematologic malignancy. One hundred and forty five patients (45%) were transferred to ICU, 42% of these patients died. Multiple RRT activations was independently associated with in-hospital mortality (OR 2.45, 9% CI 1.63-3.69) (Gershkovich et al., 2019). Patients with haematologic malignancy are vulnerable to complications from their underlying disease, and from the treatments that they recieve (e.g. cytotoxic drugs and immunotherapies). This may explain why the morality of this specific cohort is higher than other patient cohorts (Tirkkonen, Tamminen & Skrifvars, 2017; Zhang et al., 2021; Austin et al., 2014; Barocas et al., 2014).

Findings of a systematic review and from other pieces of primary research, suggest that mortality for patients reviewed by the RRT is high, and may be particularly high in older patients or those with a specific diagnosis of haematoligic malignancy. From the systematic review, a knowledge gap was identified in that no studies included in the review measured functional or quality of life outcomes for patients who required RRT activation but survived (Tirkkonen, Tamminen & Skrifvars, 2017). Whilst there is a signal that mortality for patients reviewed by the RRT may be high, further research is required in order to understand the morbidity and qualty of life outcomes for this vulernable cohort of patients, and if/how the RRT impacts on these outcomes.

2.6 Interventions to mitigate sub-optimal care of deteriorating patients

Arguably, the most ubiquitous intervention to reduce sub-optimal care of the deteriorating patient has been implementation of the RRS itself. Concurrent implementation of afferent and efferent limb interventions (e.g. a track-and-trigger tool plus a rapid response team) has made it extremely difficult to tease out the precise impact of these discrete interventions, each of which is a complex intervention in its own right (Downey et al., 2017; Hogan et al., 2019). Further, the widespread implementation of RRS internationally means that the equipoise required for multi-centre studies with experimental designs (i.e. randomised controlled trials) is now lacking.

Consequently, attention has turned to opportunities for ‘natural experimentation’ where naturally occurring variations within and between organisations are exploited for research purposes (Hogan et al., 2019).

The potential span of RRS interventions across both the afferent and efferent limbs was highlighted in a *post-hoc* evaluation of data derived from a multi-centre stepped wedge, cluster, randomised controlled trial conducted to evaluate the efficacy of a multi-site intervention in Belgium (Haegdorens et al., 2019). Specific intervention components related to the afferent limb were the delivery of NEWS (in both paper-based and electronic form), face-to-face staff education on the use of NEWS, and face-to-face staff education on a tool to structure and enhance communication (to facilitate escalation of care). The intervention component related to the efferent limb was a pragmatic medical response protocol, linked to the NEWS calling criteria, which was ‘nested’ within existing systems and processes within each hospital (a specific RRT was not implemented as part of the evaluation) (Haegdorens et al., 2019). A large cohort of patients were included in the study (n=60,956); 32,722 patients were in the intervention group. In 668 patients, vital signs were collected before a SAE. In the intervention group, patients who were clinically stable (according to NEWS criteria) had vital signs monitored less frequently, whilst those who were deteriorating had more frequent vital signs. This finding contradicts the findings of other work (Lee et al., 2018a), where EWS implementation has been associated with increased frequency of all patient monitoring. However, the authors reported that this behaviour was consistent with the intervention, as shifting resources away from stable patients towards more unwell patients was emphasised in education sessions (Haegdorens et al., 2019). The researchers also found a significant increase in the recording of all six vital signs parameters in the intervention group compared to the control (mean number of vital signs per monitoring episode 5.77 versus 3.07 ($p<0.001$)). In relation to the impact on patient outcomes, a significant negative association between NEWS protocol compliance and unexpected death was reported. This result remained significant when adjusted for patient age and co-morbidity index. Findings here suggest that there may be a ‘dose-dependent’ relationship between NEWS protocol compliance and SAE, with ‘higher doses’ of NEWS reducing the likelihood of unexpected patient death. The validity of these data are limited by the *post-hoc*

analysis, which increases the risk of spurious associations being identified (Polit & Beck, 2018; Davey Smith & Ebrahim, 2002).

The presence of a potential ‘dose response’ between the delivery of a RRS intervention and SAE was also reported in an older publication from an Australian group (Mitchell et al., 2010). Here, a before-and-after intervention trial was conducted to assess the efficacy of an intervention that included a newly designed track-and-trigger tool, a structured education programme incorporating e-learning and simulation (i.e. use of manikin-based role-play), and a formalised escalation protocol and response team. The researchers reported a 72% relative reduction in unexpected ICU admissions and an 82% relative reduction in unexpected deaths in general medical and surgical patients following introduction of the intervention (Mitchell et al., 2010). These findings, the weight of which are enhanced by the prospective study design, are favourable and broadly suggest a positive impact from the RRS intervention. However, it was noted that the efferent limb response team was not activated for a significant number of patients who met criteria for escalation of care in both the control and experiment sub-groups (Mitchell et al., 2010). This finding underscores the potential inconsistencies in staff afferent limb behaviour, even when the RRS is in place.

Both multi-faceted interventions reported here included components that spanned the afferent and efferent limbs of the RRS. Common to both, was a lack of clear reporting of the process of intervention development. Specifically, it is unclear how certain intervention components were selected, if the intervention components were adjusted for context, if any were directed towards specific barriers and, if so, which specific barriers the intervention components were targeting. It is also unclear precisely how all the intervention components were delivered in practice. Consequently, despite some favourable findings, replication of these interventions in different settings and with different populations would be challenging (Eccles et al., 2007; Craig et al., 2017).

2.6.1 Interventions for afferent limb failure (ALF)

Behaviours of the afferent limb remain problematic despite evidence underpinning the implementation of RRS as a system-wide intervention to mitigate sub-optimal care (Haegdorens et al., 2019). Specifically, nurses' compliance with monitoring and escalation protocols remain inconsistent (Downey et al., 2017; Friman et al., 2019; Findlay et al., 2012; Credland, Dyson & Johnson, 2018). To address the pervasive problem of afferent limb failure, more targeted interventions have been developed with the broad aim of strengthening underpinning components of the afferent limb to mitigate ALF. Notwithstanding the implementation of the broader (i.e. system-level) interventions, more targeted interventions (i.e. individual-level) reported in the literature are: 1.) tools to structure and enhance communication 2.) educational packages targeting ward staff (Hogan et al., 2019).

2.6.1.1 Tools to structure and enhance communication

Ineffective or poor communication has been reported as a potential barrier to nursing staff escalating care for deteriorating patients in multiple published review papers (Treacy & Stayt, 2019; Wood, Chaboyer & Carr, 2019; Massey, Chaboyer & Anderson, 2017; Olsen et al., 2019; Chua et al., 2019a). As ward-based doctors are frequently the first contact as part of the graded response escalation algorithm (Royal College of Physicians, 2017; Sprogis et al., 2017), existing research has tended to focus on communication between nursing staff and doctors; a relationship that can be challenging and is often complicated by workplace hierarchy (Allen, Elliott & Jackson, 2017; Chua et al., 2017; Olsen et al., 2019; Ede et al., 2021). Poor communication between nurses and doctors may be compounded by a mismatch in expectations regarding the type and volume of information that is exchanged in relation to deteriorating patients. In one interview-based study where both RNs and junior doctors were sampled, nurses reported their communication about deteriorating patients to be effective and not lacking in key information. By comparison, doctors perceived nurses' communication to be 'long winded', lacking in focus, and reported difficulties in identifying the exact issues from the information provided (Chua et al., 2019a). Considering these inconsistencies, attention has turned to specific communication tools that may be used to structure

information, enhance communication, and standardise practice (Payne et al., 2012). One such tool that is commonly cited within the academic literature is the SBAR tool (where SBAR abbreviates Situation, Background, Assessment, Recommendation) (De Meester et al., 2013; Müller et al., 2018).

The extensive diffusion of the SBAR tool into clinical practice is reflected by its inclusion as a discreet element of a broader RRS intervention (Haegdorens et al., 2019) and reports of its application in other healthcare systems and clinical settings (Cornell et al., 2013; Pucher et al., 2015; Burger et al., 2017). Further, in a survey that was distributed to 171 acute UK hospitals and returned by 139, 122 hospital (88%) reported using SBAR as the predominant communication tool (Hogan et al., 2019).

To report the impact of SBAR implementation on patient outcomes, a systematic review was conducted (Müller et al., 2018). Of the 11 studies that met inclusion criteria, eight were conducted in North America and three were conducted in Europe. Most of the studies used a before-and-after design with only one RCT identified. Measured patient outcomes were numerous (n=26) and varied across the studies ranging from general outcomes (e.g. incidence of adverse events) to more specific outcomes (e.g. incidence of falls or medication-related errors). Findings from the implementation of SBAR were also varied and included significant improvements in some outcomes (n=8); improvements in some outcomes without a statistical test (n=11); no effect on outcomes (n=1), and an increase in adverse events (n=1). Broadly, the evidence of effect of SBAR implementation on patient outcomes remains equivocal due to contradictory findings and poor-quality evidence. This conclusion is consistent with the findings of older systematic reviews in this space, where the broad aim has been to evaluate the efficacy of communication interventions including, but not limited to, tools such as SBAR (Robertson et al., 2014; Foster & Manser, 2012). Authors of these reviews also emphasised the generally poor design of the studies included and the accompanying susceptibility to multiple forms of bias and confounding (Robertson et al., 2014; Foster & Manser, 2012).

Techniques used to translate the SBAR tool into practice were also varied across the different studies included with the most recent systematic review (Müller et al., 2018). Reported approaches included combinations of training, group discussions, role play and the deployment of *in situ* prompts (e.g. SBAR stickers by the telephone, posters, pocket cards) (Müller et al., 2018). From the review paper, it is unclear which, if any, of these techniques and/or modes of delivery (or combinations thereof) resulted in more effective and/or consistent use of the SBAR tool in practice.

Despite the pragmatic appeal of tools to structure and enhance communication (i.e. SBAR), the evidence underpinning their use is largely methodologically weak and heterogeneous with varied outcome measures. Studies included within published systematic reviews, have focused broadly on the application of SBAR in a variety of different settings and with different forms of communication including general staff 'handovers' or 'handoffs' in person and on the telephone (Müller et al., 2018; Robertson et al., 2014). As such, it is difficult to tease out which findings are relevant to communication that relates specifically to a deteriorating patient. The reported methods of implementation used to translate the SBAR tool into practice are equally varied with no consideration of how the specific implementation approaches might have impacted on findings (positive or null).

2.6.1.2 The role of education in addressing afferent limb failure

A mixed-methods systematic review was conducted, to report the nature and impact of educational interventions that broadly aimed to improve care of deteriorating patients (Connell et al., 2016). Twenty-three studies from UK, USA, Australia, Singapore, and Europe met inclusion criteria (20 quantitative; 2 mixed methods; 1 qualitative). Effectiveness of the educational interventions were measured using three types of outcomes: learner outcomes, patient outcomes and system outcomes. Duration of the educational interventions ranged from 25 minutes to 45 hours with a mean time of 8 hours. Various teaching and learning modalities were employed across educational interventions. All interventions included traditional didactic classroom teaching, blended with combinations of paper-based scenarios without simulation, e-learning, case studies, and simulation. Medium to high fidelity simulation (fidelity refers to the degree of 'realism' in the

simulation context) was used in 87.5% of the educational interventions. A high proportion of the studies reviewed (n=21) reported a positive impact from the educational intervention. Many studies included within the review, used indirect outcome measures (i.e. self-reported confidence or competency) to evaluate the impact of the intervention. This type of measure is particularly prone to reporting bias, and the predictive validity of these measures in relation to actual clinical performance remain questionable (Liaw et al., 2012, 2015). A single centre Australian study with an educational focus demonstrated some broadly positive findings but was subject to similar methodological limitations as the research synthesised within this systematic review. Here, the impact of a 'multi-modal' educational intervention on nurses' recognition and response to deteriorating patients was examined (Duff et al., 2018). A convenience sample of nursing staff (n=60) were recruited to receive the intervention which included a workshop involving e-learning modules, a simulation exercise covering deteriorating patient assessment and immediate intervention, and ongoing clinical coaching in the participant's own clinical environment. Participants completed a survey on 4 separate occasions: 1 month prior to the workshop, immediately pre and post workshop, and 2-3 months post workshop. The survey included questions related to demographics, perceived ability to recognise and respond to deteriorating patients and communicate with colleagues, and impact of the intervention on technical and non-technical skills in relation to deteriorating patients (Duff et al., 2018). Broadly, participants reported that engagement in this multi-modal educational strategy improved their performance in recognising and responding to deteriorating patients (Duff et al., 2018). Notwithstanding the limitations of using participant self-reporting to evaluate outcome, the absence of a comparison group makes it impossible to identify if the positive outcomes reported relate to the intervention or just reflect improvements over time (Polit & Beck, 2018).

Only a small number of studies included within the systematic review (Connell et al., 2016) evaluated the impact of the intervention on patient care (n=4) and only one study attempted to associate measurable patient outcomes to the educational intervention (Fuhrmann et al., 2009). This study did not show any positive effect on patient mortality at 30 or 180 days as a result of the

educational intervention, nor was it able to improve nurses' awareness of the deteriorating patient (Fuhrmann et al., 2009).

A further systematic review was conducted with more stringent inclusion criteria to report the impact of educational interventions on nurses' knowledge, confidence, and clinical performance specifically in relation to the use of an EWS (Saab et al., 2017). Ten studies reported across 11 publications met inclusion criteria; one study was quasi-experimental; five used a pre-and-post-test design; four were RCTs. The EWS educational interventions reported within the included studies were varied and included one or more of the following: face-to-face training; small group discussions; e-learning; manikin-based simulations; computer-generated (virtual reality) simulations. Broadly, EWS educational interventions were associated with short term improvements in nursing staff performance in documentation of vital signs and the accurate calculation of an EWS. However, several interventions were reported to have little or no effect on nurses' ability to detect deterioration, to escalate care, or to use a tool to structure communication (e.g. SBAR) (Saab et al., 2017). Broadly, the authors concluded a mixed picture of findings with a lack of high-quality evidence to support educational interventions in this context. In particular, it is noteworthy that in several of the studies reviewed, the effectiveness of the intervention was determined by an instrument designed by the research team with no reporting of the reliability or validity of the assessment tool (Saab et al., 2017).

The exact processes used to develop the EWS educational interventions included within this review are poorly reported (Saab et al., 2017). Given the absence of any clear reporting of how the intervention content was selected and operationalised, it is plausible that these interventions were developed pragmatically or intuitively (i.e. based on the researcher's perception of what the barriers were) rather than targeting specific barriers reported by the intervention recipients. Similar to the limitations identified in the reporting of SBAR interventions (Müller et al., 2018), the lack of clear reporting here makes it difficult to identify which (if any) particular intervention components were associated with a change in staff behaviour and which were not.

Broadly, the implementation of tools to enhance and structure communication, and educational packages appear to improve staff self-reported confidence and competency in recognising and responding to deteriorating patients. However, there is a lack of high-quality evidence that these interventions lead to sustained behaviour change in clinical practice nor that these interventions result in improved patient outcomes. Many of the existing interventions to optimise nursing staff afferent limb behaviour were heterogeneous in terms of design, content, and delivery. Frequently, the reporting of the processes used to develop the interventions were very limited making it unclear how intervention content was selected and delivered. Further, no reports were found where theory had been applied to drive the selection of intervention content, making it likely that existing interventions were developed pragmatically or intuitively rather than using systematic and replicable methods. Interventions that are developed intuitively may be susceptible to cognitive bias (Nisbett & Wilson, 1977; Bargh et al., 2001; Dyson & Cowdell, 2021), which may explain why the majority of interventions are educational and appear to target presumed deficits in knowledge and skills, rather than considering the wider determinants of afferent limb behaviour. Consequently, it has been recommended that future interventions targeting ALF should incorporate techniques that go beyond enhancing nursing staff' knowledge and confidence (Saab et al., 2017).

2.6.1.3 Non-educational interventions targeting afferent limb failure

Notwithstanding interventions with an educational focus, a protocol paper was identified reporting a proposed evaluation strategy for an intervention with the broad aim of strengthening the afferent limb of the RRS in multiple hospitals in Australia (Bucknall et al., 2017). The intervention reported in the protocol paper is titled PRONTO (Prioritising Responses Of Nurses To deteriorating patients Observations) and is a facilitation intervention that involves the deployment of hospital-level and ward-level facilitators to support the translation of Clinical Practice Guidelines (CPGs) for deteriorating patients into practice, using flexible and tailored[5] approaches. Specifically, it is proposed that facilitators will work with staff in intervention areas to review barriers and enablers to

[5] Tailoring is defined as adapting or personalising an intervention for an individual, or groups of individuals, based on recipient's preferences, context, or situation. Tailoring means that not all recipients receive an identical intervention (Cotterill et al., 2018; Hoffmann et al., 2014).

the uptake of CPGs into practice, audit ward-specific systems and processes (to allow the intervention components to be tailored to context), and deliver a range of interventions as indicated including education, case presentations, role play and goal setting (Bucknall et al., 2017). This publication is a protocol and therefore findings are not available. However, the clear reporting of the knowledge translation framework that underpins the intervention, the detailed overview of intervention content, and the rigorous methods proposed to evaluate the proposed intervention (cluster RCT with embedded process evaluation and cost analysis) are noteworthy strengths of this work. However, due to the lack of published findings, the efficacy of this proposed intervention remains unknown.

Most published interventions targeting ALF to date have leant towards the provision of staff education. Notwithstanding the papers outlined in this section, the processes followed to develop the interventions have typically been poorly reported, despite recommendations for attention to detail and clear reporting of the development stage in complex intervention guidelines (Craig et al., 2008; Skivington et al., 2021). Only one published protocol was identified where the application of theory during intervention development was proposed by a group of researchers from Australia (Bucknall et al., 2017). To the best of my knowledge, no results-based outputs for this work are available. Despite evidence that the application of theory can increase efficacy and replicability of an intervention (Taylor, Conner & Lawton, 2012; Webb et al., 2010; Little, Presseau & Eccles, 2015), there is a noteworthy gap in the evidence as no UK-based work was identified reporting the development of a theory-based intervention to target specific behaviours that are antecedents to ALF. The PhD research reported in this thesis was driven by this identified research gap.

2.7 Aim and objectives of the research

The aim was to develop a theory-based, preliminary, complex intervention to enhance enablers and overcome barriers to (registered nurses and healthcare assistants) performing expected afferent limb behaviours.

Objectives:

1. To identify where ALF occurred in the sequence of behaviours by comparing expected behaviours of the afferent limb with those observed on hospital wards, and to specify which afferent limb behaviours could be targeted for change.
2. To report the determinants (i.e. barriers and enablers) of the specified target afferent limb behaviours using a theoretical framework of behaviour change.
3. To populate a preliminary, behaviour change intervention with theoretically informed content targeting specific determinants of afferent limb behaviour.
4. To explore how intervention content could be applied in hospital wards, and to prioritise content according to its acceptability and feasibility for implementation in an acute ward, as perceived by clinical staff and healthcare managers.

2.8 Summary

Despite the implementation of RRS, sub-optimal care of deteriorating patients, specifically ALF, persists. Whilst there is an expansive body of literature aiming to elucidate reasons for ALF, no reports were found of UK-based work where behaviour change theory, or a theoretical framework of behaviour change, had been systematically applied. Pragmatic educational interventions (i.e. developed without specific theory underpinning the interventional components) have been developed to improve recognition and response to deteriorating patients. Staff report that these interventions make them feel more confident and competent in managing deteriorating patients, but there is limited evidence that they change behaviour in clinical practice. If these interventions did result in favourable behaviour change, it would be difficult to report the mechanism of change and/or to replicate the intervention due to a lack of theory and a lack of description of the expected pathway of change i.e. the logic model for how the intervention is expected to change the outcome (Smith et al., 2020). These research gaps could be addressed by using an integrative theoretical framework of behaviour change to develop an intervention to improve responses to deteriorating patients. In the next chapter, the methodologies underpinning the study design will be examined and the research situated within the wider field of implementation science. The chosen theoretical framework will be evaluated, and its use justified.

3 CHAPTER 3: METHODOLOGY

3.1 Introduction

Evidence based practice involves the integration of the best available evidence with clinical expertise, patient preference, and local contextual factors (Sackett et al., 2000). The uptake of the best available evidence by clinicians, to inform their clinical practice, can be a slow and haphazard process (Eccles et al., 2005). Consequently, the scientific discipline of *Implementation Science* emerged with the broad aim of creating generalisable knowledge about the most effective means to translate research findings and evidence-based innovations into clinical practice (Presseau et al., 2021; Eccles et al., 2005; Foy, Eccles & Grimshaw, 2001). Implementation interventions aim to enhance the translation of empirical evidence, obtained in specific and often atypical trial settings, into more heterogeneous 'real world' settings. For implementation to be successful (i.e. for evidence to translate effectively), at least one individual is typically required to change their behaviour (i.e. to do more or less of a specific action) (Presseau et al., 2019; Patey et al., 2018). Consequently, theories of behaviour and behaviour change offer a useful lens through which to empirically examine implementation problems in the healthcare setting (Cane, O'Connor & Michie, 2012; Michie et al., 2005). In this chapter, the background to the discipline of *Implementation Science* is provided. The overarching process (French et al., 2012) used in this PhD research to develop the implementation intervention is reported and key elements of the process evaluated including the need to identify evidence-practice gaps, to specify target behaviours, and to engage with clinical stakeholders. Given the centrality of theory within the implementation process, a rationale for opting to apply theory systematically throughout the intervention development process is provided, and the strengths of the theoretical framework used (the Theoretical Domains Framework) (Cane, O'Connor & Michie, 2012) are critically evaluated.

3.2 The background to Evidence Based Practice

During the 1980s, Research Utilisation (RU) in clinical practice became an important topic in healthcare and healthcare practitioner education. The emphasis of RU was the translation of new knowledge into the real world (Polit & Beck, 2018). By the 1990s, the call for increased uptake of

RU was superseded by the Evidence-Based Practice movement. Evidence Based Practice (EBP) involves the identification of the best available evidence, and the integration of that evidence alongside clinical expertise, patient preference, and local factors to inform decision making and to solve clinical problems (Polit & Beck, 2018; Sackett et al., 2000). Unlike the RU process, where the starting point is typically the research itself, the starting point for EBP is usually a clinical question or problem requiring a solution (Polit & Beck, 2018; Craig & Smyth, 2012).

It has been reported that 30-40% of patients do not receive healthcare according to best available evidence, and that up to 25% of patients may receive interventions that are unnecessary or even cause harm (McGlynn et al., 2003; Grol, 2001). Evidence based practice is considered a key component to closing the gap between research evidence and 'real-world' clinical practice, reflected by its centrality in healthcare practitioner training curricula across disciplines and on an international scale (Lehane et al., 2019). Despite the acknowledged importance, the adoption of evidence into clinical practice is not straightforward and has been described as an unpredictable, slow, and haphazard process (Eccles et al., 2005). Whilst doctors may be receptive to scientific advances, challenges have been reported related to their ability to search, acquire and appraise the research-based literature (Tomlin, Humphrey & Rogers, 1999; Wyatt et al., 1998; Guyatt et al., 2000). Similarly, findings of empirical work suggest that Registered Nurses (RNs) find accessing research-based information 'problematic' due to the volume of literature available and the need for additional expertise to access and critique the material (Marshall, West & Aitken, 2011). To make the best available evidence accessible to healthcare practitioners, research is commonly synthesised and presented in the form of clinical guidelines which are ubiquitous within healthcare systems in high income countries (Grol, 2001). In the UK context, part of the remit of The National Institute of Health and Care Excellence (NICE) is to develop and publish such guidelines ('National Institute for Health and Care Excellence,' n.d.).

Historically, attempts to get healthcare practitioners to base their decisions on research-based evidence, was rooted in rationalist science and epidemiological models where the diffusion of new information was considered analogous with the 'spread of disease' within a population

(Greenhalgh et al., 2005). In this context, *diffusion* was defined as the uncontrolled and natural spread of an idea or innovation; in contrast to the concept of *dissemination* which is a more proactive process typified by deliberate attempts to share information (Green et al., 2009). This rationalist model of diffusion is reflected in the following simple algorithm (as reported by Greenhalgh et al., 2005 p425):

Research → Published evidence → Change in Health professional behaviour

This model is underpinned by the assertion that contact with new information is sufficient to prompt the spread of the same information and ultimately its adoption into everyday practice (Greenhalgh et al., 2005). In relation to this specific model, if a healthcare practitioner does not encounter the new information, or fully understand it, then diffusion is unlikely. Likewise, diffusion may be hampered if the intended audience do not engage with the information or reject it for being irrelevant or simply different. Given the tendency that individuals have to reflect upon, contest, adapt or reject new information, rather than merely accepting it, the assumptions that underpin this model are flawed (Bhattacharyya et al., 2006; Greenhalgh et al., 2005; Green et al., 2009). A seminal study with an experimental design was carried out to evaluate the impact of education on doctors' use of evidence-based innovations (Sibley et al., 1982). The researchers reported that education had low success in prompting doctors to adopt the innovations into their practice (Sibley et al., 1982). The findings of this work are corroborated by more recent research, where the use of educational material was reported to have a modest and short-lived effect on the uptake of clinical guidelines by healthcare practitioners (Grimshaw et al., 2004). The findings of this empirical work underscore the limitations of the rationalist model, implying that being exposed to, or educated about, a new concept does not necessarily equate with adoption of that information into everyday practice.

The incorporation of research findings into routine clinical practice can be associated with a time-lag of up to 17 years (Morris, Wooding & Grant, 2011; Grant, Green & Mason, 2003; Bauer et al., 2015; Robinson et al., 2020) and, even then, only partial adoption may occur (Green et al.,

2009). The significant wane in the translation of evidence from 'bench to bedside' has been conceptualised using the analogy of a 'pipeline' (Green et al., 2009 p155, figure 1) (Figure 3.1).

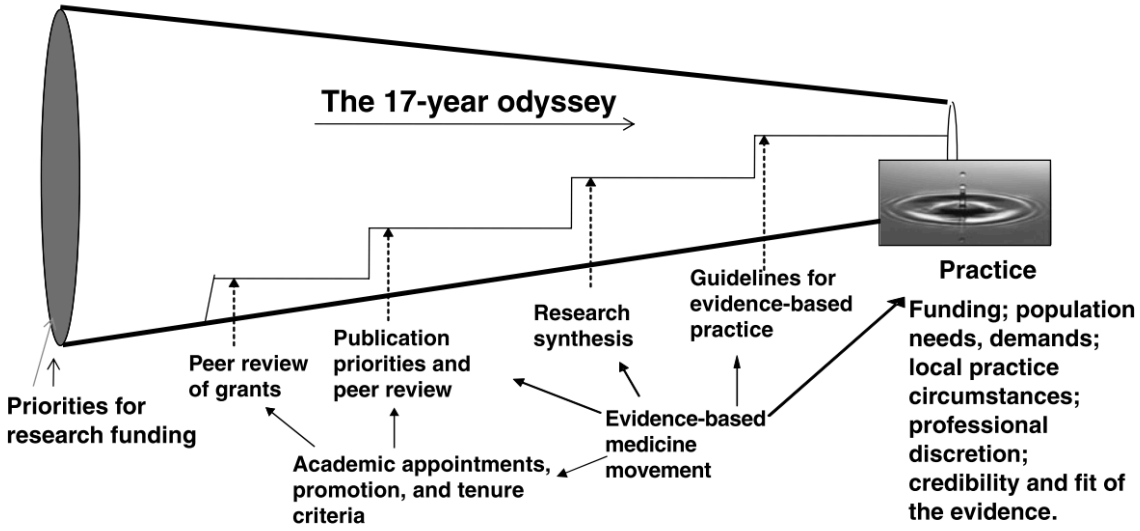

Figure 3.1 – the pipeline model representing the wane of research-based knowledge from 'bench to bedside'

Green et al., 2009, p.155, fig. 1.

The funnel shape of the pipeline is reported to reflect the disparity between the amount of research that is carried out versus the proportion that is actually used in clinical practice (Green, 2008). The overarching premise of the pipeline analogy is that the vetting processes required to ensure research rigor exerts successive constrictions on research-based knowledge, as it flows distally towards the practitioner. The resultant clinical guideline, whilst informed by the best available evidence, may not align with the operational priorities of clinical practice which reduces the uptake of its contents (Green, 2008; Bauer et al., 2015).

A key publication, where the findings of 36 systematic reviews were synthesised, highlighted broad inadequacies in intervention studies aimed at promoting evidence-based innovations (Grol, 2001). Broad themes reported in the review were: ambiguous and/or poorly written clinical guidelines that only addressed part of the decision-making process, or the actions required during a clinical consultation; a requirement for system-level reforms and/or individual healthcare practitioner behaviour change; and/or poor value for money or limited evidence of economic

evaluation (Grol, 2001). In addition to reporting the paucity of evidence, it was noted that the process of intervention development was often driven by the beliefs and traditions of specific professional groups working in *silos* (i.e. in isolation from other key stakeholders) (Grol, 2001). To mitigate this*,* recommendations were made for improved collaboration across professional boundaries, an increase in external accountability, and an increase in the involvement of patients and service users (Grol, 2001). Broadly, this paper provided an early signal of the complexity of translating evidence into clinical practice (Grol, 2001), and arguably reflected a paradigm shift away from a purely rationalist model towards alternative approaches that go beyond epidemiological or medical traditions (Greenhalgh et al., 2005).

3.3 The emergence of Implementation Science as a scientific discipline

Almost two decades ago, a systematic review was conducted to evaluate and report the efficacy of different guidelines dissemination and implementation activities (Grimshaw et al., 2004). Based on the findings, the authors reported a sub-optimal evidence-base to support decisions regarding which guidelines dissemination or implementation approaches would be effective in different circumstances (Grimshaw et al., 2004). In response to this knowledge gap, the scientific discipline of *Implementation Science* emerged followed by a peer reviewed journal of the same name; the first edition of which was published in 2006 (Nilsen, 2015). Implementation Science is defined as: '*the scientific study of methods that promote the systematic uptake of research findings, and other evidence-based practices, into routine practice hence improving the quality and effectiveness of health services.'* (Taken from: Presseau et al., 2021 p3, elaborated from the following sources: Eccles et al., 2005; Foy et al., 2001). The discipline focuses squarely on the accumulation of evidence related to the translation of research findings into routine healthcare (Presseau et al., 2021). Consequently, research activities that occupy this space typically involve the systematic evaluation of the process of implementation, and its impact on the EBP of interest, with the goal of developing generalisable knowledge that can be widely applied beyond the individual system under investigation (Bauer et al., 2015; Rothman, 2004). In contrast to alternate but overlapping approaches, where the starting point of inquiry is a specific clinical problem (e.g. in quality improvement methodology), implementation research is typically driven by an element of

EBP (e.g. a clinical guideline or a component thereof) that is under-utilised in clinical practice (i.e. where there is evidence of a translation gap) (Bauer et al., 2015).

3.4 Processes for developing implementation interventions

For implementation of a new or adapted intervention or process to be effective, it is a common requirement for at least one individual to change their behaviour (Presseau et al., 2019). In the implementation context, behaviour change could involve the adoption of a new behaviour never previously enacted, the substitution of one or more behaviours for an alternative, or even the termination of behaviour/s that may be unnecessary or harmful (so-called 'de-implementation') (Presseau et al., 2019; Patey et al., 2018; Haskell et al., 2021). Broadly, implementation interventions may target behaviour change at individual (patient and/or healthcare practitioner), system, or policy levels depending on the particular evidence-practice gap (Bauer et al., 2015; Powell et al., 2012; Eccles et al., 2005). Further, implementation interventions might involve a singular approach (i.e. one discrete process or action) or a multitude of approaches, termed complex interventions (Skivington et al., 2021; Craig et al., 2008). Alternate language used in the wider literature to describe complex interventions include 'multi-faceted' or 'blended' interventions (Powell et al., 2012). Whilst in practice the notion of a 'simple intervention' may not exist, it is plausible that interventions will differ according to the degree of complexity; that is, complexity in this context may exist on a continuum (Petticrew, 2011). The following 'dimensions of complexity' were proposed to make the degree of complexity more tangible:

- Number of components involved
- The range of behaviours targeted
- Expertise and skills required by those delivering and receiving the intervention
- The number of groups, settings, or levels targeted by the intervention
- Degree of flexibility permitted (i.e. extent to which the intervention can be tailored to the implementation context).

Skivington et al., 2021 p2

Alongside helping to define a complex intervention, guidelines from the UK Medical Research Council (MRC) (Skivington et al., 2021) provide a guide for the development and evaluation of complex interventions, which includes the following four phases: 1. development or identification; 2. feasibility; 3. evaluation; 4. implementation (Figure 3.2). It is recommended that equal time and effort be devoted to each phase within the process (Craig et al., 2008). Progressing prematurely to evaluation and implementation stages without adequate development and/or feasibillty testing beforehand may result in an intervention that is weaker (Craig et al., 2008). Central to the development phase is the need to acquire a theoretical understanding of the likely causal mechanisms of change (Craig et al., 2008; Skivington et al., 2021). Whilst the application of theory is broadly advocated within MRC guidelines, it has been acknowledged that they do not provide precise information about *how* theory should be used to design interventions (Michie & Prestwich, 2010; French et al., 2012). Consequently, further implementation processes have been proposed that broadly align to the guidelines, but also offer greater clarity regarding how theory could be applied systematically throughtout intervention development.

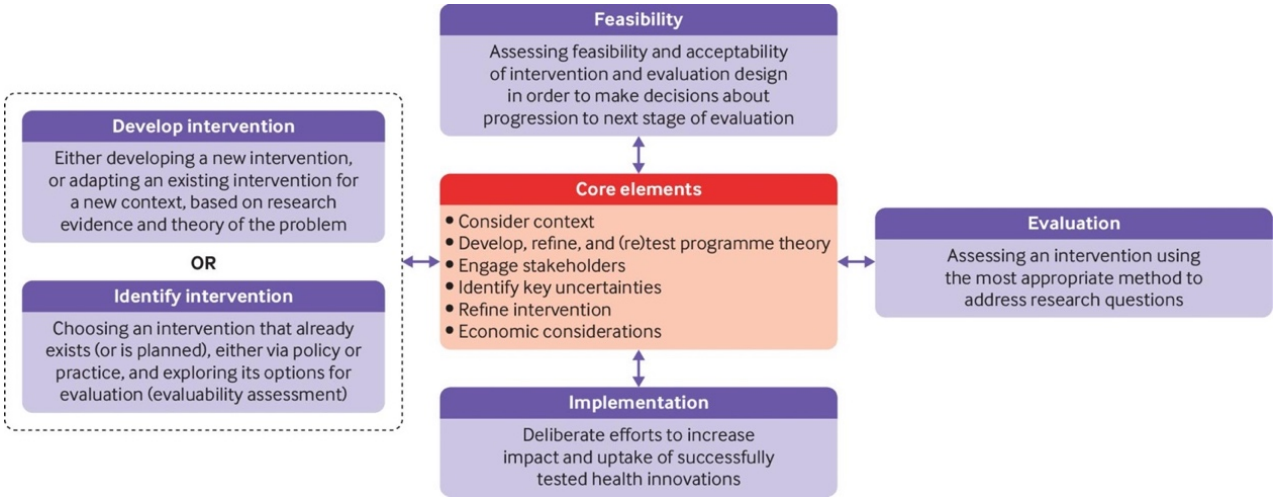

Figure 3.2 – key phases in the development and evaluation of a complex intervention

Skivington et al., 2021, p.4, fig. 1.

To design an implementation intervention requires a systematic approach underpinned by robust rationale and explicit reporting of the development process (Baker et al., 2008; Des Jarlais, Lyles & Crepaz, 2004). Whilst there are numerous approaches to intervention development

(O'Cathain et al., 2019), the application of theory is one approach that may be used to develop an intervention (Eccles et al., 2005; O'Cathain et al., 2019). French et al (2012) proposed a four stage process for the development of a theory-based implementation intervention (Table 3.1). Broadly, overlap exists between the stages of this process and alternative theory-based approaches such as the Behaviour Change Wheel (Michie, Atkins & West, 2014) and the Theoretical Domains Framework Implementation (TDFi) approach (Taylor et al., 2013).

Table 3.1 – a 4-stage systematic approach for developing complex implementation interventions

Implementation intervention development process[1]			**Development activities within MRC guidelines[2]**
Stage	**Guiding question**	**Specific activities**	
Stage 1	Who needs to do what, differently?	– Identify the evidence-practice gap – Specify the behaviour change needed to reduce the evidence-practice gap – Specify the healthcare practitioner group whose behaviour needs changing	Identifying the evidence base
Stage 2	Using a theoretical framework, which barriers and enablers need to be addressed?	– From the literature, and experience of the development team, select which theory or theoretical framework is likely to inform the pathways of change – Use the chosen theory, or framework, to identify the pathways of change and the possible barriers and enablers to that pathway – Use qualitative and/or quantitative methods to identify barriers and enablers to behaviour change	Identifying and developing theory
Stage 3	Which intervention components could overcome the modifiable barriers and enhance enablers?	– Use the chosen theory, or framework, to identify potential behaviour change techniques and modes of delivery – Identify what is likely to be feasible, locally relevant, and acceptable and combine identified components into an acceptable intervention that can be delivered	
Stage 4	How can behaviour change be measured and understood?	– Identify mediators of change to investigate the proposed pathways of change – Select appropriate outcome measures – Determine feasibility of outcomes to be measured	Modelling process and outcomes

Key:
[1]French et al (2012)
[2]Craig et al (2008)

The process reported by French et al (2012) incorporates the activities underpinning intervention development outlined in the MRC guidelines (Craig et al., 2008; Skivington et al., 2021), but with sufficient detail for intervention developers to systematically progress towards populating a complex implementation intervention with theoretically informed content (French et al., 2012; Presseau et al., 2021). Examples were found in the literature where this process had been followed to develop interventions targeting evidence-practice gaps in the management of patients with lower back pain (French et al., 2012; McKenzie et al., 2008; Eilayyan et al., 2020); with stroke (Craig et al., 2017); with traumatic brain injury (Tavender et al., 2015); in the delivery of optimal haemodialysis for patients requiring renal replacement therapy (Presseau et al., 2017); in the delivery of optimal bronchiolitis treatment for children (Haskell et al., 2021); and to improve patient adherence with multiple medications in the community setting (Patton et al., 2018).

3.5 The importance of identifying and specifying the behaviours required for successful implementation

3.5.1 Identifying evidence-practice gaps

Direct interactions between a healthcare practitioner and a patient represent a significant proportion of healthcare delivery. Consequently, the behaviours of healthcare practitioners are important ‘proximal determinants’ of the quality of care that a patient receives (French et al., 2012). Broadly, this explains why implementation interventions frequently focus on the individual actions of healthcare practitioners (French et al., 2012). Identifying and clearly reporting who needs to do more or less of an action is advocated as a common preliminary step in several frameworks of behaviour change and implementation (Taylor et al., 2016; Michie, Atkins & West, 2014; French et al., 2012), highlighting its significance within the wider process. Practically, this process typically begins with identification of gaps between desired behaviour/s (i.e. those required for successful implementation of EBP), and the behaviour/s enacted in the ‘real world’. These evidence-practice or implementation gaps (French et al., 2012; Grimshaw et al., 2012) may be identified using audit (Taylor et al., 2013), discussions with key stakeholders (Presseau et al., 2021; Taylor et al., 2016, 2013), documentary analysis, or through the use of empirical methods (Atkins et al., 2017).

When developing implementation interventions, the context in which the intervention will be delivered is recognised as an important consideration (Taylor et al., 2013; Pronovost, Berenholtz & Needham, 2008; Leistikow, Kalkman & De Bruijn, 2011; Skivington et al., 2021). It has been posited that context is both complex and multi-dimensional and that it may extend beyond a physical space (Skivington et al., 2021). Context should be recognised as a process involving persons, resources, perspectives and activities (Cotterill et al., 2018). In order to design interventions that can be effectively delivered in practice, capturing and reporting contextual factors that may influence the transferability of an intervention is crucial (Cotterill et al., 2018; Leistikow, Kalkman & De Bruijn, 2011). Despite this, there is evidence of context being under-reported within the wider patient safety literature (Øvretveit et al., 2011). To ensure a deeper and more nuanced understanding of the interactions between context and behaviour, it has been advocated that researchers 'physically walk through the steps with clinicians' to observe what behaviours are required for successful implementation and to report how context might shape these behaviours (Pronovost et al., 2008 p3). Consequently, research methods that include direct observation of staff enacting the behaviours of interest have been advocated (Atkins et al., 2017). Despite potential advantages, these methods appear under-utilised in the wider implementation literature for the identification and reporting of evidence-practice gaps.

3.5.2 The importance of behavioural specificity

Last century, Fishbein (1967) hypothesised that attitude[6] towards a specific action would have greater validity for predicting behaviour than attitude towards the target of the action. To exemplify, attitude towards *the specific action of monitoring a deteriorating patient's vital signs* would predict vital signs monitoring behaviour more accurately than *attitudes about the deteriorating patient* (Presseau et al., 2019; Fishbein, 1967). This assertion represented the beginning of a paradigm shift in behavioural science, and underpinned subsequent motivational theories of purposeful human behaviour (Nilsen, 2015), including the Theory of Planned Behaviour (TPB) (Ajzen, 1991) which is an extension of the earlier Theory of Reasoned Action (Fishbein &

[6] Attitude refers to a person's evaluation of an object, concept, or behaviour along a dimension of favour or disfavour, good or bad, like or dislike (Ajzen & Fishbein, 2000).

Ajzen, 1975). The TPB was proposed to predict behaviour in a specific context and at a specific time (Presseau et al., 2019). In accordance with the TPB (Ajzen, 1991), an individual's *behavioural beliefs* reflect the extent to which they have made a favourable or unfavourable evaluation of attempting a behaviour (Michie et al., 2014). An individual's behavioural beliefs shape their *attitudes* towards the behaviour which, in turn, influences their *intention* (i.e. their commitment or resolve to enact the behaviour); a direct precursor to behaviour (the observable response resulting from the aforementioned cognitions) (Michie et al., 2014).

On this basis of all these principles, it was suggested that behaviours should be specified according to Target (i.e. the person with/for whom the behaviour is enacted), Action, Context and Time (TACT) (Fishbein & Ajzen, 2010). Proponents of the TACT principle, argue that clear specification of target behaviour[7] in empirical work, permits stronger linkages between the target behaviour/s and the theoretical constructs[8] that predict them (i.e. increased compatibility between behaviour and construct) (Siegel et al., 2014; Presseau et al., 2019; Fishbein & Ajzen, 2010). Further, failure to explicitly report and specify the target behaviour/s could make it difficult to identify if behaviour change has occurred or not (Presseau et al., 2019).

The TACT framework (Fishbein & Ajzen, 2010) has since been elaborated to include a fifth element; the specification of 'the actor' i.e. the person or persons responsible for enacting the behaviour (Presseau et al., 2019). The researchers who proposed the extended behaviour specification framework, argue that leaving the actor implicit could introduce ambiguity, undermine 'change efforts', and hamper the measurement of behaviour change (Presseau et al., 2019). Consequently, the AACTT framework was proposed where AACTT abbreviates Action, Actor, Context, Target, and Time (Presseau et al., 2019).

A noteworthy advantage of the AACTT framework, is that it can be applied at all stages of the implementation process proposed by French et al (2012). Specifying the target behaviours

[7] Target behaviour/s are the behaviours required for implementation of EBP to occur (Atkins et al., 2017)
[8] Theoretical construct is defined as a concept specially designed to be part of a theory (Michie et al., 2005)

using the AACTT framework, permits the development of research materials (e.g. interview topic guides) where questions are constructed to elicit participants' beliefs about the determinants of specific behaviour/s rather than the broader topic (Presseau et al., 2019). Likewise, during subsequent data analysis, use of the AACTT specification framework enables researchers to code beliefs reflecting barriers and enablers to the specific target behaviours, and to discount beliefs that do not relate to the actions or actors of interest (Presseau et al., 2019). Where participants' beliefs include perceived barriers and enablers to performing a behaviour, interventions can be applied to influence individual behaviour through modifying beliefs, attitudes and/or intention (Michie & Abraham, 2004; Michie et al., 2014, 2008). Application of the AACTT framework, allows precise intervention content to be selected that will target modifiable barriers and/or enablers to specific behaviour/s, enacted by specific individuals, in a particular context. Ensuring behavioural specificity can help to establish more sensitive causal links between theoretical constructs and the target behaviour, and potentially permits more accurate measurement of whether behaviour change has taken place or not (Presseau et al., 2019; Fishbein & Ajzen, 2010; Siegel et al., 2014; Craig et al., 2008).

3.6 The application of theory to develop an implementation intervention

3.6.1 Distinctions between theories, models, and frameworks

Interest has grown in the potential application of theories, models, and frameworks to improve understanding of the mechanisms through which successful implementation occurs (Nilsen, 2015). Whilst these terms have been used interchangeably within the field of implementation science (Kitson et al., 2008; Estabrooks et al., 2006), discernable differences have been reported. A theory has been defined as a set of analytical principles or statements that helps structure our observation, understanding, and explanation of phenomena (Wacker, 1998; Carpiano & Daley, 2006; Michie & Prestwich, 2010). It has been posited that a 'good theory' provides a clear explanation of *how* and *why* specific relationships may precede specific events (Nilsen, 2015). In this context, a model can be viewed as a deliberate simplification of a theory or an aspect of a theory, where the variables and their interrelationships are described but not explained (Polit &

Beck, 2018; Nilsen, 2015). Finally, frameworks typically include descriptive categories, consisting of concepts, constructs or variables, that represent empirical phenomena but do not explain the relationship between them (Nilsen, 2015). Historically, implementation researchers have 'borrowed' theories from aligned disciplines including psychology, social sciences, and organisational theory, to underpin implementation research (Nilsen, 2015; Presseau et al., 2021; Grimshaw et al., 2004). More recently, alternative models, theories and frameworks have emerged from within the discipline (Nilsen, 2015). The theories and frameworks used in implementation science have been concisely summarised into five broad categories:

1. Process models – specify steps in the process of translating research into practice.
2. Determinant frameworks – specify types of determinants and individual determinants, that act as barriers and enablers that influence implementation outcomes.
3. Classic theories – theories that originate from fields external to implementation science (e.g. psychology, sociology).
4. Implementation theories – theories that have been developed by implementation researchers to provide understanding and/or explanation of aspects of implementation.
5. Evaluation frameworks – specify aspects of implementation that could be evaluated to determine implementation success.

Nilsen, 2015 p3

3.6.2 The use of theory and intervention efficacy

There is contradiction within the literature regarding whether the application of theory increases the efficacy of the resultant intervention. Several published review papers have reported positive associations between the application of theory and effective health behaviour change. Specifically, the application of theory was reported to increase efficacy of implementation interventions with a health promotion or public health focus (Glanz & Bishop, 2010), and interventions delivered using the internet (Webb et al., 2010). Theory use was also associated with increased efficacy of interventions targeting specific health behaviours including cancer screening behaviours (Albada et al., 2009), behaviours that reduce sexual transmission of immunodeficiency

virus (Albarracín et al., 2005), and interventions targeting physical activity (Taylor, Conner & Lawton, 2012). However, there are several review papers where no association, or even a negative association, from theory use is reported (Michie et al., 2014). Review papers with 'null findings' include interventions that targeted healthy eating behaviours (Roe et al., 1997), behaviours to limit gestational weight gain (Gardner et al., 2011), and behaviours that reduce the risk of acquiring sexually transmitted infections (Stephenson, Imrie & Sutton, 2000).

This mixed picture of evidence regarding the efficacy of theory-based interventions may be partly explained by inconsistencies in the application of theory across the implementation process and/or a lack of clear reporting of theory use in research outputs (Michie et al., 2014; Prestwich et al., 2014). This assertion is supported by findings of a recent systematic review of interventions aimed at improving dietary behaviours (n=9) (Timlin et al., 2020). Here, the researchers reported that only one of the included interventions demonstrated a strong application of theory, with the remainder meeting criteria for weak (n=1) or moderate (n=7) use (Timlin et al., 2020). Whilst all the interventions reviewed were reported to have been developed using theory, in three publications there was no explicit mention of an association between the theoretical constructs and target behaviours, and in only four of the interventions were all theoretical constructs linked explicitly to intervention technique/s (Timlin et al., 2020). Given these inconsistencies, the existing evidence regarding the efficacy of theory-based interventions should be interpreted with some degree of caution (Timlin et al., 2020; Cowdell & Dyson, 2019; Prestwich et al., 2014). Clearer selection, application, and reporting of theory-use is required to understand further how, and to what extent, theories and frameworks improve implementation and in what circumstances and contextual conditions they apply and do not apply (Nilsen, 2015). As eloquently argued by Eccles et al (2005), if the benefits of theory use are to be challenged, this should be based 'on a process of scientific scrutiny, not scientific neglect' (p111).

3.6.3 The advantages of using theory

Notwithstanding the equivocal evidence surrounding the potential of theory to increase the efficacy of implementation interventions, a broader argument for theory use has been made within

the wider literature. The application of theory permits the explicit reporting of the proposed causal mechanisms of behaviour change, the selection of intervention content, and the modes of delivery (Patton et al., 2018). As theory is explicit, deductions made using theory can be questioned and scrutinised using empirical methods (Nilsen, 2015). If theoretical deductions are found to be untrue, theory can be adapted, extended, or even abandoned (Nilsen, 2015). Where there is evidence of benefit (i.e. desirable behaviour change) from the delivery of a theory-based intervention, the components of the intervention responsible for the behaviour change can be identified, replicated and evaluated in different settings and with different populations (Little, Presseau & Eccles, 2015; Michie et al., 2008; Michie & Prestwich, 2010; Skivington et al., 2021; Eccles et al., 2005; Haskell et al., 2021). Practically, the use of theory may help to increase efficiency within research teams. First, opting to use a theory-based approach enables researchers to address research questions systematically using implementation processes from the published literature (French et al., 2012; Taylor et al., 2013; Craig et al., 2008; Eccles et al., 2005). Second, theory may help multi-disciplinary research teams to develop a consensually agreed set of terminology, thereby improving communication between stakeholders and potentially increasing productivity (Michie et al., 2014).

3.6.4 The challenge of selecting a suitable theory

Whilst there are several cited advantages to using theory, selecting an appropriate theory or theoretical framework to underpin the implementation process can be challenging, as theories are numerous and their components (i.e. the constructs) frequently overlap (Michie et al., 2005). From a scoping review, 82 different theories of behaviour and behaviour change were identified from behavioural and social sciences highlighting the abundance of different theories (Davis et al., 2015). This was verified by the findings of a more recent observational study where the views of 223 self-identified implementation scientists from 12 different countries were obtained (Birken et al., 2017). Through paper-based and electronic surveys, participants were asked to identify which theories they had used, in what ways they had applied theory (e.g. data collection, analysis etc.), and to report the criteria they use to select a theory (the 19 criteria that were provided as part of this survey are listed in volume 2, appendix 3). Across participants, the use of more than a hundred

different theories was reported drawn from implementation science, organisational studies, sociology, and business (Birken et al., 2017). Some participants also reported using theories in combination or adjusting them for bespoke purposes. On average, participants reported using seven different criteria to select theory; some participants reported using all 19. One explanation given by the authors for the use of multiple criteria was a lack of clarity regarding how to select theory (Birken et al., 2017). In the absence of a more robust approach for deciding which theory or framework is most suitable for a particular implementation problem, researchers and practitioners may be driven to make decisions based on convenience, prior experience, and familiarity, reflected by the quotation below from a post-doctoral implementation researcher:

> *'To some degree selection is arbitrary. There are probably several theories that would be fruitful, and I tend to use ones that are familiar to me'*
>
> Birken et al., 2017, p6

Given that the processes for selecting theory were found to be 'haphazard' amongst potential experts (Birken et al., 2017), it is likely that the selection of a theory would be even more challenging for non-experts. This may partly explain why theory remains under-utilised (Birken et al., 2017; Prestwich et al., 2014; Timlin et al., 2020).

3.7 The Theoretical Domains Framework (TDF) of behaviour change

3.7.1 Development and content validation

Where selection of a suitable theory to underpin intervention development is driven by convenience or familiarity, there is a risk that critical theories and constructs will be missed or that unnecessary constructs will be targeted (Michie et al., 2005; Cane, O'Connor & Michie, 2012). The Theoretical Domains Framework (TDF) was developed, in part, to mitigate this.

To develop the TDF, a group of researchers used a multi-phase expert consensus process to synthesise, evaluate and content validate a list of theoretical domains that could be applied when seeking explanations for failure to implement EBP, and for designing interventions to

improve implementation (Michie et al., 2005). Here, the term 'domain' was used to describe a broad conceptual category encompassing a set of similar theoretical constructs (Michie et al., 2005). During the consensus process, 128 constructs were identified from 33 different theories including theories from each of the following broad categories: *motivation theories, action theories, and organisation theories* (Michie et al., 2005, 2014). The main output of this work was an integrative theoretical framework consisting of 12 domains (Table 3.2) representing the expansive list of theoretical constructs (Michie et al., 2005). The authors noted that eight of the domains overlapped with an existing (older) framework produced using a similar process, but developed in the context of a different set of behaviours, and published for a psychology audience (Fishbein et al., 2001). Michie et al (2005) suggest that the inclusion of four additional domains within their framework could be explained by the breadth of expertise within their consensus groups, and by developments within the literature. As part of the broader programme of work, a list of interview questions was also developed to enable identification of domains most relevant to behaviour change in the context of a particular implementation problem (Michie et al., 2005). An adapted version of this interview schedule was used in a subsequent study, to identify the construct domains relevant to clinicians' blood transfusion behaviour in the Intensive Care Unit (ICU) setting (Francis et al., 2009). This was the first publication to report the application of a 'theoretical domains interview' following the development and initial validation of the framework (Cowdell & Dyson, 2019; Francis et al., 2009).

In a key publication in 2012, the aforementioned theoretical framework was first formally labelled as the Theoretical Domains Framework (TDF) (Cane, O'Connor & Michie, 2012). Authors of the same paper used a cross-sectional study design and sort task methodology to validate the original 12-domain framework. First, both open and closed sort tasks were carried out with behavioural experts. In the open sort task, participants sorted constructs into groups of their choosing and labelled the groups according to content. Fuzzy cluster analysis was then used to identify optimal groupings of constructs. In the closed sort task, participants sorted and rated constructs (for confidence of allocation) into the domains defined in the original framework (i.e. TDF v1.0). Discriminant content validation methods were used to assess the extent to which each

construct belonged to the domain (Cane, O'Connor & Michie, 2012). The results from both sort tasks were used to validate the TDF using a 3-step procedure as follows: the optimal number of domains was identified; domain content was established in view of suitable construct allocation; domain labels were finalised (Cane, O'Connor & Michie, 2012). The output of this work was a refined version of the TDF containing 14 domains representing 84 constructs (TDF version 2 – hereafter just referred to as the TDF) (Table 3.2) (Cane, O'Connor & Michie, 2012). For a full description of content for each of the 14 domains see Table 1.2.

Table 3.2 – domain labels included in both versions of the Theoretical Domains Framework

Domain labels (Listed alphabetically)	**12-domain TDF (v1.0)** (Michie et al., 2005)	**14- domain TDF (v2.0)** (Cane et al., 2012)
Behavioural Regulation	✓	✓
Beliefs about Capabilities	✓	✓
Beliefs about Consequences	✓	✓
Emotion	✓	✓
Environmental Context & Resources	✓	✓
Goals	×	✓
Intentions	×	✓
Knowledge	✓	✓
Memory Attention & Decision Processes	✓	✓
Motivation & Goals	✓	×
Nature of the Behaviours	✓	×
Optimism	×	✓
Reinforcement	×	✓
Skills	✓	✓
Social Influences	✓	✓
Social, Professional Role & Identity	✓	✓

3.7.2 Strengths of the TDF

The TDF does not propose 'testable relationships between elements' and is therefore not considered a theory. However, it offers a 'theoretical lens' through which to view the influences on behaviour, including healthcare practitioner behaviour (Atkins et al., 2017 p2). The domains of the TDF specify the types of determinants (which may act as barriers and/or enablers) that have been hypothesised to influence implementation outcomes (Nilsen, 2015). For this reason, the TDF has been categorised as a 'determinant framework' (Nilsen, 2015). A number of strengths have been cited in the literature, which may explain why the TDF has been well adopted internationally within the field of implementation science (Presseau et al., 2021; Birken et al., 2017; Dyson & Cowdell, 2021). As the 14 domains represent 84 theoretical constructs, drawn from 33 theories, the TDF offers a robust and expansive theoretical underpinning (Cane, O'Connor & Michie, 2012). Practically, this permits inquiry across a wide range of potential determinants (Atkins et al., 2017; French, Green, O'Connor, McKenzie, & Francis, 2012; Wilkinson et al., 2015), and reduces the likelihood of important variables being missed and interventions being developed without significant constructs being targeted (Michie, van Stralen & West, 2011).

A further strength of the TDF is its flexibility (Phillips et al., 2015); exemplified by the range of methods that have been incorporated into TDF-based studies. Examples were found where the TDF had been used to inform the content of questionnaires (McGoldrick et al., 2016; Taylor et al., 2013; Jobber et al., 2021), focus group topic guides (Patton et al., 2018; Cassidy et al., 2018; Anekwe et al., 2020; Jedwab et al., 2022), and topic guides used to deliver semi-structured interviews (Roberts et al., 2017; Patey et al., 2012; Debono et al., 2017; Patey et al., 2017; Presseau et al., 2017; Roberts et al., 2016; Pearse et al., 2021; Fasugba et al., 2021). The flexibility of the TDF is also evidenced by the variety of implementation problems that it has been used to address. Within the international literature, there are numerous examples of where the TDF has been used to elucidate determinants of healthcare practitioners' behaviour related to a wide range of EBP translation gaps (Roberts et al., 2017; Sargent et al., 2017; Patey et al., 2017; McGoldrick et al., 2016; Cassidy et al., 2018; McBain et al., 2016; Presseau et al., 2017; Goddard

et al., 2018; Patey et al., 2012). There is also evidence of the TDF being used to drive the selection of specific intervention content (Craig et al., 2017; Debono et al., 2017; Patton et al., 2018; Cadogan et al., 2015; Tavender et al., 2015; Matthews et al., 2015; Long et al., 2018; Eilayyan et al., 2020; Haskell et al., 2021). A systematic review was conducted to synthesise the international literature reporting application of the TDF in designing interventions to support healthcare practitioner behaviour change (Dyson & Cowdell, 2021). Here, a search of the literature yielded 3,540 papers (following de-deduplication), of which only 60 (1.7%), were included in the review. In 237 publications that were screened and excluded from the review, the TDF was applied to elucidate determinants (i.e. barriers and enablers) but the reported methods did not include intervention development (Dyson & Cowdell, 2021). These findings led to the conclusion that whilst the framework has been well used to report barriers and enablers, its application in the development of interventions targeting healthcare practitioners is more limited (Dyson & Cowdell, 2021). To advance the science, clearer guidelines on the processes for selecting and delivering intervention content are required (Dyson & Cowdell, 2021), and further research extending beyond the use of the TDF to report barriers and enablers is needed to expand and diversify the body of evidence.

Whilst an objective of the researchers who synthesised the TDF was to make psychological theory more accessible to non-experts (Michie et al., 2005; Atkins et al., 2017), it remains debatable about whether or not the TDF has fully achieved this objective. There is some evidence that multi-disciplinary healthcare practitioners attempting to apply the framework, find the language of the TDF challenging and the definitions of its domains difficult to comprehend (Phillips et al., 2015). Consequently, it remains necessary for research teams conducting TDF-based research to include individuals with experience in applying the TDF and an understanding of the theories from which it draws (Atkins et al., 2017; Dyson & Cowdell, 2021).

3.8 Targeting theoretically deduced determinants with precise intervention content

Within the wider literature, there is modest evidence that healthcare practitioner behaviour change occurs more effectively when interventions are populated with strategies directed towards the behavioural determinants (Baker et al., 2015; Michie & Prestwich, 2010). Use of the TDF as part of the aforementioned systematic implementation process (French et al., 2012), permits the development of an intervention where precise intervention content targets specific barriers and enablers (Haskell et al., 2021).

Almost two decades ago, it was proposed that a detailed taxonomy of Behaviour Change Techniques would provide an 'invaluable resource' for researchers and practitioners (Michie & Abraham, 2004). Behaviour Change Techniques (BCTs) have been defined as the smallest, irreducible units of a behavior change intervention that are responsible for bringing about the change in behaviour (Michie, Atkins & West, 2014; Abraham et al., 2015). Recommendations for a BCT taxonomy came following a review of intervention evaluations, where it was found that descriptions of change techniques included within interventions were often poor and that the theoretical linkages were not explicit, making replication (a key element of knowledge accumulation) difficult (Michie & Abraham, 2004; Michie et al., 2013). It was posited that developing a taxonomy of BCTs would promote accurate replication; increase opportunity for high quality systematic reviews (through consistent labelling of techniques in intervention evaluations); and provide intervention developers with a comprehensive 'menu' of BCTs to choose from, rather than selecting from the smaller number of techniques that spring to mind (Michie et al., 2013). Subsequently, a hierarchically structured taxonomy of 93 BCTs (version 1) was developed and published (Michie et al., 2013). The procedure for developing the taxonomy was as follows: first, a BCT prototype classification system was compiled from existing literature; second, an improved list of BCTs was developed from a 2-round Delphi approach involving behaviour change experts; third, an improved list of BCTs was scrutinised by an international advisory board; fourth, members of the study team used the BCT list to code existing interventions and assessed inter-rater agreement

for each BCT; fifth, an open sort grouping task was carried out to create the hierarchical structure. To accumulate evidence regarding which BCTs, or groups of BCTs, enhance effectiveness of interventions, reliable identification of BCTs across interventions is required (Abraham & Michie, 2008). Findings reported in more recent publications suggest that trained coders can reliably identify BCTs from the taxonomy within reported interventions, with some temporal stability (Abraham et al., 2015). To reach this conclusion, 40 trained coders applied the BCT taxonomy to 40 intervention descriptions from published protocols, at two points, with one month between each coding episode. Reliability of coding judgements was assessed using the Prevalence And Bias Adjusted Kappa (PABAK) statistic (where a k of ≥0.70 is considered acceptable reliability) (Abraham et al., 2015). At time point one, coders identified 80 of the 93 BCTs from the taxonomy (Michie et al., 2013). Mean PABAK scores were ≥0.70 for 64 (80%) BCTs, and ≥0.80 for 59 (74%) BCTs, suggesting good inter-coder reliability (Abraham et al., 2015). Thirty-two coders provided data at both time points. For 14 (44%) coders mean PABAK scores between coding episodes were ≥0.80, and for 18 (56%) coders mean PABAK scores were ≥0.90, suggesting good re-test reliability (Abraham et al., 2015).

In addition to developing a hierarchical taxonomy of BCTs from which intervention developers can select BCTs, expert consensus processes have been used to establish linkages between BCTs and determinants (Michie et al., 2008; Cane et al., 2015). In the first publication of this kind, in-press before the 93 BCT taxonomy (Michie et al., 2013), experts in behaviour change extracted BCTs from published sources, expanded the BCT list through brainstorming, and mapped 35 BCTs onto 11 behavioural determinants (Michie et al., 2008). The behavioural determinants used in this mapping work were eleven of the domains from the first (12 domain) version of the TDF (although the TDF label was not used explicitly within the paper) excluding the domain *Nature of the Behaviours* (Michie et al., 2005). Broadly, findings of this work provided an early signal of the feasibility of identifying and defining BCTs, and of mapping BCTs onto theoretically derived behavioural determinants (Michie et al., 2008). Consequently, this paper was

an important precursor to the 93 BCT taxonomy (Michie et al., 2013) and subsequent work where BCTs were linked to the 14 TDF domains.

As previously established, theoretical constructs of behaviour and behaviour change are numerous and frequently overlapping (Michie et al., 2005). Consequently, attempting to link BCTs to constructs may be impractical. On this basis, it was proposed that use of 'higher order' theoretical domains, representing groups of constructs, could be a useful alternative (Cane et al., 2015). Using the aforementioned BCT taxonomy (Michie et al., 2013), a group of researchers used expert consensus methods to re-group the BCTs from the taxonomy using the 14 domains of the TDF (Cane et al., 2015). Linkages were established on the basis that a BCT *could* be effective at changing a behaviour when a specific domain represented a theoretical determinant of that behaviour. Broadly, the procedure used by participants to sort and allocate BCTs to TDF domains was a deductive 'top-down' approach; that is, the starting point was the higher-order TDF domain and the BCTs were sorted and allocated to sit beneath them (Cane et al., 2015). Fifty nine of the BCTs from the original 93 (Michie et al., 2013) were reliably allocated to 12 of the 14 TDF domains (Cane et al., 2015). The explicit linkages established between the TDF domains and the BCTs permit intervention developers to link intervention content (i.e. BCTs) to specific theoretical determinants (i.e. TDF domains) (Atkins et al., 2017). This specific approach to developing a theoretically informed intervention is reported in a small body of published implementation research where the Cane et al (2015) paper has been used as the primary source to drive the mapping of TDF domains to BCTs (Patton et al., 2018; Cadogan et al., 2015; Haskell et al., 2021). Given the paucity of research reporting these methods, further empirical work is required to accumulate evidence of how the groupings reported by Cane et al (2015) impact on usability of the BCT taxonomy (Michie et al., 2013) with different users, in different contexts, and with different combinations of techniques (Cane et al., 2015).

3.9 Engaging stakeholders in the implementation process

'Implementation Research is an applied science, and strategies will need to be adapted to local situations and contexts.'

Powell et al., 2012 p148

To permit suitable adjustments for context and 'local factors' (Baker et al., 2015) it has been recommended that interventions targeting healthcare practitioners be developed through interactive methods that allow local expertise and tacit contextual knowledge to be incorporated (Taylor et al., 2013; Leistikow, Kalkman & De Bruijn, 2011; McCullough et al., 2015; Pronovost, Berenholtz & Needham, 2008; Lewis & Fletcher, 2005). This may be achieved by researchers actively engaging or partnering with stakeholders at different stages within, or across, research activities (Flinders, Wood & Cunningham, 2016; Pronovost, Berenholtz & Needham, 2008; Cowdell et al., 2020). Here, stakeholders include 'individuals who are targeted by the intervention, those involved in its development, or those whose personal and or professional interests are affected' (Skivington et al., 2021 p5). A typology of stakeholder engagement in research from the business and management literature was extrapolated to the healthcare context in one published paper (Hewison, Gale & Shapiro, 2012). Five different types of stakeholder engagement were described which broadly characterise the different levels of participation in the research process (Table 3.3) (Martin, 2010).

The importance of stakeholder participation in implementation research targeting healthcare practitioners has been emphasised (Leistikow, Kalkman & De Bruijn, 2011; Taylor et al., 2013; Greenhalgh et al., 2004). It has been argued that interventions are more likely to be successfully adopted when user perspectives are captured during the development stage of the implementation process (Greenhalgh et al., 2004). Similarly, it has been suggested that adoption is more likely when the intervention does not appear overly complicated, and is perceived as compatible with organisational and professional norms, values and ways of working (Denis et al., 2002; Greenhalgh et al., 2004; Grimshaw et al., 2004). On the basis of these insights, some

overarching implementation processes explicitly advocate stakeholder engagement either throughout the implementation process (i.e. as research co-producers) (Taylor et al., 2013, 2016; Long et al., 2018), or through active participation in specific activities (French *et al.*, 2012).

Table 3.3– a typology of stakeholder engagement with descriptions at each level

The 5 types of stakeholder engagement[1]	Description of clinical stakeholder engagement[2]
1. Clinical stakeholders as informants	Clinical stakeholders may be the objects of investigation or act as gatekeepers to important data sources. Clinical stakeholders do not have an active role in funding or design and there is no strategy for dissemination beyond the academic community.
2. Clinical stakeholders as recipients	Study findings are pro-actively disseminated to clinical stakeholders. However, they have no active role in what is studied or when/where findings are shared.
3. Clinical stakeholders as endorsers	Clinical stakeholders are consulted about research priorities, programmes and/or individual research projects. Researchers may seek feedback and endorsement from individual stakeholders or groups of expert users.
4. Clinical stakeholders as commissioners	This type of participation is typically seen in Government departments with large budgets. Clinical stakeholders conceive and initiate the research. Researchers may join the process later as part of a competitive tender process. Whilst researchers gather and analyse the evidence, commissioners influence the design and reporting. Dissemination activities are typically shared endeavours.
5. Clinical stakeholders as co-producers	Clinical stakeholders and researchers work alongside each other in partnership at all stages of the research process including design, data collection, data analysis, and dissemination activities.

Key:
[1] Hewison et al.,2012, p.297
[2] Martin, 2010, p.214-217

In stage 3 of the implementation process proposed by French et al (2012) (Table 3.1), intervention developers are prompted to explore what intervention components are like to be locally relevant, acceptable, and feasible to users. This provides an opportunity for intervention developers to explore these areas using participatory approaches or structured consensus methods as exemplified in the implementation literature (French *et al.*, 2012; McCullough *et al.*, 2015; Wolk *et al.*, 2017). In the context of behaviour change research in the healthcare setting, examples were found where stakeholder panels were convened with the explicit purpose of exploring how theoretically derived BCTs could be applied in practice (McCullough et al., 2015;

Haskell et al., 2021). Providing opportunities for clinical stakeholders to shape the content of implementation interventions, increases the likelihood of the intervention being accepted into practice (Greenhalgh et al., 2004). Incorporating 'local intelligence' in this way may also help ensure that interventions targeting healthcare practitioners are able to adapt and sustain the dynamic and changing clinical environments within which they are delivered (Green et al., 2009; Skivington et al., 2021).

3.10 Summary

The translation of best available evidence into clinical practice can be a slow and 'haphazard process' (Eccles et al., 2005). The discipline of *Implementation Science* emerged to address these challenges by creating a generalisable body of knowledge related to the translation of research-based knowledge into 'the real world' (Presseau et al., 2021; Eccles et al., 2005; Foy, Eccles & Grimshaw, 2001). The implementation approach proposed by French et al (2012) provides a systematic approach that can be used to underpin the development of a theory-based implementation intervention. The 4-stages included within the process, broadly align to UK Medical Research Council guidance (Craig et al., 2008; Skivington et al., 2021) for developing and evaluating complex interventions. The Theoretical Domains Framework (TDF) is an integrative theoretical framework of behaviour change which includes 14 domains, representing 84 overlapping constructs, drawn from 33 theories (Cane, O'Connor & Michie, 2012). Within the implementation literature, the TDF has been applied to report healthcare practitioners' behavioural beliefs related to an action i.e. perceived barriers and enablers to performing the target behaviour. Subsequently, using a published taxonomy, specific BCTs can be mapped to TDF domains that represent the most important barriers and enablers to the target behaviour/s. Through engaging with clinical stakeholders, collaborative decisions can be made about how BCTs are operationalised in the clinical setting, to ensure that 'local intelligence' and context are considered.

Despite evidence that early warning scores and associated escalation protocols improve patient outcomes, compliance with these tools remains inconsistent in clinical practice. The overarching implementation process reported in this chapter will be applied to develop a theory-

based behaviour change intervention to facilitate implementation of NEWS. In the following chapter, the specific methods used to underpin this implementation process will be reported in detail. In addition, researcher reflexivity will be introduced, and the procedures followed related to research governance and ethics will be described.

4 CHAPTER 4: METHODS

4.1 Introduction

There is currently a limited body of research reporting the development of interventions targeting behaviours that are potential antecedents to Afferent Limb Failure (ALF). There is evidence that interventions developed from the systematic application of theory are more effective at changing behaviour (Albarracín et al., 2005; Noar & Zimmerman, 2005; Webb et al., 2010; Taylor, Conner & Lawton, 2012). Further, the explicit use of theory in intervention development provides a generalisable framework permitting more efficient replication in different settings and with different populations (Little, Presseau & Eccles, 2015). From the international literature, no reports were found of interventions where theory had been applied systematically to elucidate determinants of best practice behaviours of the afferent limb, and to drive the selection of intervention content to address empirically deduced barriers and enablers. A description of the methods used to develop the theory-based, preliminary, behaviour change intervention (targeting Registered Nurses (RNs) and Healthcare Assistants (HCAs)) to improve responses to deteriorating patients, is provided in detail within this chapter.

4.2 Study design

A multi-phase, prospective mixed methods study was conducted. A published protocol for this research (Smith et al., 2019) can be found in volume 2, appendix 4. A diagrammatic overview of the study design in provided in figure 4.1 (page 116). Research was conducted in three phases:

Phase 1:

- To identify the target behaviours for change, focused ethnography was used to compare the expected (i.e. policy specified) behaviours of nursing staff (RNs and HCAs) when actioning the afferent limb with those directly observed on acute hospital wards.
- Potential target behaviours for change were specified and shortlisted using published criteria and consensus discussion with research and clinical supervisors (addressing objective 1).

Phase 2:

- Brief (not audio-recorded but paraphrased in field notes) and semi-structured (audio-recorded) interviews, informed by the Theoretical Domains Framework (TDF) of behaviour change, were used to elucidate determinants of nursing staff enacting the specified target behaviours of the afferent limb (addressing objective 2).
- TDF domains of high importance were identified using published criteria and mapped to specific Behaviour Change Techniques (BCTs) using published expert consensus literature (addressing objective 3).

Phase 3:

- BCTs were shortlisted through consensus discussion with research and clinical supervisors.
- Nominal Group Technique (NGT) methods were used in stakeholder groups (hereafter referred to as nominal groups) to identify how the shortlisted BCTs could be applied in practice, and to prioritise content according to acceptability and feasibility of implementation in acute ward areas (addressing objective 4).

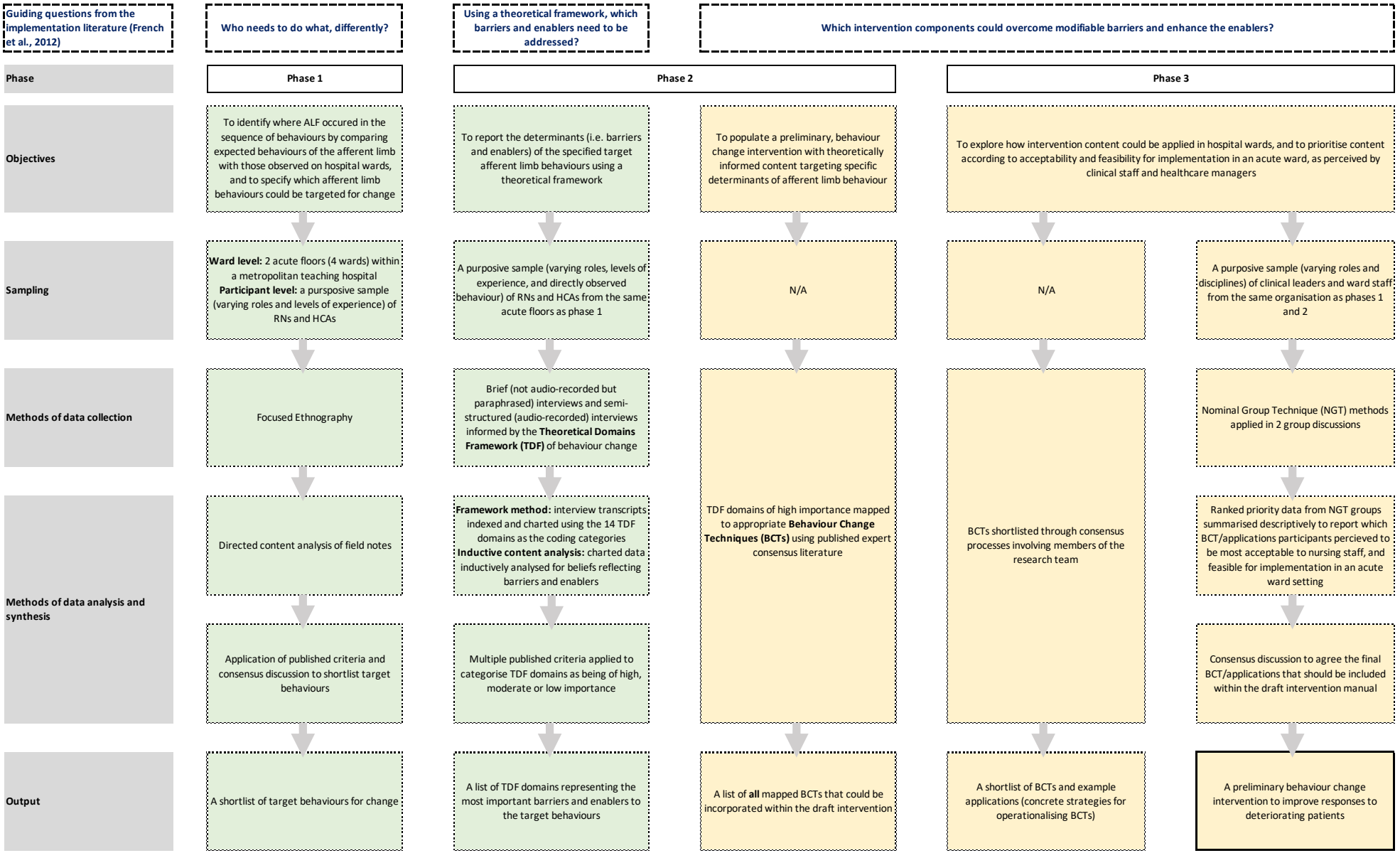

Figure 4.1 - a diagrammatic overview of the DECIDE study design

4.3 The organisational context of the research

This research was conducted in an acute NHS Trust that provides emergent care for the local population as well as a range of specialist services. The Trust comprises seven geographically separate hospitals with a total bed-base of 1,161. Over 8,500 staff are employed within the organisation. The specific hospital within which this study was conducted is the largest in-patient site within the organisation. The Trust was last inspected by the Care Quality Commission (CQC) in 2018. In the year preceding the CQC inspection (i.e. 2017-2018), over one million patients were seen within the Trust, including 137,500 visits to the emergency department. Care Quality Commission inspectors rated the organisation as 'good' overall and specifically in the following areas:

- Services are effective
- Services are caring
- Services are responsive
- Services are well-led
- Resources are used productively.

For 'safe services' the organisation was rated as 'requires improvement' (the only domain with this rating) for the following reasons:

- Poor mandatory training compliance from key medical staff
- Lapses in infection control practice in some areas
- Evidence of medicines storage and management policy not being followed consistently
- Deficiencies in the numbers of qualified staff in some clinical areas.

In relation to the use of NEWS to recognise and escalate care for deteriorating patients, the following observations were made by the CQC inspectors:

- People were assessed using the National Early Warning System (NEWS). Staff were knowledgeable in responding to any changes in the observations which necessitated the need to escalate the patient to be seen by medical staff.
- Staff were aware of what action to take to respond to a patient's condition in case of deterioration, including sepsis. Our review of records and the service audits demonstrated staff used the National Early Warning System (NEWS) appropriately.

A quality account is a mandatory report that all National Health Service (NHS) healthcare providers are obligated to publish on an annual basis (National Health Service, 2019). The document includes detail on the quality of services provided and on the progress that an organisation has made in relation to patient safety initiatives. From the quality account for the Trust within which this research was conducted, patient safety goals related specifically to the recognition and response to the deteriorating ward patient (for 2022/2023) are summarised in Table 4.1.

In 2018, it was confirmed that the Trust would be switching from paper-based patient records to an Electronic Health Record (EHR). As part of this process, the Trust announced plans to migrate from using a paper based NEWS1 chart to an electronic version of NEWS2. These plans were announced after this study had been designed and the original protocol written (Smith et al., 2019). However, it was identified that this period of transition would provide a unique opportunity for data collection before and after the implementation of an EHR, and an embedded electronic version of NEWS. Given the fixed nature of the EHR 'go-live' date, and the need for the pre EHR data collection to be completed before implementation, this pre EHR period of data collection was finite. Three months of data collection (phases 1 and 2) was conducted in the pre EHR period. Once the EHR was activated, no further data were collected for a 3 month period (Bedoya et al., 2019). This was to allow the system to be implemented and to undergo early phase optimisation. It was also acknowledged that during this period of transition staff behaviour was unlikely to reflect 'usual practice'. Subsequently, the same data collection activities (phases 1 and 2) were replicated in the post EHR context.

Table 4.1 – patient safety priorities as published in the 2022/2023 quality account from the Trust within which this research was conducted

Trust quality priority and rationale	What success will look like
1. Review escalation and management of patients with unplanned critical care admissions (linked to CQUIN[1])	
Review recorded documentation of NEWS2 score, time and date of escalation, and time and date of response by appropriate clinicians of 100 patients (per quarter) with unplanned critical care admissions.	– Completed a review of 100 patients with unplanned critical care admissions (from non-critical care wards aged 18+) per quarter and achieve a compliance of 20-60% of documented NEWS2 score, time of escalation, and time of clinical response recorded.
2. Standardise and embed SBAR[2] as a communication tool for escalation.	
Update NEWS2 eLearning and deliver Trust-wide teaching through Trust clinical practice facilitator network.	– Updated the e-learning and implemented teaching Trust wide.
Launching SBAR and establishing a baseline on the use of the SBAR tool on EHR[3] when escalating deteriorating patients and agree a target once baseline is established.	– Established a baseline and agreed a target. – Increased use of the SBAR communication tool in practice as reflected in post implementation survey.
3. Continue to develop the nurse-in-charge dashboard to improve patient management and utilise data at bedside to inform day-to-day care of the patient.	Completion of the nurse-in-charge dashboard and assessing its value.
[1]CQUIN – Commissioning for Quality and Innovation – a financial insensitive scheme to reward organisations that provide excellent care [2]SBAR – Situation Background Assessment Recommendation – a structured communication tool for clinical staff to use when escalating care [3]EHR – Electronic Health Record	

The hospital in question has an established RRS that was implemented in 2000. The efferent limb response is provided by the primary medical team and a designated Critical Care Outreach Team (CCOT) which is available throughout the day, at night, and on every day of the year. Whilst the team is nurse-led, the primary responders (senior critical care nurses) can refer to a designated critical care doctor (with a minimum of 5 years post-graduate experience) at any time. Aside from the implementation of the EHR and electronic NEWS2, all other aspects of the RRS remained the same throughout the period of data collection. Specifically, no changes were made regarding how patients' vital signs were monitored or how the efferent limb was activated.

4.4 Patient and public involvement and engagement

Patient and Public Involvement and Engagement (PPIE) in research involves the 'development of an active partnership between service users and/or members of the public and researchers' (National Institute for Health Research (NIHR) Research Development Service, 2018 p5). In the UK context, PPIE is increasingly recognised as a core component of health services research, reflected by its inclusion in the criteria used by several research funders to evaluate bids and award grants (National Institute for Health Research (NIHR), 2019). A consensus study was conducted to examine the potential role of PPIE in implementation research, specifically where healthcare practitioners may be the target of the implementation intervention (Gray-Burrows et al., 2018). In this study, participants (patient advisors experienced in PPIE and researchers), strongly supported PPIE in the following areas:

- Setting priority areas for further research
- Helping to shape research questions
- Advising on methods to obtain consent
- Reviewing and commenting on applications for research funding
- Setting the agenda for PPIE meetings (alongside researchers)
- Ensuring that researchers are acting responsibly (i.e. serving a governance function)
- Sharing learning with other relevant stakeholders
- Guiding the direction of future research

Gray-Burrows *et al.*, 2018 p4

From this consensus work, the authors concluded that Patient Advisors (PAs) should be engaged in implementation research but suggest involvement is tailored to the individual project to avoid 'tokenism' and misuse of time and resources (Gray-Burrows et al., 2018).

A James Lind Alliance priority setting exercise was conducted to identify and prioritise unanswered questions about adult intensive care (Reay, Arulkumaran & Brett, 2014). Thirty-seven intensive care research topics were identified and ranked using consensus techniques (modified

Delphi and Nominal Group Technique) by ex-intensive care patients, their families and healthcare practitioners. The following question, which broadly aligns to my PhD research, was ranked 15 of 37 (Reay, Arulkumaran & Brett, 2014):

> *How can patients who might benefit from intensive care be identified early and admitted to the ICU at the right time?*

Whilst the preliminary intervention that I developed will target healthcare practitioners rather than patients, this consensus work (Reay, Arulkumaran & Brett, 2014) provides an early signal of the importance of the wider topic to patients and their relatives and strengthens the argument for PPIE. To seek PAs to be involved in my project, I created a plain-English summary and simple person specification which were peer reviewed by the PPIE manager from the Trust where my research was conducted. Revisions were made based on her feedback. Documents were then sent to two managers with access to ex-intensive care patients:

- A matron for ICU in the Trust (to recruit local patient advisors).
- The lead of a national critical illness charity ('ICUsteps') (http://www.icusteps.org) which aims to support patients and family members who have experienced critical illness.

Two PAs agreed to be involved in the development of the study protocol. One PA was recruited via 'ICUsteps' and agreed to review documents and send feedback via email. A second PA, who was recruited locally (i.e. from the Trust where the research was conducted), agreed to review documents electronically and to meet in person to discuss the aim, objectives, and methods. Both PAs who participated in the development of the study agreed to remain involved throughout the research process. The specific contribution patient advisors made across the study is listed below:

- Communicated electronically (quarterly) and met with me (biannually) throughout the project (either face-to-face or on Microsoft® Teams).
- At the outset of phases 1 and 2, reviewed and commented on research materials including the participant information sheets, opt-out form, consent forms, and interview topic guides.

- At the outset of phase 3, reviewed and commented on the participation information sheet, consent form, nominal group facilitator's guide, and nominal group information package (for participants).
- After phase 3, reviewed and provided feedback on the preliminary behaviour change intervention (with a specific focus on how coherently the intervention components were presented and described).

4.5 Phase 1 – reporting 'who needs to do what differently'

4.5.1 Research materials (phase 1)

4.5.1.1 Development of an observation guide and field journal

During phase 1, observation focused on the behaviour of RNs and HCAs undertaking specific activities (behaviours of the afferent limb) within the ward environment. To focus the observation on the behaviours of interest, and to ensure dependability of the data collected, a structured observation guide (volume 2, appendix 5) was developed based on recommendations within existing literature (Roller & Lavrakas, 2015; Ede et al., 2019) and using examples from publications where similar methods were used (Cardona-Morrell et al., 2015). The first iteration of the observation guide was populated with broad descriptions of afferent limb behaviour from published sources (Davies et al., 2014; Lyons, Edelson & Churpek, 2018). For clarity of reference, I labelled these broad descriptions of afferent limb behaviour as the 'key moments' of the afferent limb (Table 4.2). Each of the 5 key moments were then elaborated with more specific content derived from documentary analysis of the Trust's local policy for deteriorating patients (see section 1.6). To populate each of the key moments with statements of expected (i.e. policy specified) afferent limb behaviour, each statement extracted from the local policy was read multiple times before being grouped beneath the key moment that best represented it. This process led to multiple statements of behaviour beneath each of the key moments (range 2-4 statements per key moment). For example, the following two statements of behaviour from the local policy: *'If the HCA is measuring the vital signs and the NEWS is elevated (i.e. ≥5), the HCA escalates to the RN so that they can perform further assessment'* and '*All patients identified as at risk (i.e.* with raised

NEWS) *require a RN to inform the nurse-in-charge and decide on the escalation needed'* were behaviours both linked to the key moment *'escalation within the ward-based nursing team'.*

Prior to data collection, the observation guide was reviewed for appropriateness and clinical accuracy by a supervisor with expertise in critical care research (LMA) and members of the hospital's CCOT. The structured observation guide was also reviewed between the pre EHR and post EHR periods of data collection. Any behaviours that were no longer relevant in the electronic context (i.e. those that specifically related to staff using the paper NEWS chart) were removed before data collection activities were replicated post EHR implementation.

In conjunction with the observation guide, a document for recording field notes (a field journal) was developed (volume 2, appendix 6). The document included space for the following data to be recorded during the period of focused ethnography:

- Contextual detail related to directly observed behaviours (including who, what, where, when and how) (Polit & Beck, 2018)
- Whether an alternative behaviour (including no behaviour) was observed instead of the expected (i.e. policy specified) behaviour
- Vital signs data (e.g. heart rate, blood pressure, respiratory rate) from chart reviews that took place alongside observation of staff
- Participants' responses from brief interviews were also paraphrased within the field journal (Gillespie, Wallis & Chaboyer, 2008; Pattison et al., 2018).

As a registered nurse with experience of managing deteriorating patients, I needed to maintain a high level of self-awareness and situational awareness during data collection activities (attributes promoting 'reflexivity') (Tracy, 2019; Vindrola-Padros & Vindrola-Padros, 2018). Consequently, a section for 'reflexive notes' was incorporated into the field

journal (as advised by Roller & Lavrakas, 2015). This space was used to journal my feelings, reactions, and perceptions (Willig & Stainton Rogers, 2010). A section to record any actions taken to protect patient safety during the period of observation was also included.

The observation guide and field journal were piloted on both floors for one week and revised thereafter. After piloting the materials, field notes and reflexive jottings were presented to supervisors (LMA and MC), allowing data collection decisions to be challenged and defended and enabling revisions to the structure and content of the field journal.

Table 4.2 - five key moments of the afferent limb of the Rapid Response System

Key moment	Description
Routine monitoring of vital signs	Monitoring a group of patients' vital signs consecutively at a specified time
Responsive monitoring of vital signs	A targeted episode of vital signs monitoring that occurs outside of – or more frequently than – routine monitoring
Recording the vital signs and/or calculating the aggregate NEWS	Actions related to documenting vital signs on a paper NEWS chart/entering the data into the EHR and/or calculating an aggregate NEWS (if using a non-automated system)
Escalation within the ward-based nursing team	Notifying a nursing colleague within the same ward-based team that a patient is deteriorating
Escalation outside of the ward-based nursing team	Notifying a colleague from outside of the ward-based team (doctor or specialist nurse/practitioner) that a patient is deteriorating

4.5.2 Recruitment and ward-level sampling (phase 1)

Two acute floors (4 wards) were recruited for focused ethnography using local data. As the hospital in which the research was conducted is arranged in a 16-floor tower, the term 'floor' is used to describe each specific level of the tower block. In practical terms, the floors are then further sub-divided into separate ward areas (frequently 2 wards per floor, occasionally 3). To increase the

likelihood of observing a range of different staff behaviours, floors with contrasting characteristics were approached for recruitment purposes. Adverse Event (AE) data were routinely presented to the Trust's strategic steering committee focusing on deteriorating patients. Permission was sought from the committee chair to use these data to identify a ward-level sample. Use of these local data enabled targeted recruitment of a floor where a recent (i.e. in the 12 months preceding recruitment) AE associated with ALF had occurred, alongside a floor where no such incidents had been reported. In addition to targeting a ward with and without a reported AE, wards were also selected based on contrasting clinical specialisms. To ensure that local contextual knowledge was considered when sampling decisions were made, the floors selected from the local data were discussed independently with the lead nurse for the hospital's CCOT and the Trust project lead for patient safety. Senior nurses and ward managers for the selected floors were issued with written information about the research.

Based on precedent within the literature (Mackintosh, Humphrey & Sandall, 2014; Gillespie, Wallis & Chaboyer, 2008), I planned to observe staff behaviour for 180 hours or until data saturation was achieved. Here, data saturation was defined as the point when no new behaviours (expected or unexpected) were observed despite observations taking place on different days of the week, and at different times of day and night (Saunders et al., 2018). Using a small sample of wards (and the same wards for the pre and post EHR data collection), allowed immersion in each and ensured a 'thick description' of the setting and participant behaviour (Reeves, Kuper & Hodges, 2008; Tracy, 2019). This may also have helped participants 'habituate' to my presence on the ward and therefore mitigated observer effects (Pope, 2005; McCall, 2002).

From the sample wards, all RNs and HCAs who had not prospectively opted-out of participating (see section 4.9.1.1 for opt out procedure), were eligible to be observed during a clinical shift. In the UK context, unregistered HCAs are frequently involved in enacting behaviours of the afferent limb, particularly the monitoring of patients' vital signs (Ede et al.,

2019; Smith et al., 2020). Consequently, both RNs and HCAs were recruited. As there is evidence that the frequency of monitoring and nursing staff' compliance with escalation protocols decreases at night and during weekends (Credland, Dyson & Johnson, 2018), observation was carried out during weekdays, weekends and at night.

4.5.3 Data collection (phase 1)

Focused ethnography was conducted to explore the behaviour of nursing staff when they were actioning behaviours of the afferent limb of the RRS. Focused ethnography is an applied qualitative methodology that is well suited to research in which participants reflect a small sub-group of society (e.g. a particular professional group), where the objective is to elucidate a reported problem in a particular context, and where the researcher's access to participants is limited to brief, episodic contact (Cruz & Higginbottom, 2013; Knoblauch, 2005). In qualitative research, multiple data collection strategies may be employed (i.e. use of triangulation) to facilitate a deeper understanding of the phenomena under investigation and to ensure rigour within the research process (O'Cathain, Murphy & Nicholl, 2010; Polit & Beck, 2018). Specifically in the context of ethnographic research, use of participant observation and examination of relevant documents are reported methods (Cruz & Higginbottom, 2013). Both approaches were incorporated into phase 1 of this research.

In keeping with the concept of focused ethnography, observation focused on the activities of clinical personnel (RNs and HCAs) undertaking specific actions (behaviours of the afferent limb) within the ward environment. Given the vast number of different behaviours that were enacted in the clinical environment, the structured observation guide was used to maintain focus on the relevant behaviours. As highlighted in other research where observational approaches were used, the subject of observation (i.e. the RN or HCA) can change based on patient acuity (Ede et al., 2019). It was anticipated that when patient acuity was higher, more opportunities would be provided to observe the behaviours of interest. As such, decisions regarding where I positioned myself physically were made iteratively and reflexively depending on the level of activity that I observed on the clinical floors (Ede et al., 2019; Vindrola-Padros & Vindrola-Padros, 2018).

Although the aim was to provide approximately equal time observing on both floors, if the acuity in one area appeared to be lower and/or the behaviours of the afferent limb were not being witnessed, I moved to an alternate floor or ward within the sample to maximise opportunities to observe behaviours of the afferent limb.

NEWS chart reviews were conducted throughout the data collection period. Vital signs and aggregate scores from the NEWS chart (paper and electronic) were extracted and recorded in the field journal. Chart reviews were conducted on an *ad-hoc* basis or soon after direct observation of staff. It was expected that chart reviews would be particularly useful, in conjunction with direct observation of staff, to identify alternative behaviours or missed opportunities when no behaviour was enacted when it should have been. For example, if when reviewing a patient's chart their NEWS was found to be elevated (i.e. a score consistent with medium or high risk), then there should have been evidence of further monitoring within one hour of the vital signs being recorded (the expected behaviour). If continual observation in the vicinity of the patient, and/or a follow-up chart review, did not provide evidence of further monitoring, this was recorded as a moment of 'unexpected behaviour'. A chart review was also performed when discussions about an unwell patient were overheard at nursing staff handovers or a 'huddle', or when 'heightened activity' was seen around a particular patient (e.g. staff bringing emergency equipment to the patient's bedside).

In adult patients hospitalised for a range of clinical diagnoses respiratory rate was found to be an independent predictor of adverse events (Fine et al., 1997; Escobar et al., 2012; Fieselmann et al., 1993; Churpek, Adhikari & Edelson, 2016). Unlike the other vital signs entered into NEWS, the respiratory rate is typically not measured using electronic equipment and must be measured visually by a healthcare provider (i.e. manually) (Badawy et al., 2017). Despite its importance, there is evidence that manually obtained respiratory rates are frequently inaccurate with errors reported at the point of measurement and at the point of recording (Kallioinen et al., 2020). Based on this evidence, I elected to compare the

respiratory rate recorded on NEWS with the respiratory rate that I count *in situ.* When I directly observed vital signs being measured, or the NEWS chart indicated that they had been recorded within 15 minutes of my arrival, then I counted the patient's respiratory rate myself over one minute. This allowed direct comparison with the respiratory rate recorded by the ward staff (i.e. the data on the chart). The decision to use a cut-off of 15 minutes was informed by the results of a prospective observational study where a sample of patients had their respiratory rate counted twice (by the same and/or a different practitioner) with an approximate 15 minute interval between measurements (Lim et al., 2002). Here, the researchers reported negligible differences between the two recorded rates and good agreement irrespective of whether the measurements were undertaken by the same or different individuals (Lim et al., 2002). These findings suggest that any noteworthy discrepancy between two measurements, taken 15 minutes apart, may be more reflective of poor practice in the measurement and/or recording of the respiratory rate, rather than temporal fluctuations or inter-observer variation. It is worthy of note that this study included a small sample of patients the characteristics of whom are poorly described. As such, it is unclear if these findings are generalisable to a more acutely unwell patient population (like the patients being cared for by participants of this research) who may have more rapid changes in vital signs. Notwithstanding these limitations, and in the absence of more robust evidence to inform this, a cut-off of 15 minutes was applied.

The decision to undertake this measurement was contingent on my ability to discretely position myself where I could reliably observe the patient's breathing, without my presence interrupting clinical care or being intrusive to the patient or the member of nursing staff. These measurements were taken on an *ad hoc* basis, typically alongside direct observation, and chart review. Where the respiratory rate I recorded was considerably different to the respiratory rate recorded on the chart (i.e. different enough to change the NEWS risk-level), an agreed safety protocol was followed as described in section 4.9.2.2.

4.5.4 Data analysis (phase 1)

Directed content analysis (Hsieh & Shannon, 2005) was used to analyse field notes from focused ethnography. The exact procedure that I followed for data analysis was as follows:

- Handwritten descriptions of direct observations of staff (RNs and HCAs) and chart review data were read superficially and then more thoroughly to ensure familiarisation with the subject matter.
- Initially, data were labelled and categorised by the five key moments of the afferent limb (Table 4.2).
- Within each of the five categories, data were examined further and compared directly to policy-specified behaviour (obtained from the preparatory work reported in chapter 1 section 1.6). Where the observational data, or information extracted from chart review, aligned to policy-specified behaviour, they were categorised as 'expected behaviour'. Where these exerts from field notes did not align to the policy-specified behaviour, they were categorised as 'unexpected behaviour'. Data representing a lack of action were also categorised as 'unexpected behaviour'.
- Frequencies and proportions of expected and unexpected behaviours were counted across the corpus of data and for each of the key moments of the afferent limb.
- Unexpected behaviours were scrutinised and statements describing 'who needs to do what differently' synthesised and structured using a published specification framework (AACTT – Action, Actor, Context, Target, Time) (Presseau et al., 2019). In keeping with recommendations in the literature (Atkins et al., 2017), the behaviours were specified in accordance with the expected and desired behaviour (i.e. the target behaviour), rather than the unexpected alternative. These specified statements of behaviour were a key output of phase 1.

Where the data extracted from the field notes included a respiratory rate measurement that I counted *in situ* (hereafter referred to as the researcher respiratory rate), alongside the respiratory rate extracted from the NEWS chart (the recorded respiratory

rate), a sub-analysis was performed by comparing the two respiratory rate measurements. Where the difference between the two measurements was greater than 5 (in either direction) then the episode was categorised as 'unexpected behaviour'. The decision to consider a difference of 5 as a signal of unexpected behaviour, was informed by a published study reporting levels of agreement between vital signs measured by different clinicians (Dinh et al., 2013). Here, the researchers set *a priori* limits of agreement for respiratory rate measurements as ± 5 breaths, and reported differences beyond this to be outside the range of clinical acceptability (Dinh et al., 2013). Where the difference between the researcher respiratory rate and the recorded respiratory rate was not greater than 5, but was sufficient to change the aggregate NEWS, then this was also categorised as 'unexpected behaviour'. This decision was made pragmatically, given the potential implications on patient safety (a difference in score may have resulted in a change in the patient's degree of risk) and nursing staff behaviour (a change in risk level may have changed the actions recommended by the NEWS escalation algorithm (Royal College of Physicians, 2017)).

Where the difference between the two measurements was less than 5 and/or it did not result in a change in the aggregate NEWS, then the episode was categorised as 'expected behaviour'. Differences between the researcher respiratory rate and the recorded respiratory rate were summarised descriptively.

4.5.5 Shortlisting the target behaviours

In the wider behaviour change literature, it is posited that interventions targeting a small number of carefully selected and specified behaviours, are more likely to be effective than those that aim to change too much too quickly (Michie, Atkins & West, 2014). Consequently, it is recommended that intervention developers select a small number of target behaviours in the first instance (Michie, Atkins & West, 2014; Atkins et al., 2017). Despite these recommendations, there is a noteworthy lack of clarity and consensus in the literature regarding what constitutes an optimal number of target behaviours. Within the published TDF literature, examples were found of studies that explored barriers to a single behaviour (Sargent et al., 2017); two behaviours (French *et al.*, 2012; Presseau *et al.*, 2017); six behaviours involving different actors (Craig et al., 2017), through

to 19 different behaviours (Debono et al., 2017). Selecting a suitable number of target behaviours may be particularly challenging for intervention designers attempting to address complex problems that involve numerous behaviours that are interdependent (Atkins et al., 2017). In these circumstances, it is recommended that intervention developers engage with key stakeholders to mutually agree which target behaviours should be prioritised for change (Michie, Atkins & West, 2014; Atkins et al., 2017; Taylor et al., 2013; Kok et al., 2015). Based on these recommendations, a shortlisting exercise was conducted, between the pre and post EHR data collection periods (a period of three months when no new data were collected) to prioritise the target behaviours that would drive the ongoing inquiry. The procedure for this shortlisting exercise was as follows:

- All potential behaviours for change (identified from focused ethnography in the pre EHR context) were reviewed and evaluated independently (by the lead of the hospital's CCOT and I) using 4 shortlisting criteria. As the implementation process by French et al (2012) did not offer any specific criteria for this purpose, criteria were obtained from an alternate but overlapping approach (the Behaviour Change Wheel) (Michie, Atkins & West, 2014).
- For all listed behaviours, a score (range 0-3) was allocated for each of the criteria (Table 4.3), and then totalled (as reported by Sargent et al., 2017). A higher total score (range 3-10) signalled that a potential behaviour for change met shortlisting criteria more favourably.
- As the application of these criteria was subjective, the total scores were not considered to be definitive, but instead were used as a stimulus for discussion and debate during a subsequent meeting involving both reviewers and an independent third party (an academic supervisor - LMA).
- Behaviours that scored highly and/or were considered important during consensus discussion, were reported as the target behaviours for change. Shortlisted target behaviours were presented to all academic (MC, JD, LMA) and clinical (JH) supervisors.
- Questions within the pre EHR interview topic guides were reviewed and, where necessary, adjusted to ensure that they adequately aligned to the target behaviours. The revised topic

guides were subsequently used to inform semi-structured interviews in the post EHR data collection period.

Table 4.3 – criteria and scoring system used to shortlist target behaviours

Shortlisting Criteria (taken from Michie, Atkins & West, 2014)	**Score and scoring criteria**			
	0	**1**	**2**	**3**
How likely is it that changing this behaviour will have a positive impact on the recognition of and response to deteriorating patients?		Very unlikely	Likely	Very likely
Is it likely that the behaviour can be changed?	No	Yes		
How likely is it that changing this behaviour will have a positive or negative impact* on other related behaviours?		Negative or no impact*	Potential impact*	Positive impact*
How easy will it be to measure the behaviour?		Difficult/not measurable	Possible with effort	Easy

***Definition of impact in the context of this exercise:**

Positive impact	Changing the target behaviour increases the likelihood that other behaviours in the causal chain will be enacted as expected (e.g. positive spill-over)
Negative impact	Changing the target behaviour will interrupt, block, or reduce the likelihood that other behaviours within the causal chain will be enacted as expected (e.g. negative spill-over)
Potential impact	Changing the target behaviour may have a spill-over effect on other behaviours however it is not clear what the spill-over effect would be (e.g. could be positive or negative) or if it would happen at all

4.6 Phase 2 – using a theoretical framework to identify determinants to the target behaviours

4.6.1 Research materials (phase 2)

4.6.1.1 Development of interview topic guides informed by the TDF

Two semi-structured interview topic guides (one for HCAs; one for RNs) were developed (appendices 7 and 8) and revised using reported methods from the existing TDF literature, and

expertise from within the research team. The specific procedure for the development of the topic guides was as follows:

- Questions, informed by TDF topic guides from published (Roberts et al., 2017; Sargent et al., 2017) and grey (Blay, 2014) literature, were devised to broadly explore all behaviours recognised to be part of the afferent limb (e.g. monitoring vital signs, calculating NEWS, escalating care as appropriate). At least one question for each of the 14 TDF domains was included (Goddard et al., 2018).
- A pilot interview was conducted with a member of nursing staff from a non-participating ward within the same hospital. The pilot interview was transcribed and read, and questions that appeared to confuse the participant (i.e. where the participant expressed a lack of understanding or asked for clarification) or that lead to an unanticipated response, were identified. Audio recordings of these specific questions, and the participant's responses, were presented to a local research group. The group was led by a Professor of Health Services Research (JJF) with considerable expertise in the use of the TDF. Membership included doctoral students and post-doctoral fellows with an interest in implementation science and behaviour change research. The questions and responses were discussed and debated amongst the group and the topic guide questions revised based on these discussions.
- To further validate the appropriateness of the questions to the TDF domains they reflected, the following process was carried out (as advised by: Roberts et al., 2016): questions were separated from the TDF domains to which they were originally mapped, and listed; the list of un-labelled questions was sent to a supervisor (MC), who had not been involved in the initial topic guide development; the supervisor independently allocated each question to one or more TDF domains; differences between the original question mapping and the supervisor's allocations were reconciled through consensus discussion, and further revisions to topic guide content were made.
- A second pilot interview was undertaken using the updated topic guide prior to data collection.

To avoid the conversation during an interview drifting away from the behaviours of interest towards general issues, it is advocated that questions within topic guides be 'anchored' to specific target behaviours (Atkins et al., 2017). To ensure this, topic guide content was reviewed and, where necessary, adjusted iteratively throughout the period of data collection. Between the pre and post EHR data collection periods, a comprehensive review of topic guide content was carried out by an academic supervisor (LMA), a clinical supervisor (JH) and I, to ensure that questions within the interview topic guides adequately explored barriers and enablers to the *specific* target behaviours identified and shortlisted in phase 1 (see section 4.5.5). At this time, questions were also reviewed to ensure that they were relevant to the electronic context and, where necessary, re-worded accordingly.

4.6.1.2 Development of a coding manual

As advocated in the TDF (Roberts et al., 2017; Presseau et al., 2017) and qualitative literature (Tracy, 2019), a coding manual (volume 2, appendix 9) was developed through an iterative process to ensure a transparent audit trail of coding decisions and to increase dependability of the data (Forero et al., 2018). The first version of the codebook was developed using example coding manuals from published TDF research (Craig et al., 2017; Presseau et al., 2017). Subsequently, the coding manual was customised using data from two pilot interviews as follows: pilot interview data were deductively coded (by myself) using the 14 TDF domains as the coding categories; each of domains were populated with at least one example quote and a short rationale for the coding decision; the codebook (populated with example quotes and rationale) was sent to a health psychologist (JJF) with considerable expertise in the application of the TDF, who reviewed the examples coding decisions; any disagreements in coding were reconciled through consensus discussion with academic supervisors (LMA, MC, JJF). This process was then repeated using data from the second pilot interview. Further coding decision rules were added iteratively to the coding manual, based on the consensus discussions between academic supervisors (LMA, MC) and I, following double coding of semi-structured interview transcripts.

4.6.1.3 Development of a mapping tool to link domains of the TDF to BCTs

Using a published taxonomy of BCTs (Michie et al., 2013) a table (volume 2, appendix 10) was produced linking BCTs (n=59) to the TDF domains. These linkages were identified from published expert consensus work (Cane et al., 2015). This paper was selected as the primary source, as the BCTs (n=59) were mapped specifically to the 14 domains of version 2 of the TDF (Cane, O'Connor & Michie, 2012); the same iteration of the TDF used throughout this research. However, in the work by Cane et al (2015) experts were unable to reliably allocate BCTs to the TDF domains *Social, Professional Role and Identity* and *Memory, Attention and Decision Processes*. Consequently, the original consensus work by Michie et al (2008) was used as a secondary source to allocate BCTs to these specific domains to ensure complete coverage within the table (i.e. a minimum of one BCT linked to each of the 14 TDF domains) (Cadogan et al., 2015).

4.6.2 Recruitment and sampling (phase 2)

4.6.2.1 Recruitment for brief (unrecorded) interviews

To ensure maximum variation within the sample, RNs and HCAs of varying clinical bands were approached for a brief (unrecorded) interview. As recruitment was conducted *in situ* (i.e. was concurrent with observation of staff behaviour) decisions to approach staff for a brief interview were also determined by the afferent limb behaviours that they were seen to enact. A range of staff were recruited including those directly observed enacting the expected (i.e. policy-specified) afferent limb behaviour, those seen to enact an alternative behaviour (unexpected behaviour), and those who did not act in a situation where policy stipulates that they should have (also considered unexpected behaviour in this context). Initially, any staff member observed enacting the behaviours of interest, who had not prospectively opted out of participating, was approached for a brief interview. Later, recruitment became more targeted as only 'new participants' (i.e. those staff members not previously observed or interviewed) or participants seen enacting a 'new behaviour' (i.e. a specific behaviour not previously observed) were approached for a brief interview.

4.6.2.2 Recruitment for semi-structured (audio-recorded) interviews

A purposive sample based on seniority (employment grade or role) and experience (duration of time in role) of nursing staff were recruited to participate in an audio-recorded semi-structured interview. Like the brief interviews, recruitment decisions were also informed by the behaviours that participants were seen to enact. Initially, all staff observed enacting the behaviours of interest (expected or unexpected), who participated in a brief interview, were invited to participate in a follow-up semi-structured interview. As the study progressed, recruitment for the semi-structured interviews became more targeted. Participants were prioritised for participation in a semi-structured interview if they were seen enacting a new behaviour (i.e. a behaviour never observed) or enacting a previously observed behaviour in a different way (i.e. using a different technique or approach), and/or voiced a 'new belief' (i.e. a belief not previously heard) in a brief interview. It was anticipated that adopting these approaches would maximise the diversity of beliefs captured during data collection activities. At the point of recruitment, staff were informed that they had been invited to participate because they were seen enacting a behaviour related to monitoring and/or escalating care for a deteriorating patient. Whether or not their behaviour was considered expected or unexpected was not disclosed.

4.6.3 Data collection (phase 2)

4.6.3.1 Data collection methods for brief (unrecorded) interviews

Brief interviews were conducted, after notable observations, to elucidate participants' immediate interpretations of an observed event (Gillespie, Wallis & Chaboyer, 2008; Ede et al., 2019; Foley & Dowling, 2019). Practically, these interactions began with an open question related directly to an observed event e.g. *'I noticed that you attached that patient to the monitoring equipment, would you mind talking me through what was going on there?'* The interviews were initiated as soon as feasible after an observed event, although the exact timing was influenced by the participant's level of activity and where they were located on the ward (it would have been inappropriate to trigger a brief interview whilst the staff member was still in earshot of patients). As the interviews were conducted *in situ* (i.e. within the clinical setting) they were not audio-recorded

but were paraphrased into the field journal as soon as possible after they had taken place, before later being transcribed. For consistency, hereafter these interviews will be referred to simply as brief interviews.

4.6.3.2 Data collection methods for semi-structured (audio-recorded) interviews

Semi-structured interviews were conducted in a private room, separate from the ward, and digitally audio-recorded to enable transcription. Given the clinical context of the research, the timing of the interview was negotiated with the participant. The interviews were informed by the appropriate TDF topic guide (there were separate guides for HCAs and RNs – see appendices 7 and 8) and explored the factors that staff perceived to influence their afferent limb behaviour. To ensure coverage of all potential determinants (i.e. TDF domains), participants were asked a set of standardised, pre-prepared questions from the relevant topic guide. However, topic guide flexibility permitted more individualised questions to be asked of specific participants, based on the afferent limb behaviour/s they were seen enacting during the period of observation, and/or the beliefs that they expressed during a preceding brief interview. This degree of flexibility also enabled questions to be posed in a different sequence, based on participant responses, to promote a 'natural flow' to the conversation (as advocated by Atkins et al., 2017).

In the pre EHR period (a finite period of 3 months) I planned to continue semi-structured interviews until no new behaviours (expected or unexpected) were observed or until the EHR go-live date (whichever of these events occurred first).

In the post EHR period (an indefinite period), semi-structured interviews continued until the point of theoretical saturation. Theoretical saturation was determined using a method proposed specifically 'for theory-based interview studies in which conceptual categories (e.g. domains of the TDF) are pre-established from existing theory' (Francis *et al.*, 2010 p1230). Specifically, the following procedure was followed: 1. an *initial analysis sample* of ten interviews were conducted with nursing staff; 2. data from the *initial analysis*

sample were deductively coded (into the 14 TDF domains) and within each domain the quotations inductively analysed; 3. a *stopping criterion* of three was used, meaning that theoretical saturation was considered to have been reached when no new themes (synthesised from inductive analysis of coded data) were identified from three subsequent consecutive interviews (Francis et al., 2010).

Theme level data were selected to determine the point of theoretical saturation as opposed to the domains or belief statements. Pragmatically, as conceptual categories, it was considered likely that the domains would be too broad, and that their use to operationalise theoretical saturation could have resulted in the stopping criterion being met prematurely i.e. before an adequately diverse sample of participants had been interviewed. By comparison, use of the more 'granular' belief statements could have made achieving the stopping criterion unrealistic and/or resulted in a corpus of data that was too large to manage effectively. Consequently, theme level data were used in-keeping with the procedure proposed in the methodological paper (Francis et al., 2010).

4.6.4 Data analysis (phase 2)

The Framework method (Gale et al., 2013) was used to systematically and deductively index and chart the brief interview and semi-structured interview data (Patton et al., 2018), using the 14 domains of the TDF (Cane, O'Connor & Michie, 2012) as the coding categories. The procedure for coding was as follows:

- For each interview transcript, quotes were copied into a Microsoft® Excel spreadsheet to produce a framework matrix.
- Each quote was read and, using the decision rules stipulated in the coding manual, sections of text highlighted according to the TDF domain/s to which it belonged (a different colour was allocated for each of the domains).
- New spreadsheets were created for each of the 14 domains (a domain specific matrix), and indexed quotes from across the entire sample were copied and pasted into the relevant domain/s spreadsheet/s. Where multiple TDF domains were represented in a single quote, the

quote was copied into all the relevant spreadsheets (to ensure that it was considered in the context of all relevant domains in the subsequent content analysis).

Investigator triangulation (Cadogan et al., 2015) was used to increase confirmability of these data (Forero et al., 2018). Two members of the research team planned to independently code all transcribed brief interviews (coding by DS and MC), and a minimum 10% sample (Tracy, 2019; Maharaj et al., 2021) of semi-structured interview transcripts (coding by DS and LMA). To reduce the likelihood of analysis bias (Smith & Noble, 2014), semi-structured interview transcripts were numbered and a computer-based random number generator used to identify which transcripts were double coded.

After independent coding, disagreements were reconciled through consensus discussion including an academic supervisor not involved in the initial coding (LMA brief interviews, MC semi-structured interviews). Further semi-structured interview transcripts were coded (by DS/LMA) until the calculated level of overall inter-coder percentage agreement reached 60% (Atkins et al., 2017). After this, I coded all the remaining transcripts independently with the opportunity to discuss uncertainties with academic supervisors (LMA, MC) throughout.

Content analysis (Hsieh & Shannon, 2005) was used to report participant beliefs relating to barriers and enablers of the target afferent limb behaviours. Broadly, I adopted an inductive approach (Elo et al., 2014) and each of the matrices (containing quotes indexed to a specific TDF domain) developed during primary coding were analysed as follows:

- Quotes were read and re-read to ensure familiarisation; quotes reflecting similar beliefs from participants were grouped and categorised using a simple label in the first instance (i.e. a brief description of content).
- Grouped and categorised quotes were scrutinised further and more descriptive ‘belief statements’ synthesised to represent beliefs held by (a minimum of two) participants (Roberts

et al., 2017; Islam et al., 2012; McBain et al., 2016; Maharaj et al., 2021). Where participant beliefs were discordant i.e. a barrier for some whilst an enabler for others, this was reflected in the wording of the belief statement (e.g. registered nurses know/do not know that…).

- The frequency of HCAs and RNs who held a particular belief were counted and recorded alongside each belief statement. In this context, frequency referred to the number of different participants who mentioned the belief, as opposed to the number of times a single participant raised it. If the language used by a participant, within a quote, suggested that a belief was of personal importance to them, then the quote was highlighted. Frequency counts and highlighted quotes containing emphatic language were used in subsequent prioritisation exercises (see section 4.6.5).
- Belief statements representing overlapping or related content were grouped and a suitable theme heading synthesised (Presseau et al., 2017; Patey et al., 2017; Pearse et al., 2021; Fasugba et al., 2021; Maharaj et al., 2021).
- A chart displaying all levels of data (i.e. domain, theme, belief statement, illustrative quote) was presented to academic (LMA, MC, JD) and clinical (JH) supervisors, to assess clinical and theoretical face validity (Goddard et al., 2018).

4.6.5 Procedure for identifying and mapping TDF domains of high importance to specific BCTs

To identify TDF domains of particular importance in determining afferent limb behaviour, multiple prioritisation criteria from the published literature were applied. This decision was underpinned by evidence that using singular approaches to determine important beliefs may be unreliable and could lead to variation in intervention content depending on the measure of importance used (Francis et al., 2014). Consequently, recommendations have been made that when using belief level data to inform intervention content, multiple criteria should be applied (Francis et al., 2014). Four criteria with binary assessments from published TDF literature (Atkins et al., 2017; Islam et al., 2012; Patey et al., 2012; Goddard et al., 2018; McGoldrick et al., 2016) were selected and applied at belief statement level. These criteria were: 1. frequency – the belief was reported by more than a third of the sample; 2. personal importance – the belief was

expressed using emphatic language in one or more illustrative quote/s; 3. direction of effect – there were discordant views between participants about the belief operating as a barrier or enabler; 4. professional discordance – the belief was held by RNs but not by HCAs or *vice versa*. Whilst not explicitly stated within TDF literature, it is plausible that conflicting beliefs between healthcare practitioners will result in inconsistent behaviour/s being enacted in clinical practice. This explains the use of criteria 3 and 4. The 4 criteria were used to categorise the TDF domains as being of high, moderate, or low importance based on the number of criteria met. Domains with any belief statement that met 3 or 4 of the above criteria were considered of high importance; 2 criteria of moderate importance; 1 or 0 criteria of low importance (Goddard et al., 2018). Using the table linking TDF domains to BCTs (see section 4.6.1.3), the specific TDF domains meeting criteria of high importance were mapped to the relevant BCTs to produce an initial list of possible BCTs that could be used to populate the preliminary intervention. This was considered the key output of phase 2 of this research.

4.7 Phase 3 – selecting intervention components to overcome modifiable barriers and enhance enablers

4.7.1 Shortlisting the BCTs

The evidence that increasing the number of different BCTs increases the effect size of an intervention is contradictory. From a systematic review and meta-analysis of internet-based health behaviour change interventions, it was reported that the inclusion of more BCTs within an intervention increased intervention effect size (Webb et al., 2010). However, in a more recently published meta-analysis and meta-regression of physical activity interventions, an increase in the frequency of the desired behaviour was not observed in interventions that included more BCTs (Taylor, Conner & Lawton, 2012). Given the evidence for including a large number of different BCTs within behaviour change interventions is equivocal, and there is a pragmatic requirement to ensure that a manageable number of BCTs are taken forward for stakeholder discussions (Patton et al., 2018), a shortlisting exercise was carried out prior to the nominal groups, as follows. First, a

minimum of two researchers (DS and MC or JD or LMA) independently reviewed all BCTs mapped from the TDF domains of high importance and their definitions for anticipated acceptability (to the intended recipient) and anticipated feasibility (in the intended context). Second, using simple criteria (Table 4.4), a decision was made to include the BCT, exclude the BCT, or to bring the BCT for discussion with all academic and clinical supervisors. BCTs that were included from this initial shortlisting process (either immediately or after further consensus discussion) were taken forward for further scrutiny, by relevant stakeholders, during nominal groups.

Table 4.4 – criteria applied by members of the research team during the BCT shortlisting exercise

Label applied to BCT and action	Criteria for labelling
Include – take forward for discussion at nominal groups	1. The BCT could feasibly be delivered in a clinical environment **AND** 2. The BCT is likely to be acceptable to a healthcare practitioner
Exclude – no further action	1. The BCT would take time to deliver and/or would require repeated delivery over a prolonged period (i.e. unlikely to be feasible) **AND/OR** 2. The BCT is ethically dubious e.g. applying punitive techniques to clinical staff (i.e. unlikely to be acceptable)
Uncertain – take forward for consensus discussion with the entire research team	1. Reviewer uncertain which criteria are met by the BCT – warrants further consensus discussion to inform decision-making

4.7.2 Research materials (phase 3)

4.7.2.1 Developing a nominal group facilitator's guide and ranking document

In the original published protocol (Smith et al., 2019), it stated that the NGT would be delivered in group meetings held in a physical space i.e. face-to-face. Due to the COVID-19 pandemic, and the consequent need to maintain social distancing and to minimise unnecessary travel (GOV.UK, 2020), the groups were delivered virtually using Microsoft® Teams. This online platform was selected as it was the virtual platform commonly used for meetings and other team

events within the organisation, therefore increasing the likelihood that participants were familiar with its use.

To inform the content and structure of the nominal groups, a facilitator's guide (volume 2, appendix 11) was developed using papers reporting the use of NGT in research (Dening, Jones & Sampson, 2012; Miller et al., 2000), a published NGT facilitator guide (Varga-Atkins et al., 2011), and literature related to the delivery of nominal groups and/or focus groups virtually (i.e. online using appropriate software) (Kulczycki & Shewchuk, 2008; Michel et al., 2021). The activities outlined within the facilitator's guide centred around the three-stage approach to delivering NGT (as described by Varga-Atkins et al., 2011):

1. Individual participant responses
2. Clarification and consolidation of responses amongst the group
3. Ranking exercises.

As the groups were facilitated by all members of the research team (myself and all academic supervisors), the roles of each individual facilitator were also stipulated within the facilitator's guide. Guidance, in written and pictorial form, on how to display participant ideas to the entire group (necessary for stage 2) was provided for facilitators (as an appendix) less familiar with the use of Microsoft® Teams for group-level discussions.

To facilitate ranking activities within stage 3, a template ranking document was created online using the Qualtrics® platform (see www.qualtrics.com/uk). This online document was populated with shortlisted BCTs and example applications for participants to rank during the NGT. The Qualtrics® platform was selected as it permits content to be added in real time and allows items to be ranked numerically (broadly in keeping with NGT methods).

4.7.2.2 Developing a nominal group information package for participants

Advantages and limitations of both virtual and face-to-face modes of delivery have been proposed in the literature. Whilst virtual groups offer greater flexibility for harder to

access participants e.g. shift workers (a noteworthy advantage given the target participants in this research), effective participation is contingent on participants' access to technology and their computer literacy (Turney & Pocknee, 2005; Daniels et al., 2019). Given that participants in this research were NHS employees, who were required to use computers and hand-held electronic devices in their professional roles, a basic level of digital literacy was assumed. However, it was anticipated that there was likely to be some variance in the degree of digital literacy amongst group participants. Consequently, detailed written guidance on how to participate was provided ahead of the group.

As the participants of the nominal groups were clinicians and healthcare managers, it was plausible that they would have no prior experience of behaviour change concepts and processes. Consequently, a 'pre-elicitation technique' (Gonzales & Leroy, 2011) was used to increase participant understanding and manage expectations ahead of the groups. Practically, this was delivered in the form of an information package (Tsourtos et al., 2019) that was sent to participants (via email) a minimum of two weeks before the groups convened.

The information package (volume 2, appendix 12) included a table that was populated with the shortlisted BCTs, plain-English definitions, and example applications. Plain-English definitions of BCTs were obtained from published literature (Michie et al., 2013), whilst example applications were initially derived from pragmatic resources including 'The Cards for Change' (Byrne-Davis, Bull & Hart, 2019) and from innovations reported in the wider patient safety literature (Thompson, Estabrooks & Degner, 2006; Edbrooke-Childs et al., 2017; Goldenhar et al., 2013). To maintain the theoretical integrity of the process, both groups were presented with an identical list of BCTs (mapped from TDF domains of high importance in phase 2). However, after the leadership group had convened, applications (i.e. concrete strategies for operationalising specific BCTs) suggested by participants of the leadership group were incorporated, as examples, into the table. The information package containing the revised example applications of the BCTs were sent to participants of the subsequent clinical group. It was anticipated that running the groups sequentially and revising the information package between groups, would enable patient-facing

clinical staff to discuss, debate and vote upon ideas proposed by leaders and decision-makers from within their own organisation (alongside their own suggestions).

The information package also included the following practical information for participants of both groups:

- Information on what to do if their circumstances changed and they could no longer attend the group discussion
- Guidance, in written and pictorial form, on how to access the online group using Microsoft® Teams, and how to participate in the discussion e.g. how to signal that they wanted to raise a point during the discussion phase
- A detailed description of the NGT process
- Ground rules during the group meeting
- Guidance on how to access the online ranking documents in Qualtrics®.

Prior to recruitment, the facilitator's guide and information package for participants were reviewed by academic (MC, JD, LMA), and clinical supervisors (JH), a patient advisor, and by members of a research group led by an academic supervisor (LMA). Membership of this research group included clinical academics and researchers with an acute/critical care focus. Feedback from these sequential reviews was used to amend the information package prior to distribution to participants.

To ensure that the structure and content laid out in the topic guide were tested, and that any issues with technology were identified and resolved (Daniels et al., 2019), two pilot discussion groups with NGT were carried out. Participants of these pilot groups were members of the local acute and critical care research group and members of a health psychology research group. These pilot group discussions were used to further amend the topic guide before the leadership group convened.

4.7.3 Recruitment and sampling (phase 3)

RNs and HCAs of varying clinical bands, and with varying levels of experience, were recruited to participate in a nominal group (labelled as the clinical group). As the target recipients of the behaviour change intervention, deliberations and decisions from the clinical group regarding how the BCTs could be delivered in practice, have helped shape the content of the preliminary behaviour change intervention (Reed et al., 2018; Taylor et al., 2013; Skivington et al., 2021). It is reported within the literature, that the success of patient safety interventions may also be contingent on approval from managers and leaders within the organisation (Leistikow, Kalkman & De Bruijn, 2011). Consequently, a purposive sample (mix of job roles and professional backgrounds) of senior corporate (i.e. non-patient facing) nurses, senior clinicians from non-nursing backgrounds, healthcare managers, and educators were recruited to participate in a second nominal group (the leadership group). Two groups have been reported as adequate for garnering an array of responses on a given topic and in achieving a degree of 'idea saturation' (Kulczycki & Shewchuk, 2008). Based on recommendations within the literature (McMillan, King & Tully, 2016), a maximum of 14 participants were recruited for each group. So that ideas generated by the leadership group could be presented to the clinical group for discussion and debate, the leadership group convened first.

It is posited within the NGT literature, that through the use of highly structured activities the power imbalances reported in traditional focus groups are mitigated (Varga-Atkins et al., 2011; Williams et al., 2006). However, where it is plausible that participants may feel overwhelmed or intimidated by other group members, it is permissible to separate participants to optimise the group dynamic (Aspinal et al., 2006; McMillan, King & Tully, 2016). For this reason, the corporate-level senior nurses/healthcare leaders and the clinical nursing staff were recruited into separate groups, to reduce power imbalances and the negative consequences thereof.

To recruit for the leadership group, members of the organisation's strategic steering group focusing on deteriorating patients were targeted. Membership of this steering group included nurse

leaders, members of the Trust executive leadership team, deteriorating patient project managers, and senior nursing educators. To recruit for the clinical group, HCAs, and RNs with varying levels of experience and expertise from acute inpatient wards within the Trust were targeted.

The procedure for recruitment, was as follows: an email outlining the nature and broad objectives of the research was sent to the chair/project lead of the steering group and nurse managers of acute inpatient wards respectively. Within this email, permission was sought to access participants from the steering group/ward areas. The project lead and ward managers were provided with a template email to cascade electronically to potential participants via an appropriate group email list. Recipients of the email (steering group members and ward RNs/HCAs) were asked to respond via email if they were interested in participating. A snowball sampling technique was also be used to access potential participants beyond the limits of the initial group emails (Tracy, 2019; Kulczycki & Shewchuk, 2008). Practically, this meant that when a potential participant responded to the recruitment email, they were offered the chance to identify colleagues from within the organisation who might also have been interested in participating. Any individuals who were nominated by a colleague, were then sent a copy of the standard recruitment email requesting that they too make contact if they wished to participate. This approach was repeated until an adequate sample of participants had been recruited.

Upon receipt of an expression of interest email from any potential participant, further information about the date/time of the group and the structure and content was sent to the participant via email.

4.7.4 Data collection (phase 3)

Nominal Group Technique and Delphi surveys are two reported methods that may be used to develop consensus (Van Teijlingen et al., 2006). NGT and Delphi have shared characteristics with both methods providing a degree of anonymity, iteration, controlled

feedback, and a statistical group response (Jones & Hunter, 1995; Van Teijlingen et al., 2006). Despite some overlap, there are also distinct differences between these two methods. Delphi studies are typically administered to individuals using multiple rounds of questionnaires (Green et al., 1999). This approach is relatively inexpensive and can accrue a large volume of data from geographically dispersed participants (Van Teijlingen et al., 2006). However, questionnaire completion may be time consuming for participants increasing the likelihood of reduced response rates as the study progresses (Kulczycki & Shewchuk, 2008; Williams & Webb, 1994; Van Teijlingen et al., 2006). This reported problem of 'survey fatigue' may be particularly pertinent when questionnaires are issued to participants in short succession (Porter, Whitcomb & Weitzer, 2004).

Unlike Delphi studies, where participants are approached (at minimum) three times to complete questionnaires (Green et al., 1999), each NGT participant is typically only required to attend a single pre-arranged group meeting (Aspinal et al., 2006; Dening, Jones & Sampson, 2012; McMillan et al., 2014). In this research, participants were either healthcare managers or clinical staff delivering direct patient care. It was anticipated that these individuals would have a high workload, and that some of the clinical group participants may have already contributed to phases 1 and/or 2 of this research. Consequently, the potential for reduced participant 'burden' associated with NGT was a noteworthy advantage. Further, the opportunity that NGT provides for discussion and ideas sharing, alongside private reflection and voting, aligned well to the overarching objective of this research. Consequently, NGT was considered the more suitable consensus method for phase 3 of this study. The group discussions where NGT was applied were facilitated by my academic supervisors (MC, JD, LMA) and I.

Prior to the groups convening, information was emailed to participants (as an appendix to the information package) notifying them how to access the virtual meeting and outlining ground rules for participation in a virtual nominal group. Participants were also offered the opportunity to participate in a test call beforehand to test the efficacy of their audio-visual equipment (as advoacted by Archibald et al., 2019; Daniels et al., 2019).

At the start of the virtual meeting, participants were welcomed, and each member of the group (both participants and facilitators) introduced themselves. Subsequently, the NGT was delivered using activities reported in the wider literature (Dening, Jones & Sampson, 2012; McMillan, King & Tully, 2016) and a three-stage process (described by Varga-Atkins et al., 2011) as follows:

1. **The individual response stage** – I posed the following question to the group: '*Are there any other ways (or better ways) that the BCTs listed in the table could be applied in this organisation, that were not included in the information package?'* and participants were asked to silently consider the question and privately generate responses. Participants were then brought back into the virtual space and asked, in turn, to feedback in a 'round robin' format i.e. each participant shared a single idea at a time before the cycle repeated. This approach is advocated as a means of achieving objectivity and equity in relation to participants' contributions (Williams et al., 2006). To avoid duplication, participants were asked not to repeat any idea that had already been proposed, but were encouraged to share if the idea represented a variation of an existing idea or had a different point of emphasis (Aspinal et al., 2006). Participant responses were posted (by LMA) onto a virtual display board, in real time, for all group members to see. Posted responses were numbered for ease of reference (Varga-Atkins et al., 2011). It is advocated within the literature that ideas sharing continue until all ideas are exhausted (McMillan, King & Tully, 2016). However, it was impossible to predict how many ideas would be shared by each participant. Consequently, participants were asked to share their views in order of priority (i.e. to voice their most important ideas first). This provided some assurance that the ideas captured reflected the most strongly held views of participants. All participants were given the chance to offer at least one idea with the exercise being repeated as many times as possible within the allotted time.
2. **Clarification and consolidation of responses -** participants were then invited to seek clarification from other participants about their suggestions, and to edit the virtual display board by merging any suggestions that they considered to be similar (Varga-Atkins et al., 2011). The product of any merged ideas was allocated a new number for clarity. Participants then took a

short break, whilst my supervisors and I met to rapidly review the new ideas suggested by participants, and to identify any obvious discrepancies in the linkages between the BCTs and the suggested applications (i.e. where the application suggested by a participant was not obviously suitable for the BCT it had been linked to). Where such discrepancies were identified, a decision was made to either adjust the application to improve the alignment, to re-align the application to a more suitable BCT from the longer list, or to exclude. The decision to exclude was made when the suggested application did not align with any of the BCTs and/or did not target the previously identified barriers/enablers. These decisions were driven by the health psychologists within my supervision team (MC, JD). Following any adjustments, new BCT/applications (i.e. those suggested by the group) from the virtual display board were added onto the online ranking documents (by LMA).

3. **Ranking exercises –** The health psychologists from my supervision team (MC, JD) summarised any adjustments that had been made during the breakout time and offered participants the opportunity to comment. A hyperlink was then posted into the discussion thread so that participants could access the ranking document in Qualtrics®. From the longer list provided, which included original BCTs/applications from the information package, and ideas generated and discussed in stages 1 and 2, participants were asked to vote on the 5 BCTs and applications that they considered would be most acceptable to ward nursing staff from 1 (most acceptable) to 5 (least acceptable). Participants were then requested to repeat this ranking exercise according to how easily the BCT/applications could be delivered (i.e. feasibly operationalised) on the wards from 1 (most easy) to 5 (least easy).

The decision to only permit participants to vote on 5 BCT/applications from the longer list was based on precedent within the published NGT literature (Michel et al., 2021; Rankin et al., 2016) and findings from one paper, where participants of two pilot nominal groups reported that ranking up to 10 points was too difficult and that ranking 5 was more manageable (McMillan et al., 2014). However, from the same paper, some pilot participants reported difficulty in voting on only 5 points, as they considered them all to be of importance (McMillan et al., 2014). On this basis, before participants began the ranking tasks, it was highlighted to them that all the BCTs would be

considered by the research team when compiling the preliminary intervention, but that those ranked highly would be prioritised (I delivered this information verbally during the group, and it was also emphasised within the information package).

After the group, participants were sent a summary of the ranking information and offered the opportunity to comment. Whilst this 'member checking' approach has been advocated when using NGT (Varga-Atkins et al., 2011) in the wider methodological literature, there is some debate regarding the usefulness of this method for ensuring trustworthiness of the data. In particular, it is suggested that a participant may not recognise their individual response within the broader summary data and, as a result, may challenge the findings (Morse, 2015). On this basis, the data was sent to participants with the caveat (outlined in an email) that the data represented the broader picture of participant responses and should be interpreted accordingly.

4.7.5 Data analysis (phase 3)

Scores were assigned to each of the BCT/application combinations (including those from the information package and ideas generated by group participants) based on the ranking information from NGT participants. Where a BCT/application was ranked first by a participant it was scored 5; second it was scored 4; third it was scored 3; fourth it was scored 2; fifth it was scored 1; not ranked it was scored 0. This exercise was repeated for ranking data for each participant. Individual scores were then combined to identify summative ranked priorities from across the group (Dening, Jones & Sampson, 2012; Aspinal et al., 2006). To exemplify, if 12 participants voted then the maximum score for any single BCT/application was 60 (requiring all 12 participants to rank the item first). In contrast, if a BCT/application was not ranked by any participants it would score 0. Combined scores were presented as absolute figures and as percentages. The frequency that each BCT/application was prioritised by a participant (i.e. ranked 1-5) was also counted for both ranking activities i.e. acceptability and feasibility.

4.7.6 Compiling the preliminary intervention

All BCT/application combinations were reviewed during subsequent consensus discussions involving nurse academics (LMA, DS), health psychology academics (MC, JD), and a lead nurse (JH). During consensus discussions, a spreadsheet displaying the TDF domains (of high importance), the belief statements (meeting prioritisation criteria) representing barriers and/or enablers to one or more of the target behaviour/s, and the relevant BCT/s that could be applied was made available to all members of the research team (an example page of this spreadsheet can be found in volume 2, appendix 13). It was anticipated that having this detailed picture, would enable careful and precise consideration of the suitability of each BCT in context. Where a single BCT had several potential applications, nominal group ranking data were used to prioritise which specific application/s to include in the intervention (higher scoring and more frequently prioritised applications were included). Where a BCT/application combination received a low score from nominal groups, and/or was not frequently prioritised (i.e. not frequently ranked 1-5), the decision to include or exclude from the intervention was made through discussion and debate, guided by the following considerations:

- The potential consequences of eliminating the BCT and its application/s on the theoretical integrity of the intervention (i.e. where exclusion would result in specified TDF domain/s and/or target behaviours not being addressed by intervention content).
- Further scrutiny of the BCT and its application/s in relation to the APEASE criteria (where APEASE stands for Acceptability, Practicability, Effectiveness, Affordability, Side effects, Equity) (Michie, Atkins & West, 2014). As the implementation process proposed by French et al (2012) does not offer any specific criteria for the purpose of prioritising intervention content, these criteria were obtained from an alternate approach (the Behaviour Change Wheel) (Michie, Atkins & West, 2014).

4.8 Reflexivity - my position as the researcher

There is wide acceptance amongst researchers who use qualitative methods that the researcher is a central figure with an active role in constructing the collection, selection and

interpretation of the data (Finlay & Gough, 2003). As such, reflexivity has been described as a defining feature of qualitative research (Finlay & Gough, 2003; Tracy, 2019). Broadly, reflexivity focuses on the explicit and transparent acknowledgement of the potential effects of the researcher on the research process and findings (Cruz & Higginbottom, 2013; Polit & Beck, 2018). However, reflexivity has many guises (Koch & Harrington, 1998; Dowling, 2006) and its application may vary according to the research aims and the theoretical and methodological traditions being embraced (Finlay & Gough, 2003).

This research is broadly situated within the academic discipline of implementation science and more specifically within the field of behaviour change research. Within the published behaviour change literature, qualitative methods are frequently reported with the use of semi-structured interviews (Sargent et al., 2017; Roberts et al., 2017; McGoldrick et al., 2016; Patey et al., 2012, 2017; McBain et al., 2016; Presseau et al., 2017) and focus groups (Patton et al., 2018; Cassidy et al., 2018; Taylor et al., 2013; Anekwe et al., 2020) particularly common. Despite this, limited attention has been given to reflexivity within these publications. Likewise, an acknowledged group of international experts within the field of behaviour change, published a guide detailing how to address implementation problems using the TDF (Atkins et al., 2017). Despite advocating a range of qualitative methods to investigate behavioural problems (e.g. interviews, focus groups, structured observation, documentary analysis), no reference to reflexivity could be found within the paper (Atkins et al., 2017).

Given the limited precedent for researcher reflexivity within the field of behaviour change research, guidance was drawn from broader sources. A common theme within the wider qualitative literature is the requirement for researchers to self-examine and declare their position and beliefs prior to data collection (Koch & Harrington, 1998; Reid et al., 2018; Berger, 2015) and throughout the research process (Finlay & Gough, 2003). Practices that promote self-awareness and transparency encourage researcher ‘self-reflexivity’ (Tracy, 2019) and are frequently reported as being synonymous with enhanced quality and rigor in

qualitative research (Berger, 2015; Forero et al., 2018; Tracy, 2019). This is particularly emphasised when the study design incorporates data collection through ethnography (Koch & Harrington, 1998). Declaration of the researcher's position aids understanding of the potential impact that the researcher may have had on the participants, as well as providing insight into 'the lens' through which the phenomena under investigation were viewed (Berger, 2015; Scott, 1997).

Exploration of my own position in this research was essential to my own reflexive practice and influenced how I managed my multiple identities as an educator, clinician, and PhD student. Central to self-reflexivity is the researcher examining and reporting areas where they may lack neutrality (Berger, 2015; Ahern, 1999). Overt acknowledgement of potential sources of bias, together with continual self-scrutiny are advocated approaches that encourage the researcher to 'put aside' or suspend their preconceptions prior to and during data collection activities (a concept often referred to in the literature as 'bracketing') (Ahern, 1999; Koch & Harrington, 1998). Before embarking on this research, I held the belief that there was an over-reliance on non-registered staff (i.e. HCAs) to undertake safety critical aspects of the nursing role. My view was that activities related to patient monitoring and assessment (including the measurement of patient's vital signs) were often under-valued by RNs and were frequently left for HCAs or pre-registration student nurses to undertake. As study participants included both RNs and HCAs, it was important for me to acknowledge this belief and be cognisant of its potential impact throughout the research period.

I am a clinical-academic nurse with a background in acute/critical care nursing. I hold a substantive academic post within the Higher Education Institution (HEI) hosting this study. The hospital within which this research was conducted is a practice partner of the HEI, meaning that they provide placements for pre-registration students as well as purchasing Continuing Professional Development (CPD) modules for registered members of the workforce. Whilst I had no direct line management responsibility within the HEI, I have taught widely across both undergraduate and postgraduate programmes and have been an academic link for the hospital within which this research was carried out. For this reason, when I was on the wards collecting data, it was not uncommon for me to encounter RNs who I had taught either as part of their

undergraduate programme or when they were undertaking a CPD module. For a small number of RNs who agreed to participate in this research, I had been their lecturer when they were undergraduate students. I was mindful, during data collection activities, that these individuals might experience my presence differently to their peers who had not known me in an educator role. I also considered it plausible that the power asymmetry (Reid et al., 2018) between these individuals and I would be more imbalanced, and that our historical teacher-student relationship might have resulted in them feeling obligated to participate in my research. When interacting with these staff, I was very careful not to exploit this power differential; avoiding language that might have been construed as coercive (even implicitly) and emphasising participant agency at all stages.

Having qualified as a nurse, I spent the first year of my clinical career working within acute ward environments. Thereafter, all my clinical experience has been working in either a critical care setting (an environment where a single nurse typically cares for one or two patients) or as a specialist nurse in various CCOT roles. In addition to my substantive academic role, I hold an honorary clinical contract which provides the necessary indemnity for me to deliver direct patient care within my scope of practice. Despite having chosen to leave full-time clinical work, being a registered nurse remains central to my professional identity. Throughout the duration of this research, I continued to work occasional clinical shifts (typically two shifts per month) with the CCOT in the hospital within which this research was carried out.

Due to the infrequency of my clinical shifts, and the hospital-wide remit of the CCOT, I was unknown to many of the RNs and HCAs on the participant wards (notwithstanding those who had known me as a lecturer). Disclosing my clinical background to participants was important for transparency and to uphold the ethical integrity of the study (Tracy, 2019; Reid et al., 2018). Participants were made aware that I was a RN linked to the local CCOT both verbally and within participant information sheets. However, as I had not had contact with most staff before the period of data collection for phases 1 and 2, I

was able to use my clinical anonymity virtuously, presenting myself to staff as ‘a researcher’ first and foremost and a ‘senior nurse’ second.

During the first UK surge of COVID-19 (GOV.UK, 2020) cases in spring 2020, I returned to work full time in clinical practice to support colleagues within the NHS. Specifically, I was assigned a clinical leadership role working within a newly developed high dependency respiratory unit, established to provide care for patients with respiratory failure secondary to COVID-19 infection. The pandemic placed significant demand on the system, increasing the need for individuals within the system to be resilient and adaptable to an extent that I had never encountered before within my UK-based career. Given the unprecedented circumstances, close working relationships were established between staff of all disciplines. As part of my role, I worked alongside ward-based RNs and HCAs of varying clinical grades redeployed from across the organisation. This included working with staff who I would later approach as part of my recruitment activities for phase 3 of this study. My increased presence within the Trust during the pandemic, and the relationships that I developed during this time, may have resulted in staff feeling more compelled to participate in the final phase of data collection. I was acutely aware of this during communication with these individuals, and careful to highlight that participation was voluntary and that there would be no negative consequences from non-participation.

Practically, various strategies may be used to promote self-reflexivity during data collection and analysis. Cited approaches include use of a reflexive field journal to record feelings and perceptions (Koch & Harrington, 1998; Finlay & Gough, 2003), and meetings with colleagues to discuss field notes and to surface areas of unconscious bias (Forero et al., 2018; Berger, 2015; Reid et al., 2018; Probst, 2015; Ahern, 1999). For researchers with a dual role (e.g. a researcher and clinician), adopting a self-reflexive position enables the researcher to both pre-empt and respond ethically to challenging situations that may arise during field work (Reid et al., 2018; Pope, 2005).

4.9 Research governance and ethics

4.9.1 Managing consent

A sample of RNs and HCAs were targeted for recruitment. As NHS employees, these individuals had the rights and freedoms to make informed decisions about their willingness to participate in the research. In order to promote potential participants' autonomy i.e. their right to make an informed, independent decision free from coercion (Cranmer & Nhemachena, 2013), a comprehensive consenting procedure was used. First, I contacted ward managers, via email, to obtain permission to visit their wards and speak to staff. Once permission from ward managers had been given, I attended handover meetings and staff 'huddles' to provide verbal and written information to nursing staff on the goals and scope of the research. These interactions took place over a period of two to three weeks, to ensure that all staff received information about the study and were aware of how data would be collected and when these activities were planned. My academic email address was shared with staff so that they could make contact individually and confidentially to request further information about the research. Thereafter, consent was managed using both 'opt-out' and 'opt-in' approaches.

4.9.1.1 Opt-out procedure for focused ethnography and brief interviews

Opt-out approaches have been cited as beneficial in obtaining more diverse and less biased sampling in studies considered to be low risk to participants (Junghans et al., 2005; Vellinga et al., 2011; Krousel-Wood et al., 2006). Focused ethnography and brief interview data collection methods were considered low risk because:

- Participants were clinical staff who could opt-out at any stage
- Participants were observed carrying out usual activities i.e. actions considered part of their job role
- No direct audio or video recordings of staff was made during the field work.

At every meeting or briefing prior to data collection, I reiterated that staff should report if they did not wish to be observed or approached for a brief interview during the period of data collection. Staff who did not wish to be observed/approached, were asked prospectively to sign an opt-out form (volume 2, appendix 14). Copies of these forms in addition to the relevant PIS (volume 2, appendix 15) were made available at every meeting between staff and I. Copies of both were also be left in the staff room along with a sealed box so that staff could privately complete and return the opt-out form. I visited the clinical floors periodically, prior to commencing data collection, to collect the opt-out forms from the sealed box.

During field work, using the completed opt-out form, I was able to identify staff on duty who had chosen to opt-out (by cross-checking with the staff duty-rota and staff allocation board), so that no further information was collected from these individuals. Details of staff who had opted out were not shared with colleagues or managers (staff who opted-out were made aware of this on the opt out form).

At the beginning of a period of observation (i.e. at the start of a clinical shift), staff on duty were given a further opportunity to opt-out (typically during a staff handover or huddle) if they did not wish to be observed or approached. All staff were reminded that they could opt-out at any stage, and that they would not be required to justify or rationalise their decision to do so.

It was anticipated that some staff members would not opt-out prospectively, but instead elect to opt-out midway through the period of data collection. In these circumstances, no further data were collected from these staff; however, any data that pre-dated their decision to opt-out was not identifiable (for the purpose of taking observational field notes, participants were assigned a label e.g. RN1, RN2, HCA1) as their name was only collected if they agreed to participate in a subsequent semi-structured interview. As such, it was not possible to destroy field data already collected prior to the participant deciding to opt-out. This was emphasised within the PIS.

4.9.1.2 Consenting procedure for participation in a semi-structured interview

Following observation and/or a brief interview, some participants were approached and invited to take part in a TDF-informed semi-structured interview. Contact with potential participants was made on an *ad-hoc* basis during the period of focused ethnography. Only staff who volunteered and prospectively consented (i.e. opted-in) were interviewed. Participants were issued with the relevant PIS (volume 2, appendix 15), and I gave verbal information about the interview at least 24 hours beforehand. Participants were asked to sign a consent form (volume 2, appendix 16) at the beginning of the interview before any questions were asked. Voluntariness of participation was stressed on the consent form. Participants were also asked for their consent to use direct quotations within the write-up of this research. A signed copy of the participant consent form was returned to the participant at the end of the interview.

4.9.1.3 Consenting procedure for participation in an online group discussion where NGT was applied

Potential participants were invited (via email) to attend a group meeting. As a consequence of the COVID-19 pandemic, the decision was made to conduct the groups online (a deviation from the original protocol) to ensure that national public health guidance regarding social distancing and the minimising of unnecessary travel were adhered to (GOV.UK, 2020). In addition to protecting all potential participants from unnecessary contact, facilitating the groups in a virtual space rather than a physical space increased opportunity for participation to include individuals who were clinically vulnerable and therefore 'shielding' and/or working at home during the pandemic.

Staff were contacted a maximum of two months prior to the date when the groups were scheduled. Initially, contact with potential participants was made via the chair of the Trust's strategic steering group focusing on deteriorating patients (to recruit for the leadership group), and ward mangers (to recruit for the clinical group). With their permission, a template email was sent to these individuals for wider distribution using a

group email cascade. As the initial recruitment emails were sent via these key people, individual email addresses for each staff member were not collected. For those potential participants nominated by a colleague (as part of the snowball sampling strategy), the template recruitment email was sent to these individuals using their NHS email account. If these individuals did not respond, then an assumption was made that they did not wish to participate, and they were not contacted again. When a staff member responded to express interest in participating, further individual contact (via email) was made to ensure that they received more detailed information. This included a copy of the relevant PIS (volume 2, appendix 17), the more detailed information package for participants, and a link to access the online group discussion.

Reminder emails were sent to staff who expressed an interest in participating a week prior to the group convening. Staff who voluntarily opted-in, were sent an information package and a link to an electronic consent form (in the Qualtrics® platform), a minimum of one week before the group meeting. All participants were required to sign the electronic consent form (a paper copy of this form can be found in volume 2, appendix 18) before the group meeting commenced. The importance of signing the consent form prospectively, was emphasised in the reminder emails sent ahead of the groups. As participants require an opportunity to ask additional questions before they provide consent (Lobe, Morgan & Hoffman, 2020), a clear statement was added to the email encouraging them to reply with questions (as many times as they wished) before signing the electronic consent form (Hewson, Vogel & Laurent, 2016).

4.9.2 Minimising risks to participants and patients

4.9.2.1 Identifying and mitigating risks to participants (RNs and HCAs) in phases 1 and 2

The overarching ethical principles of beneficence (i.e. the obligation to do good), and non-maleficence (i.e. the moral imperative to do no harm) (Cranmer & Nhemachena, 2013) were considered when evaluating both the ethical challenges associated with the delivery of this research, and the actions to minimise these potential issues. As the research was conducted in busy clinical environments, in a research-active teaching hospital, it was plausible that the clinical floors selected would already be enrolled in other studies and that staff may have been

participating in other research activities. This could have increased the burden placed on staff from a workload perspective. It was considered highly likely that the senior nurses, matrons, and ward managers would have an overview of any other research taking place on their ward areas and/or involving the nursing staff that they line-managed. Consequently, this was raised when I first met with these senior staff before any visits to the clinical floors were planned or scheduled. If the senior staff had felt that their ward and nursing staff were already over-burdened with research (or similar) activities, then alternative clinical floors would have been identified using local data.

Asking nursing staff to discuss their actions in response to deteriorating patients could potentially have caused emotional distress. The following strategies were used to minimise the risks of phases 1 and/or 2 data collection activities leading to emotional distress or creating additional burden on participants:

- I undertook specific training on participant observation and complex interviewing to ensure the questioning approaches that I used during brief interviews and semi-structured interviews were both effective and sensitive.
- Participants were informed that they could ask questions or express their concerns about the study throughout its entire duration and that they could withdraw at any point.
- I was vigilant for signs of discomfort or distress amongst participants and planned to address this on an individual basis. Planned actions included signposting facilities for counselling (provided though the Trust's occupational health department) or outlining the options for withdrawal from the study.
- During a semi-structured interview, participants were informed that they could refuse to answer any questions, they could return to a question later or not answer at all, and that they could take a break from the interview at any point if they wished (i.e. if they became upset).
- The information sheets contained my contact information. Participants were informed that they were free to contact me with questions and concerns even after the data collection period had ended.

- In case participants wished to ask questions or to raise concerns and did not feel comfortable approaching me, the PIS also contained contact information for my primary supervisor (LMA) and a research governance manager from the host organisation (an objective person not directly involved in this research).

For transparency, my professional background (including my clinical role) was summarised within the PIS. However, I did not approach potential participants in this role, but instead as a researcher. To ensure that this was visibly clear, and that staff (particularly more junior members of the nursing workforce) were not intimidated by seniority/hierarchy, I did not wear nursing uniform at any point during data collection activities and consistently presented myself to staff as 'a researcher' rather than 'a senior nurse'.

4.9.2.2 Identifying and mitigating risks to patients being cared for by participants (RNs and HCAs) in phases 1 and 2

Patients were not recruited as they were not the target participants of this research (participants were nursing staff). No identifiable patient data were recorded or used during this research. The patient data of interest were the vital signs and the aggregate NEWS. These were the only patient data to be recorded in the field notes. From these physiological data, it was not possible for an individual patient to be identified.

Within the nursing workforce, the monitoring and recording of patients' vital signs is not considered a 'sensitive task'. These actions were regularly performed in full view of other patients, staff, and relatives. Therefore, at points where nursing staff were engaged in these direct patient-facing activities, I was witnessing the same actions as other bystanders on the ward. However, it was considered plausible that patients would not want the RN or HCA caring for them to be observed for the purpose of research, particularly when they were the recipient of care e.g. having their vital signs measured. Patients were notified verbally (by myself and members of nursing staff) when I was present on the ward. Laminated signs were also displayed around the ward when I was present and collecting data. These signs were used to signal my presence and to encourage

patients or visitors to speak up if they did not wish for the nurse caring for them to be observed (volume 2, appendix 19). If a patient and/or visitor indicated that they were unhappy with their RN or HCA being observed, then I withdrew and did not observe nursing staff any further when they were in the vicinity of the patient.

The conversations (between healthcare practitioners) that I aimed to observe and hear during the focused ethnography, specifically related to abnormal vital signs and patients' NEWS (all un-identifiable information). However, it was considered possible that during these clinical conversations, other identifiable and potentially sensitive patient information could have been disclosed without warning. It was impossible to predict which patients would deteriorate and therefore which patients would be the focus of these conversations. As such, it was impractical for me to seek consent from patients prior to the information being disclosed. As no audio or video recording equipment was taken into the field, there was no plan to record or collect this information. Likewise, no identifiable or sensitive information was recorded in the field notes. I did not discuss or disclose this information to any other person. As the holder of an honorary clinical contract within the Trust, I was required to adhere to good information governance practice which included non-disclosure of clinical information outside of the immediate care team. If I was in earshot of a conversation between healthcare practitioners, related to a patient with an elevated NEWS, and the focus of the conversation changed from the vital signs/NEWS to another unrelated subject, or to another patient, I physically moved away from the area in which the conversation was occurring.

It was anticipated that, during fieldwork, I could observe clinical practice that was considered unsafe and/or did not adhere to local policy and procedure e.g. a patient with clear signs of physiological deterioration not receiving an appropriate response. In the event of such a situation, as a registered nurse, I had both an ethical and professional duty to take 'appropriate action' thereby preserving safety of the patient as stipulated in The Code (Nursing and Midwifery Council (NMC), 2015). To specify this 'appropriate action', a

safety protocol was devised, reviewed, and agreed by local stakeholders (including the lead of the hospital's CCOT and the relevant ward managers). If I observed a clinical situation that I judged to be unsafe, I was prompted by the protocol (volume 2, appendix 20) to take a stepwise series of actions beginning with notification of the responsible RN, followed by escalation to the nurse-in-charge of the ward, followed by, if necessary, a call to the medical team or CCOT. My planned responses were proportionate to the degree of physiological abnormality (i.e. how high the NEWS or how deranged the vital signs) and the appropriateness of the observed response from the ward-based nursing staff e.g. if I prompted the RN to act, and they appeared to enact the policy specified behaviour, then I did not undertake any further escalation of care myself. If they were not seen enacting the policy specified behaviours, then I escalated my response in accordance with my safety protocol.

It was also considered plausible that a participant might make a disclosure during an interview that pertained to overt patient harm or an issue of safeguarding. Participants were informed, at the beginning of the interview, that in these circumstances I would need to notify their line manager so that further investigation could take place. If such a disclosure had been made, I planned to signal this within the interview and offer the participant the opportunity to be part of the conversation with their line manager

4.9.2.3 Identifying and mitigating risks to Trust staff participating in a group discussion where NGT was applied (phase 3)

Conducting the group discussions using a virtual space rather than a shared physical space offers both advantages and disadvantages from an ethical perspective. As participants were able to self-select the environment in which they joined the virtual group, there was a risk of participants being interrupted during the group discussion (e.g. from family members if joining from home or colleagues if joining from a work office space). In addition to the risk of the participant being distracted and the NGT process being disrupting, this could have also compromised confidentiality for the individual and other group participants (Daniels et al., 2019). To mitigate this risk, participants were prompted (in the information package sent ahead of the group) to join the

meeting from as private a space as possible and, where they could, to use personal headphones (as opposed to a speaker system) so that group discussions could only be heard by those within the virtual space. Irrespective of these measures, confidentiality could not be guaranteed in these circumstances and therefore the following statement was included within the online consent form:

I understand that confidentiality cannot be guaranteed for information which I may disclose in the group discussion.

At the beginning of the group, participants were also asked to respect one another's privacy by not discussing who attended or repeating anything that was said outside of the group (Lobe, Morgan & Hoffman, 2020).

There is some suggestion that confidentiality may be more assured when hosting virtually due to the inbuilt security and privacy features of virtual platforms (Turney & Pocknee, 2005). Specifically, these features may reduce the likelihood of individuals who have not been invited to participate, entering the virtual space, and identifying group participants. Likewise, features of virtual platforms such as Microsoft® Teams may increase privacy during independent activities. For example, during private ideas generation (stage 1) and the ranking activities (stage 3) of the NGT, participants were able to deactivate their cameras and microphones and therefore fully withdraw from the shared space.

4.9.3 Ethical approvals received to conduct this research

Favourable opinion and permissions to conduct all phases of this research were granted in October 2018 by an NHS Research Ethics Committee randomly allocated through the UK-wide system (the project was allocated to and reviewed by the NHS North of Scotland Research Ethics Committee - REC ref: 18/NS/0118) (see volume 2, appendix 21 for favourable opinion letter). Subsequently, permissions from the Confidentiality Advisory Group and Health Research Authority were granted in November 2018 (see appendices 22 and 23 for letters of confirmation). Finally, local (hospital-level) permissions

and final ‘sign-off’ from the Research and Development department were granted in November 2018 (R&D ref: 18/0569) prior to formal recruitment activities.

An application for a major amendment was submitted to the NHS North of Scotland Research Ethics Committee in July 2020, requesting the following amendments to phase 3 data collection:

1. Facilitating the group discussions where NGT was applied online (as opposed to face-to-face).
2. Recruiting participants from ward areas beyond the original sample (i.e. beyond the two floors where phase 1 and 2 data collection activities were carried out). The decision to recruit from other acute ward areas in the Trust, was driven by the significant organisational re-structure and staff re-deployment that took place in the aftermath of the first COVID-19 surge. As the original wards no longer existed in their pre-pandemic form (in terms of clinical specialty and staff composition), it was deemed appropriate to recruit more widely to capture staff who may have been re-deployed and to maximise opportunities for participation.

Favourable opinion for this amendment was received in July 2020 (volume 2, appendix 24).

4.10 Summary

A mixed method, multi-phase study was implemented. Using the principles of focused ethnography, a sample of nursing staff from two floors (four wards) were observed in clinical practice enacting behaviours of the afferent limb. Brief interviews were conducted to explore participant’s immediate cognitions related to observed events. A sub-set of staff observed were then invited to participate in an audio-recorded, semi-structured, TDF-informed, interview to explore in greater depth what they perceived to influence their afferent limb behaviours. Transcripts of brief and semi-structured interviews were coded deductively (by TDF domains) and inductively; belief statements and themes were synthesised reflecting barriers and enablers to expected afferent limb behaviour. Priority TDF domains were identified using reported methods and mapped to appropriate Behaviour Change Techniques from a published taxonomy. BCTs and potential applications were presented to stakeholders, who had the opportunity to suggest different

approaches for operationalising BCTs in the context of an online nominal group. Finally, and in accordance with NGT methods, group participants independently voted on their preferred BCT/applications (according to perceived acceptability and feasibility). These data informed the content of the preliminary intervention (the final output of this research). Results from the three phases of this PhD project are reported in the next chapter, which includes three publications (embedded into the chapter) from peer reviewed journals.

5 CHAPTER 5: RESULTS

5.1 Introduction

To develop a complex behaviour change intervention to improve responses to deteriorating patients, a multi-phase programme of work was devised broadly shaped by Medical Research Council guidelines (Skivington et al., 2021; Craig et al., 2008) and more specifically modelled on the implementation process reported by French et al (2012). Given the burgeoning international literature on the topic of afferent limb failure, and to ensure maximum impact, results from all three phases were published in peer reviewed journals across the duration of the PhD. Consequently, this chapter includes three published papers (co-authored with my supervisors) and additional content to report findings not included in publications, link sections together coherently, and ensure results are presented in adequate depth, particularly where journal word limits constrained more detailed reporting. In this chapter, the concept of reflexivity is also re-visited with a more specific focus on the impact of my presence on hospital wards during data collection, and the actions that I took during this time to ensure patient safety and adherence with my professional code of conduct (Nursing and Midwifery Council (NMC), 2015).

5.2 Phase 1 results

5.2.1 Results from focused ethnography (first publication)

Focused ethnography was used including direct observation of nursing staff enacting afferent limb behaviours and review of vital signs charts on two clinical floors (four wards). From structured content analysis of field notes, ten behaviours were identified where the behaviour directly observed on the ward/s deviated from expected (i.e. policy-specified) behaviour, or where no - action was taken when it should have been. One further observed behaviour, not specified in policy, was seen to expedite care for a deteriorating patient. A published framework (Presseau et al., 2019) was used to specify the eleven afferent limb behaviours as potential targets for a behaviour change intervention. These results were published in the *Journal of Advanced Nursing* (impact factor: 3.187, ranked 9/124 for nursing). According to information from Scopus

(www.scopus.com) the paper has been cited eight times since publication. As first author, I led on writing and amending the manuscript with support from my supervisors. Reporting was guided by the Consolidated criteria for Reporting Qualitative studies (COREQ) checklist (Tong, Sainsbury & Craig, 2007). Several documents included as online supplementary files to this publication have been included in the main body of this thesis (i.e. volume 1) or the appendix (i.e. volume 2). For ease of reference, the location of these documents is sign-posted in a table at the end of the manuscript.

STATEMENT OF CO-AUTHORS of JOINT PUBLICATIONS

TO WHOM IT MAY CONCERN

Title of publication: Patterns of behaviour in nursing staff actioning the afferent limb of the rapid response system (RRS): A focused ethnography

Name of candidate: Duncan Smith

Title of research thesis: DEveloping a Complex Intervention for DEteriorating patients using theoretical modelling (DECIDE study).

Name of first supervisor: Professor Leanne M Aitken

We, the undersigned, co-authors of the above publication, confirm that the above publication has not been submitted as evidence for which a degree or other qualification has already been awarded.

We, the undersigned, further indicate the candidate's contribution to the publication in our joint statement below.

Signature:

Name: **Duncan Smith**

Date: 15/6/22

Signature:

Name: **Martin Cartwright**

Date: 15/6/22

Signature:

Name: **Judith Dyson**

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Name: **Jillian Hartin**

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Signature:

Name: **Leanne M Aitken**

Date: 15/6/22

The candidate's contribution to the publication

Contribution	Author				
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Funding acquisition	✓				✓
Conceptualisation	✓				✓
Data collection	✓				
Data analysis	✓				
Drafting the manuscript	✓				
Editing the manuscript	✓	✓	✓	✓	✓
Approving the manuscript	✓	✓	✓	✓	✓

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Patterns of behaviour in nursing staff actioning the afferent limb of the rapid response system (RRS): A focused ethnography

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Abstract

Aim: To improve understanding of afferent limb behaviour in acute hospital ward settings, to define and specify who needs to do what differently and to report what afferent limb behaviours should be targeted in a subsequent multi-phase, theory-based, intervention development process.

Design: Focused ethnography was used including direct observation of nursing staff enacting afferent limb behaviours and review of vital signs charts.

Methods: An observation guide focused observation on "key moments" of the afferent limb. Descriptions of observations from between 7 January 2019–18 December 2019 were recorded in a field journal alongside reflexive notes. Vital signs and early warning scores from charts were reviewed and recorded. Field notes were analysed using structured content analysis. Observed behaviour was compared with expected (policy-specified) behaviour.

Results: Observation was conducted for 300 hr. Four hundred and ninety-nine items of data (e.g., an episode of observation or a set of vital signs) were collected. Two hundred and eighty-nine (58%) items of data were associated with expected (i.e. policy-specified) afferent limb behaviour; 210 (42%) items of data were associated with unexpected afferent limb behaviour (i.e. alternative behaviour or no behaviour). Ten specific behaviours were identified where the behaviour observed deviated (negatively) from policy or where no action was taken when it should have been. One further behaviour was seen to expedite the assessment of a deteriorating patient by an appropriate responder and was therefore considered a positive deviance.

Conclusion: Afferent limb failure has been described as a problem of inconsistent staff behaviour. Eleven potential target behaviours for change are reported and specified using a published framework.

Impact: Clear specification of target behaviour will allow further enquiry into the determinants of these behaviours and the development of a theory-based intervention that is more likely to result in behaviour change and can be tested empirically in future research.

KEYWORDS
critical care, ethnography, nurse roles, nursing observations, qualitative approaches, research implementation

1 | INTRODUCTION

Sub-optimal care of the deteriorating ward patient was first reported in the academic literature over 20 years ago (McQuillan et al., 1998). Sub-optimal care is a complex and multi-faceted concept that has no absolute definition. However, in the context of the deteriorating patient, key characteristics have been reported as delays in diagnosis, treatment or referral, poor assessment and/or inappropriate or inadequate treatment (Quirke, Coombs, & McEldowney, 2011). Sub-optimal care may precede a serious adverse event (SAE) such as unplanned intensive care unit (ICU) admission, cardiac arrest or death (Tirkkonen et al., 2013; Trinkle & Flabouris, 2011).

To improve responses to deteriorating patients and mitigate the risk of sub-optimal care, acute hospitals have implemented rapid response systems (RRS) in the UK, North America, and Australasia (DeVita et al., 2006; Johnstone, Rattray, & Myers, 2007; Lyons, Edelson, & Churpek, 2018). While there is international and inter organizational variance in the operational characteristics of these systems, RRS are broadly seen to include an afferent (detection) limb and an efferent (response) limb. Behaviours of the afferent limb typically include the routine monitoring of vital signs, identification of physiological abnormality, escalation to an appropriate responder (e.g., a doctor or specialist nurse) and a subsequent increase in the frequency of monitoring (DeVita et al., 2006; Lyons et al., 2018). The afferent limb is modelled on evidence that at least 60% of patients who deteriorate in hospital have antecedent changes in vital signs preceding SAE (Andersen et al., 2016; Kause et al., 2004). Efferent limb behaviours (enacted by the responder) include further assessment, initiation of treatment or stabilizing interventions, and facilitation of patient transfer to a higher-care setting, for example, a critical care unit (Bannard-Smith et al., 2016; DeVita et al., 2006). In this work, the behaviours of interest were those of the afferent limb.

Given the relatively high frequency of premonitory signs in deteriorating patients, the use of "track and trigger" tools is recommended in national guidelines from the UK (National Institute of Health and Care Excellence (NICE), 2007), Australia (Australian Commission on Safety & Quality in Health Care, 2017) and by the Institute for Healthcare Improvement in the USA (Institute for Healthcare Improvement (n.d.)). Broadly, "track and trigger" is a universal term describing a tool (either paper-based or electronic) on which vital signs are recorded. The tool provides a signal to clinical staff when the vital signs fall outside of acceptable parameters and then prompts staff to follow an escalation protocol (Grant, 2018).

Historically, different tools have been used creating inconsistency within and between organizations (Jansen & Cuthbertson, 2010; Shiloh, Lominadze, Gong, & Savel, 2016). To standardize UK practice, the National Early Warning Score (NEWS) was developed, published (Royal College of Physicians, 2012) and subsequently revised as NEWS2 (Royal College of Physicians, 2017). NEWS2 signals patient risk on the basis of the total score (total score range 0–20) aggregated from individual scores assigned to six routinely recorded vital signs (Table 1). The patient's risk level is then stratified according to the aggregate score (File S1) which aligns to an associated escalation algorithm (Royal College of Physicians, 2017). Since its original inception, an expansive body of literature has emerged validating the ability of NEWS to discriminate patients at risk of SAE in medical, surgical, and emergency department settings (Green et al., 2018; Klepstad, Nordseth, Sikora, & Klepstad, 2019; Spångfors, Bunkenborg, Molt, & Samuelson, 2019).

Despite international implementation of RRS and the availability of NEWS2 in the UK, there is evidence that staff do not change their behaviour to increase the frequency of vital signs monitoring or escalate care when criteria are met (Credland, Dyson, & Johnson, 2018). This lack of compliance has been termed "afferent limb failure" (ALF) (Johnston, Arora, King, Stroman, & Darzi, 2014; Trinkle & Flabouris, 2011). There is an abundance of literature describing the potential causes of ALF (Olsen, Søreide, Hillman, & Hansen, 2019; Treacy & Stayt, 2019; Wood, Chaboyer, & Carr, 2019) but paucity of work reporting interventions to target it (Bucknall et al., 2017; Connell et al., 2016; Duff, Massey, Gooch, & Wallis, 2018). Further, most of the interventions described are educational with methodological limitations including risks of bias and/or consistently poor detailing of the development process, suggesting that these interventions may have been developed pragmatically (i.e., based on clinician or researcher intuition) rather than using a replicable method. Given its pervasive nature, there is an argument for using more systematic behavioural approaches to investigate and address ALF.

2 | BACKGROUND

While several different approaches for developing interventions are reported, we used a theory-based approach for intervention

TABLE 1 Vital signs measured and aggregated to calculate a NEWS2

Respiratory rate (RR)
Peripheral oxygen saturations (with a score uplift of 2 for any patient requiring supplementary oxygen therapy) ($Sp0_2$)
Heart rate (HR)
Blood pressure (BP)
Temperature (Temp)
Level of consciousness (graded as **A**lert, new **C**onfusion, responsive to **V**oice, responsive to **P**ain, **U**nresponsive)

Note: (Royal College of Physicians, 2017).

development (O'Cathain et al., 2019) modelled on the Medical Research Council's guidance for developing and evaluating complex interventions (Medical Research Council, 2006). The application of theory enables determinants (i.e., barriers and enablers) of behaviour to be identified and for intervention components that specifically target these determinants to be selected and tailored to context (Cadogan et al., 2015; Patton et al., 2018). To develop a theory-based intervention, clear specification of target behaviours is required to enable measurement of behaviour change in subsequent intervention testing (Atkins et al., 2017; Presseau et al., 2019). Before reporting undesirable or deviant behaviours (i.e., those that will be targeted by the intervention), expected behaviour must first be specified. To specify expected behaviours of the afferent limb, a documentary analysis of policy and guidelines was carried out (Smith, Sekhon, Francis, & Aitken, 2019) using a simple behaviour specification framework incorporating five elements (action, actor, context, target, time – AACTT) (Presseau et al., 2019).

3 | THE STUDY

3.1 | Aim and objectives

The aim of this project was to improve understanding of afferent limb behaviour in an acute hospital ward setting. Specific objectives were:

- To compare expected (i.e., policy specified) behaviours of nursing staff with those observed on hospital wards
- To report where afferent limb failure was occurring in the sequence of observed behaviours
- To define and specify the behaviours that could be targeted by a theory-based intervention, using the five criteria of a published behaviour specification framework - action, actor, context, target, and timing (Presseau et al., 2019).

3.2 | Design

This project is one component of a multi-phase intervention development process, for which a protocol has been published (Smith, Francis, et al., 2019). Focused ethnography was conducted to explore the behaviour of nursing staff, working in acute hospital wards, when they were actioning behaviours of the afferent limb of the RRS. Focused ethnography is an applied qualitative methodology that is well suited to research where participants reflect a small sub-group of society (e.g., a particular professional group), where the objective is to elucidate a reported problem in a particular context, and where the researcher's access to participants is limited to brief, episodic contact (Cruz & Higginbottom, 2013; Knoblauch, 2005).

3.3 | Sample

This research was conducted in an acute metropolitan hospital in England that provides care for the local population as well as specialist services. The organization comprises seven geographically separate hospitals with a total bed-base of 1,161. This study was conducted in the largest in-patient site in the organization. In 2018, it was confirmed that the hospital would be switching from paper-based patient records to an Electronic Health Record System (EHRS). Part of this process was migration from a paper-based NEWS chart to an electronic version of NEWS2. These plans were announced after this study had been designed and the original protocol written. It was identified that this period of transition would provide a unique opportunity for data collection before and after the implementation of an EHRS and an embedded electronic version of NEWS2. Aside from the implementation of the EHRS and electronic NEWS2, all other aspects of the RRS remained the same throughout data collection. Specifically, no changes occurred regarding how patients' vital signs were monitored or how the efferent limb was activated. The hospital in question has an established RRS that was implemented in 2000. The efferent limb response is provided by the primary medical team and a critical care outreach team (CCOT) which is available 24/7.

To capture a variety of different behaviours, two contrasting clinical floors were selected using local data. One area (floor B) had an open investigation into a case of ALF at the time of recruitment. The other area (floor A) had no such investigations in progress. Further characteristics of the clinical floors are described in Table 2. Based on methodological precedent (Mackintosh, Humphrey, & Sandall, 2014), we proposed to observe for 180 hr on different days of the week and at different times of day and night, or until data saturation was achieved (i.e., no new behaviours were seen). A purposive sample (balance of clinical banding) of nurses enacting behaviours of the afferent limb were observed.

3.4 | Data collection

Data collection activities were conducted in two phases. Between 7 January 2019 – 27 March 2019, data were collected in the paper-based context. Between 1 January 2019 – 18 December 2019 data were collected in the electronic context. We acknowledged that staff behaviour immediately after EHRS implementation was unlikely to reflect usual practice. As such, an acclimation period of 3 months (Bedoya et al., 2019) was allowed when no data were collected.

In keeping with the concept of focused ethnography, observation concentrated on the activities of specific clinical personnel (Registered Nurses - RNs and Healthcare Assistants - HCAs) undertaking specific activities (behaviours of the afferent limb) in the ward environment. To focus observation on the behaviours of interest, an observation guide was developed. The observation guide (File S2) was initially populated with broad descriptions of afferent

TABLE 2 Characteristics of the ward-level sample

Floor A	Floor B
Two adjacent wards	Two adjacent wards
Thirty-eight inpatient beds (open bays and side rooms)	Sixty-two inpatient beds (open bays and side rooms)
Provides care for patients under the following specialties: acute internal medicine, respiratory medicine, infectious/tropical diseases	Provides care for patients under the following specialties: gastro-intestinal medicine and surgery (upper and lower), hepato-biliary medicine and surgery, gut failure and clinical pharmacology
Nursing staff (RNs and HCAs) rotate across the entire floor	Nursing staff (RNs and HCAs) work in two separate teams
Staffed by 32 RNs; 21 HCAs	Staffed by 61 RNs; 27 HCAs
Fully staffed during data collection period (i.e., no vacancies declared)	Fully staffed during data collection period (i.e., no vacancies declared)
No serious incident investigations related to ALF at the time of recruitment	One open serious incident investigations related to ALF at the time of recruitment

limb behaviour (termed "key moments" of the afferent limb) from published literature (Davies, DeVita, Ayinla, & Perez, 2014; Lyons et al., 2018). Each key moment was then elaborated with more specific content derived from documentary analysis of the organization's local policy for deteriorating patients, using previously reported methods (Smith, Sekhon, et al., 2019) and guided by a behaviour specification framework (Presseau et al., 2019). The guide focused observation on five key moments of the afferent limb (Table 3).

In conjunction with the observation guide, a document for recording field notes was developed (File S3). This document was structured to enable descriptions of staff behaviour to be recorded in addition to data from vital signs charts (paper and electronic). The document also provided a space for "reflexive notes," that is, a space for the researcher to record thoughts, feelings and interpretations of events.

The researcher conducted NEWS chart reviews throughout the data collection period. Individual vital signs and aggregate scores from the NEWS chart were extracted and recorded in the field notes. Chart review was frequently performed alongside, or in response to, direct observation. A chart review was also performed if the researcher overheard discussions about an unwell patient at nursing staff handover or a "huddle," or if the researcher observed "heightened activity" around a particular patient (e.g., staff bringing emergency equipment to the bedside).

In adult patients hospitalized for a range of clinical diagnoses respiratory rate was found to be an independent predictor of adverse events (Escobar et al., 2012; Fieselmann, Hendryx, Helms, & Wakefield, 1993; Fine et al., 1997). Unlike the other vital signs entered into NEWS, the respiratory rate is typically not measured using electronic equipment and must be measured visually by a healthcare provider (Badawy, Nguyen, Clark, Halm, & Makam, 2017). Despite its importance, there is evidence that recorded respiratory rates are frequently inaccurate (Badawy et al., 2017; Treacy & Stayt, 2019). Based on this evidence, we elected to compare the respiratory rate recorded on NEWS with the respiratory rate counted by the researcher in situ. If the researcher directly observed vital signs being measured, or the NEWS chart indicated that they had been recorded within 15 min, then he counted the patient's respiratory rate himself over 1 min. This allowed direct comparison with the respiratory rate recorded by the ward staff (i.e., the data on the chart). The decision to undertake this measurement was contingent on the researcher being able to discretely position himself where he could reliably observe the patient's breathing, without his presence interrupting clinical care or being intrusive to the patient. These measurements were taken on an *ad hoc* basis, typically alongside direct observation and chart review. Where the researcher respiratory rate was considerably different to the recorded respiratory rate (i.e., different enough to change the NEWS risk level), an agreed safety algorithm was followed to safeguard the patient. This algorithm prompted the researcher (DS) to take a stepwise series of actions beginning with notification of the responsible RN, followed by escalation to the nurse in charge of the ward, followed by, if necessary, a call to the medical team or CCOT. The response was proportionate to the degree of physiological abnormality (i.e., how high the NEWS or how deranged the vital signs) and also the appropriateness of the observed response from the ward-based nursing staff (e.g., if the researcher prompted the RN to take action and they appeared to enact the policy specified behaviour, then no further escalation was taken by DS). Further detail of this escalation algorithm can be found in the study protocol (Smith, Francis, et al., 2019).

3.5 | Ethical considerations

Permission to conduct this research was granted by the National Health Service North of Scotland Research Ethics Committee (REC) (reference:18/NS/0118). Subsequently, favourable opinions

TABLE 3 Five key moments of the afferent limb of the Rapid Response System

Key moment	Description
Routine monitoring of vital signs	Monitoring a group of patients' vital signs consecutively at a specified time
Responsive monitoring of vital signs	A targeted episode of vital signs monitoring that occurs outside of – or more frequently than – routine monitoring
Recording the vital signs and/or calculating the aggregate NEWS	Actions related to documenting vital signs on a paper NEWS chart/entering the data into the EHRS and/or calculating an aggregate NEWS (if using a non-automated system)
Escalation within the ward-based nursing team	Notifying a nursing colleague within the same ward-based team that a patient is deteriorating
Escalation outside of the ward-based nursing team	Notifying a colleague from outside of the ward-based team (doctor or specialist nurse/practitioner) that a patient is deteriorating

to proceed with the research were granted by the Health Research Authority (reference as for REC) and the hospital's Research and Development Department (reference: 18/0569). We received ethical approval to use an "opt-out" consent approach for this research, meaning that nursing staff were provided with multiple opportunities to opt out of participating in the study. At the beginning of a shift where DS was present, staff were reminded that they should declare (verbally or in written form) if they did not wish to be observed or approached during the period of observation. These staff were asked to prospectively sign an opt-out form. Copies of the opt-out form were also left in the staff room along with a sealed box so that staff could privately complete and return an opt-out form, if they did not wish to approach DS in person. Staff who opted out were not required to specify their reasons for doing so. The completed opt-out form allowed DS to identify staff on duty who did not wish to participate (by cross-checking with the roster and staff allocation board) so that no further information was collected from these individuals. Further details of the consent procedures can be found in the study protocol (Smith, Francis, et al., 2019).

3.6 | Data analysis

One member of the research team (DS) used structured content analysis (Hsieh & Shannon, 2005) to analyse field notes as follows:

- Handwritten descriptions of direct observations and chart review data were read superficially and then more thoroughly to ensure familiarization with the subject matter.
- Data were initially labelled and categorized by the five key moments of the afferent limb.
- Within each of the five categories, data were examined further and compared directly to policy-specified behaviour (obtained from documentary analysis). If the observational data, or information extracted from chart review, aligned to policy-specified behaviour, this was categorized as "expected behaviour." Where the recorded data did not align to the policy-specified behaviour, it was categorized as "unexpected behaviour." A lack of action was also categorized as "unexpected behaviour."
- Where the extracted data included a researcher respiratory rate measurement alongside a recorded respiratory rate, a sub-analysis was performed by comparing the two respiratory rate measurements. If the difference between the two measurements was greater than 5, or the difference was sufficient to change the aggregate NEWS, the episode was categorized as "unexpected behaviour." If these criteria were not met, the episode was categorized as "expected behaviour." The difference between the researcher respiratory rate and the recorded respiratory rate was summarized descriptively.
- Frequencies and proportions of expected and unexpected behaviours were counted across the corpus of data and for each of the key moments of the afferent limb.
- Unexpected behaviours were scrutinized and statements describing "who needs to do what differently" were synthesized and structured using the AACTT framework (Presseau et al., 2019) to report target behaviours for a behaviour change intervention (to be reported in a subsequent paper).

3.7 | Rigour

In qualitative research, multiple data collection strategies may be employed (i.e., use of triangulation) to facilitate a deeper understanding of the phenomena under investigation and to ensure rigour within the research process (O'Cathain, Murphy, & Nicholl, 2010). Specifically in the context of ethnographic research, use of participant observation and examination of relevant documents are reported methods (Cruz & Higginbottom, 2013). Both these approaches were incorporated into this design.

Comprehensive field and reflexive notes were taken throughout the period of data collection to ensure dependability of the

data. The observation guide and field journal were both piloted for 1 week. After this period, field and reflexive notes were presented to two other members of the research team (LMA, MC) allowing data collection decisions to be challenged and defended and enabling revisions to the documents. Similarly, target behaviours (synthesized during data analysis) were presented to and critically discussed with other stakeholders in the research team which includes a Professor of Critical Care (LMA), an Implementation Scientist (MC), and the lead for the hospital's CCOT (JH).

All data collection activities were carried out by a single researcher (DS); a clinical-academic nurse with a background in acute/critical care nursing, including 10 years of experience working in critical care outreach teams. While DS has not worked clinically in a ward environment for 17 years, he is clinically experienced in the recognition and response to deteriorating patients and in clinical assessment more broadly. Prior to data collection, DS undertook training on qualitative methods including specific training on ethnographic methods (delivered by a Professor of Anthropology).

4 | FINDINGS

Across the two clinical floors, a total of 300 hr of observation was carried out; 150 hr when a paper-based NEWS chart was in use (i.e., pre EHRS implementation) and 150 hr when an electronic NEWS2 chart was in use (i.e., post EHRS implementation) (Figure 1 shows a detailed breakdown of these hours by floor). Four members of staff (all HCAs) prospectively opted-out of being observed (staff were not required to declare why they chose to opt out).

Four hundred and ninety-nine discrete items of data (e.g., a single episode of observational data, or a single set of vital signs from one occurrence of patient monitoring) were extracted from field notes and analysed; 253 items of data were collected pre EHRS; 246 items of data were collected post EHRS. Two hundred and eighty-nine (58%) items of data were associated with expected (e.g., policy-specified) afferent limb behaviour; 210 (42%) items of data were associated with unexpected afferent limb behaviour (e.g., alternative behaviour or no behaviour) (Table 4 displays the frequency of expected and unexpected behaviour for each of the five key moments of the afferent limb). Ten specific behaviours were identified where the behaviour observed deviated (negatively) from policy or where no action was taken when it should have been (these potential targets for behaviour change are described in Table 5). One further behaviour was seen to expedite the assessment of a deteriorating patient by an appropriate responder and was therefore considered a positive deviant behaviour. Descriptive accounts of field data are reported below in relation to each key of the key moments of the afferent limb. File S4 contains exerts extracted directly from field notes in support of each of these accounts.

4.1 | Routine monitoring of vital signs

Expected routine monitoring of vital signs was observed on both floors and typically occurred in 4-hr intervals. All routine monitoring witnessed involved the use of electronic equipment (except respiratory rate measurement). These activities were observed in both the pre and post EHRS context. On floor A, both HCAs and RNs were observed enacting routine monitoring behaviours. On floor B, only HCAs were witnessed carrying out routine monitoring.

In some cases, it was very clear that the HCA or RN being observed were enacting expected behaviour in counting the patient's respiratory rate as part of routine monitoring. In these instances, staff were seen looking at a fob watch on their uniform, at a wall-mounted clock or, more frequently, at a timer on an electronic thermometer. Often, it was less clear if the respiratory rate had been counted as expected. On one occasion, a HCA was heard openly

TABLE 4 Frequencies and proportions of expected and unexpected behaviour for each of the five key moments of the afferent limb in the paper based and EHRS NEWS context

Key moment of the afferent limb	Context in which behaviour witnessed	Frequency (%) expected behaviour	Frequency (%) unexpected behaviour	Total frequency (%) of data for this key moment
Routine monitoring of vital signs	Paper-based NEWS	22 (63)	13 (37)	35 (7)
	EHRS based NEWS	11 (44)	14 (56)	25 (5)
Responsive monitoring of vital signs	Paper-based NEWS	27 (36)	48 (64)	75 (15)
	EHRS based NEWS	29 (39)	45 (61)	74 (14)
Recording the vital signs and/or calculating the NEWS	Paper-based NEWS	65 (57)	53 (43)	118 (24)
	EHRS based NEWS	103 (79)	28 (21)	131 (26)
Escalation within the ward-based nursing team	Paper-based NEWS	9 (82)	2 (18)	11 (2)
	EHRS based NEWS	4 (50)	4 (50)	8 (2)
Escalation outside of the ward-based nursing team	Paper-based NEWS	12 (86)	2 (14)	14 (3)
	EHRS based NEWS	8 (100)	0	8 (2)
Frequency (%) of discrete items of data		289 (58)	210 (42)	499

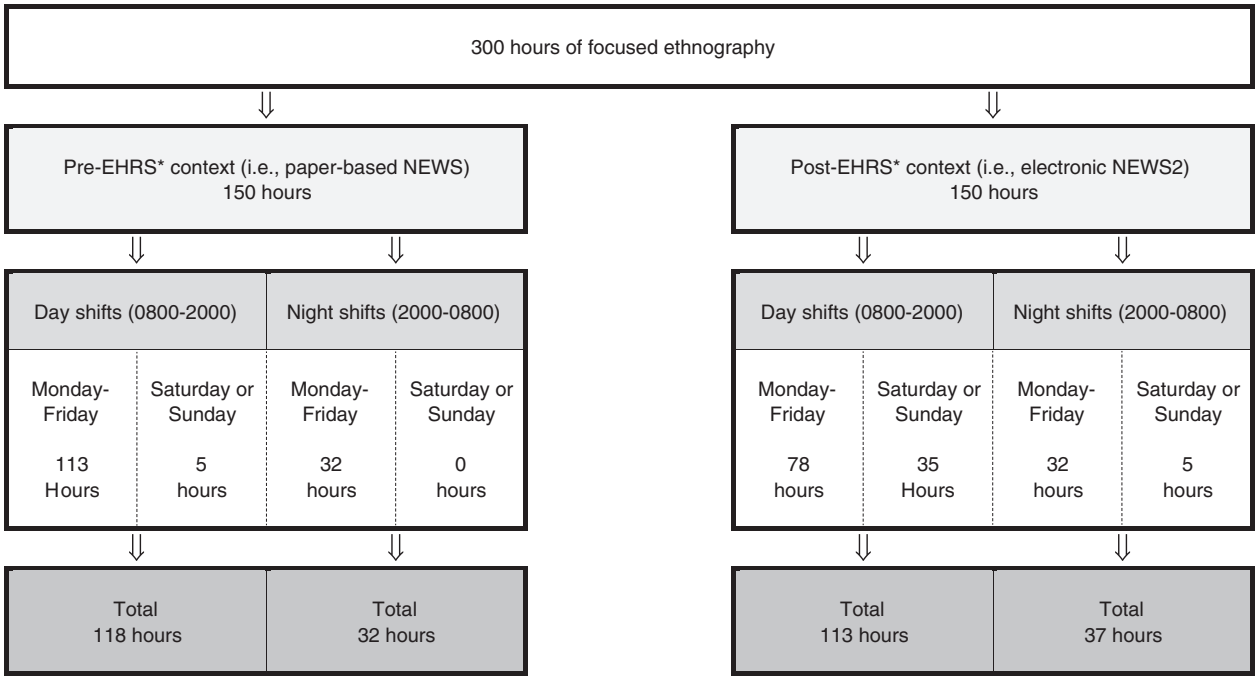

FIGURE 1 Breakdown of fieldwork hours

stating to a colleague that they did not have sight of a clock. Despite this, they proceeded to record a respiratory rate on the NEWS chart.

Some staff were also seen enacting unexpected behaviour in relation to the use of electronic monitoring equipment. On several occasions, HCAs were observed applying finger probes for measuring $Sp0_2$ to a patient's ear. This was often seen in response to the monitoring equipment alarming when first applied to a digit.

4.2 | Responsive monitoring of vital signs

The expected behaviour of responsive monitoring typically involved the monitoring of vital signs in a single patient more frequently than other patients in their bay. Both RNs and HCAs were seen enacting these behaviours in the pre and post EHRS context. RNs were more frequently observed enacting responsive monitoring compared with routine monitoring. On some occasions, electronic monitoring devices were left connected to the patient and stationed in the patient's bed space to permit more frequent measurement of vital signs. This was recorded as expected behaviour in the context of a deteriorating patient.

When approached by a HCA about a patient with an elevated NEWS or abnormal vital signs, RNs were seen to delegate further monitoring back to a HCA or student nurse, rather than assessing the patient further themselves (the expected behaviour). This was observed on multiple occasions involving different patients including a patient with an un-recordable blood pressure, a patient who had already been reviewed by critical care and a patient with a high NEWS.

Chart reviews were frequently conducted to assess the timeliness of repeat monitoring after a NEWS trigger. Examples of expected behaviour were found illustrating monitoring frequency being increased, according to policy, for medium and high-risk NEWS. There was also evidence of unexpected behaviour in view of delayed monitoring (i.e.,> 1 hr between episodes) for patients with both medium and high-risk scores.

4.3 | Recording vital signs and/or calculating the NEWS

The behaviours related to the recording of vital signs and the generation of an aggregate NEWS, were the most variable between the pre and post EHRS periods. In the pre EHRS context, review of paper NEWS charts highlighted inconsistency in the accuracy of recorded information. On some occasions, evidence of expected behaviour was found whereby all vital signs were recorded legibly and an accurate NEWS was calculated. On other occasions, specific vital signs were missing, or an aggregate NEWS was not recorded, or the aggregate NEWS was recorded but was not calculated correctly. Infrequently, the time recorded on the NEWS tool (paper and electronic) appeared to reflect the time that the vital signs were due rather than the time that they were seen to be measured. This was considered unexpected behaviour.

The EHRS appeared to remedy errors in the calculation of NEWS, however, there were still occasions where incomplete recording of vital signs by staff (unexpected behaviour) prevented the

TABLE 5 Description of policy-practice gaps and specification of afferent limb behaviours that could be targeted by a theory-based behaviour change intervention

Policy-specified behaviour	Actual behaviour (from field notes)	Context in which the behaviour was observed	Who needs to do what differently (potential target for the behaviour change intervention)
Every time an HCA/RN measures vital signs, all 6 parameters should be recorded, and an accurate NEWS calculated (this is automated on the EHRS)	HCAs were observed writing vital signs on a piece of paper or handover sheet or paper towel, and were later were seen entering a whole bay/group of patients' vital signs into NEWS	Paper and EHRS	All vital signs should be recorded directly on the NEWS chart/EHRS *(action)* by HCAs *(actor)*, every time a ward patient's *([a]secondary target)* vital signs are measured *(context)*, within 5 minutes of measurement *(timing)*. Information should not be recorded on handover sheets or other miscellaneous pieces of paper.
Every time an HCA/RN measures vital signs, all 6 parameters should be recorded accurately and contemporaneously	HCAs and RNs do not consistently measure or record the respiratory rate accurately when taking vital signs	Paper and EHRS	Ward patients' *(secondary target)* respiratory rates should be counted *(action)* by HCAs and RNs *(actors)* for a full minute *(timing)*, every time vital signs are measured *(context)*.
	HCAs do not always document the time that the vital signs were actually taken on the NEWS chart. Instead, they write the time that they were due to be taken.	Paper and EHRS	HCAs *(actor)* should record the exact time that the vital signs were measured *(action)* for every episode of patient monitoring *(context)*, on all ward patients *(secondary target)*, during the day or night *(timing)*.
	When measuring vital signs, HCAs sometimes place the oximetry finger probe on the patient's ear, or on a finger on the same side as the arm to which the BP cuff is also attached	Paper	Whenever *(timing)* vital signs are measured *(context)* on a ward patient *(secondary target)*, HCAs *(actor)* should attach the pulse oximetry probe to a digit on the opposite side to the blood pressure cuff *(action)*. Finger probes should only be applied to a digit and not to the ear to ensure accurate readings (unless a specific ear probe is being used).
NEWS should be uplifted by 3 points for patients with new confusion	HCA and RNs do not score patients for 'new confusion', using the ACVPU tool	Paper	If a ward patient *(secondary target)* appears to have new confusion during the measurement of vital signs *(context)*, by RNs/HCAs *(actor)*, the level of consciousness should immediately *(timing)* be recorded as 'C' - for confusion on the NEWS tool *(action)* (resulting in a NEWS uplift of 3 points).
When the patient's NEWS is low risk (1-4), the RN/HCA should measure vital signs 4 hourly (at minimum)	If a patient is sleeping, HCAs sometimes write 'patient sleeping do not disturb' (or similar) on the paper NEWS chart and do not measure the routine vital signs when they are due	Paper	HCAs *(actor)* should seek guidance *(action)* from the RN *([a]primary target)*, if they are unsure about whether or not to disturb a sleeping patient *(secondary target)* to take routine vital signs *(context)* during the day or at night *(timing)*.
Abnormal vital signs/raised NEWS must always be reported to the RN responsible for the patient	HCAs do not always escalate to RNs when the NEWS ≥5	Paper and EHRS	HCAs *(actor)* should escalate *(action)* to a RN *(primary target)* whenever a ward patient's *(secondary target)* NEWS is ≥5 *(context)*, after every episode of vital signs monitoring *(timing)* unless a reasonable variance has been agreed and documented.
If a RN is notified about a patient with an elevated NEWS (i.e., ≥5), they respond by performing further bedside assessment e.g., further vital signs monitoring, ABCDE assessment	When abnormal vital signs are communicated to RNs by HCAs, the vital signs are infrequently repeated by the responsible RN to check the accuracy. More commonly, the RN delegates back to an HCA	Paper and EHRS	RNs *(actor)* should re-measure vital signs *(action)* on a ward patient *(secondary target)* if they are informed that said patient's NEWS is elevated *(context)* prior to further escalation *(timing)*.

(Continues)

TABLE 5 (Continued)

Policy-specified behaviour	Actual behaviour (from field notes)	Context in which the behaviour was observed	Who needs to do what differently (potential target for the behaviour change intervention)
After recording a NEWS ≥5, the RN should escalate to the parent medical team +/- CCOT +/- night nurse practitioners	RNs do not consistently escalate patients with elevated NEWS. This includes patients under CCOT and/or those flagged as 'at risk' (at safety huddles etc.)	Paper	Escalation (*action*) to the parent medical team and/or CCOT and/or night nurse practitioners *(primary targets)* should be carried out by RNs *(actor)* when NEWS is ≥5 *(context)*, in any ward patient *(secondary target)*, after they have re-measured vital signs and/or completed an ABCDE assessment *(timing)* unless a reasonable variance has been agreed and documented.
	If the first responder to whom the RN escalates does not respond as expected, then the RN contacts other personnel (e.g., a different doctor or CCOT nurse) to ensure that the patient is assessed and/or a clear plan is made	EHRS	Further escalation (*action*) to second responder (e.g., a different doctor or CCOT nurse) *(primary target)* should be carried out by a RN *(actor)*, if the first practitioner they approached cannot attend or does not respond as policy states, during any episode of escalation to any responder *(context)* at any time of day or night *(timing)*.
After recording a NEWS ≥5, the frequency of vital signs monitoring should be increased to a minimum of 1 hourly measurements	HCAs/RNs do not always repeat vital signs within 1 hour, when the NEWS is medium or high risk	Paper and EHRS	A ward patient's *(secondary target)* vital signs should be repeated *(action)* by HCAs/RNs *(actor)*, when the NEWS ≥5 *(context)*, every hour (at minimum) *(timing)* unless a reasonable variance has been agreed and documented.

[a]The *primary target(s)* of the specified behaviour are the individual(s)/group(s) who must decide whether subsequent behaviours are required, while the *secondary target(s)* are the individual(s)/group(s) who benefit from the specified behaviour but are not required to enact anything themselves.

EHRS generating an aggregate score. Also, where patients were visibly confused/delirious, this was not always recorded and scored as expected on the NEWS chart.

The practices of staff when recording the vital signs was highly variable. In the post EHRS context, some HCAs and RNs were seen to enter vital signs directly into either a desktop computer or a workstation on wheels. Some HCAs used hand-held devices to enter the vital signs immediately after they had measured them. All these behaviours facilitated contemporaneous recording and were therefore considered expected. Other HCAs were observed jotting several patients' vital signs down on a piece of paper (typically a paper towel or clinical handover sheet) before then entering them into the EHRS later using a desktop computer. These behaviours created a delay in recording and were therefore considered unexpected.

4.4 | Differences between recorded respiratory rate and researcher respiratory rate

On 37 occasions (across the pre and post EHRS data collection periods), a researcher respiratory rate was counted and compared with values recorded by HCAs and RNs. The median difference between the recorded respiratory rate and researcher respiratory rate was 5 (IQR 1–10). In 28 (76%) cases, the researcher respiratory rate was higher than the recorded respiratory rate. In 24 (65%) cases, the researcher's calculated NEWS was higher than the recorded NEWS; in 17 (46%) cases, the researcher NEWS resulted in an upgrade of the NEWS risk level and therefore a different recommended course of action. In 10 (27%) cases, the level of risk would have been upgraded to either medium (19%) or high (8%) risk, from a lower-risk category.

4.5 | Escalation within the ward-based nursing team

In both the pre and post EHRS context, escalation behaviours were less frequently observed than monitoring, recording, and scoring behaviours. HCAs were observed escalating, as expected, to RNs in the pre and post EHRS contexts and were typically overheard reporting concerns with specific vital signs. Less frequently, HCAs were overheard raising concerns about an elevated NEWS. However, on both floors, there were situations where patients with abnormal vital signs and elevated NEWS had not been escalated, as expected, by the HCA who undertook the measurements to the responsible RN.

4.6 | Escalation outside of the ward-based nursing team

On both floors, RNs were observed escalating, as expected, to external personnel including medical staff and CCOT. These behaviours were enacted in both the pre and post EHRS contexts. In most cases, the escalation occurred via the hospital pager system, which

involved staff dialling a pager number into the telephone, entering their contact extension for the responder and then waiting by the telephone for the responder to return their call. On floor A, there were several occasions where escalation to medical staff occurred in person rather than over the telephone. Typically, this involved an RN approaching a doctor from the office on the ward and bringing them to the bedside of a patient.

There were instances where patients met the criteria for escalation but had not been escalated by RNs to the CCOT. One example of this unexpected behaviour involved a patient who had already been identified as potentially needing a step-up of care to ICU, who was not escalated in response to an elevated NEWS.

5 | DISCUSSION

During the period of observation, expected and unexpected behaviours were observed in four of the five key moments of the afferent limb in both the paper and EHRS contexts. For the key moment of "escalation outside of the ward-based nursing team," only expected (policy-specified) behaviour was observed in the EHRS context. More than 90% of the data collected related to monitoring, recording and, when required, scoring behaviours. Less than 10% of the data collected reflected behaviours of escalation. There were clear areas of "role overlap" where the expected behaviour was enacted by both RNs and HCAs, particularly in responsive monitoring of vital signs. Other behaviours were more delineated by role. In particular, routine monitoring of vital signs was nearly always enacted by HCAs. Conversely, higher level escalations (i.e., outside of the ward-based nursing team) were exclusively actioned by RNs. Some unexpected behaviours involved actions that deviated from policy or practice guidelines. In these cases, the behaviour was broadly enacted but not to the standard of best practice, for example, monitoring vital signs but misusing equipment (e.g., applying a pulse oximetry probe designed to be applied to a patient's finger, to the ear). More commonly, unexpected behaviour involved no action, for example, an RN not escalating an elevated NEWS to CCOT.

Most routine monitoring of vital signs involved the use of electronic monitoring equipment and was typically performed by HCAs. These findings are consistent with other literature (Ede, Jeffs, Vollam, & Watkinson, 2019; Mackintosh et al., 2014; Smith & Aitken, 2016) implying this may be common practice. There were exceptions where RNs were seen undertaking routine monitoring, this typically occurred in the context of short staffing or when a HCA was re-deployed to a "heavier" part of the ward. The assumption that HCAs will undertake what Ede et al. (2019) describe as "bulk monitoring" (p4) presents several potential challenges. First, it establishes a disconnect within the afferent limb between the actor responsible for collecting the clinical data, that is, measuring the vital signs and the actor expected to evaluate the information and act (Mackintosh et al., 2014). Arguably, it also denies the RN a further opportunity to interact with the patient and capture additional clinical information (Cardona-Morrell et al., 2015). In the context of patient deterioration, there is evidence that "nurse worry" is important in predicting adverse patient outcomes (Douw, Huisman-de Waal, van Zanten, van der Hoeven, & Schoonhoven, 2016; Romero-Brufau et al., 2019). While "nurse worry" has been linked to tacit knowledge, it may also arise from a more comprehensive assessment and the collection of additional clinical cues (e.g., patient appearing agitated or skin clammy to touch) (Douw et al., 2015). Through undertaking routine monitoring, RNs would be well positioned to identify these additional cues alongside the vital signs. At present, there is no information in the published literature about HCA worry, including whether or not HCAs are sensitive to the same cues of deterioration as RNs, or if their sense of worry has predictive validity. In view of this, deteriorating patient policies typically stipulate that HCAs, carrying out routine monitoring, should have a low threshold to escalate if the NEWS is elevated or vital signs abnormal (Smith, Sekhon, et al., 2019). Despite this, situations were observed where HCAs had measured and recorded an elevated NEWS but not notified the RN. The lack of expected behaviour from the HCA created a "hard stop" in the sequence (i.e., no further action taken), as the RN behaviours were contingent on activation from the HCA. Some authors have argued that increasing reliance on un-registered staff to undertake safety-critical aspects of nursing, reflects a wider challenge facing the workforce where RN expertise is increasingly devalued and diluted (Leary, 2019). This is particularly concerning, given the evidence that adverse outcomes are reduced when patients are cared for in organizations with higher numbers of well-educated registrants (Aiken et al., 2011).

Using focused ethnography, we identified unexpected behaviour in the monitoring and recording of patients' respiratory rate by HCAs and RNs. In three quarters of cases, the observed respiratory rate by the researcher was higher than the respiratory rate recorded on the chart and, in almost half of the cases, the NEWS would have been higher if the recorded respiratory rate was replaced with the researcher respiratory rate. Our finding that respiratory rate is often under reported, leading to a potential underestimation of patient acuity, is consistent with other research including a study that compared respiratory rate measured by an electronic wearable device to respiratory rate measured by nurses (Weenk et al., 2019). Cited explanations for this unexpected behaviour include a lack of skill in obtaining the measurement and a lack of knowledge of its importance (Treacy & Stayt, 2019). Use of wearable continuous respiratory rate monitoring devices offer one solution to this pervasive problem (Weenk et al., 2019). However, a targeted intervention to ensure more consistent staff behaviour in this area could be a feasible alternative.

As the use of technology in healthcare becomes increasingly pervasive, interest has grown on the impact of technology on patient safety, more specifically on its impact on the RRS (Wilson & Khansa, 2018). In the paper context, errors have been reported in the recording and calculation of aggregate early warning scores (EWS) often leading to an under estimation of patient risk and sub-optimal responses (Kolic, Crane, McCartney, Perkins, & Taylor, 2015; Odell, 2015). Our findings broadly corroborate these reports, as more than 40% of observed recording and scoring behaviours

were categorized as unexpected in the paper NEWS context. Comparatively, there is evidence that scoring automation within an EHRS-embedded EWS completely eliminates human error in score calculation (Credland et al., 2018; Jones et al., 2011). However, in some EHRSs, the healthcare provider is still required to manually key the data into the system. We observed cases where the NEWS was not calculated by the EHRS due to missing or inaccurately entered data. Our findings align to other published literature, also reporting the problem of incomplete vital signs in an EHRS context (Stevenson, Israelsson, Nilsson, Petersson, & Bath, 2016). This unexpected behaviour could be the result of a lack of knowledge among nursing staff about the importance of an aggregate NEWS in determining risk, or lack of awareness of the potential consequences of not completing a thorough and timely patient assessment (Treacy & Stayt, 2019; Wood et al., 2019).

In view of unexpected behaviour in the recording and scoring key moment, we also observed staff (predominantly HCAs) writing a series of vital signs on paper before, then entering them all into the EHRS. This appeared to delay the availability of the data to other members of the healthcare team (including the RN), delayed the generation of a NEWS and led to transcription error. While this unexpected behaviour was seen in both the paper and EHRS contexts, the frequency of this specific behaviour increased after implementation of the EHRS. These behaviours, described in the literature as use of paper "workarounds" (Stevenson, Israelsson, Petersson, & Bath, 2018), have been attributed to dissatisfaction of staff with the layout and presentation of vital signs on the EHRS and a lack of equipment to enter the data, leading them to enact alternative behaviours (Stevenson et al., 2016, 2018). What is clear, is that the implementation of the EHRS is not a panacea for ALF. While some negative deviant behaviours are reconciled, others may increase suggesting these systems may have the potential to improve patient safety (Jones et al., 2011), however, careful consideration of the environmental and behavioural context is required.

We elected to collect data before and after the implementation of an EHRS to maximize researcher exposure to different behaviours of the afferent limb. While our study was not designed to signal cause and effect of EHRS implementation, it is noteworthy that 6 of 10 negative deviant behaviours were observed in both the pre and post EHRS contexts, suggesting these behaviours may be deeply entrenched. Further, in light of evidence that habit plays a significant role in health professional behaviour (Potthoff et al., 2019), it is plausible that some of these behaviours are enacted automatically, rather than based on careful and deliberative reasoning (Presseau et al., 2014). If this is the case, carefully selected and tailored intervention components will be required to change staff behaviour.

5.1 | Strengths and Limitations

In the context of the deteriorating hospital patient, we believe that this is the first paper to report, comprehensively, the use of focused ethnography to describe and specify behaviours that could be targeted by a theory-based implementation intervention. In the wider behaviour change literature, researchers have used local audit to identify who needs to change their behaviour (Taylor et al., 2016). While an acceptable approach, there is arguably a risk that some of the more nuanced and context-specific aspects of behaviour may not be captured. By comparison, focused ethnography has the potential to provide deeper insight into behaviour as it occurs within the "natural setting" (Leslie, Paradis, Gropper, Reeves, & Kitto, 2014; Vindrola-Padros & Vindrola-Padros, 2018).

Methodological limitations of our research include the use of a single hospital site and collection and analysis of the data by a single researcher. We mitigated the former through careful selection of clinical floors with different profiles. The latter we addressed by the researcher (DS) maintaining detailed reflexive notes and having meetings (throughout the period of data collection) with other members of the research team (LMA, MC) to discuss observations, feelings, and potential areas of unconscious bias. Similarly, at numerous intervals during data analysis findings were presented to other members of the team permitting critical discussion. Further, once specified, all of our potential target behaviours were scrutinized by academic (LMA, MC, JD) and clinical stakeholders (JH) for theoretical and clinical face validity.

As stated, there was an open serious incident investigation into ALF on floor B at the point of recruitment. As such, some of our participants may have been involved in the investigation, or the related activities, immediately before or during the period of data collection. It is plausible that participating in the investigation may have increased their familiarity with deteriorating patient guidance and/or influenced some of their behaviours. Consequently, the reported findings may underestimate the range and scale of "unexpected behaviours" that would have been present on one ward prior to the ALF incident and subsequent investigation.

Our procedure for the counting and comparing of respiratory rates had inherent limitations. First, it is plausible that the respiratory rate may have changed in the period (maximum 15 min) between it being recorded by the nurse/HCA and the researcher. In these circumstances, the behaviour may have been reported as unexpected when, in fact, the change was physiological rather than "user error," that is, a miscount by the RN or HCA. Further, it is possible that the "user error" belonged to the researcher rather than the ward staff. However, the researcher is an experienced RN with expertise in clinical assessment, specifically the assessment of deteriorating patients. In addition, the researcher was arguably less likely to be distracted by other activity on the ward and was able to repeatedly measure the respiratory rate, over a full minute, until he felt confident in the measurement.

6 | CONCLUSION

Using focused ethnography, we identified and specified 10 deviant afferent limb behaviours that could be targeted for change and a further

behaviour that could be enabled, by a theory-based implementation intervention. Five of these behaviours were only observed in the pre or post EHRS context. However, it is possible that these behaviours were enacted in both settings but not detected by the observer. As such, all 11 specified behaviours could be considered as potential intervention targets. Further theory-based inquiry is required to elucidate the determinants of these behaviours, to map these determinants to intervention components and tailor the delivery to context.

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CONFLICT OF INTEREST

No conflict of interest has been declared by the author(s).

AUTHOR CONTRIBUTIONS

All authors have agreed on the final version and meet at least one of the following criteria (recommended by the ICMJE (http://www.icmje.org/recommendations/): (1) substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; (2) drafting the article or revising it critically for important intellectual content.

PEER REVIEW

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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CORRIGENDUM

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In the article by Smith Duncan et al., the following error was published on page 3550, under section 3.4 Data Collection, line 3.

Between 1 January 2019–18 December 2019 data were collected in the electronic context.

It should have read:

Between 1 July 2019–18 December 2019 data were collected in the electronic context.

The authors apologize for this error.

REFERENCE

Smith, D., Cartwright, M., Dyson, J., Hartin, J., & Aitken, L. M. (2020). Patterns of behaviour in nursing staff actioning the afferent limb of the rapid response system (RRS): A focused ethnography. *Journal of Advanced Nursing*, *76*, 3548–3562. https://doi.org/10.1111/jan.14551

5.2.2 Supplementary files from the first publication included within this thesis (either in volume 1 or volume 2)

Supplementary file label in publication 1	Document title	Volume and page number within this thesis
File S1	The levels of patient risk associated with NEWS2 score ranges	Volume 2, appendix 25, page 117
File S2	Structured observation guide used during focused ethnography in phase 1 data collection	Volume 2, appendix 5, page 22
File S3	Field journal template used to record field data during phase 1	Volume 2, appendix 6, page 24
File S4	Exerts extracted directly from field notes related to each key moment of the afferent limb (phase 1)	Volume 2, appendix 26, page 118

5.2.3 Results from target behaviour shortlisting activities

To prioritise which of the behaviours identified from focused ethnography (reported in the first publication) would be taken forward into subsequent phases of the programme of work, four shortlisting criteria from the published literature were applied independently by me and my clinical supervisor (JH). The criteria and scoring system used is reported in Table 4.3. These criteria were used to generate scores which were then totaled for each behaviour. The maximum total score was 20 (derived from a maximum score of 10 for each reviewer). The scores assigned to each behaviour by both reviewers and the total scores are reported in Table 5.1. From consensus discussion involving my clinical supervisor, my primary PhD supervisor and I, it was agreed that six negative deviant behaviours (all scoring ≥17) would be prioritised and explored further in subsequent TDF interviews. These behaviours were:

1. Ward patients' respiratory rates should be counted by HCAs and RNs for a full minute, every time vital signs are measured.
2. All vital signs should be recorded directly on the NEWS chart/EHR by HCAs, every time a ward patient's vital signs are measured, within 5 minutes of measurement. Information should not be recorded on handover sheets or other miscellaneous pieces of paper.
3. HCAs should escalate to a RN whenever a ward patient's NEWS is ≥5, after every episode of vital signs monitoring unless a reasonable variance has been agreed and documented.
4. RNs should re-measure vital signs of a ward patient if they are informed that the patient's NEWS is elevated prior to further escalation.
5. Escalation to the parent medical team and/or CCOT and/or night nurse practitioners should be carried out by RNs when NEWS is ≥5, in any ward patient, after they have re-measured vital signs and/or completed an ABCDE[9] assessment unless a reasonable variance has been agreed and documented.
6. A ward patient's vital signs measurements should be repeated by HCAs/RNs, when the NEWS ≥5, every hour (at minimum) unless a reasonable variance has been agreed and documented.

[9] ABCDE abbreviates Airway, Breathing, Circulation, Disability, Exposure

Although it was not scored in the shortlisting exercise, during consensus discussions my supervisors and I agreed that the positive deviant behaviour identified from focused ethnography should also be explored further. The behaviour was reported and specified as follows:
Further escalation to second responder (e.g. a different doctor or CCOT nurse) should be carried out by a RN if the first practitioner they approached cannot attend or does not respond as policy states, during any episode of escalation to any responder at any time of day or night.
Identifying the enablers to this behaviour (in subsequent TDF interviews), could permit the selection of behaviour change techniques to enhance the enablers and potentially increase adoption in practice. Overall, this entire exercise resulted in a shortlist of 7 target behaviours (six negative deviant behaviours and one positive deviant behaviour) to drive the ongoing inquiry (these target behaviours are listed and specified in Publication 2, table 1).

For two of the target behaviours that were shortlisted (*counting respiratory rates for a full minute* and *recording vital signs directly into the EHR*) (see Publication 2, table 1) further questions were added to the interview topic guides (see questions highlighted yellow in appendices 7 & 8) to ensure that the barriers and enablers to these specific target behaviours were adequately explored in subsequent interviews. The decision to include more focused questions related to these target behaviours was informed by the findings from focused ethnography, where the chain of relevant behaviours was identified. For the remaining five target behaviours, my supervisors (LMA, MC, JD, JH) and I agreed that existing questions included within the topic guides were adequate (i.e. sufficient in number and focus) to explore barriers and enablers to these target behaviours, and that revisions or additions to the topic guide were not necessary.

Table 5.1 – scores assigned to the negative deviant behaviours reported from focused ethnography to shortlist the target behaviours

Potential target behaviour (identified from focused ethnography)	Reviewer 1's scores for each of the 4 shortlisting criteria (labelled C1 – C4) (the score range for each criterion is in brackets)					Reviewer 2's scores for each of the 4 shortlisting criteria (labelled C1 – C4) (the score range for each criterion is in brackets)					Total score (6-20)
	C1 (1-3)	C2 (0-1)	C3 (1-3)	C4 (1-3)	Score for reviewer 1 (3-10)	C1 (1-3)	C2 (0-1)	C3 (1-3)	C4 (1-3)	Score for reviewer 2 (3-10)	
1. All vital signs should be recorded directly on the NEWS chart/EHR by HCAs, every time a ward patient's vital signs are measured, within 5 minutes of measurement. **	3	1	3	2	9	3	1	3	2	9	**18**
2. Ward patients' respiratory rates should be counted by HCAs and RNs for a full minute, every time vital signs are measured. **	3	1	3	2	9	3	1	3	2	9	**18**
3. HCAs should record the exact time that the vital signs were measured for every episode of patient monitoring, on all ward patients, during the day or night.	2	1	2	2	7	2	1	2	3	8	**15**
4. Whenever vital signs are measured on a ward patient, HCAs should attach the pulse oximetry probe to a digit on the opposite side to the blood pressure cuff. Finger probes should only be applied to a digit and not to the ear to ensure accurate readings (unless a specific ear probe is being used).	1	1	2	1	5	1	1	2	2	6	**11**

5.	If a ward patient appears to have new confusion during the measurement of vital signs, by RNs/HCAs, the level of consciousness should immediately be recorded as 'C' - for confusion on the NEWS tool (resulting in a NEWS uplift of 3 points).	2	1	3	2	8	3	1	2	2	8	**16**
6.	HCAs should seek guidance from the RN, if they are unsure about whether to disturb a sleeping patient to take routine vital signs during the day or at night.	2	1	2	1	6	2	1	3	2	8	**14**
7.	HCAs should escalate to a RN whenever a ward patient's NEWS is ≥5, after every episode of vital signs monitoring unless a reasonable variance has been agreed and documented.	3	1	3	2	9	3	1	3	1	8	**17**
8.	RNs should re-measure vital signs on a ward patient if they are informed that the patient's NEWS is elevated prior to further escalation.	3	1	3	2	9	3	1	3	2	9	**18**
9.	Escalation to the parent medical team and/or CCOT should be carried out by RNs when NEWS is ≥5, in any ward patient, after they have re-measured vital signs and/or completed an ABCDE assessment unless a reasonable variance has been agreed and documented.	3	1	3	2	9	3	1	3	2	9	**18**

10. A ward patient's vital signs measurements should be repeated by HCAs/RNs, when the NEWS ≥5, every hour (at minimum) unless a reasonable variance has been agreed and documented.	3	1	3	2	9	3	1	3	2	9	**18**

Key:

Shortlisting criteria	**Description of criterion** (taken from Michie et al., 2014)
C1	How likely is it that changing this behaviour will have a positive impact on the recognition of and response to deteriorating patients?
C2	Is it likely that the behaviour can be changed?
C3	How likely is it that changing this behaviour will have a positive or negative impact on other related behaviours?
C4	How easy will it be to measure the behaviour?
**	For these target behaviours, further questions were added to the interview topic guides (after the shortlisting activity), to ensure that the barriers and enablers were adequately explored in subsequent interviews.

5.3 Phase 2 results

5.3.1 Results from brief interviews

A total of 89 brief interviews were conducted across the period of data collection (53 pre EHR; 36 post EHR). Forty-two interviews took place on floor A (28 pre EHR; 14 post EHR), and 47 interviews on floor B (25 pre EHR; 22 post EHR). Thirty-nine interviews were conducted with RNs (27 pre EHR;12 post EHR), and 50 were conducted with HCAs (26 pre EHR; 24 post EHR). Three HCAs deposited an opt out form in the locked box placed within the staff room (see section 4.9.1.1). These staff were not approached to participate in subsequent data collection activities. No staff approached for a brief interview opted out at the point of contact (i.e. when they were approached in the ward area).

All paraphrased brief interviews transcribed from field notes were coded independently by a supervisor (MC) and I (see section 4.6.4). Initial percentage agreement (at TDF domain level) for independent coding was 50%. All disagreements between coders were fully reconciled through consensus discussion (between MC, LMA and I). Barriers and enablers to the target behaviours were coded into nine of the 14 TDF domains (listed below). Illustrative quotations from field notes for these domains are reported in Table 5.2.

- Knowledge
- Social Professional Role and Identity
- Beliefs about Consequences
- Reinforcement
- Intentions
- Memory, Attention and Decision Processes
- Environmental Context and Resources
- Social Influences
- Behavioural Regulation

Following deductive coding in the domains, paraphrased quotes from field notes that I recorded soon after a brief interview were inductively analysed alongside quotes from semi-

structured interviews (see section 4.6.4). Forty-three belief statements and 23 themes that were synthesised during inductive analysis (volume 2, appendix 27) reflected barriers and/or enablers expressed by one or more participant/s during a brief interview.

Table 5.2 – example paraphrased quotes (extracted from field notes) from brief interviews reported alongside the relevant TDF domain/s to which they were deductively coded

TDF domain to which the quote was coded	Example brief interview quotes (for context, the question (Q) asked has been included) – for longer exerts, and those coded at multiple TDF domains, the specific text relevant to the identified domain is emboldened.	
	Paraphrased quotes from staff observed on floor A	Paraphrased quotes from staff observed on floor B
Knowledge	**Q:** Can you talk me through how you assessed that patient's breathing? *You **count the resps for 1 minute** [seen to place his hand in the centre of his chest]. **"I know how long a minute is from CPR and things like that".** You must try and do it without a patient noticing (particularly the ladies). **So whilst you are talking, you are looking and counting**. The easiest time is at night because it's just natural - the body just tells you.* HCA (pre EHR)	**Q:** Can you talk me through how you assessed that patient's breathing? *"You check by feeling the vein at the wrist and counting for a minute. Or you can look [simulates looking at the chest] and count that way". You can count the heart. If it's above 18 you must tell the nurse that the pulse is high."* HCA (pre EHR)
Social Professional Role and Identity	No example available for floor A for this domain	**Q:** How is your unwell patient doing now? *I had to call CCOT. My colleague said, "why are doing that?" [the patient is not for resuscitation] but they are still for active treatment. **We are the advocates.** Sometimes I am a bit tough with the doctors, but I am not going to keep something like that to myself"* RN (pre EHR)
Beliefs about Consequences	**Q:** How do you find the handheld devices for recording vital signs [into the EHR]? *I prefer to enter it on a main computer. I write it on my paper first. I prefer to do that as **it can take some time to scroll through on the hand-held device**.* HCA (post EHR)	**Q:** Can you talk me through how you assessed that patient's breathing? *Because of the way that this lady is breathing, and I am worried. I pay very careful attention. Also, if it's a new patient so I know what I am dealing with. If it's a patient whose breathing has been stable, **am I going to do if for a minute? No, for 15 seconds as I don't want to waste my time.*** HCA (post EHR)
Reinforcement	No example available for floor A for this domain	**Q:** How is your unwell patient getting on? *The lady is a bit better. Her NEWS is now 4 and she is on 3-hourly obs. **The nurse from yesterday thanked me** [following appropriate escalation of care]**. It made me feel**

		good, I left work pleased. I am more likely to do the same thing again. HCA (pre EHR)
Intentions	**Q:** Why were you measuring vital signs then? *He was a bit tachycardic and tachypnoeic, so **I wanted to check them**.* RN (post EHR) **Q:** Why did you monitor the vital signs? *BP was a bit low – 89 systolic. **I just had to re-check it.*** RN (post EHR)	**Q:** Were these [referring to the vital signs taken at 10:15 am] routine? *Yes, but this is normal for the patient – it's normally like that. **I will tell the nurse if the NEWS is greater than 4. Even if it's 4, I will tell them.*** HCA (post EHR) **Q:** Were you entering the vital signs just then? *Yes, I was entering. **I jot them down on a piece of paper and then type them in.*** HCA (post EHR)
Memory, Attention and Decision Processes	**Q:** What went on with that patient in the side room? *I was the 3rd person there. The bank nurse did some obs and called for [names other RN on night duty] - she spotted the sats were 77% and started 15 litres of oxygen via a non-re-breathe [a type of oxygen mask]. She then came and got me. I contacted the doctors and CCOT. Both took their time coming. **I did consider dialling 2222 but the sats were coming up and the patient wasn't agonal breathing.*** RN (pre EHR) **Q:** Why did you call CCOT just then? *Because I can't get hold of the team. I've bleeped 3 times and they have not responded. CCOT have been very helpful, but they need the team's advice too. I have tried the team and the on-call.* **Q:** What will you do next? *I will ring the switchboard for the oncology registrar's number. If not, I will have to go up to the oncology ward.* RN (post EHR)	**Q:** What was going on there in bed 26? *I noticed that his sats had been a bit low since morning…92, 95, 94…they were 93% this time so I got him to do some deep breaths so he wouldn't need oxygen. Also, his pulse is a bit fast, but it's been like that since he came in "so that's OK" - scoring 1 for pulse but that might be because he's moving.* HCA (pre EHR) **Q:** Did you make the referral to CCOT? *Yes – **the [NEWS] score is high and the blood pressure dropping, and he is so chesty.** He should go to ITU, but he doesn't want to go. I've been trying to convince him because his BP is dropping again. I've just started fluids. I'm going to ring doctors and CCOT again.* RN (post EHR)
Environmental Context and Resources	**Q:** Are you having equipment problems? *We don't have enough Dinamaps [electronic devices for measuring vital signs] - some patients are on hourly obs, and we don't have enough - we must fight.* HCA (pre EHR)	**Q:** Are you having some problems with the [vital signs monitoring] equipment? *I am not sure if it's the patient or the machine, but I will find out later.* HCA (pre EHR)
	Q: Why are you doing vital signs now?	**Q:** How do you find the hand-held device?

	They were due at 2pm [observation took place at 2:35pm] and we are short staffed, so they are a little late. There is no HCA in this whole area. RN (pre EHR) **Q:** How do you find the hand-held device? *I use the [names handheld device] if I have less than 5 patients as it takes time.* **Q:** Why is that? *You must click through several options, find the patient and so on. It's quicker to do it on paper and enter it into the computer.* HCA (post EHR)	*I like it. It took a bit of getting used to, but I actually find it quicker than entering on the computer, I keep it with me all day.* HCA (post EHR) **Q:** How are you getting on with the EHR generally? *It's good actually because you don't have to add up the score – it's automatic. You just enter the obs and it's there. No need to add anything up. No mistakes on the chart. Also, no charts – so you are not running around to find them when they are left by the doctors. It's also cleaner – you don't have piles of charts left at the end of the bay.* RN (post EHR)
Social Influences	**Q:** Why are you doing the vital signs now? ***[Names experienced HCA on the ward] asked me to do the obs in the side room so that when I'm done, he can go on his break. For the last 2 weeks other HCAs have been showing me how to do the obs****, ask the right questions.* HCA (pre EHR) **Q:** Why were you doing vital signs then? *It was a one off reading just for this patient.* ***The [names deputy sister on the ward] asked me*** *because the patient feels warm even though the room is cold. Her temperature is fine though.* HCA (post EHR)	**Q:** Why were you doing vital signs now? *He came in with bleeding from the back-passage.* ***The nurse asked me to do them at handover.*** HCA (post EHR) **Q:** How do you know when to tell the nurse? ***HCAs who have been on the ward for over 9 years*** *[told me]. You get told lots of different things – I need to find out which one is true.* HCA (post EHR)
Behavioural Regulation	No example available for floor A for this domain	**Q:** Why CCOT and not another responder? *Well, I know that the doctors will be slow at this time and when CCOT comes they will be with the patient so I can see my other patients - and then the PERRT nurse will give me feedback.* RN (pre EHR)

5.3.2 Additional information about semi-structured interview participants

The methods for purposive sampling used for semi-structured interviews are reported in full in chapter 4 (section 4.6.2.2). Due to the word limit constraints of the journal, the details of the sample were only briefly reported in the *findings* section of the second publication (upcoming in the next section of this chapter). To supplement the information provided within the publication, further descriptive information about the characteristics of the sample for semi-structured interviews is provided below.

Of the 16 RN participants, 10 were employed as band 5 staff nurses (the most junior clinical grade for a RN) and 6 were employed as band 6 senior staff nurses. Nursing staff at band 6 are typically involved in direct patient care but may also take on the role of nurse-in-charge of the ward. Nine RNs were interviewed in the pre-EHR phase, and 7 were interviewed in the post-EHR phase; 10 RNs worked on floor A; 6 worked on floor B. The mean duration in current role for the band 5 RNs was 13 months (range 3 – 36 months) and for band 6 RNs was 23 months (range 12 – 132 months). Seven RNs who were interviewed (n=4 band 5; n=3 band 6) were directly observed enacting expected afferent limb behaviour; 2 (both band 5) were observed enacting unexpected behaviour, and 4 (n=2 band 5; n=2 band 6) were observed enacting some behaviours that were expected and some that were unexpected (e.g. the RN did not re-assess the patient when their NEWS was reported, by an HCA, to be elevated, but then escalated care to the medical team as expected). Three RNs (n=2 band 5; n=1 band 6) were not directly observed enacting the afferent limb behaviours of interest but were recruited based on their clinical banding and/or experience.

One HCA who was invited to participate in a semi-structured interview (following participation in a brief interview), declined at the point of contact. Of the 16 HCAs who participated, 7 were employed as band 2 HCAs (the most junior clinical grade for an un-registered HCA) and 9 were employed as band 3 senior HCAs. Promotion from band 2 to band 3 typically occurs following completion of a vocational ‘care certificate’ and/or is based on experience in the HCA role. Eight HCAs were interviewed in the pre-EHR phase, and 8 were interviewed in the post-EHR phase; 8

HCAs worked on floor A; 8 worked on floor B. The mean duration in current role for the band 2 HCAs was 19 months (range 3 – 144 months) and for band 3 HCAs was 131 months (range 22 – 228 months). During focused ethnography, 5 HCAs (n=2 band 2; n=3 band 3) were directly observed enacting expected afferent limb behaviours; 10 were observed enacting unexpected behaviours (n=4 band 2; n=6 band 3), and 1 (a band 2) was observed enacting some behaviours that were expected and some that were unexpected (e.g. the HCA did not count and/or record an accurate respiratory rate but, when the NEWS was elevated, escalated care to the RN as expected).

5.3.3 Results from semi-structured interviews (second publication)

A Theoretical Domains Framework (TDF) topic guide was used to deliver semi-structured interviews with RNs and HCAs from the same clinical floors as phase 1. Transcripts from 32 audio-recorded interviews were analysed deductively using the 14 domains of the TDF as the coding categories, and then inductively to report barriers and enablers within each of the domains. Barriers and enablers to target behaviours were identified in all 14 TDF domains. Using published criteria, nine of the TDF domains were classified as being of high importance (i.e. represented the most important barriers and enablers). These results were published in the *Journal of Advanced Nursing* (impact factor: 3.187, ranked 9/124 for nursing). According to information from Scopus (www.scopus.com), the paper has been cited three times since publication. As first author, I led on writing and amending the manuscript with support from my supervisors. Reporting was guided by the Consolidated criteria for Reporting Qualitative studies (COREQ) checklist (Tong, Sainsbury & Craig, 2007). Several documents included as online supplementary files to this publication have been included in the main body of this thesis (i.e. volume 1) or the appendix (i.e. volume 2). For ease of reference, the location of these documents is sign-posted in a table at the end of the manuscript.

STATEMENT OF CO-AUTHORS of JOINT PUBLICATIONS

TO WHOM IT MAY CONCERN

Title of publication: Barriers and enablers of recognition and response to deteriorating patients in the acute hospital setting: A theory-driven interview study using the Theoretical Domains Framework.

Name of candidate: Duncan Smith

Title of research thesis: DEveloping a Complex Intervention for DEteriorating patients using theoretical modelling (DECIDE study).

Name of first supervisor: Professor Leanne M Aitken

We, the undersigned, co-authors of the above publication, confirm that the above publication has not been submitted as evidence for which a degree or other qualification has already been awarded.

We, the undersigned, further indicate the candidate's contribution to the publication in our joint statement below.

Signature:

Name: **Duncan Smith**
Date: 15/6/22

Signature:

Name: **Martin Cartwright**
Date: 15/6/22

Signature:

Name: **Judith Dyson**
Date: 15/6/22

Signature:

Name: **Jillian Hartin**
Date: 15/6/22

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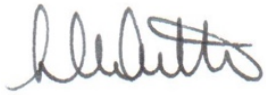

Name: **Leanne M Aitken**
Date: 15/6/22

The candidate's contribution to the publication

Contribution	Author				
	Duncan Smith	Martin Cartwright	Judith Dyson	Jillian Hartin	Leanne M Aitken
Funding acquisition	✓				✓
Conceptualisation	✓				✓
Data collection	✓				
Data analysis	✓	✓			✓
Drafting the manuscript	✓				
Editing the manuscript	✓	✓	✓	✓	✓
Approving the manuscript	✓	✓	✓	✓	✓

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ORIGINAL RESEARCH:
EMPIRICAL RESEARCH - QUALITATIVE

Barriers and enablers of recognition and response to deteriorating patients in the acute hospital setting: A theory-driven interview study using the Theoretical Domains Framework

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ABSTRACT

Aim: To explore barriers and enablers of recognition and response to signs of patient deterioration by nursing staff in an acute hospital.

Design: A theory-driven interview study underpinned by the Theoretical Domains Framework of behaviour change.

Methods: Between 07/01/2019 and 18/12/2019 a purposive sample of registered nurses and healthcare assistants was recruited to participate in a semi-structured (audio-recorded) interview, to explore the determinants of seven specified behaviours of the afferent limb. Anonymised transcripts were deductively coded (using the 14 Theoretical Domains Framework domains as coding categories) and then extracts within each domain were inductively analysed to synthesise belief statements and themes. Prioritisation criteria from published literature were applied.

Results: Thirty-two semi-structured interviews were conducted. From 1,888 quotes, 184 belief statements and 66 themes were synthesised. One hundred and forty-six belief statements, represented by 58 themes, met prioritisation criteria. Nine domains of the Theoretical Domains Framework were of high importance: *Knowledge*; *Social, Professional Role and Identity*; *Beliefs about Consequences*; *Reinforcement*; *Intentions*; *Goals*; *Memory, Attention and Decision Processes*; *Environment, Context and Resources and Social Influences*.

Conclusions: Barriers and enablers most likely to impact on nursing staff afferent limb behaviour were identified in nine domains of the Theoretical Domains Framework.

KEYWORDS
critical care, nurse roles, nursing observations, qualitative approaches, research implementation

Impact

Rapid response systems have been implemented internationally including an afferent and efferent limb. Behaviours of the afferent limb include monitoring vital signs and escalating care. Despite global uptake of rapid response systems, there is evidence that nursing staff do not consistently enact afferent limb behaviours according to policy (afferent limb failure). New insights into the complex and pervasive problem of afferent limb failure have been offered. Use of theory will permit mapping of these identified domains of high importance to precisely targeted behavioural intervention strategies, and subsequent evaluation of how these strategies may best be operationalised in different clinical settings.

1 | INTRODUCTION

Hospitalised patients who deteriorate in a ward setting without recognition or an appropriate response are at risk of a serious adverse event (SAE) such as unplanned admission to the Intensive Care Unit (ICU), cardiac arrest or death (Tirkkonen et al., 2013; Trinkle & Flabouris, 2011). To optimise responses to deteriorating patients, rapid response systems (RRS) have been implemented internationally within acute hospitals (DeVita et al., 2006). While RRS broadly include an 'afferent limb' (the recognition arm) and an 'efferent limb' (the response arm; Figure 1), how RRS are implemented varies across providers (DeVita et al., 2006; Lyons et al., 2018).

Deleterious changes to vital signs (e.g. heart rate, respiratory rate, blood pressure) are frequently seen in patients preceding a SAE (Andersen et al., 2016; Kause et al., 2004). Consequently, track-and-trigger tools have been implemented as part of the afferent limb of the RRS. These tools, which may be paper based or electronic, allow healthcare professionals (typically nursing staff) to record routinely measured vital signs, providing a signal when the vital signs fall outside of acceptable parameters. In these circumstances, staff are prompted to increase the frequency of subsequent monitoring and to consult a practitioner with expertise in the management of acute/critical illness (Grant, 2018). In some regions, including Australasia and North America, track-and-trigger tools typically include dichotomous criteria, that is, when any vital sign crosses a specific threshold (e.g. a respiratory rate >30 or <10 breaths/min) the patient is considered to be at risk and care should be escalated (Davies et al., 2014; Sprogis et al., 2017). Within the United Kingdom and parts of Europe, early warning scores are more common, particularly the National Early Warning Score (NEWS), which was developed to standardise practice between organisations (Royal College of Physicians, 2017). The NEWS signals patient risk based on six routinely recorded vital signs, each of which accrues a score (range 0–3) that is combined to produce the aggregate NEWS (range 0–20). The higher the aggregate score, the greater the risk to the patient and the more senior the practitioner to whom care should be escalated (Royal College of Physicians, 2017; supplementary file 1). The use of early warning scores and an accompanying escalation protocol are associated with improved patient outcomes (Credland et al., 2020).

Like the track-and-trigger tools themselves, the nomenclature and composition of efferent limb response teams also differ internationally, with nurse-led Critical Care Outreach Teams in the UK and more medically driven or multi-disciplinary Medical Emergency Teams and Rapid Response Teams common in

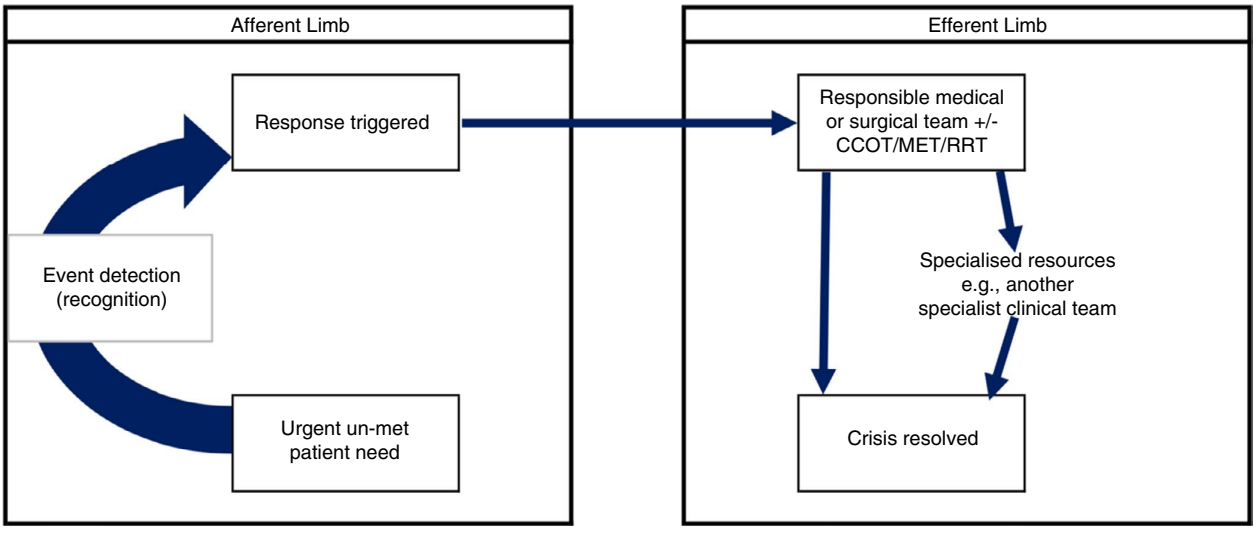

FIGURE 1 Conceptual model of the Rapid Response System (RRS). Adapted from: DeVita et al. (2006) [Colour figure can be viewed at wileyonlinelibrary.com]

FIGURE 2 The domains of the Theoretical Domains Framework (TDF). Taken from: Atkins et al. (2017)

TDF domain	Content of the domain
1. Knowledge	An awareness of the existence of something
2. Skills	An ability or proficiency acquired through practice
3. Social/Professional role and identity	A coherent set of behaviours and displayed personal qualities of anindividual in a social or work setting
4. Beliefs about Capabilities	Acceptance of the truth, reality or validity about an ability, talent or facility that a person can put to constructive use
5. Optimism	The confidence that things will happen for the best or that desired goals will be attained
6. Beliefs about Consequences	Acceptance of the truth, reality, or validity about outcomes of a behaviour in a given situation
7. Reinforcement	Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus
8. Intentions	A conscious decision to perform a behaviour or a resolve to act in a certain way
9. Goals	Mental representations of outcomes or end states that an individual wants to achieve
10. Memory, Attention and Decision Processes	The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives
11. Environment, Context and Resources	Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence and adaptive behaviour
12. Social Influences	Those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviour
13. Emotion	A complex reaction pattern, involving experiential, behavioural, and physiological elements, by which the individual attempts to deal with a personally significant matter or event
14. Behavioural Regulation	Anything aimed at managing or changing objectively observed or measured actions

Australasia and North America respectively (Churpek et al., 2017; Hughes et al., 2014; Priestley et al., 2004). Actions common to all of these response teams include patient assessment, initiation of definitive treatment or supportive care and facilitation of transfer to a higher-care setting, for example, an ICU (Bannard-Smith et al., 2016). In the current research, the focus is on the behaviours of the afferent limb.

Review findings suggest that escalation to a designated response team is associated with reduced in-hospital cardiac arrest and mortality (Maharaj et al., 2015; Rocha et al., 2018). However, patients will only benefit from the additional expertise provided by these teams if they are activated and mobilised to the patient's location (Lyons et al., 2018). Consequently, patient benefit is contingent on the precursory afferent limb behaviours of the RRS being enacted. Despite the widespread implementation of RRS and availabilty of track-and-trigger tools, there is evidence that nursing staff do not consistently follow guidance (Credland et al., 2018). This lack of compliance has been termed 'afferent limb failure' (ALF; Johnston et al., 2014; Trinkle & Flabouris, 2011).

2 | BACKGROUND

The determinants (i.e. barriers and enablers) of nursing staff enacting best practice behaviours of the afferent limb have been broadly described in a number of published review papers (Massey et al., 2017; Olsen et al., 2019; Treacy & Stayt, 2019; Wood et al., 2019). Despite acknowledgement that ALF is a problem characterised by inconsistent staff behaviour (Credland et al., 2018; Ede et al., 2019), no reports of studies were found where behaviour change theory had been applied to explore determinants. Furthermore, from the modest body of literature reporting interventions to address ALF (Bucknall et al., 2017; Connell et al., 2016; Duff et al., 2018; Liaw et al., 2016), no explicit reports of theory being applied during intervention development were identified. There is evidence that using theory to elucidate determinants and drive the selection of intervention content increases efficacy (Noar et al., 2007; Taylor et al., 2012; Webb et al., 2010) and replicability (Little et al., 2015; Michie et al., 2008) of the resultant intervention compared to pragmatic (i.e. intuition based) or non-theoretical approaches.

Theories of behaviour change attempt to understand the context in which desirable behaviours occur (or do not occur) as well as mechanisms of action and moderators of change along various causal pathways (Michie et al., 2016). There are numerous theories of behaviour and behaviour change available (Davis et al., 2015) making the selection of a suitable theory challenging for non-specialists (Francis et al., 2012). The Theoretical Domains Framework (TDF) was developed to overcome this challenge by identifying a parsimonious set of broad theoretical domains drawn from behavioural theories (Cane et al., 2012; Michie et al., 2005). The revised TDF (v2) specifies 14 theoretical domains (Figure 2) that each represent between 3 and 11 conceptually related constructs. The 84 constructs of the TDF were obtained from 33 different behaviour change theories (Atkins et al., 2017; Holdsworth et al., 2015). In addition to the accessibility of the framework, benefits of the TDF include its versatility, enabling its application to a range of behavioural problems and

extensive coverage of the determinants of behaviour change (Atkins et al., 2017; French et al., 2012).

3 | THE STUDY

3.1 | Study aim

The aim of this interview study was to explore determinants (barriers and enablers) of recognition and response to signs of patient deterioration by nursing staff in an acute hospital. Specific objectives were as follows:

1. To elucidate determinants of nursing staff enacting behaviours of the afferent limb, using a theoretical framework of behaviour change (the TDF)
2. To report TDF domains that represent the most important barriers and enablers to nursing staff enacting the specified behaviours, through the application of published prioritisation criteria.

3.2 | Design

This was a qualitative semi-structured interview study informed by the TDF. The research described here is one component of a multiphase intervention development process modelled on the Medical Research Council's guidance for developing and evaluating complex interventions (Medical Research Council, 2006). A full protocol for the wider process within which this research is situated has already been published (Smith et al., 2019).

3.3 | Sample

A purposive sample based on seniority (employment grade or role) and experience (duration of time in role) of nursing staff was recruited from two acute floors (four wards) within a UK metropolitan teaching hospital. In the UK context, unregistered Healthcare Assistants (HCAs) are frequently involved in enacting behaviours of the afferent limb, particularly the monitoring of patients' vital signs (Ede et al., 2019; Smith et al., 2020). Consequently, both registered nurses (RNs) and HCAs were recruited.

In 2018, it was confirmed that the hospital would be switching from paper-based patient records to Electronic Health Records (EHR). Part of this process was migration from a paper-based NEWS chart to an electronic version. It was identified that this period of transition would provide a unique opportunity to explore determinants of afferent limb behaviour in both paper and EHR contexts. Consequently, participants were recruited pre- and post-EHR activation. An acclimation period of 3 months (Bedoya et al., 2019) was allowed following EHR implementation when no data were collected.

3.4 | Data collection

TDF topic guides (supplementary file 2) were developed to explore the determinants of seven specific behaviours of the afferent limb (referred to hereafter as the target behaviours). The target behaviours (Table 1) were shortlisted from a longer list of behaviours identified through an extensive period of focused ethnography in an earlier phase of this programme of work (Smith et al., 2020). A minimum of one question for each of the 14 TDF domains was included. Interviews were carried out by a single researcher [DS], in a room adjacent to, or away from, the ward in which the participants worked. Interviews were audio-recorded, transcribed verbatim, checked for accuracy and anonymised. DS, a clinical-academic nurse with 11 years of experience of working in critical care outreach roles, received specific training on in-depth/complex interviewing prior to data collection.

As the pre-EHR period of data collection was finite (a period of 3 months), sampling continued until the EHR was implemented. In the post-EHR period (an indefinite period), sampling continued until the point of theoretical saturation which was determined as follows: (1) an *initial analysis sample* of 10 interviews was conducted with nursing staff; (2) data from the *initial analysis sample* was deductively coded (into the 14 TDF domains) and within each domain the text inductively analysed; (3) a *stopping criterion* of three was used, meaning that theoretical saturation was achieved when no new themes (synthesised from inductive analysis of coded data) were identified from three subsequent consecutive interviews (Francis et al., 2010).

3.5 | Ethical considerations

Permission to conduct this research was granted by the National Health Service North of Scotland Research Ethics Committee (REC; reference: 18/NS/0118). Subsequently, favourable opinions to proceed with the research were granted by the Health Research Authority (reference as for REC) and the hospital's research and development department (reference: 18/0569). Participation in the study was voluntary. Those who agreed to participate in an audio-recorded semi-structured interview prospectively gave written consent including consent for de-identified quotes to be used in publications.

3.6 | Data analysis

First, using Framework method (Gale et al., 2013), interview data were systematically and deductively indexed and charted using the 14 TDF domains as the coding categories (Cane et al., 2012).

Second, inductive content analysis (Elo et al., 2014) was used to generate 'belief statements' reflecting participant-reported barriers and enablers. Beliefs about behaviours are important precursors of attitudes, intentions and behaviour (Ajzen, 1991; Francis et al., 2014; Michie et al., 2005; Presseau et al., 2019). That is, beliefs about behaviour influence whether the behaviour is performed or not, and how consistently. Therefore, while

TABLE 1 Specific behaviours of the afferent limb targeted during data collection

Target behaviours (labelled according to action, actor, context, target & timing (Presseau et al., 2019)
Ward patients' ([1]*secondary target*) respiratory rates should be counted (*action*) by HCAs and RNs (*actors*) for a full minute (*timing*), every time vital signs are measured (*context*)
All vital signs should be recorded directly on the NEWS chart/EHR (*action*) by HCAs (*actor*), every time a ward patient's (*secondary target*) vital signs are measured (*context*), within 5 min of measurement (*timing*). Information should not be recorded on handover sheets or other miscellaneous pieces of paper
HCAs (*actor*) should escalate (*action*) to a RN (*primary target*) whenever a ward patient's (*secondary target*) NEWS is ≥5 (*context*), after every episode of vital signs monitoring (*timing*) unless a reasonable variance has been agreed and documented
RNs (*actor*) should re-measure vital signs (*action*) of a ward patient (*secondary target*) if they are informed that said patient's NEWS is elevated (*context*) prior to further escalation (*timing*)
Escalation (*action*) to the parent medical team and/or CCOT and/or night nurse practitioners (*primary targets*) should be carried out by RNs (*actor*) when NEWS is ≥5 (*context*), in any ward patient (*secondary target*), after they have re-measured vital signs and/or completed an ABCDE assessment (*timing*) unless a reasonable variance has been agreed and documented
A ward patient's (*secondary target*) vital signs should be repeated (*action*) by HCAs/RNs (*actor*), when the NEWS ≥5 (*context*), every hour (at minimum; *timing*) unless a reasonable variance has been agreed and documented
Further escalation (*action*) to 2nd responder (e.g. a different doctor or CCOT nurse; *primary target*) should be carried out by a RN (*actor*), if the 1st practitioner they approached cannot attend or does not respond as policy states, during any episode of escalation to any responder (*context*) at any time of day or night (*timing*)

Abbreviations: ABCDE, Airway, Breathing, Circulation, Disability, Exposure; CCOT, Critical Care Outreach Team; HCA, Healthcare Assistant; EHR, Electronic Health Record; NEWS, National Early Warning Score; RN – Registered Nurse.

[1]Note: the *primary target*(s) of the specified behaviour are the individual(s)/group(s) who must decide whether subsequent behaviours are required, while the *secondary target*(s) are the individual(s)/group(s) who benefit from the specified behaviour but are not required to enact anything themselves.

domain-level data are typically used in TDF studies to select intervention content (Cadogan et al., 2015; Patton et al., 2018), belief-level data are required in order to prioritise the most important determinants.

The approach used [by DS] to synthesise participants' beliefs was as follows: quotes from each of the charts developed during deductive coding were read and re-read to ensure familiarisation; quotes reflecting similar beliefs were grouped and categorised using a simple label (i.e. a brief description of content); quotes were scrutinised further and 'belief statements' were synthesised to represent beliefs held by (a minimum of two) participants (e.g. RNs and HCAs believe that their professional responsibility **ends/does not end**, when the next clinician along the escalation pathway is notified; (Islam et al., 2012; McBain et al., 2016; Roberts et al., 2017)). Where participant beliefs were discordant, that is, a barrier for some while an enabler for others, this was reflected in the wording of the statement (see bold text in example above). Belief statements representing overlapping or related content were grouped and a suitable theme heading synthesised (Patey et al., 2017; Presseau et al., 2017). In this study, theme-level data were used to establish theoretical saturation in keeping with reported methods (Francis et al., 2010).

To identify TDF domains of particular importance; first, four criteria (Table 2) with binary assessments were selected from the TDF literature (Atkins et al., 2017; Goddard et al., 2018; Islam et al., 2012; Patey et al., 2012) and applied at belief statement level. Second, these criteria were used to categorise the TDF domains as being of high, moderate or low importance based on the number of criteria met. Domains with any belief statement that meet 3 or 4 of the criteria were considered of high importance; 2 criteria of moderate importance and 1 or 0 criteria of low importance (Goddard et al., 2018).

3.7 | Rigour

To achieve trustworthy interpretation of the data, a number of recommended methods were applied. To ensure credibility of findings, audio-recordings of two pilot interviews were listened to by [DS] and other researchers not involved in the study, permitting self-reflection and peer debrief on both topic guide content and questioning approaches (Morse, 2015). Reflection continued throughout the period of data collection and analysis, facilitated by the recording of reflexive notes and regular debrief with other members of the research team (Forero et al., 2018; Koch & Harrington, 1998).

The interview data were collected over a period of 8 months as part of a bigger study that included direct observation of ward staff in situ (Smith et al., 2020) and brief, unrecorded interviews. This prolonged and varied engagement with participants increases the credibility of our data set (Forero et al., 2018); while the use of methodological triangulation increases confirmability (Morse, 2015).

To enhance dependability of the data, a codebook (supplementary file 3) was developed to ensure a clear audit trail and to enable reliable coding (Forero et al., 2018; Morse, 2015). During deductive coding, investigator triangulation was used (Cadogan et al.,

2015) as a sample of semi-structured interviews (10%, randomly selected) were coded independently by two researchers [DS and LMA] (Tracy, 2013). After independent coding, disagreements were reconciled through consensus discussion including a third impartial researcher [MC]. This process was repeated until the calculated level of overall inter-coder percentage agreement reached 60% (Atkins et al., 2017).

4 | FINDINGS

Data collection activities were conducted between 07/01/2019 and 18/12/2019. Between 07/01/2019 and 27/03/2019, data were collected pre-EHR implementation. Between 01/07/2019 and 18/12/2019, data were collected post-EHR implementation.

Thirty-two semi-structured interviews were conducted (16 RNs, 16 HCAs) across the period of data collection; 17 were conducted pre-EHR and 15 were conducted post-EHR. The denominator of potential participants (obtained from human resources data) was approximately 140 nursing staff including both RNs and HCAs. Across the sample of participants (RNs and HCAs), median time in role was 2 years (range 3 months – 19 years). The median length of an interview was 54 min (range 28–74 min).

The entire corpus of data consisted of 1,888 quotes from which 184 belief statements and 66 themes were inductively synthesised (supplementary file 4). One hundred and forty-six belief statements, represented by 58 themes, met prioritisation criteria (Table 2). Based on the prioritised themes and belief statements, nine of the fourteen TDF domains were of high importance, four domains of moderate importance and one domain of low importance (Table 3). High importance domains are elaborated below.

4.1 | Knowledge

Participants' knowledge of local deteriorating patient policy and protocol was inconsistent. Some RNs and HCAs were aware of the existence of policy but had limited knowledge of its content; others believed that the NEWS tool *was* the local policy; while others were

TABLE 2 Prioritisation criteria applied (at the belief statement level) to identify Theoretical Domains Framework (TDF) domains of importance

Criterion	Description
Frequency[a]	The belief (a barrier or an enabler) was reported by more than a third of the sample
Personal importance	The belief was expressed using emphatic language in one or more illustrative quote/s
Direction of effect	There were discordant views between participants about the belief operating as a barrier or enabler
Professional discordance	The belief was held by RNs but not by HCAs or *vice versa*

[a]Frequency, in this context, relates to the **number of different** participants who express a belief rather than the number of times it is mentioned.

TABLE 3 Summary of prioritisation criteria met, and level of importance for each of the 14 domains of the Theoretical Domains Framework (TDF; ranked by number of acriteria met)

TDF domain	Frequency of belief statements meeting at least 1 of the 4 prioritisation criteria	Number of different prioritisation criteria met by belief statements within the domain (denominator = 4)	Level of importance in determining the target behaviours
Beliefs about consequences	10	4	High
Environment, context & resources	33	4	High
Memory, attention & decision processes	14	4	High
Reinforcement	6	4	High
Social, professional role and identity	12	4	High
Goals	8	3	High
Intentions	13	3	High
Knowledge	22	3	High
Social influences	9	3	High
Behavioural regulation	4	2	Moderate
Beliefs about capabilities	7	2	Moderate
Emotions	4	2	Moderate
Skills	3	2	Moderate
Optimism	1	1	Low
Total	146	–	–

completely unaware of the existence of a policy document within the organisation.

> There is the NEWS policy, for goals, and what I was saying about the timing, of how often you do the obs according to the NEWS score. I'm sure that is all the Trust's goals. Although I wasn't actually able to completely say them, I wasn't one hundred per cent. I didn't know the exact goal timings… (RN9)

Some participants lacked procedural knowledge of how a respiratory rate should be accurately measured; reporting that it need only be counted for 15 s or conflating the procedure for measuring respiratory rate with the procedure for assessing other vital signs.

> I count from the heart right there to check [gesturing towards their chest]. I assess it is beating and working the time. At the end I am able to come up with what I think the respiration is. (HCA3)

Similarly, some RNs and HCAs demonstrated knowledge of the importance of an abnormal respiratory rate as an early signal of deterioration. Other participants did not demonstrate this knowledge and described de-emphasising the respiratory rate in favour of other measurements.

> I think it's the blood pressure, as well as the oxygen saturation, even the heart rate as well. (RN11)

4.2 | Social, professional role & identity

Some RNs explicitly linked the action of measuring vital signs with their professional registration and accountability, reporting that they felt more secure when they had taken the vital signs measurements themselves. Despite this, RNs and HCAs frequently reported the action of measuring vital signs as being part of the HCAs role.

> I feel like I'm a bit of a glorified healthcare assistant at the moment. I suppose if we are fully staffed, healthcare assistants are there…I feel like the skills I've got can be better put to use rather than me being stood there and doing a set of obs. (RN4)

Furthermore, numerous participants shared the belief that HCAs did not require any explicit instructions or direct delegation from a RN.

> Oh, just automatically. We do the obs, you know. There's not even a discussion, it's just like we know that before ten o'clock we start our observations, and that's our role. (HCA5)

Some participants believed that they continued to be responsible for their patient even after they had escalated to another practitioner. Other participants believed that the weight of responsibility was transferred to another practitioner after escalation.

> …I feel a weight off my shoulders because I'm like, 'Right, I've told someone who's had this medical training [about] these obs, now I've handed over that responsibility'… (RN3)

4.2.1 | Beliefs about consequences

Participants held competing beliefs about the consequences of escalating to the nurse in charge of the ward. While some participants reported that this level of escalation would result in further support, others believed that the nurse in charge would not be in a position to support them and that this action was therefore futile.

> …So, informing the person who is in charge, it doesn't make any difference. So, maybe on another ward, and the nurses in charge do not have patients, you inform them, and they might take over but, with me, when I tell my nurse in charge, it's not going to make any difference on X WARD. (RN8)

Similarly, HCAs reported mixed beliefs about that consequences of escalating subtle signs of deterioration to a RN. While some HCAs believed that RNs would be receptive and helpful, others anticipated that RNs would push back and even be dismissive.

> Because you can't just run to the nurse every two seconds saying, 'Nurse!', you know, because they'll be like, 'Well, use your initiative. Use your common sense as well'. (HCA5)

4.3 | Reinforcement

A number of participants held the enabling belief that if they acted appropriately to escalate a deteriorating patient, then they would be praised and validated by senior nursing colleagues and/or medical staff. This was often based on previous experience of receiving positive validation from senior colleagues.

> Yes, sometimes, the nurse will say 'X has saved a life today.' And I'm happy that I've saved a life because I take quick action. So next time I do more. I get in more. Because I'm so excited and so happy because I've been praised. (HCA4)

4.4 | Intentions

Numerous RNs and HCAs reported the intention to increase the frequency of vital signs monitoring in patients with an elevated NEWS.

Likewise, staff reported the intention to escalate in the event of an elevated NEWS.

> I have to phone the CCOT quickly to let them know… (RN7)

Some participants also expressed an intention to continue escalation, along the line of different responders, until the desired response occurred.

> I'd still be really concerned, and I would make sure that the doctor came as a priority and a CCOT came as a priority and if the SHO [a junior doctor] wasn't going to come then I'd just ring the Registrar [a more senior doctor]. (RN4)

4.5 | Goals

Goals related to the measurement of vital signs were often described by participants as being of higher priority than other clinical tasks.

> I think it's [measuring vital signs] extremely important because it gives us an idea of the state of being of the patient at any point in time… that helps us in making the clinical decisions as to the kind of care or interventions we need to basically give to the patient. (RN14)

In the event of a patient deteriorating with an elevated NEWS, some RNs reported setting the personal goal of re-measuring the patient's vital signs themselves to ensure that the data recorded by the HCA were correct.

> It affects how you manage the patient because if they're [referring to HCAs] doing it wrong, then you might think that the patient is suffering from something, that you have to make sure that you do it the right way. So, I have to check it by myself to make sure that what we get is correct. (RN11)

4.6 | Memory, attention and decision processes

A number of participants believed that when a patient's NEWS was persistently elevated, this became their normal (i.e. the patient's 'baseline') and reported taking the decision to disregard NEWS guidance in these circumstances.

> If the patient's always having that kind of data and that kind of score, I feel it's not necessary to tell the nurse, because I have to find the nurse. She must be doing medication. It has to be something important I want to tell her. When it's, like, a regular thing, I feel like there's no point walking all the way round and also telling her when she's doing something else. (HCA14)

Likewise, several RNs and HCAs described searching for simple explanations to justify a patient's elevated NEWS and, when a simple explanation was found, reported disregarding escalation guidance.

> I don't always tell the nurse straightaway, because if they've just had a shower, I just think, 'Okay, you've just had a shower. You know, your blood pressure might be up because you've been in a hot shower. Your pulse might be up because you've been walking about. You've been doing more than what you would normally do… (HCA5)

In the event of an elevated NEWS, both RNs and HCAs reported delivering first-line interventions to a deteriorating patient before assessing further. The patient's response, or lack of response, to these interventions was described as a factor in the decision making about subsequent escalation.

> …ask the patient how they're feeling, ask them if they've drank enough water during the day… if not, we encourage them, 'Try to drink more and in 30 minutes time, we do the blood pressure again'…maybe in 30 minutes time, it might be alright. (HCA 6)

4.7 | Environment, context and resources

Numerous participants reported a mismatch between human resource (i.e. the number of nursing staff on duty) and patient dependency as a barrier to staff reviewing NEWS charts or taking further timely measurements of vital signs. Similarly, some RNs and HCAs believed that they often did not have sufficient time to undertake these actions during the course of the shift due to unpredictable nature of the working environment.

> I think I can do them [vital signs] if I want them. It's just that we don't have the time. Generally, to go around and do six obs and six sets of meds and six discharges or whatever you're doing that day is quite a heavy job. I think, in some wards, RNs do it and think it's great, but I think our ward is just too busy. (RN10)

When escalating to practitioners external to the ward-based team (e.g. medical staff or CCOT), using the hospital's pager system, some participants reported experiencing long delays before a response, particularly when enacting this behaviour at night.

> Yes, well, sometimes when you call, and call, and call, and call, and no one is calling back. So, you get worried. (RN8)

RNs and HCAs reported mixed beliefs about the use of a handheld electronic devices for recording vital signs within the EHR. Some participants reported finding these devices easy to use when recording vital signs at the patient's bedside, while other staff stated that the handheld devices were not user friendly and reported using paper and/or desktop computers instead.

> I think it was just the simple thing…the screen vanished and went to another screen. That was annoying enough for me to go to the desktop…it's not like I have so much time to, for that, so it's a simple problem with the [names hand-held device] and I've stopped using it. (HCA14)

Participants held competing beliefs about the usefulness of the display format of vital signs in the electronic NEWS compared to the paper NEWS chart. Specifically, several participants reported finding it difficult to identify which individual parameters were contributing to the elevated score when using the electronic NEWS.

> …But, because on the [names EHR] it's not thoroughly specified why we calculated the score this way… You just have to basically rely on your previous knowledge that, okay, this is why the NEW score is like that… (RN12)

Some RNs and HCAs also reported the lack of colour on the display format of the electronic chart to be a barrier to its effective use, compared to the paper chart which incorporated different coloured zones associated with the different score ranges and degrees of patient risk.

> …because it's [referring to the paper NEWS chart] really colourful. That's what helps as well. It's very bright and colourful, so once a value passes a line or it goes below a line, then you know that it's going to score [high]… (HCA8)

4.8 | Social Influence

Some RNs and HCAs believed that their peers were supportive and encouraging of them in diligently monitoring a patient's vital signs and, when appropriate, escalating deterioration. This was particularly influential when the colleague was perceived to be more senior and/or experienced. In contrast, other RNs and HCAs reported that their nursing colleagues could, at times, be discouraging and even dismissive about them enacting target behaviours.

> …All of my colleagues, the healthcare assistants, they are saying it's between a joke and serious. 'Oh, X, you worry so much.' All the time I am complaining about the obs or they say, 'X, relax.' One said, 'Go to your break.' I said, 'I will finish my job and after I will go to my break.' … (HCA2)

Some RNs reported that their behaviour in escalating to an external practitioner, specifically CCOT, was influenced by previous responses from the team when they escalated to them. Some RNs described positive interactions with the CCOT, while others reported less positive and even discouraging interactions.

> I've had a few moments where CCOT have asked me, you know, 'Do you think this was an appropriate referral?' Then I don't know what to say after that. (RN5)

5 | DISCUSSION

From the corpus of data derived from 32 semi-structured interviews, 184 belief statements and 66 themes were synthesised. Four prioritisation criteria from the published literature were applied at the level of the belief statement. Five domains (*Social*, *Professional Role & Identity*; *Beliefs about Consequences*; *Reinforcement*; *Memory, Attention and Decision Processes*; *Environment*, *Context & Resources*) were underpinned by belief statements that met all four of the prioritisation criteria. In a further four domains (*Knowledge*; *Intentions*; *Goals*; *Social Influences*) underlying belief statements met three of the prioritisation criteria. These nine domains of the TDF were identified as highly important determinants of RNs and HCAs enacting seven specified target behaviours of the afferent limb of the RRS.

In our research, decisions to 'normalise the abnormal' and tolerate elevated NEWS were reported by both RNs and HCAs. These decisions were typically informed by the patient's medical history and how persistent the abnormality appeared, that is, how long the NEWS had been elevated. There is currently a paucity of research related to the adjustment of escalation criteria for deteriorating patients. In a retrospective cohort study conducted in Australia (Ganju et al., 2019), modifications in calling criteria were found to be relatively frequent (63% of the patients had modified criteria) but did not reduce the number of rapid response activations. Furthermore, an increased mortality was reported in patients who had modified calling criteria, specifically where the adjustments resulted in a more conservative approach than the standard guidance (Ganju et al., 2019). In a more recent study (also conducted in Australia) similar findings were reported, whereby patients with adjusted criteria more frequently triggered an efferent limb activation, more frequently had a cardiac arrest and more frequently died in hospital compared to patients with standard (i.e. unmodified) criteria (Crouch et al., 2020). These findings highlight the potential vulnerability of the sub-group of patients likely to have response criteria modified, the potential safety implications of reducing the level of response

and the complexity of the clinical decisions that underpin these adjustments. Consequently, it is concerning that nursing staff in our study reported making individualised adjustments to response thresholds without consulting senior personnel. It is plausible that there may be a 'spill over' effect (Michie et al., 2014) here, where the behaviour of nursing staff is influenced by the actions, or lack thereof, of their medical colleagues. Some documented adjustments to calling criteria (made by medical staff) have been found to be vague and ambiguous (Foley & Dowling, 2019; Ganju et al., 2019). In these circumstances, nursing staff may be required to make their own decisions about what specific abnormalities should be tolerated and which should be acted upon. However, this is currently unproven and further empirical work is required to better understand adjustments to calling criteria in the NEWS context.

The specific behaviours of monitoring vital signs and escalating initial signs of patient deterioration (i.e. an elevated NEWS) to more senior nursing staff, typically falls to unregistered HCAs in the UK context (Ede et al., 2019; Mackintosh et al., 2014). The authors of an ethnographic study reported how, through enacting behaviours of the afferent limb, HCAs exerted control over clinical care by taking ownership of vital signs data (Mackintosh et al., 2014). Similar to previous work, HCA participants in our study believed that they had a key role in detecting deterioration due to their frequent and often intimate contact with patients. Our results also expand upon previous findings, as several HCAs who participated reported making similar clinical decisions to the RNs. Specifically, HCAs reported making decisions to tolerate elevated NEWS in certain patients (therefore, disregarding NEWS escalation protocol), to delay escalation in favour of further monitoring and to deliver nursing interventions (e.g. patient repositioning and encouraging oral fluids) in an attempt to correct the abnormal vital signs/NEWS before deciding if further escalation was required. Given the potential complexity of these clinical decisions, and the degree of inconsistency in training and education that HCAs receive (Kessler et al., 2010), these beliefs are a notable finding and may explain why some HCAs do not consistently escalate immediately to an RN when the NEWS is elevated.

Participants from our research reported competing beliefs about the need for RNs to delegate monitoring of vital signs to HCAs. While some participants believed that it was the role of the RN to explicitly delegate and oversee HCAs when enacting this behaviour, more participants reported that delegation was not required and believed that HCAs should 'inherently know' when and where this behaviour should be enacted. This is worthy of note given that, in the UK context, RNs are accountable for the actions and omissions of their unregistered colleagues, and are required by their professional code of conduct to appropriately delegate care (Nursing & Midwifery Council, 2015). Notwithstanding the difference in context, similar discrepancies were reported in a qualitative study conducted in Singapore (Chua et al., 2019). Here, the researchers reported inadequate direction and supervision of Enrolled nurses (licensed practitioners who are educated at a lower level than a RN) by RNs, when vital signs were being monitored (Chua et al., 2019). The belief that RNs do not need to delegate to junior colleagues is particularly problematic given the reported association between poor delegation and aspects of nursing care being delayed or missed entirely (Kalisch, 2006). On this basis, we echo the suggestions in other work (Chua et al., 2019; Kalisch, 2006), and recommend that attention be given to raising the importance of delegation as a safety critical aspect of the RN role. We also encourage educators to equip registrants with the necessary communication and leadership skills to delegate care effectively in increasingly complex clinical environments.

5.1 | Limitations

The semi-structured interviews that were conducted generated a large volume of data. Consequently, it was necessary to identify TDF domains with barriers and enablers most likely to impact on nursing staff afferent limb behaviour (i.e. the domains of high importance) to subsequently target for change. We used a number of reported criteria to identify the TDF domains of importance. However, there is currently no evidence that using these criteria will result in a more successful intervention (Goddard et al., 2018) reflecting a broader limitation of the methods employed.

The potential for social desirability bias is a limitation of our study. Participants were made aware that the researcher was a clinician with a background in acute/critical care, and a specific interest in the recognition and response to deteriorating patients. As such, it is plausible that participants may have answered questions in a way that they perceived would please the researcher. Interviews were conducted over a period of 8 months, during which time the researcher was frequently present on the clinical floors. This strong presence increased the likelihood of participants habituating to the researcher (Pope, 2005) and therefore may have mitigated the extent of social desirability bias.

A further limitation of the study is that our sample included only nursing staff and excluded all medical staff. Given the close working relationships between ward-based nurses and their medical colleagues (particularly, the primary medical teams responsible for the ward-based patients), we may have missed part of the picture by opting to focus only on nursing staff. Given the evidence that junior medical staff do not consistently escalate deteriorating patients to their senior colleagues (Callaghan et al., 2017), there is grounds for further theory-driven work to improve understanding of the determinants of medical staff behaviour in this space.

6 | CONCLUSION

Through the use of structured methods, and the systematic application of theory, we identified a range of determinants (i.e. barriers and enablers) to RNs and HCAs enacting specified behaviours of the afferent limb. Consistent with other published research, we identified barriers related to lack of knowledge, fear of reprimand, high workload and lack of physical resources needed to enact these

behaviours. We offer new insights into barriers and enablers relating to motivation and intentions, goals, professional role and responsibility, decision-making processes, social interactions with peers and colleagues and feedback received or anticipated from more senior staff. Having reported the TDF domains that appear to influence the target behaviours, further work is required to map determinants to intervention content as part of the development of a tailored behaviour change intervention (Baker et al., 2015).

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CONFLICT OF INTEREST

No conflict of interest has been declared by the author(s).

AUTHOR CONTRIBUTIONS

All authors have agreed on the final version and meet at least one of the following criteria (recommended by the ICMJE*): (1) substantial contributions to conception and design, acquisition of data or analysis and interpretation of data; (2) drafting the article or revising it critically for important intellectual content. * http://www.icmje.org/recommendations/

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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5.3.4 Supplementary files from the second publication included within this thesis (either in volume 1 or volume 2)

Supplementary file label in publication 2	Document title	Volume and page number within this thesis
Supplementary file 1	The levels of patient risk associated with NEWS2 score ranges	Volume 2, Appendix 25, page 117
Supplementary file 2	Interview topic guides structured according to the Theoretical Domains Framework (for both HCAs and RNs)	Volume 2, Appendices 7 and 8, pages 26-36
Supplementary file 3	Coding manual	Volume 2, Appendix 9, page 36
Supplementary file 4	TDF domains, themes, belief statements, and frequency counts from analysis of audio-recorded semi-structured TDF-informed interviews (phase 2)	Volume 2, Appendix 28, page 126

5.3.5 Additional information about how theoretical saturation was determined for semi-structured interviews

In chapter 4 (section 4.6.3.2) the proposed methods for determining an adequate sample size for semi-structured interviews, i.e. establishing the point of theoretical saturation are reported. Due to word limit constraints, the specific outcomes of this procedure were not explicitly reported in the second co-authored publication. To supplement the information provided within the publication, results from operationalising theoretical saturation in accordance with the reported methods of Francis et al (2010) are described in more detail below.

In the post EHR context, 10 interviews were conducted as proposed (Francis et al., 2010). Verbatim transcripts from these interviews were deductively coded and inductively analysed (using the methods described in section 4.6.4). Following the *initial analysis sample* of 10 participants, a further interview was conducted (interview number 11). No new themes were constructed from inductive analysis of quotations. However, when the subsequent interview was deductively coded and inductively analysed (interview number 12), a new theme was constructed within the TDF domain *Knowledge*. This theme was *procedural knowledge for recording vital signs*. Subsequently, a further three interviews were conducted. From sequential coding and inductive analysis of these interviews (interview numbers 13, 14, and 15) no new themes were constructed for data coded into all TDF domains; that is, all quotations from these interviews were adequately represented by existing themes. Consequently, the *stopping criterion* (Francis et al., 2010) for theoretical saturation was met with a sample of 15 interviews.

5.3.6 Integrating findings from brief and semi-structured interviews

The application of published prioritisation criteria (Publication 2, table 2) to the corpus of data derived from semi-structured interviews resulted in the categorisation of nine TDF domains as being of 'high importance'. That is, these domains were thought to represent the most important barriers and/or enablers to the target behaviours. Beliefs expressed by participants of brief interviews were coded to nine of the 14 TDF domains. Eight of these nine domains overlapped with domains of high importance from semi-structured interviews (Table 5.3). This overlap in findings

between the different interviews, conducted at different time points and in differing contexts, further underscores the importance of these domains through methodological triangulation[10] (Polit & Beck, 2018; Carter et al., 2014). On this basis, these eight TDF domains were taken forward for BCT mapping.

For the two domains where overlap was not present between the two interview approaches (Table 5.3), the decision to include or exclude the domain from further analysis was made through consensus discussion (involving DS, MC, JD, JH, LMA). From analysis of the data derived from semi-structured interviews, the domain *Goals* met criteria of high importance but was not identified from coding of paraphrased brief interview data. As the methods used to conduct the semi-structured interviews were more robust than the brief interviews (in relation to sampling approaches and data collection procedure), the decision was made to uphold the categorisation of the domain as being of 'high importance' and to take it forward for BCT mapping. The TDF domain *Behavioural Regulation* was identified from coding of paraphrased brief interviews but only met criteria of 'moderate importance' following analysis of data from semi-structured interviews. Upon close inspection of the paraphrased illustrative quotes from brief interviews, only one participant was noted to have expressed a belief (a potential enabler) that was coded at the *Behavioural Regulation* domain. It was agreed unanimously that this was not adequate to inflate the status of the domain from moderate importance to high importance and consequently the domain was excluded from further analysis (alongside all other domains of moderate or low importance). Consequently, nine TDF domains of high importance were taken forward for BCT mapping. These 9 domains were:

- Knowledge
- Social Professional Role and Identity
- Beliefs about Consequences
- Reinforcement
- Intentions
- Goals

[10] Methodological triangulation involves the use of multiple methods to explore the same phenomenon (Carter et al., 2014; Polit & Beck, 2010).

- Memory, Attention and Decision Processes
- Environmental Context and Resources
- Social Influences

Table 5.3 – overlap between TDF domains identified from deductive coding of brief interviews and domains of high importance from analysis of semi-structured interviews

TDF domain	The domain represented barriers and/or enablers expressed by participant/s during a brief interview	The domain was of 'high importance' in representing barriers and/or enablers expressed by participant/s during a semi-structured interview
Beliefs about Consequences	✓	✓
Environmental Context & Resources	✓	✓
Memory, Attention & Decision Processes	✓	✓
Reinforcement	✓	✓
Social, Professional Role & Identity	✓	✓
Goals	×	✓
Intentions	✓	✓
Knowledge	✓	✓
Social Influences	✓	✓
Behavioural Regulation	✓	×

5.3.7 Mapping TDF domains of high importance to Behaviour Change Techniques

Using the mapping tool (described in chapter 4, section 4.5.1.3) the nine domains of high importance (listed under section 5.3.5) were mapped to specific Behaviour Change Techniques

(BCTs). This initial mapping exercise resulted in a provisional list of 57 BCTs. As 7 of the listed BCTs were duplicated (i.e. were mapped from two TDF domains), 50 unique BCTs were identified that could be used to populate the preliminary behaviour change intervention. The number of BCTs mapped by TDF domain and the labels of the different BCTs are displayed in Table 5.4. All 50 of these BCTs were taken forward into phase 3 of this PhD work.

Table 5.4 – the number and labels of the BCTs mapped from each of the 9 TDF domains of high importance

TDF domains of high importance	**No. of belief statements representing specific barriers and/or enablers**	**No. of BCTs mapped from the domain**	**BCT labels (from the mapping tool in appendix 10)** *BCTs in red were mapped from two different TDF domains.*
Knowledge	22	4	– Antecedents – Biofeedback – Feedback on behaviour – Health consequences
Social Professional Role and Identity	12	1	– Social, support or encouragement (general)
Beliefs about Consequences	10	10	– Anticipated regret – Comparative imagining of future outcomes – Covert conditioning – Covert sensitization – Emotional consequences – Pros/cons – Salience of consequences – Social and environmental consequences – Threat – Vicarious reinforcement
Reinforcement	6	17	– Anticipation of future rewards or removal of punishment – Classical conditioning – Counter conditioning – Differential reinforcement – Discrimination training – Extinction – Incentive – Material reward – Negative reinforcement – Non-specific reward – Punishment – Response cost – Self-reward – Shaping – Social reward – Thinning – Threat

Intentions	13	2	– Behavioural contract – Commitment	
Goals	8	5	– Action planning – Goal setting (behaviour) – Goal setting (outcome) – Review behavioural goals – Review of outcome (goals)	
Memory, Attention and Decision Processes	14	3	– Action planning – Prompts/cues – Self-monitoring of behaviour	
Environmental Context & Resources	33	5	– Avoidance/changing exposure to cues for the behaviour – Discriminative cue – Prompts/cues – Re-structuring the physical environment – Re-structuring the social environment	
Social Influences	9	10	– Identification of self as a role model – Information about others' approval – Modelling or demonstrating the behaviour – Re-structuring the social environment – Social comparison	– Social reward – Social support (emotional) – Social support (practical) – Social support or encouragement (general) – Vicarious reinforcement

5.4 Re-visiting reflexivity

5.4.1 My position during field work (phases 1 and 2)

Based on formal education and experiential learning, I consider myself to have expertise in clinical assessment and decision making, particularly in relation to the management of deteriorating patients. However, having not worked as a RN within a ward setting for 19 years, and having only had limited experience of ward nursing at a junior level, I would not describe myself as a 'ward nurse'. Consequently, during field work, I found myself inhabiting the space of both the 'insider' (some participants and I shared the identity of RN) and 'outsider' (I was not part of the ward team and was outside of my usual work role and setting) (Reid et al., 2018). In this context, my 'outsider' status may have been beneficial as it limited the opportunities that I had to make assumptions about the behaviours that I was observing, and/or why they might have been happening (Probst, 2015). On reflection, this may have led me to ask more open questions during interviews driven by genuine curiosity (Tracy, 2019).

It has been posited that the role of a researcher during field work is rarely fixed and more likely to exist on a continuum between outsider/complete observer and full participant (Pope, 2005). This suggestion that the researcher role is dynamic, and can fluctuate, aligns to my experience on the wards as my role often changed based on the activities that were occurring, the participant/s with whom I was interacting, and the context within which these interactions were taking place.

On several occasions during field work, I was required to intervene to protect patient safety. Although my principal role was one of researcher, in accordance with my regulatory body (The Nursing and Midwifery Council) I was duty bound to act in the best interest of patients (Nursing and Midwifery Council (NMC), 2015). I found these moments to be particularly challenging, despite having an approved safety protocol that had been ratified locally and by the research ethics committee (see section 4.9.2.2 and volume 2, appendix 20). A high level of self-reflexivity was required when deciding on the exact moment to step in and in selecting the appropriate language to use when communicating with nursing staff. In these moments, when I was required to step across the boundaries of my researcher role and act in accordance with my duty of care as a registrant (Nursing and Midwifery Council (NMC), 2015), it was likely that my clinical role would have been brought into sharp focus for participants (i.e. RNs and HCAs). Consequently, it is conceivable that the behaviours staff enacted in my presence would have changed thereafter. In addition to changing subsequent participant behaviour, it is plausible that my actions in these moments may also have changed the course for a vulnerable patient. Moments such as this, where patients potentially receive better care as a consequence of the research process, or the researcher's presence, have been framed positively within the literature (Groenkjaer, 2002).

5.4.2 Reflexive accounts of my actions to protect patient safety

When conducting focused ethnography in the pre-EHR context, there were four occasions where I felt that I needed to act beyond the scope of my research role to protect patient safety. These interventions were informed by my safety protocol but also driven by knowledge and experience acquired in my clinical role as a critical care outreach nurse.

The first occasion involved an at-risk patient who had previously been known to the hospital's CCOT and had been having daily assessments by members the team. However, whilst still considered at risk, colleagues from the CCOT had decided that the patient's condition had improved enough for her to be removed from the team's regular review caseload. I was aware of this from my clinical role (honorary CCOT nurse within the organisation). Whilst observing on the ward, I heard several staff members refer to this patient as being "under CCOT" suggesting that staff were not aware she had been discharged from the team's regular review list. This message was also shared with the entire team during the morning 'safety briefing'. Given the patient was still vulnerable to deterioration, I felt concerned that staff may have a false sense of security and may not escalate care promptly due to an assumption that the patient was being regularly reviewed by CCOT. As this occurred in the first two weeks of data collection, I was also worried that stepping in and highlighting this could affect staff perception of my role on the ward. As such, I made the decision to contact a CCOT nurse colleague directly to explain the situation, and to request that they clarify with the nurse-in-charge that this patient was no longer having regular reviews, and that ward staff should re-refer the patient formally if there were any concerns.

On another occasion, I had been observing outside a side room occupied by a patient who had been highlighted as "under CCOT' and "under the ICU registrar". During observation, I witnessed an ICU registrar reviewing the patient and then informing the ward RN that the patient "needed to be monitored closely but did not need admission to the ICU". I then observed the doctor writing in the patient's notes. Thirty minutes after the ICU registrar left the ward, the CCOT nurse arrived and immediately informed the RN that the patient had been "accepted by ICU". The RN appeared confused by the conflicting information but did not question or challenge this. The CCOT nurse began to apply personal protective equipment (i.e. apron and gloves) prior to entering the patient's room. It struck me that there may have been a breakdown in communication, and I was concerned at this point that the patient may receive conflicting information. As such, I discreetly highlighted what I had observed and overheard to the CCOT nurse and suggested that he review the patient's notes and speak with the ICU registrar before discussing any decision-making with the patient.

Whilst observing the care of a patient with a NEWS of 8 and suspected sepsis I also provided some subtle intervention to expedite care. On this occasion, the patient had been highlighted by the Nurse-In-Charge (NIC) as having rapidly deteriorated from the point of being medically fit for discharge home in the morning to being “very unwell” in the evening. Whilst observing, I noted an increase in the frequency of vital signs monitoring by the RN (a new member of staff) caring the patient. I also overheard the RN and the NIC discussing the need for the CCOT to be contacted about the patient. Despite this conversation, I did not witness either member of staff making a referral to CCOT, as both appeared to become pre-occupied with other tasks, answering patient call-bells etc. Soon after, a member of the CCOT arrived on the ward to review another patient. As neither the NIC nor the responsible RN had made a referral, I located the NIC who was in clinical room checking medication with another staff member. I informed her that a CCOT nurse was on the ward with the hope that this would prompt her to make a referral. Soon after, the NIC came out of the clinical room, found the responsible RN, and located the CCOT nurse who was still on the ward. Together the RN and NIC handed-over the patient. When I returned to the ward the next shift, I discovered that this patient had deteriorated further and had been admitted to ICU for blood pressure support. This left me feeling particularly relieved that I had intervened on this occasion.

On the fourth occasion, I was observing an HCA routinely measuring vital signs in an open bay of patients. From my position in the entrance to the bay, I observed a female patient who appeared particularly unwell. Her breathing was fast, and I could hear rattling and bubbling sounds from her chest. When the HCA reached this patient and attached the electronic monitoring equipment, I was able to hear the monitor alarming and to see that the oxygen saturations were 90% despite the patient receiving supplemental oxygen (I was not close enough to see how much oxygen the patient was receiving). From my position, I counted the patient’s respiratory rate myself at 30 breaths per minute. I then observed the HCA disconnecting all monitoring equipment before leaving the bedspace with the patient’s NEWS chart. Within two minutes, the HCA returned and started re-connecting the patient to all the monitoring equipment. Soon after, the responsible RN appeared. I observed her entering the bedspace, glancing at the data on the monitoring

equipment, and then immediately picking up the telephone. At this point, I was able to see the patient's NEWS chart which was open on the bench by the entrance to the bay. I could see that the NEWS had been added up incorrectly (scored at 7 when it should have been 8) and that the patient's respiratory rate had been miss-recorded as 24 breaths/min. With the faster respiratory rate, the patient's aggregate score should have been 9. I then overheard the RN speaking with the on-call doctor and reporting the NEWS of 7 as part of this conversation. Although a NEWS of 7 and 9 both signal high risk, I felt concerned that the level of urgency may not be fully reflected and that a score of 9 was more in-keeping with the level of acuity that I was directly observing. After the RN completed the call with the on-call doctor, I highlighted to her that the respiratory rate may be higher and suggested that she re-check the vital signs herself. She did as I suggested and scored the patient 9. After repeating the vital signs, she contacted the CCOT nurse and referred the patient using the correct NEWS. Both the medical team and CCOT responded to this patient.

In the post EHR context, I was required to step over the boundary of my researcher role and act to safeguard patient safety on three occasions. All these actions were prompted by the identification of a patient with an elevated NEWS on the EHR. Due to the functionality of the system, it was possible to quickly view a snapshot of the aggregate NEWS for all patients on the ward, without opening notes or viewing more detailed clinical information (which was beyond the scope of my ethical clearance for this research). Consequently, it was far easier to identify patients with elevated NEWS from chart review in the post EHR context than in the paper based (pre-EHR) context. On the paper NEWS chart, staff were required to sign beneath the vital signs that they had recorded. However, signatures were often indecipherable, and it was frequently difficult to determine if measurements had been recorded by an RN or an HCA (unless I had directly observed them taking the measurements). In the EHR, name and job role were displayed next to data making this aspect of chart review easier and more reliable.

On two occasions, abnormalities in a patient's vital signs had triggered a high NEWS, but the HCAs who had measured and recorded the information had not escalated care to the responsible RN. On the first occasion, I noted from reviewing NEWS charts on the EHR, that a

patient on the ward had a NEWS of 7 recorded by an HCA at 1:00pm. By 2:12pm, I had observed no further monitoring of the patient's vital signs or any other activity in the patient's bedspace. Consequently, I made the decision to approach the RN responsible for the patient's care. I asked the RN *"did you know that the patient in bed X has a NEWS of 7?".* The RN told me that she had *"just spotted it [the NEWS of 7] on the [EHR] system".* When I asked her if she had been told, she responded *"No, I was told that the BP was fine"* [from chart review, the patient's blood pressure was noted to be 99/58mmHg]. The RN informed me that she had already escalated care to the patient's medical team and was planning to also contact the CCOT. On another similar occasion, when carrying out chart review, I noted that a patient on the ward had an aggregate NEWS of 5 based on vital signs recorded by an HCA at 10:11am. The score was elevated due to a heart rate of 119bpm and a blood pressure of 84/53mmHg. Whilst the aggregate score was meeting criteria for medium risk rather than high risk, I felt concerned about the combination of tachycardia (fast heart rate) and hypotension (low blood pressure), and the lack of any follow-up monitoring for a prolonged period (policy stipulated that for a medium risk NEWS, vital signs should have been repeated within 1 hour). I approached the RN responsible for the patient and drew her attention to the NEWS by saying *"just to make you aware that the patient in bed X has a NEWS of 5".* The RN looked rather startled and responded by saying *"I didn't know that I have been busy".* I then observed the RN fetching the monitoring equipment and immediately measuring the patient's vital signs herself. After measuring and recording the vital signs on the EHR, the RN passed me by (on her way to return the monitoring equipment to its station) and I heard her say *"it's a bit better".* When I returned to review the patient's NEWS chart, the blood pressure had improved, and the NEWS was 3 (a low-risk aggregate score). At that time I felt satisfied that the patient was safe and that no further escalation of care was required.

The final occasion where I was required to intervene also occurred when I was carrying out NEWS chart reviews on the EHR. At the time that I was reviewing information (2:10pm), I noted that the patient had vital signs recorded at 11:15am and at this time the NEWS was 8. After the score of 8, the patient had no further monitoring for over 2 hours, despite local policy stipulating continual monitoring in this context. When vital signs were repeated at 1:55pm the respiratory rate

was recorded as 24 breaths per minute and the aggregate NEWS had been calculated (by the EHR) at 7, based on data entered by an HCA. As the patient's vital signs had been recorded within 15 minutes of my observation, I counted this patient's respiratory rate myself and found it to be 28 breaths per minute. With the faster (researcher) respiratory rate, I calculated the patient's NEWS to be 8. The score inflation from 7 to 8 would not have changed the 'risk-level' for the patient or the recommended actions in accordance with the NEWS guidance. However, I perceived this patient to be vulnerable because their NEWS had been at a high-risk level for several hours and their requirement for supplemental oxygen had doubled within a 2-hour period. Consequently, I opted to approach the RN responsible for the patient and draw their attention to the potentially inaccurate respiratory rate. The nurse who I approached acknowledged my concern but was not seen to take any immediate visible action based on the prompt. When I returned to the vicinity of the patient shortly after, I noticed that a doctor from the ICU (who was known to me from my clinical work) had arrived and was with the patient. I felt reassured that the patient was safe despite the lack of immediate action from the RN. Within several hours the patient had been accepted and admitted to the ICU. Whilst patient safety was maintained, this was the only occasion where my prompt did not result in any obvious action from the RN. This left me feeling disappointed and curious about whether the presence of the ICU team might have moderated the RN's response by creating a sense of safety.

5.5 Phase 3 results

5.5.1 Shortlisting BCTs and using Nominal Group Technique methods to inform how BCTs will be operationalised (third publication)

The 9 TDF domains of high importance (identified in phase 2), were mapped to Behaviour Change Techniques. A list of 50 BCTs were shortlisted to 14 using consensus processes involving my supervisors and I. Shortlisted BCTs and example applications (concrete strategies for operationalising the BCTs), were compiled within an information package. Nominal Group Technique methods were applied during two virtual groups with relevant stakeholders who were sent the information package ahead of the groups. Nominal group participants proposed new ways in which the specified BCTs could be delivered in practice and ranked the BCT/applications

(including those proposed in the information package and new ideas from the group) according to acceptability and feasibility. Ranking data were used to drive decision making about the content of the intervention. These results were published in the *BMC Health Services Research* journal (impact factor: 2.655) in June 2022. As first author, I led on writing and amending the manuscript with support from my supervisors. Several documents included as online supplementary files to this publication have been included in the main body of this thesis (i.e. volume 1) or the appendix (i.e. volume 2). For ease of reference, the location of these documents is sign-posted in a table at the end of the manuscript.

STATEMENT OF CO-AUTHORS of JOINT PUBLICATIONS

TO WHOM IT MAY CONCERN

Title of publication: Selecting intervention content to target barriers and enablers of recognition and response to deteriorating patients: an online nominal group study.

Name of candidate: Duncan Smith
Title of research thesis: DEveloping a Complex Intervention for DEteriorating patients using theoretical modelling (DECIDE study).

Name of first supervisor: Professor Leanne M Aitken

We, the undersigned, co-authors of the above publication, confirm that the above publication has not been submitted as evidence for which a degree or other qualification has already been awarded.

We, the undersigned, further indicate the candidate's contribution to the publication in our joint statement below.

Signature:

Name: **Duncan Smith**

Date: 15/6/22

Signature:

Name: **Martin Cartwright**

Date: 15/6/22

Signature:

Name: **Judith Dyson**

Date: 15/6/22

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Name: **Jillian Hartin**

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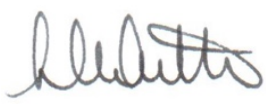

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Date: 15/6/22

The candidate's contribution to the publication

Contribution	Author				
	Duncan Smith	Martin Cartwright	Judith Dyson	Jillian Hartin	Leanne M Aitken
Funding acquisition	✓				✓
Conceptualisation	✓				✓
Data collection	✓	✓	✓		✓
Data analysis	✓				
Drafting the manuscript	✓				
Editing the manuscript	✓	✓	✓	✓	✓
Approving the manuscript	✓	✓	✓	✓	✓

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Selecting intervention content to target barriers and enablers of recognition and response to deteriorating patients: an online nominal group study

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Abstract

Background: Patients who deteriorate in hospital wards without appropriate recognition and/or response are at risk of increased morbidity and mortality. Track-and-trigger tools have been implemented internationally prompting healthcare practitioners (typically nursing staff) to recognise physiological changes (e.g. changes in blood pressure, heart rate) consistent with patient deterioration, and then to contact a practitioner with expertise in management of acute/critical illness. Despite some evidence these tools improve patient outcomes, their translation into clinical practice is inconsistent internationally. To drive greater guideline adherence in the use of the National Early Warning Score tool (a track-and-trigger tool used widely in the United Kingdom and parts of Europe), a theoretically informed implementation intervention was developed (targeting nursing staff) using the Theoretical Domains Framework (TDF) version 2 and a taxonomy of Behaviour Change Techniques (BCTs).

Methods: A three-stage process was followed: 1. TDF domains representing important barriers and enablers to target behaviours derived from earlier published empirical work were mapped to appropriate BCTs; 2. BCTs were shortlisted using consensus approaches within the research team; 3. shortlisted BCTs were presented to relevant stakeholders in two online group discussions where nominal group techniques were applied. Nominal group participants were healthcare leaders, senior clinicians, and ward-based nursing staff. Stakeholders individually generated concrete strategies for operationalising shortlisted BCTs ('applications') and privately ranked them according to acceptability and feasibility. Ranking data were used to drive decision-making about intervention content.

Results: Fifty BCTs (mapped in stage 1) were shortlisted to 14 (stage 2) and presented to stakeholders in nominal groups (stage 3) alongside example applications. Informed by ranking data from nominal groups, the intervention was populated with 12 BCTs that will be delivered face-to-face, to individuals and groups of nursing staff, through 18 applications.

Conclusions: A description of a theory-based behaviour change intervention is reported, populated with BCTs and applications generated and/or prioritised by stakeholders using replicable consensus methods. The feasibility of the proposed intervention should be tested in a clinical setting and the content of the intervention elaborated further to permit replication and evaluation.

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Keywords: Clinical deterioration, Critical care, Vital signs, Behavioural research, Group processes, Consensus, Nursing

Contributions to the literature

- To improve the recognition and/or response to deteriorating patients (by nursing staff), a range of intervention components may be required, including training and different Behaviour Change Techniques delivered using a range of concrete strategies.
- Behaviour Change Techniques, used to optimise the physical and social environment, could be delivered in acute hospital wards at the point of care.
- It may be more suitable to deliver some appropriate BCTs in a workshop setting, particularly when the end-users are healthcare staff and delivery of the techniques involves prompting reflection on the consequences of enacting or not enacting specific (clinical) behaviours, and/or making plans for future behaviour.
- Strategies for delivering BCTs within the ward setting were broadly favoured by clinical stakeholders (i.e. considered more acceptable and/or feasible) over alternate strategies for delivery in workshops. The acceptability of different approaches requires further examination during feasibility testing.

Background

Clinical deterioration has been defined as a change in the condition of a patient from one clinical state to a worse clinical state with an increased risk of morbidity or mortality [1]. Hospitalised patients who deteriorate in a ward setting, without recognition or an appropriate response, are at risk of Serious Adverse Events (SAEs) such as unplanned admission to the Intensive Care Unit (ICU), cardiac arrest, and/or death [2, 3]. To facilitate recognition of, and response to, patient deterioration, Rapid Response Systems (RRSs) have been implemented within acute hospitals internationally [4]. At the system level, RRSs typically include an 'afferent limb' (the recognition arm) and an 'efferent limb' (the response arm) (Fig. 1). However, there is often variation between organisations in how RRSs are operationalised [4, 5].

Changes in vital signs (e.g. heart rate, respiratory rate, blood pressure) are present in more than 50% of patients who suffer SAEs [6–8]. To strengthen the afferent limb of the RRS, track-and-trigger tools have been implemented internationally. These tools (which may be paper-based or embedded within an electronic health record), permit healthcare practitioners (frequently nursing staff) to record vital signs, providing a signal when the vital signs breach pre-determined criteria (i.e. when the vital signs fall outside of acceptable ranges). When criteria are breached, staff are prompted to escalate care; that is, to increase the frequency of vital signs monitoring and to contact a more senior colleague or a practitioner with expertise in the management of critical illness (e.g. a doctor or a nurse from critical care outreach team or equivalent) [9, 10]. In the UK and parts of Europe, the National Early Warning Score (NEWS) has been widely implemented and its predictive performance validated [11–13]. The NEWS comprises six routinely recorded vital signs [14]. For each vital sign, a score is applied (range 0–3) depending on the level of physiological derangement. The scores are then combined, and for patients requiring supplemental oxygen a further two points added, to produce the total NEWS (range 0–20). The higher the NEWS, the greater the risk to the patient of SAE and the more senior the practitioner to whom care should be escalated [14]. The use of early warning scores (like NEWS) and accompanying escalation of care protocols are associated with improved patient outcomes [15].

Despite implementation of track-and-trigger tools, there is evidence that deteriorating patients continue to receive sub-optimal care [16, 17]. This has been partly attributed to ward-based nursing staff failing to recognise the abnormalities in vital signs and/or not escalating care when criteria are met [18]. This phenomenon has been termed Afferent Limb Failure (ALF) [2, 19]. ALF is increasingly reported to be associated with inconsistent behaviour of nursing staff [20, 21]. Consequently, to optimise the afferent limb and to drive more consistent responses to deteriorating patients, there is a need for interventions to support nursing staff to change their behaviour [22–24]. Theories of behaviour and behaviour change are arguably the most useful guides for developing such interventions. However, there is currently paucity of research applying behavioural theories or theoretical frameworks to explore determinants of afferent limb behaviour, or to inform selection of content for interventions to improve nursing staff's afferent limb behaviour [25, 26]. Given evidence that systematic application of theory may increase replicability of methods [27, 28] and intervention efficacy [29, 30], the use of theory-based approaches to intervention development is justified. A

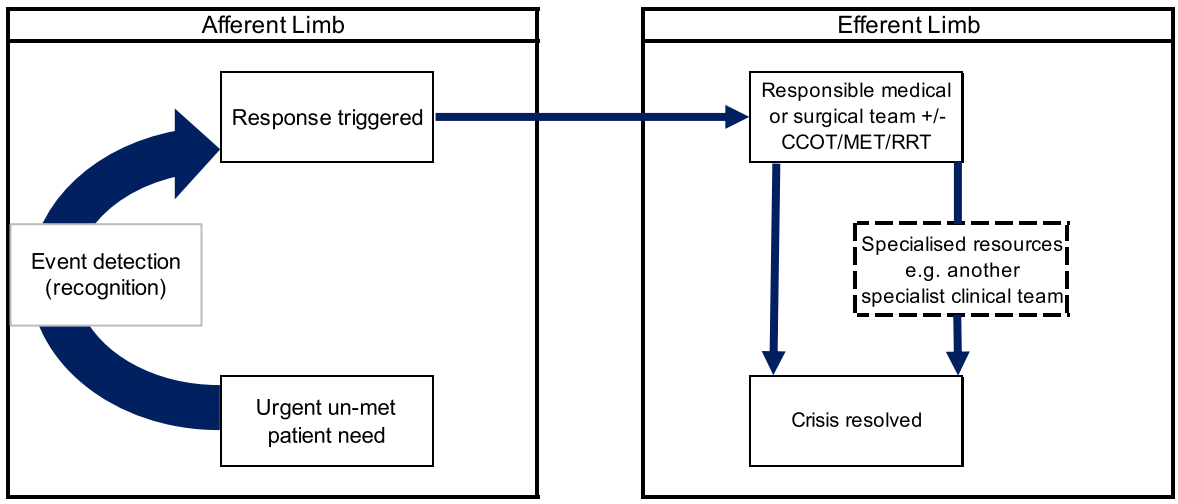

Fig. 1 Conceptual model of the Rapid Response System (RRS). Adapted from: DeVita et al. [4]

multi-phase programme of work was devised modelled on the theoretically informed implementation process reported by French et al. [31] and underpinned by the Theoretical Domains Framework (TDF) (v2). A diagrammatic overview of the entire programme of work can be found in Fig. 2. In this paper, the focus is on selecting content for a behaviour change intervention.

The observable, irreducible and active elements of a behaviour change intervention that bring about the change in behaviour are termed Behaviour Change Techniques (BCTs); 93 BCTs have been identified and defined in a taxonomy [32]. The behaviour change literature distinguishes between BCTs and the strategies used to operationalise them [27]. The mechanisms through which BCTs are delivered to recipients have been labelled modes of delivery [33]. The mode of delivery may encompass the proximity of the intervention deliverer to the recipient (e.g. face-to-face, remote), the number of individuals targeted by the intervention on a single occasion (e.g. individual, dyad, group), and the medium through which BCTs are sent to intended recipients (e.g. radio, poster, mobile phone application) [32, 33]. Reporting the operational components of an intervention in sufficient detail to be replicable requires descriptions of intervention content (what); provider (who); setting (where); recipient (to whom); intensity (over how many contacts), and fidelity (the extent to which it was delivered as intended) [33]. In this work, the concrete strategies used to operationalise BCTs were labelled as *applications*. For example, social support and encouragement (*the BCT*) could be delivered face-to-face, to individual health practitioners (*mode of delivery*), through the provision of peer support workers or 'champions' in the workplace (*the application*).

When developing behaviour change interventions, the context in which the intervention will be delivered is recognised as an important consideration [34, 35]. It has been posited that context is both complex and multidimensional and extends beyond a physical space [36]. Context should be recognised as a process involving persons, resources, perspectives, and activities [37]. To design interventions feasible to deliver in practice, assessing the contextual constraints and facilitators is crucial [37]. Despite this, there is evidence of context being under-reported within the wider patient safety literature [38]. To permit suitable adjustments for context and 'local factors' [39] it has been recommended that interventions aiming to change health practitioners' behaviour be developed through interactive methods with the target group, allowing local expertise and tacit contextual knowledge to be incorporated [34, 35]. The aims of this research were to select and shortlist possible BCTs, and to use structured consensus methods with healthcare staff to prioritise BCTs and applications for inclusion in a behaviour change intervention (targeting nursing staff).

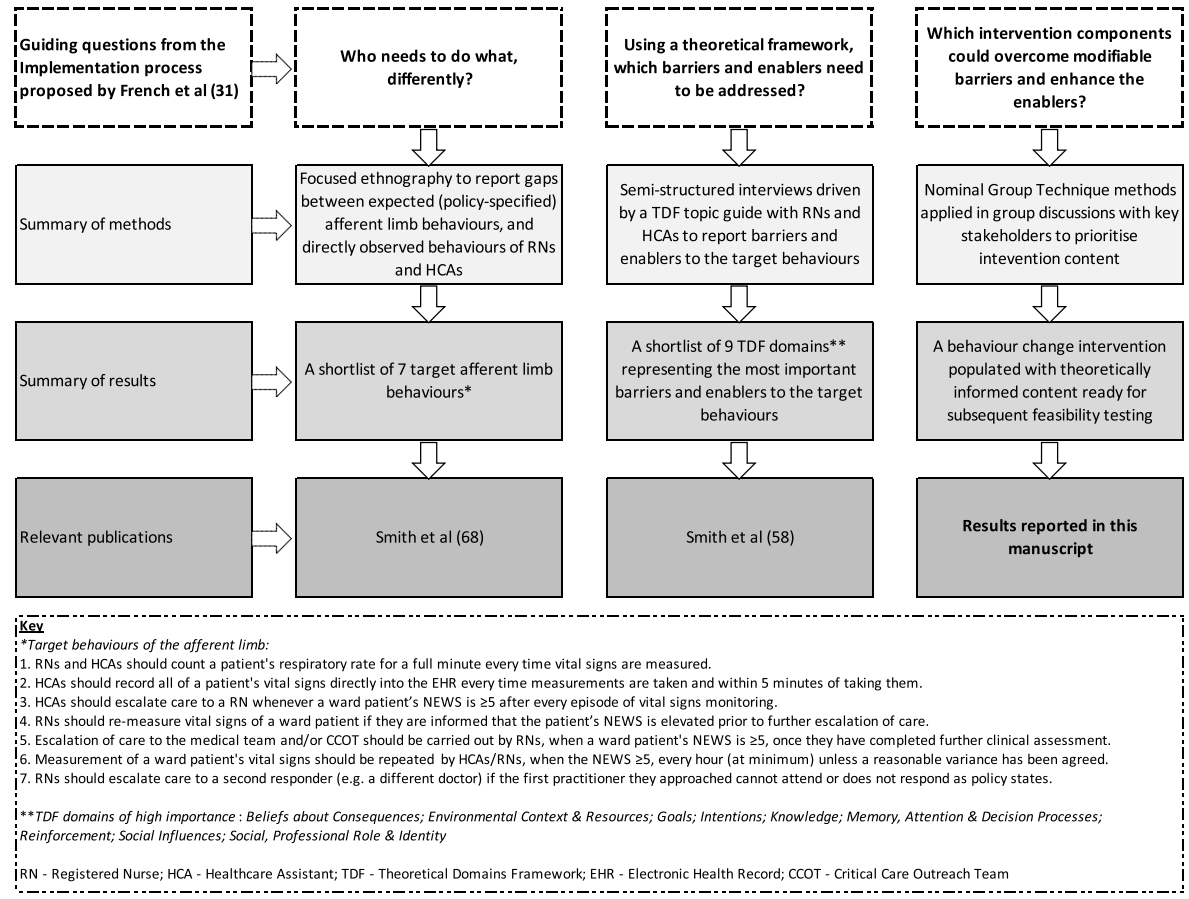

Fig. 2 Overview of the programme of work to develop a theory-based behaviour change intervention targeting behaviours that are potential antecedents to afferent limb failure

Methods

Design

A three-stage process was used to develop the content for a theoretically informed behaviour change intervention. In stage 1, mapping tools were used to identify appropriate BCTs for the previously identified determinants of target behaviours; stage 2, using additional criteria (acceptability and feasibility) and a consensus approach, the identified BCTs were shortlisted by the research team; stage 3, shortlisted BCTs and researcher-generated applications were presented to stakeholders in online group discussions where Nominal Group Technique (NGT) methods were applied (nominal groups). To further reduce the number of applications, ranking data from nominal groups guided final consensus discussions by research team members. Permission to conduct this research was granted by a National Health Service Research Ethics Committee (REC) (reference: 18/NS/0118), the Health Research Authority (reference as for REC), and the hospital's research and development department (reference: 18/0569).

Mapping and shortlisting behaviour change techniques

Using linkages between TDF domains and BCTs derived from expert consensus processes [27, 40], TDF domains of high importance were mapped to specific BCTs that could be used to ameliorate barriers and/or enhance enablers associated with a given domain. A minimum of two researchers (DS and MC or JD or LMA) independently reviewed all mapped BCTs and their definitions for anticipated acceptability (to the intended recipient) and anticipated feasibility (in the intended context). For each BCT, the criteria in Table 1 were used to determine whether to include it, exclude it or bring it for discussion with all researchers (DS, MC, JD, JH, LMA). BCTs were then taken forward for discussion and voting at stakeholder groups where NGT methods were applied.

Table 1 Criteria applied by members of the research team during BCT shortlisting

Label applied to BCT and action	Criteria for labelling
Include – take forward for discussion at nominal groups	1. The BCT could feasibly be delivered in a clinical environment **AND** 2. The BCT is likely to be acceptable to a healthcare practitioner **AND** 3. The BCT does **not** meet exclusion criteria
Exclude – no further action	1. The BCT would take time to deliver and/or would require repeated delivery over a prolonged period (i.e. unlikely to be feasible) **AND/OR** 2. The BCT is ethically dubious e.g. applying punitive techniques to clinical staff (i.e. unlikely to be acceptable)
Uncertain – take forward for consensus discussion with the entire research team	1. Reviewer uncertain which criteria are met by the BCT – warrants further consensus discussion to inform decision-making

Recruitment and sampling

Senior clinicians and leaders from a variety of disciplines were recruited for a leadership group and Registered Nurses (RNs) and Healthcare assistants (HCAs) from acute wards were recruited for a clinical group. These personnel were separated to reduce potential power imbalances [41]. An email outlining the nature and broad objectives of the research was sent to the chairperson/project lead of a Deteriorating Patient Steering Group (to recruit for the leadership group) and nurse managers of acute inpatient wards (to recruit for the clinical group), requesting permission to access potential participants. The project lead and ward managers then sent the invitation to potential participants via the appropriate group email. Recipients of the email were asked to contact DS if they were interested in participating. In addition, using a snowballing technique [42] any recruited participants were asked to identify colleagues from within the organisation interested in participating, and an invitation was sent to these individuals too. These approaches were repeated until an adequate sample of participants had been recruited.

Materials

It was likely participants of the nominal groups would have no prior knowledge of behaviour change concepts and processes. Consequently, an information package (Additional file 1) was emailed to participants 2 weeks before the nominal group [43]. The information package consisted of a participant information sheet and a further document including a table showing the BCTs shortlisted in stage 2, plain-English definitions of BCTs, and example applications (minimum 1 example application per BCT). Example applications were sourced from supplementary materials accompanying the publication reporting the taxonomy of 93 BCTs [32], from educational materials developed by implementation scientists [44], and from patient safety innovations described in published literature [45, 46]. Prior to distribution, content of the information package was sense-checked by a patient advisor and by a group of clinical-academic health practitioners not directly involved in the research.

A facilitator guide was developed to structure the nominal group activities (Additional file 2). An online ranking document was also created using the Qualtrics® platform. This document included all shortlisted BCTs, and example applications presented in the information package as well as space for new suggested applications to be added during the groups. The Qualtrics® platform was selected as it permits content (i.e. new suggestions from participants) to be added in real time and to be ranked. To test the materials and the process, pilot nominal groups were held with members of an acute and critical care research group and then a health psychology research group at *City, University of London.* Facilitator guide revisions were made iteratively based on feedback from pilot group participants, and from debrief amongst research team members following piloting.

Data collection

In the original published protocol [47], it was proposed that the groups would be conducted face-to-face. Due to the severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2) pandemic, and the consequent need to maintain social distancing and to minimise unnecessary travel [48], the groups were delivered online using Microsoft® Teams software and were facilitated by four members of the research team (DS, MC, JD, LMA).

Participants of both nominal groups were presented with an identical list of BCTs (mapped from TDF domains of high importance). After the leadership group, applications suggested by participants were incorporated as examples into the information package which was sent to participants of the subsequent (clinical)

nominal group. It was anticipated that running the groups sequentially and revising the information package between groups, would enable ward nursing staff to discuss, debate and vote upon ideas proposed by senior leaders from their own organisation (alongside their own suggestions).

NGT methods involve the use of structured activities within groups comprising relevant stakeholders, with the broad aims of achieving a level of consensus and prioritising information [49]. Key activities, central to the NGT process, as described by the originators of the method are: *independent generation of ideas; 'round-robin' sharing of ideas; discussion and clarification of ideas, and voting (ranking of ideas)* [50]. We incorporated these key activities using a three-step process:

- Step 1: The following question was posed (by DS) to the group: '*Are there any other ways (or better ways) that the BCTs listed in the table could be applied in this organisation, that were not included in the information package?*' Participants silently considered the question and privately generated responses before feeding back a single idea at a time to the group. These ideas were posted onto the virtual display-board. All participants were given the chance to offer at least one idea with the exercise being repeated as many times as possible within the allotted time.
- Step 2: Participants were given the opportunity to ask questions about suggestions made by other participants and to merge suggestions considered sufficiently similar. Participants then took a short break whilst the research team met to identify any obvious discrepancies in the linkages between the BCTs and the applications suggested by participants (i.e. where the application did not reflect the BCT). Where such discrepancies were identified, a decision was made to either adjust the application to improve the alignment, propose a re-alignment of the application to a more suitable BCT from the shortlist, or exclude the application. The decision to exclude was made when the suggested application did not align with any of the BCTs and/or did not target the previously identified barriers/enablers. These decisions were driven by health psychologists (MC, JD) within the research team. Following any adjustments, new applications (i.e. those suggested by the group) from the virtual display-board were added onto the online ranking documents.
- Step 3: The health psychologists summarised to the participants any adjustments that had been made during the break time and offered them the opportunity to comment. A hyperlink was then posted into the discussion thread so that participants could access the ranking document in Qualtrics®. From the longer list provided, participants were asked to rank the five BCTs/applications that they considered would be most acceptable [51] to ward staff from 1 (most acceptable) to 5 (least acceptable). Participants were then requested to repeat this activity according to how feasible it would be to deliver the BCTs/applications.

Data analysis

Scores were assigned to each of the BCTs/applications based on the ranking information from participants [52]. Where a BCT/application was ranked first by a participant it was scored 5; second it was scored 4; third it was scored 3 etc. Participants' scores were summed to identify ranked priorities from within and across the two nominal groups [52]. For example, if 12 participants voted for any single BCT/application then the maximum score was 60 (i.e. 12×5, requiring all participants to rank the item first). In contrast, if a BCT/application was not ranked by any participants it would score 0. Summed scores and percentages were calculated. The frequency that each BCT/application was prioritised by a participant (i.e. ranked 1–5) was also counted for both ranking activities i.e. acceptability and feasibility.

All combinations of BCTs/applications were reviewed during subsequent consensus discussions involving nurse academics (DS, LMA), health psychology academics (MC, JD), and a lead nurse (JH). Where a single BCT had several potential applications, nominal group ranking data were used to prioritise which specific application/s to include in the intervention (higher scoring and more frequently prioritised applications were included). Where a BCT/application combination received a low score from nominal groups, and/or was not frequently prioritised (i.e. not frequently ranked 1–5), the decision to include or exclude from the intervention was made through discussion and debate, guided by the following considerations:

- The potential consequences of eliminating the BCT and its application/s on the theoretical integrity of the intervention (i.e. where exclusion would result in specified TDF domain/s and/or target behaviours not being addressed by intervention content).
- Further scrutiny of the BCT and its application/s in relation to the APEASE criteria (where APEASE stands for acceptability, practicability, effectiveness, affordability, side effects, equity) [33]. We found that applying the APEASE criteria at this stage in the consensus process (i.e. when BCTs were being scrutinised alongside potential applications) allowed us

to apply all criteria to some extent. We contend this may not have been possible had we applied APEASE before BCTs had been linked to specific applications. To exemplify, we were able to judge the potential 'affordability' of the BCT *Prompts/cues* more accurately once we had clarity that the BCT would be delivered using a simple laminated sign (a relatively inexpensive mechanism in this context).

Results

We recruited 31 participants in total for the nominal groups. Six individuals withdrew on the day of the group and 6 did not attend. Twelve participants attended the leadership group (NGT1), and 7 participants attended the clinical group (NGT2) (the professional roles of participants are displayed in Additional file 3).

The mapping exercise (stage 1) resulted in a provisional list of 50 unique BCTs (listed in Additional file 4). From the application of shortlisting criteria (Table 1) and consensus discussions within the research team (stage 2), 38 BCTs were excluded resulting in a shortlist of 14 unique BCTs for discussion and prioritisation at the nominal groups (stage 3).

The duration of both nominal groups was 2 hours. Across the groups, 24 new applications were proposed for applying the BCTs. Eleven of the applications proposed by participants were considered appropriate for one or more of the 14 shortlisted BCTs. The number of applications added and excluded at different stages of the NGT process is summarised in Fig. 3. In NGT 1, 11 online Qualtrics® ranking forms were completed for the first ranking task (acceptability of different BCT and application combinations) whilst 13 forms were completed for the second ranking task (feasibility of different BCT and application combinations). This discrepancy implies that one participant did not complete the acceptability ranking document but instead completed the feasibility document twice. As both ranking documents included the same content (only the heading

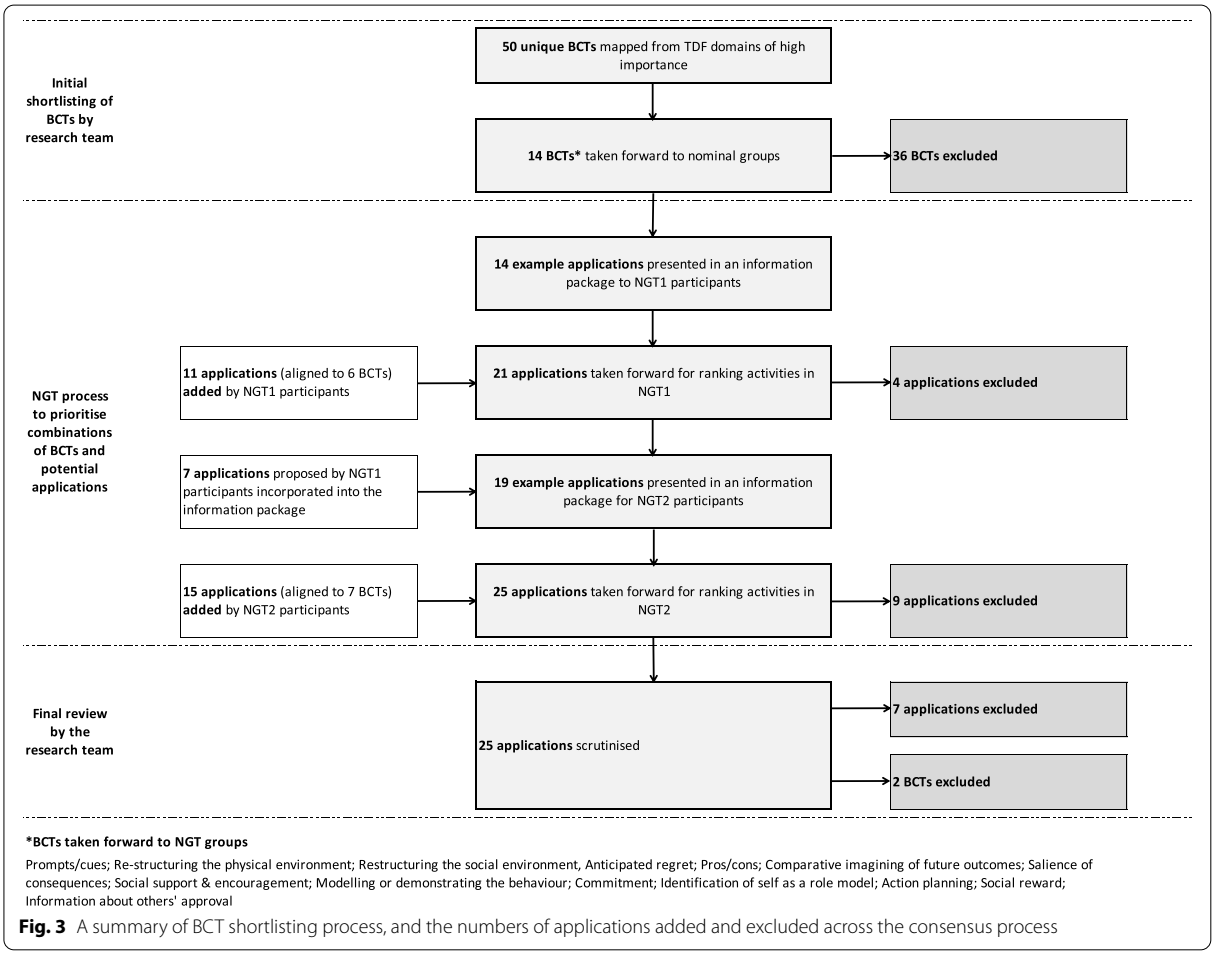

Fig. 3 A summary of BCT shortlisting process, and the numbers of applications added and excluded across the consensus process

and explanatory text varied), the summative scores were unlikely to be affected. In NGT 2, 6 ranking forms were completed for ranking task 1; with 7 completed for ranking task 2 implying that 1 participant did not rank for acceptability. This explains the variation in the denominator for the summative scores. A detailed breakdown of ranking data for both nominal groups can be found in Table 2.

The intervention (summarised in Fig. 4) was populated with 12 BCTs that will all be delivered face-to-face at group and individual levels (the modes of delivery), through 18 different applications. Four BCTs (*Re-structuring the physical environment, Re-structuring the social environment, Salience of consequences, Information about others' approval)* will be delivered using multiple applications. A brief rationale for decisions made during consensus discussions regarding which BCTs/applications were included and excluded from the intervention is provided is Table 2.

Discussion

Fifty BCTs (mapped from nine domains of the Theoretical Domains Framework) that could be used to change behaviour of RNs and HCAs were shortlisted to 14 and, alongside example applications, presented to key stakeholders in two virtual nominal groups. Participants proposed 11 new applications for the BCTs and ranked BCTs/applications (including examples provided by the research team and those suggested by nominal group participants) for acceptability to nursing staff and feasibility for delivery in an acute hospital ward. Ordinal data from ranking tasks were used to inform content of the intervention which has been populated with 12 BCTs, that will be delivered through 18 different applications in either a workshop or ward setting.

Whilst the TDF has been widely used to report barriers and enablers to health behaviour change with patients, its application in the design of interventions targeting healthcare practitioners is more limited. A systematic review was conducted to synthesise international literature reporting application of the TDF in designing interventions to support healthcare practitioner behaviour change [53]. The authors reported that only around 20% of articles (i.e. 60/297) reporting use of the TDF to explore implementation problems, extended its use to intervention design [53]. In recently updated guidelines from the Medical Research Council [36], methodological innovation and the adoption of new methods are highlighted as important for the future development of intervention research. We contend the use of NGT methods provides a structured, replicable, and expedient approach for ideas sharing and consensus building when designing a behaviour change intervention.

The interaction of an intervention with context is a crucial consideration for researchers spanning the phases of intervention design, evaluation, and implementation [34–36]. The impact of an intervention may be increased when its components are adjusted to best suit the context within which it is being delivered (i.e. when the intervention is tailored to a specific group or a particular setting) [36, 54–56]. To ensure the theoretical basis of the intervention is not compromised, it is advocated researchers reach agreement about the degree of variation that is permissible and prohibited, i.e. which components of an intervention can be adjusted and which must be maintained [36, 57]. To ensure the theoretical integrity of the intervention was upheld during NGT activities, we presented participants of both groups with an identical list of BCTs and applications and explained that the BCTs were 'fixed', but the applications could be revised or elaborated. We suggest our reported methods could be replicated in different settings, and with different stakeholders, to determine how specified BCTs could be operationalised in different contexts and tailored for different groups.

There was overlap in the TDF domains that represented important barriers and enablers to the target behaviours for both RNs and HCAs [58]. Similar overlap in the determinants of behaviour change, between different healthcare practitioners, has been reported in other work [59]. This overlap explains why the majority of BCTs included in our intervention will be directed at both RNs and HCAs. From our list of target behaviours (see the key in Fig. 2), three are enacted by RNs, two are enacted by HCAs, and two are enacted by RNs *and* HCAs. This implies that some target behaviours are enacted by individuals occupying a specific role (i.e. RN *or* HCA), whilst for others responsibility for enactment is shared. The individual responsible for enacting a specific behaviour has been termed 'the actor' [60]. Clearly specifying each target behaviour, including the actor/s, enabled us to evaluate the suitability of each application for the intended recipient/s and, where necessary, to tailor the application accordingly. For example, the laminated signage (used to apply the *Prompts/cues* BCT) will incorporate a tailored message directed specifically towards HCAs.

Our intervention includes some BCTs and applications where the mode of delivery will be a face-to-face workshop, and some for delivery in the clinical setting (ward-based applications). The ranking information from the nominal groups suggests stakeholders broadly perceived ward-based applications to be more acceptable and feasible than workshop-based applications. To attend workshops, staff must be released from their usual clinical duties. In several studies, different healthcare practitioners have reported a lack of

Table 2 Total scores from both ranking tasks (*A* - acceptability and *F* - feasibility) across the two nominal groups, and the decision to include or exclude the BCT/application from the intervention with brief rationale

No.	Behaviour Change Technique (BCT)	Application (concrete strategy for delivering the BCT in practice)	Total scores from ranking activities (% scores)				Total score	Frequency BCT/application ranked top 5 (denominator)		Included in the intervention		Brief rationale for decision to include or exclude from the intervention
			NGT1		NGT2			NGT1 (24)	NGT2 (13)			
			A (% of 55)	F (% of 65)	A (% of 30)	F (% of 35)				Yes	No	
1a	Prompts/cues	Attach laminated signs to vital signs monitoring equipment to prompt the desired behaviour +	10 (16)	46 (71)	0 (0)	14 (40)	70	12	3	✓		Highest scoring application for this BCT from nominal group participants
1b	Prompts/cues	Use best practice advisory 'pop-ups' on the Electronic Health Record to prompt the desired behaviour Δ	9 (16)	3 (5)	0 (0)	6 (17)	18	6	2		✓	Alternative (1a) application of this BCT favoured by nominal group participants
2a	Re-structuring the physical environment	Add vital signs monitoring equipment to the environment +	34 (62)	20 (31)	9 (30)	0 (0)	63	14	2	✓		High scoring from nominal group/s
2b	Re-structuring the physical environment	Add a visual marker on the floor to signal where the vital signs monitoring equipment should stand Δ	13 (24)	30 (46)	N/A	N/A	43	13	N/A	✓		High scoring from nominal group/s
2c	Re-structuring the physical environment	Add clocks with second hands to the ward to enable monitoring of respiratory rate Δ	2 (4)	15 (23)	3 (10)	11 (31)	31	7	3	✓		High scoring from nominal group/s
2d	Re-structuring the physical environment	Add more digital thermometers with timers for 15 s, 30s, 60s etc. to enable monitoring of respiratory rate Ø	N/A	N/A	3 (10)	9 (26)	12	N/A	4	✓		To ensure coverage of all target behaviours
3	Anticipated regret	*Workshop based* – ask RN/HCA to consider the degree of regret that they might feel if the desired behaviour was not enacted, and a patient came to harm +	4 (7)	0 (0)	4 (13)	0 (0)	8	1	1	✓		To ensure coverage of all TDF domains of high importance and all target behaviours
4	Pros/cons	*Workshop based* – ask RN/HCA to list and compare pros and cons of enacting the desired behaviour +	8 (15)	1 (2)	0 (0)	0 (0)	9	3	0	✓		To ensure coverage of all TDF domains of high importance and all target behaviours

Table 2 (continued)

No.	Behaviour Change Technique (BCT)	Application (concrete strategy for delivering the BCT in practice)	Total scores from ranking activities (% scores)				Total score	Frequency BCT/ application ranked top 5 (denominator)		Included in the intervention		Brief rationale for decision to include or exclude from the intervention
			NGT1		NGT2			NGT1 (24)	NGT2 (13)			
			A (% of 55)	F (% of 65)	A (% of 30)	F (% of 35)				Yes	No	
5a	Re-structuring the social environment	Set the expectation that HCAs attend ward safety huddles alongside RNs to facilitate escalation of deteriorating patients +	7 (13)	3 (5)	5 (17)	3 (9)	18	3	2	✓		Highest scoring application for this BCT from nominal group participants
5b	Re-structuring the social environment	Proactively roster HCAs who will attend the safety huddles Δ	9 (16)	4 (6)	N/A	N/A	13	4	N/A		✓	Decision made that all HCAs should be encouraged to attend the safety huddle
5c	Re-structuring the social environment	Formalise a 'HCA in-charge role' and ensure clear expectations/training Ø	N/A	N/A	8 (27)	1 (3)	9	N/A	3		✓	Alternative (5a) application of this BCT favoured by nominal group participants
5d	Re-structuring the social environment	Use clinical cases during safety huddles as a stimulus for conversation Δ	8 (15)	0 (0)	0 (0)	9 (26)	17	3	2	✓		High scoring from nominal group/s
6	Comparative imagining of future outcomes	*Workshop based* – prompt HCAs to imagine and compare likely or possible outcomes following immediate escalation of a deteriorating patient to the RN versus no escalation or delayed escalation +	2 (4)	4 (6)	2 (7)	0 (0)	8	2	1	✓		To ensure coverage of all TDF domains of high importance and all target behaviours
7a	Salience of consequences	*Workshop based* – show videos of patients speaking emotively about the consequences of delayed escalation and timely escalation +	7 (13)	0 (0)	11 (37)	5 (14)	23	3	4	✓		High scoring from nominal group/s
7b	Salience of consequences	*Workshop based* – show videos of patients speaking emotively about the consequences of timely escalation Ø	N/A	N/A	11 (37)	5 (14)	16	N/A	6	✓		Could be easily delivered alongside 7a

Table 2 (continued)

No.	Behaviour Change Technique (BCT)	Application (concrete strategy for delivering the BCT in practice)	Total scores from ranking activities (% scores)				Total score	Frequency BCT/ application ranked top 5 (denominator)		Included in the intervention		Brief rationale for decision to include or exclude from the intervention
			NGT1		NGT2			NGT1 (24)	NGT2 (13)			
			A (% of 55)	F (% of 65)	A (% of 30)	F (% of 35)				Yes	No	
8a	Social support and encouragement	Deploy deteriorating patient champions (HCA and RN level) and ensure clear expectations/training +	8 (15)	4 (6)	8 (27)	17 (49)	37	6	9	✓		Highest scoring application for this BCT from nominal group participants
8b	Social support and encouragement	Allocate junior HCAs a senior HCA mentor Δ	11 (20)	4 (6)	3 (10)	0 (0)	18	7	1		✓	Alternative (8a) application of this BCT favoured by nominal group participants
9a	Modelling or demonstrating	*Workshop based* – provide a video of a senior and respected staff member enacting the desired behaviour/s +	6 (11)	4 (6)	1 (3)	4 (11)	15	4	3		✓	The relevant target behaviours would be difficult to model using this application i.e. not practical.
9b	Modelling or demonstrating	Senior nurse/s return to clinical practice and model the desired behaviours e.g., monitoring the vital signs and using NEWS appropriately Δ	10 (18)	10 (15)	2 (6)	5 (14)	27	5	3		✓	Unlikely to be sustained (not practical), may be expensive and could have negative side effects.
10	Commitment	*Workshop based* – use "I will" statements to affirm an intention e.g., the intention to monitor respiratory rate with every set of vital signs +	2 (3)	0 (0)	0 (0)	0 (0)	2	1	0		✓	May be viewed by clinical staff as patronising – difficult to deliver in a meaningful way
11	Identification of self as a role model	*Workshop based* –ask RNs to picture themselves enacting the desired behaviour/s and then ask them to consider who might be learning from their good practice +	2 (3)	0 (0)	0 (0)	0 (0)	2	1	0	✓		To ensure coverage of all TDF domains of high importance and all target behaviours
12	Action planning	*Workshop based* - develop "if … then" statements to link a cue to the desired behaviour +	3 (5)	3 (5)	0 (0)	0 (0)	6	1	0	✓		To ensure coverage of all TDF domains of high importance and all target behaviours

Table 2 (continued)

No.	Behaviour Change Technique (BCT)	Application (concrete strategy for delivering the BCT in practice)	Total scores from ranking activities (% scores)				Total score	Frequency BCT/ application ranked top 5 (denominator)		Included in the intervention		Brief rationale for decision to include or exclude from the intervention
			NGT1		NGT2			NGT1 (24)	NGT2 (13)			
			A (% of 55)	F (% of 65)	A (% of 30)	F (% of 35)				Yes	No	
13	Social reward	Senior staff on the ward praise junior staff when they enact the desired behaviour +	4 (7)	7 (11)	2 (6)	2 (6)	15	5	3	✓		To ensure coverage of all TDF domains of high importance and all target behaviours
14a	Information about others' approval	*Workshop based* – show a video of senior and credible nursing staff describing the behaviours that they approve of +	0 (0)	2 (3)	5 (17)	0 (0)	7	1	2	✓		To ensure coverage of all TDF domains of high importance and all target behaviours
14b	Information about others' approval	CCOT nurses to provide feedback to ward staff on their approval of appropriate escalation. Feedback should be given as soon after the escalation event as possible Ø	N/A	N/A	11 (36)	14 (40)	25	N/A	9	✓		Highest scoring application for this BCT from nominal group participants

Key:

A = Total score from ranking activity related to the perceived acceptability of the BCT/application combination to ward nursing staff

F = Total score from ranking activity related to the perceived feasibility of the BCT/application combination to ward nursing staff

+ Application from the information pack compiled by the research team

Δ Application proposed during NGT1 (the leadership group)

Ø Application proposed during NGT2 (the clinical group)

HCA Healthcare assistant, *RN* Registered Nurse, *CCOT* Critical Care Outreach Team

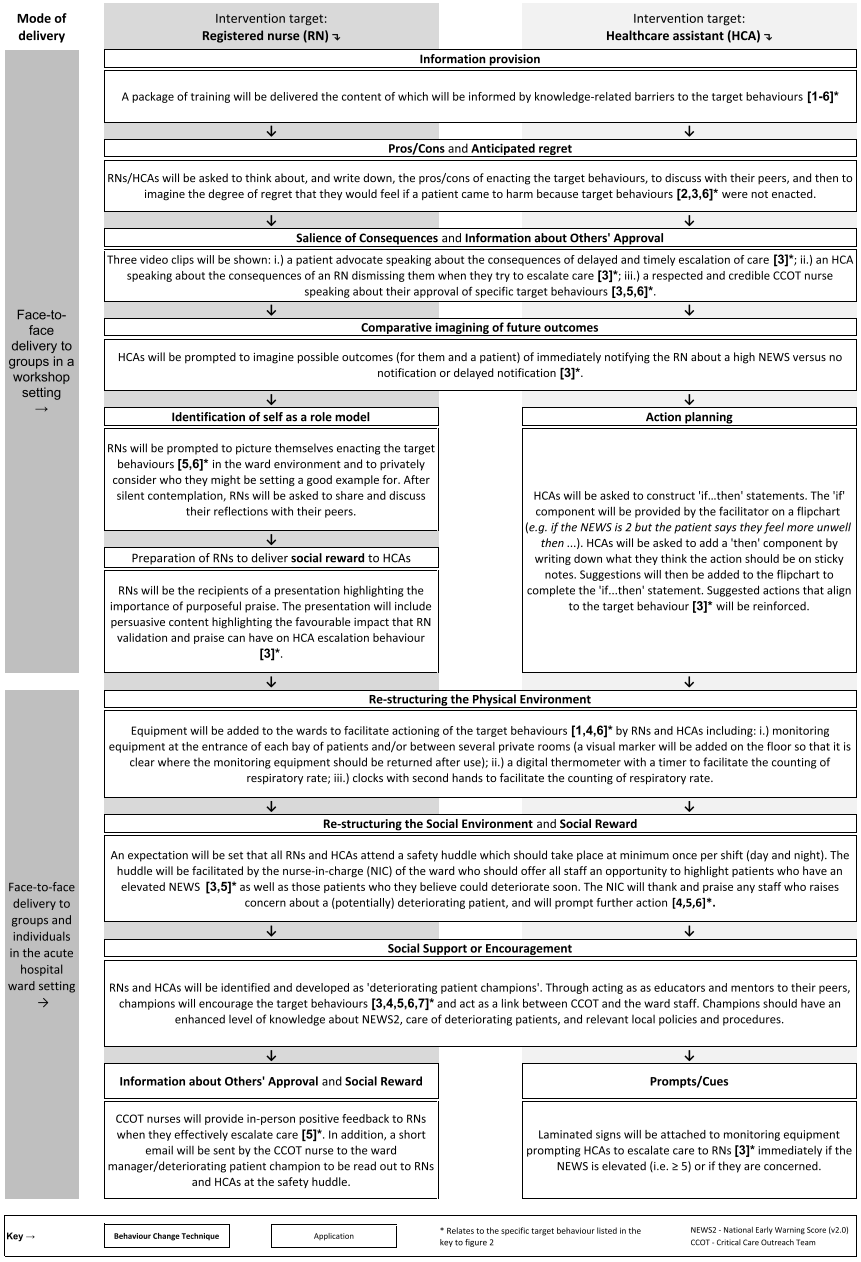

Fig. 4 An overview of a theoretically informed behaviour change intervention to drive more consistent behaviours of the afferent limb of the rapid response system by nursing staff

time and/or short staffing as barriers to participation in various activities [61, 62]. This may explain why workshop-based applications were viewed less favourably by participants. Where the application of a BCT involved modifying an existing patient safety mechanism ranking scores were favourable. An example of this is the application of the BCT *Re-structuring the Social Environment* through the re-organisation of 'safety huddles' (brief discussions that take place during a shift, between groups of clinical staff, with a focus on patient safety [45]). It is plausible that adjusting existing practices was perceived by participants to be less arduous

than introducing new approaches. Notwithstanding the potential challenges of delivering BCTs through workshops, we retained this mode of delivery for several applications, adopting a similar combined approach as reported in other published work [63]. When working in the clinical setting, healthcare practitioners often experience high cognitive load associated with interruptions and distractions [64, 65]. On this basis, we contend that some BCTs would be best applied outside the clinical environment, particularly where the specific applications involve participants imagining different clinical scenarios and/or reflecting on clinical practice. However, the acceptability and feasibility of delivering this combined intervention in the 'real world' setting will need to be explored further through piloting [36].

In a previous publication from this programme of work [58], the TDF domain *Knowledge* was identified as representing important barriers and enablers to the target behaviours. Despite this, none of the specific BCTs mapped from this domain were considered suitable for inclusion in this intervention. Whilst educational approaches alone are unlikely to be sufficient to drive behaviour change [66, 67], possession of knowledge is often a pre-requisite to the decisions individuals make and the behaviours they enact [67]. Consequently, despite the lack of appropriate BCTs, we opted to include a training component to our intervention that will address specific knowledge-related barriers identified from earlier empirical work [58, 68]. The importance of this is underscored by the wider literature where knowledge deficits have been reported as antecedents to afferent limb failure [21, 69, 70].

Throughout the process, we iteratively reviewed the broader dataset to ensure alignment between target behaviours, TDF domains, BCT/s, and their suggested application/s (this occurred during BCT shortlisting, rapidly during nominal groups, and more deliberatively during final consensus discussions). The importance of having continual oversight of the broader corpus of data to inform decision-making is highlighted by our handling of the BCT *Commitment.* This was the only shortlisted BCT linked to the TDF domain *Intentions* (a domain of high importance). Results of TDF-driven interviews (carried out earlier in this programme of work), confirmed that participant beliefs within this domain reflected strong intention to enact target behaviour/s (i.e. beliefs were enabling) with no modifiable barriers identified [58]. Consequently, inclusion of the BCT *Commitment*, which has the purpose of strengthening intention to change behaviour [32], was deemed redundant. Using findings of empirical work to inform pragmatic decision-making in this way enabled us to keep the number of BCTs to a minimum, which should increase the likelihood the intervention can be delivered to RNs and HCAs with high fidelity [59, 71].

Limitations

At present, there is no clear evidence base demonstrating that certain BCTs are more effective than others in relation to specific TDF domains. Consequently, we were reliant on expert consensus literature to identify BCTs that could be used to populate the intervention. The work by Cane et al. [40] (our primary source for BCT mapping) did not yield BCTs for two of our domains of high importance (*Memory, Attention and Decision Processes* and *Social, Professional Role and Identity*). Consequently, we relied on the original mapping matrix by Michie et al. [27] to identify additional techniques suitable for these domains. Whilst there is precedent for using these two reference sources in combination [59, 72], there is currently no single best approach for mapping TDF domains to BCTs.

Approximately 40% of individuals who volunteered to participate withdrew and/or did not attend their allocated nominal group. This resulted in a smaller than anticipated number of participants despite our decision to over-recruit. It is plausible that increased pressure on healthcare staff from the Coronavirus pandemic contributed to participant withdrawal, particularly as our clinical group participants were nursing staff involved in delivering direct patient care. Despite a smaller than anticipated number of participants, the clinical group included representatives from all grades of nursing staff who will potentially receive the intervention.

Only one HCA attended the clinical group. As HCAs are intended recipients of the intervention, the lack of representation is a noteworthy limitation. Given the potential importance of intervention acceptability in determining uptake of an intervention in practice [73], it has been advocated that intervention acceptability be assessed during feasibility testing [36]. We plan to use the Theoretical Framework of Acceptability [73] during feasibility testing to further examine the acceptability of our proposed intervention to HCAs (and other key stakeholders).

The information package provided to participants ahead of the nominal groups included a list of BCTs, their definitions, and example applications for each BCT. Providing example applications may have induced cognitive bias and specifically 'anchoring' [74]. That is, participants may have given a disproportionate level of thought to the example applications provided rather than considering alternate means of operationalising BCTs [74]. We attempted to mitigate this by emphasising the applications were only examples and through repeated encouragement of participants to think creatively and to

share their own ideas. Notwithstanding this limitation, given our participants were healthcare staff who were largely naïve to behaviour change methods, it is unlikely we would have completed all stages of the process, in the time available, if materials had not been provided beforehand [75, 76].

Conclusions

In this paper we present a behaviour change intervention populated with 12 theoretically informed BCTs that could be translated into practice through 18 different applications. Decision making regarding the content of the intervention was driven by information from group discussions where nominal group technique methods were applied. To the best of our knowledge, this is the first report of NGT methods being used to shape the content of a theory-based behaviour change intervention aimed at strengthening the afferent limb of the rapid response system. Further work will involve feasibility testing and expanding the detail of reporting (to the level of an intervention manual) to permit potential replication and evaluation.

Abbreviations

ALF: Afferent Limb Failure; APEASE: Acceptability, Practicability, Effectiveness, Affordability, Side effects, Equity; BCT: Behaviour Change Technique; ICU: Intensive Care Unit; NEWS: National Early Warning Score; NGT: Nominal Group Technique; RRS: Rapid Response System; SAE: Serious Adverse Event; TDF: Theoretical Domains Framework; UK: United Kingdom.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12913-022-08128-6.

Additional file 1. Information package for nominal group participants.

Additional file 2. Facilitator's guide for nominal groups.

Additional file 3. Professional role of participants attending nominal groups.

Additional file 4. The number and labels of the Behaviour Change Techniques (BCTs) mapped from each of the 9 Theoretical Domains Framework (TDF) domains of high importance.

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Authors' contributions

DS conceived and designed the study under the supervision of LMA. DS, LMA, MC and JD acquired the data, and DS, LMA, MC, JD and JH interpreted the data. DS drafted this paper with substantive revisions from LMA, JD, MC, and JH. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated or analysed during this study are included in this published article [and its supplementary information files].

Declarations

Ethics approval and consent to participate

Participants received an information sheet before participating in a nominal group. Informed consent was obtained from all study participants prior to the nominal groups commencing. All methods were performed in accordance with the relevant guidelines and regulations, and broadly adhered to the principles set out in the Declaration of Helsinki. Permission to conduct this research was granted by the National Health Service North of Scotland Research Ethics Committee (REC) (reference: 18/NS/0118), the Health Research Authority (reference as for REC), and the hospital's research and development department (reference: 18/0569).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Publisher's Note

5.5.2 Supplementary files from the third publication included within this thesis (either in volume 1 or volume 2)

Supplementary file label in publication 3	Document title	Volume and page number within this thesis
Additional file 1	Information package for nominal group participants (phase 3)	Volume 2, Appendix 12, page 77
Additional file 2	Facilitator's guide for nominal groups (in phase 3)	Volume 2, Appendix 11, page 67
Additional file 3	Professional roles of participants attending nominal groups	Volume 2, Appendix 29, page 143
Additional file 4	The number and labels of the BCTs mapped from each of the 9 TDF domains of high importance	Volume 1, Table 5.4, page 221

5.6 Summary

Results of a multi-phase programme of work to develop a theory-based behaviour change intervention to improve responses to deteriorating patients are reported in this chapter. In phase 1, 11 potential target behaviours of the afferent limb were identified from content analysis of field notes from focused ethnography conducted on two acute hospital wards over a period of 300 hours. The 11 behaviours identified were specified (using a published framework) and shortlisted to seven target behaviours through the application of published criteria and consensus discussion. In phase 2, paraphrased quotes from 89 brief interviews and verbatim quotes from 32 semi-structured interviews (informed by a TDF topic guide) were coded (deductively) to the 14 domains of the TDF and further analysed (inductively) to elucidate barriers and enablers (presented as belief statements and themes) to the target behaviours. Nine of the TDF domains met published criteria of high importance and were linked to BCTs using mapping tools informed by expert consensus literature. In phase 3, the 50 BCTs derived from the initial mapping exercise were shortlisted to 14 BCTs through consensus processes involving my academic supervisors and I. Shortlisted BCTs and example applications (concrete strategies for operationalising the techniques) were presented to stakeholders (healthcare staff) in two virtual nominal groups. Participants of nominal groups offered 11 additional applications suitable for the delivery of one or more BCT/s and ranked all BCTs/applications (i.e. examples suggested by my supervisors and I, and ideas generated by nominal group participants) for acceptability and feasibility. Ranking data were used to inform decision-making about which BCT/applications were included in the intervention. An outline of the intervention is provided which is comprised of 12 BCTs that will be delivered face-to-face at group and individual levels, to RNs and HCAs, through 18 applications. In the next chapter, the findings of this research and, specifically, the content of the preliminary intervention will be discussed, and the broader literature synthesised. Recommendations for further research, policy and clinical practice, and education will be made, and conclusions offered.

6 CHAPTER 6: DISCUSSION AND CONCLUSION

6.1 Introduction

Results from each phase of my PhD were presented in the previous chapter, which included three manuscripts that have been published in peer reviewed journals. Each manuscript included a discussion of findings from a specific phase of the project. In this chapter, themes discussed in the publications in chapter five will be expanded upon and new insights offered from a synthesis of findings from across the programme of research. Methods and results from each of the three phases will be summarised to demonstrate how study objectives have been met (see page 87). Findings will be broadly situated in the context of the organisation in which data were collected. Different strategies to ameliorate barriers and enablers to desired afferent limb behaviours will be discussed including system-level modifications (i.e. re-designing aspects of certain workflows within the Rapid Response System), and tailored behaviour change strategies targeting individual healthcare practitioners. The proposed preliminary intervention will be discussed further as this is the main output of my PhD research. This will include a summary of the origin of each application selected to operationalise a BCT in both workshop and ward settings. Strengths and limitations of the programme of work will be reported and recommendations made for research, policy and clinical practice, and education. Finally, a conclusion will be offered to summarise the entire programme of work and signpost future activities.

6.2 Summary of findings from the three phases of the project

In phase 1, focused ethnography was used to identify the extent to which expected behaviours of the afferent limb corresponded with behaviours observed in clinical practice, and to report where in the sequence of behaviours Afferent Limb Failure (ALF) was occurring (addressing objective 1). Eleven Registered Nurse (RN) and/or Healthcare Assistant (HCA) behaviours that could be targeted by a behaviour change intervention were identified and specified using a published framework by Presseau et al (2019) (Action, Actor, Context, Target, Time – AACTT) (Smith et al., 2020). Four behaviours were observed exclusively in the context of paper-based health records, when a paper National Early Warning Score (NEWS) chart and escalation of care

protocol were in use. One behaviour was observed exclusively in the context of the Electronic Health Record (EHR), where vital signs were recorded into a computerised version of NEWS2, and the escalation of care protocol displayed through 'pop-ups' appearing on the computer screen. Six behaviours were observed in both the paper and electronic contexts (see Publication 1, table 5). Through the application of published criteria (Michie, Atkins & West, 2014; Sargent et al., 2017) and consensus discussion (see section 4.5.5), the longer list of observed behaviours was shortlisted to seven target behaviours (see Publication 2, table 1).

In phase 2, to report determinants (i.e. barriers and enablers) of the specified target afferent limb behaviours a theoretical framework of behaviour change was applied (addressing objective 2). Barriers and enablers were linked to all 14 domains of the Theoretical Domains Framework (TDF) (Smith et al., 2021). Nine of the 14 TDF domains were identified as representing the most important barriers and enablers through the application of criteria from published TDF literature (Atkins et al., 2017; Goddard et al., 2018; McGoldrick et al., 2016) (see Publication 2, table 2). Mapping tools derived from expert consensus literature (Michie et al., 2008; Cane et al., 2015) were used to ensure the preliminary intervention was populated with theoretically informed content targeting the specific determinants of afferent limb behaviour (addressing objective 3). One hundred and twenty-seven belief statements (representing barriers and/or enablers expressed by interview participants) from nine TDF domains of high importance were linked to 50 Behaviour Change Techniques (BCTs) that could be included within the intervention (see Table 5.4).

In phase 3, using consensus processes involving my supervisors and I, the longer list of 50 BCTs was shortlisted to 14. To explore how intervention content could be applied in hospital wards and to prioritise intervention content (addressing objective 4) shortlisted BCTs and example applications were presented to clinical staff and healthcare managers in two virtual groups where Nominal Group Technique (NGT) methods were applied (nominal groups) (Smith et al., 2022). Ranking data from the NGT process were used to inform final consensus discussions (involving me and my supervisors) where the content of the intervention was agreed. The intervention comprises a training package and 12 BCTs that will be operationalised through 18 different

applications (addressing the overarching aim of the PhD) (Smith et al., 2022). Nine of the BCTs will be delivered to both RNs and HCAs through the same applications, two BCTs will be delivered exclusively to HCAs, and one BCT will be delivered exclusively to RNs. Six BCTs will be delivered in a workshop, five BCTs will be delivered in the hospital ward setting, and one BCT will be delivered in both workshop and ward settings using different applications (see Publication 3, figure 4).

6.3 Re-visiting the context in which the intervention was developed

The intervention I propose was developed in a large NHS Trust ranked in the top 60 healthcare providers globally and in the top 5 hospitals within the UK (Newsweek, 2022a). This ranking information was derived from three data sources: 1.) recommendations from healthcare practitioners, 2.) results from patient surveys, 3.) key performance indictors (e.g. quality of care, hygiene and patient safety, staff to patient ratios) (Newsweek, 2022b). Despite this favourable profile, at ward-level, close to half of the data I collected in phase 1 of my research represented behaviour/s that did not align to local deteriorating patient policy (Smith et al., 2020). Further, on seven separate occasions whilst present on an acute ward, I was required to cross the boundaries of my researcher role and take action to ensure patient safety (see section 5.4.2). Given these events occurred within an organisation considered relatively high performing, it is plausible that the policy breeches I identified (i.e. where desired behaviour is not enacted correctly or at all) will be occurring to a similar, or even greater, extent in other healthcare settings. These findings broadly highlight the importance of this programme of work.

6.4 System re-design versus individual behaviour change

During fieldwork, I was able to observe afferent limb behaviour of nursing staff before and after the implementation of an EHR system, which was activated in all clinical areas of the Trust at the same time and included a shift from paper-based NEWS to an electronic version. Before the activation of the EHR (i.e. in the paper records context), I observed incorrect calculation of the NEWS on the paper chart. This finding is consistent with results from other published work (Odell, 2015; Credland, Dyson & Johnson, 2018). In the pre-EHR context, these errors reflected one

aspect of ‘unexpected behaviour’ related to the key moment *recording the vital signs and/or calculating the NEWS* (the other behaviour related to this key moment was *documenting the vital signs on the paper NEWS chart or entering them into the EHR*). Following EHR activation, calculation of the aggregate NEWS became automated, meaning that no further calculations were performed by nursing staff. The elimination of human error related to score calculation likely explains why the proportion of unexpected behaviour for the same key moment halved after activation of EHR (dropping from 43% to 21%), with only unexpected behaviour related to recording vital signs data persisting (Smith et al., 2020). These findings demonstrate the potential of health information technology (IT) to optimise some nursing workflows[11].

In the wider context, the use of health IT is a burgeoning area with potential to improve patient safety (Carayon et al., 2014), increase organisational efficiency (Zhivan & Diana, 2012), and improve patient satisfaction (Zabada, Singh & Munchus, 2001). It has been argued that health IT systems are interventions in their own right and should be designed and evaluated using rigorous processes (Campanella et al., 2016). As system-level patient safety interventions, the implementation, evaluation, and re-design of health IT systems has been anchored to the field of Human Factors and Ergonomics (HFE) (Xie & Carayon, 2015; Carayon et al., 2014). Broadly, HFE aims to accumulate knowledge to re-design systems and processes to optimise patient care and safety (Carayon et al., 2014). Practically, models such as SEIPS (Systems Engineering Initiative for Patient Safety) have been proposed to inform systems evaluation from a HFE perspective (Carayon et al., 2006). SEIPS incorporates the conceptual model proposed by Donabedian (1988) for evaluating the quality of healthcare; the premise of which is that information about healthcare quality can be drawn from the following categories: *structure* (i.e. the context in which care is delivered), *process* (i.e. the sum of actions involved in the delivery of healthcare), and *outcome* (i.e. the effect of healthcare on patients and/or populations) (Donabedian, 1988, 1978). SEIPS has been offered as an extension of the structure-process-outcome model with ‘structure’ replaced by ‘work system’ and a more detailed description of the components thereof including person,

[11] Defined as the sequence through which a task moves from initiation to completion (Wu et al., 2017).

organisation, technology and tools, tasks, and environment (Carayon et al., 2006). These inclusions reflect growing recognition that systems re-design should take into consideration the context in which systems operate and the behaviour of individuals who interact with the system (Carayon et al., 2014). Further, system-level optimisation requires exploration of factors that hinder (termed performance obstacles) and facilitate individuals when they are operating within the system (Carayon et al., 2014). In this way, some overlap is evident between the application of a determinant framework such as the TDF (Nilsen, 2015), and HFE models such as SEIPS (Carayon et al., 2006).

In my research, numerous participants in phase 2 reported workflow barriers (or performance obstacles using HFE terminology) and enablers related specifically to the use of the EHR. Enablers reported by participants included the clear display of numerical data (i.e. vital signs) and the availability of information (e.g. vital signs and NEWS) to multiple clinicians at the same time. Barriers included the lack of colour-coding to draw attention to abnormalities in vital signs (the EHR display format was noted to be monochrome compared to the colour-coded paper chart), and information about how the aggregate NEWS was derived (i.e. which specific vital signs were abnormal and contributing to the overall score) (Smith et al., 2021). Whilst noteworthy, these features of the EHR are not directly modifiable through the application of BCTs. However, these data could be used to inform adjustments to how vital signs data are displayed within the EHR.

Whilst the implementation of the EHR completely eliminated one problematic behaviour (incorrect calculation of NEWS), other unexpected behaviours persisted after the EHR had been activated. Specifically, I observed several HCAs writing vital signs from multiple patients on miscellaneous pieces of paper or paper towels, before later entering all the vital signs into the EHR at a desktop computer, rather than entering directly into the EHR at the bedside (the desirable behaviour) (Smith et al., 2020). Similar behaviours were reported from an observational study conducted in Australia (Cardona-Morrell et al., 2015). When these behaviours were explored further during interviews, some participants reported specific barriers to recording directly into the EHR including it being difficult to input the data using a hand-held device, and challenging to

review vital signs due to the screens on the hand-held devices being small (Smith et al., 2021). These data exemplify how inadequacies in IT hardware can influence staff behaviour. Results from my research are broadly supported by those of a TDF-based study conducted in Australia, where the aim was to explore the barriers and enablers encountered by RNs when using an EHR (Jedwab et al., 2022). Here, participants reported barriers related to EHR hardware and the system including layout of information, screen navigation and language use (Jedwab et al., 2022). Collectively, these results support assertions from the literature that when IT systems are poorly designed, healthcare practitioners may use maladaptive approaches to achieve a task (i.e. they develop 'workarounds') (Stevenson et al., 2018). In addition to barriers from IT infrastructure, I identified deficits in knowledge from RNs and HCAs about the procedure for recording vital signs, and knowledge barriers related to the perceived consequences of recording vital signs on paper versus recording directly into the EHR (linked to the TDF domains *Knowledge* and *Beliefs about Consequences*) (Smith et al., 2021). Whilst replacing hardware (i.e. the hand-held devices) with equipment that is more fit-for-purpose could address equipment-related barriers, providing correct procedural information (to target gaps in *Knowledge*) and delivering suitable BCTs to address *Beliefs about Consequences* could re-shape beliefs and facilitate desirable behaviour from nursing staff who use the EHR.

In the organisation where my research was conducted, the implementation of EHR did not alter the workflows related to the monitoring of vital signs (i.e. routine and responsive) or the escalation of care (within and outside of the ward-based nursing team). In the wider literature, reports were found where specific afferent limb behaviours were replaced by technology; that is, clinician behaviours were eliminated through system re-engineering. One example of this is the substitution of intermittent measurement of vital signs by nursing staff with the use of 'wearables' for continuous monitoring. Wearables are electronic devices that are typically wireless and can be worn as an accessory by the user (i.e. a patient) (Areia et al., 2021). Components of a wearable vital signs monitoring device typically include a display console (where the vital signs appear and can be seen by the patient and healthcare staff), which may be worn (e.g. as a smart watch), and the monitoring elements which acquire the physiological data (e.g. blood pressure cuff, pulse

oximetry probe, respiratory rate electrode) (Stellpflug et al., 2021). During fieldwork in phase 1, I recorded discrepancies between the respiratory rate that I counted, and the respiratory rate recorded in NEWS on multiple occasions. On 28 of 37 (76%) occasions, the respiratory rate that I counted was higher than the respiratory rate recorded by the ward HCA or RN (Smith et al., 2020). The finding that respiratory rate is often measured and/or recorded incorrectly is consistent with other published work (Weenk et al., 2019; Kallioinen et al., 2020; Badawy et al., 2017). One potential benefit of wearable devices is the elimination of the need for nursing staff to count a respiratory rate manually (Weenk et al., 2019).

For the key moment 'responsive monitoring of vital signs', over 60% of episodes that I observed were categorised as 'unexpected behaviour' in both the paper and EHR settings (Smith et al., 2020). This high proportion of unexpected behaviour is largely explained by failure to re-assess vital signs following an elevated NEWS (Smith et al., 2020). Similar levels of non-adherence with monitoring protocol have been reported (Credland, Dyson & Johnson, 2018; Eddahchouri et al., 2021). An additional advantage of wearable devices is that they eliminate the need for nursing staff to intermittently measure and record vital signs as the information is measured continuously, displayed in real time, and stored (Areia et al., 2021; Weenk et al., 2019; Stellpflug et al., 2021). In addition to the clinical advantages, there is some evidence that wearables are more cost effective than the intermittent monitoring of vital signs (Javanbakht et al., 2020). However, this research was conducted on a post-operative cohort of surgical patients, and it remains unclear how these economic benefits might translate into other clinical settings.

During my research, I frequently observed nursing staff (particularly HCAs) carrying out routine monitoring of vital signs. Unlike the other behaviours of the afferent limb that were only enacted in specific circumstances, routine monitoring appeared to occur at four hourly intervals irrespective of patients' NEWS or clinical condition (Smith et al., 2020). Similar findings have been reported from other research where nursing staff were directly observed in clinical practice (Mackintosh, Humphrey & Sandall, 2014; Ede et al., 2019). During the TDF interviews, several participants emphasised their commitment to enact patient monitoring and reported setting the goal

to prioritise routine monitoring above other clinical tasks (Smith et al., 2021). These beliefs could partly explain why routine monitoring behaviours occurred so consistently. An alternative explanation is that routine monitoring is driven by habit; that is, the behaviour is enacted because of an automatic cognitive process triggered internally and/or cued by the environment, rather than being the endpoint of effortful and deliberative decision-making (Presseau et al., 2014b; Nilsen et al., 2012). According to NEWS2 guidelines, patients with an aggregate score of 0 may have their vital signs measured every 12 hours (i.e. once per shift) unless there is a specific indication to observe more frequently (Royal College of Physicians, 2017). This recommendation has translated into the local policy for the Trust where this study was conducted. It is plausible that for some patients having their vital signs measured every 4 hours would have been unnecessary (reflective of 'over monitoring') as 12 hourly monitoring of vital signs would have been sufficient. Whilst I observed routine monitoring occurring with a high degree of consistency, adherence with responsive monitoring guidance was less than 50%, with RNs and HCAs frequently citing high workload and competing priorities as a barrier to increasing frequency in patients with an elevated NEWS (Smith et al., 2021, 2020). To release time and resources for increased monitoring of the most vulnerable patients, it may be necessary to decrease the monitoring of patients who are more stable and less likely to deteriorate (i.e. those with a NEWS of 0). It has been suggested that de-implementation (i.e. reducing an unnecessary, wasteful, or harmful practice) requires more effort than implementation of an evidence-based desirable practice (Haskell et al., 2021; Presseau et al., 2019; Patey et al., 2018). Therefore, further empirical work is required to clearly define unnecessary monitoring in the context of the RRS, to measure frequency in clinical practice, to explore potential causal mechanisms, and to identify and evaluate intervention strategies aiming to address it (Grimshaw et al., 2020).

During semi-structured interviews in phase 2, numerous participants reported using additional clinical information to inform decision-making about what actions to take for a potentially deteriorating patient. This included reviewing trends in the vital signs and the aggregate NEWS, and considering medical history, current symptoms, and how the patient appeared (Smith et al., 2021). This finding that nurses use broader information (i.e. broader than vital signs and/or EWS)

to inform decisions about deteriorating patients (linked to the TDF domain *Memory, Attention, and Decision Processes* in my work) is consistent with results from other international research (Kitto et al., 2015; Ede et al., 2021; Minyaev, Harrington & King, 2021). The additional clinical information used in decision-making by participants of my research, has also been linked to 'nurse worry'; that is, this information can contribute to the degree of worry or concern that a nurse has about a patient in their care (Douw et al., 2015, 2017). Whilst the EHR permits nurses to access vital signs and NEWS remotely (i.e. away from the patient's bedside), other signs and symptoms (e.g. pain, agitation, noisy breathing) linked to 'worry' (Douw et al., 2017) may only be recognised when the nurse is near the patient and interacting with them. The measurement of vital signs provides an opportunity for such a nurse-patient interaction (Cardona-Morrell et al., 2015). A disadvantage of using wearable monitoring devices is that they could reduce the frequency of nurse-patient interactions, and the opportunity for broader clinical assessment (Areia et al., 2021).

It is also possible that the frequency of nurse-patient interactions could be decreased when aspects of clinical care are undertaken by other members of the healthcare team. During fieldwork, I observed RNs who had been notified by an HCA that a patient had an elevated NEWS, asking the HCA to re-measure vital signs rather than re-assessing the patient themselves. This was recorded as 'unexpected behaviour' as it breached policy (Smith et al., 2020). These moments may have represented missed opportunities for RNs to interact with patients, to perform further assessment that might inform decision-making, and to develop clinical concern for the patient. Consequently, the intervention that I propose includes techniques to overcome barriers and enhance enablers to RNs re-assessing patients themselves when they are notified that a patient in their care may be deteriorating.

During phase 1 data collection, I observed policy breaches related to escalation of care within and outside of the ward-based nursing team (Smith et al., 2020). On three occasions, where the RN or HCA did not escalate care as expected, I was required to cross the boundaries of my researcher role and intervene to ensure patient safety (see section 5.4.2). Within the wider literature, reports were found where escalation workflows had been re-engineered to include

automated escalation in place of clinician escalation. Here, an automated message is sent to a suitable clinician (e.g. via a mobile phone or pager device) when a patient's vital signs are abnormal and specified criteria are met, thereby eliminating the need for nursing staff to enact escalation behaviours (Fagan et al., 2012). Given the potential risk to patients associated with discrepancies in escalation of care, re-designing the system in this way is pragmatically appealing (Danesh & Jimenez, 2015). However, findings from empirical studies related to automated escalation are equivocal. The potential consequences of this system re-design were evaluated in a study conducted in the USA involving a large database of vital signs (n=6,948,689 consecutive records) obtained from a large cohort of patients (n=34,898) (Romero-Brufau et al., 2014). The researchers simulated alerts using a variety of commonly used track-and-trigger tools (including NEWS) and examined the possible outcomes for patients and the system at different time points. Findings of this work suggest a high frequency of false positive alerting (i.e. where an automated escalation would have occurred when it was not required), with all the track-and-trigger tools tested, leading to the conclusion that existing track-and-trigger tools are not ready to be embedded within automated systems (Romero-Brufau et al., 2014). These findings are congruent with results from earlier research on automated escalation (Fagan et al., 2012) and further corroborated by research examining the predictive performance of NEWS, where the proportion of false positive alerts has been reported at 28% (681 of 2395 patients with no negative outcomes breached criteria) (Spagnolli et al., 2017). Given the propensity of NEWS to deliver false positive alerts, it is plausible that some of the 'unexpected behaviour' related to escalation of care that I observed may have reflected decision-making from an RN or HCA to override escalation of care policy on the basis that a patient's NEWS was falsely elevated. This idea is further underpinned by my interview data, where RN and HCA participants expressed mixed beliefs about the accuracy of NEWS in predicting patient deterioration (Smith et al., 2021). Whilst the decision to override NEWS may be appropriate in some circumstances, there is a risk that false positive scoring may desensitise staff and could result in care of patients who are genuinely deteriorating being delayed (Olsen et al., 2019).

Historically, the recording of vital signs involved the use of paper-based charts which is reflected in the original design and the content of both the NEWS1 and NEWS2 charts (see appendices 1 and 2). Well-designed health IT systems have the potential to mitigate human errors within complex workflows and improve patient care (Xie & Carayon, 2015). The adoption of electronic health records by more acute hospitals increases the potential for more sophisticated and individualised track-and-trigger tools to be used including those that can generate a score from vital signs, trends in vital signs, demographic information, and/or other objective clinical data (e.g. laboratory information). Within the wider body of literature, there is already some evidence that tools that harness machine learning in this way may predict SAE more accurately than NEWS (Zhu et al., 2020; Chiu et al., 2020; Akel et al., 2021). As the use of technology in healthcare becomes increasingly pervasive, it is likely that the NEWS will be substituted with a more effective EWS. In relation to the behaviours of healthcare staff directed by NEWS, automating the monitoring of vital signs and/or escalation of care could eliminate sub-optimal behaviours. However, these fully automated systems are in their infancy, lack a robust evidence base, and have not yet been adequately evaluated for cost-effectiveness (Cardona-Morrell et al., 2016). Consequently, these technologies may not be routinely available to all patients for several years. Whilst a change in the EWS may be more imminent, it is possible that some (if not all) RN and HCA behaviours (and the determinants thereof) that I identified will remain important in clinical practice irrespective of whether the signal of potential deterioration is derived from the NEWS or an alternate EWS.

Whilst NEWS out-performs several track-and-trigger tools used internationally (particularly those that were designed to be used in a paper-based context) (Green et al., 2018; Tirkkonen et al., 2014), the empirical literature provides a clear signal that the tool itself has limitations (Spagnolli et al., 2017; Fernando et al., 2019; Haegdorens et al., 2019). There is also evidence that the policies that direct the use of NEWS in clinical practice are of variable quality with inconsistencies and ambiguities related to the context in which NEWS-directed afferent limb behaviours should occur, the timing of the behaviours, and the healthcare practitioner who is responsible for enactment (Freathy et al., 2019; Smith et al., 2019). Findings from my work suggest that around 40% of the afferent limb behaviour enacted by RNs and HCAs do not comply with

NEWS related policy (Smith et al., 2020). In the absence of a flawless EWS, encouraging nursing staff to consistently enact policy specified behaviours without opportunity for decision-making could result in high frequency efferent limb activations, alarm fatigue in responders (Olsen et al., 2019; Connolly et al., 2017), and reduced sustainability of the Rapid Response Team (RRT) (Jones et al., 2015). Consequently, it could be argued that working towards 100% adherence with NEWS guidelines is both unattainable and undesirable. This creates a challenging landscape for researchers and practitioners attempting to increase the translation of NEWS and associated guidelines into routine clinical practice.

Findings of my research highlight the need for a tailored intervention that facilitates the enactment of desired behaviours with adequate consistency to mitigate ALF, whilst creating space for appropriate actors to make clinical decisions commensurate with their professional role. Whilst important barriers and enablers to RNs' afferent limb behaviour were linked to the *Memory, Attention and Decision Processes* domain (Smith et al., 2021), in the preliminary intervention I propose, RNs are not targeted by BCTs that could modify decision processes. This decision was made through critical discussion and debate amongst members of the research team and reflects our acknowledgement of the limitations of NEWS and the important role that ward RNs have in 'filtering' RRT activations (Gerry et al., 2020; Minyaev, Harrington & King, 2021; Sprogis et al., 2021b). In comparison, selected BCTs will be delivered to HCAs to re-shape their decision-making and to prompt desired behaviour at the point of care. This content was selected based on results from my TDF interviews, where some HCAs reported making clinical decisions beyond the scope of their role, that could delay escalation of care for patients with an elevated score. Example decision processes, described by HCA participants, included encouraging patients with low blood pressure to "drink more water" before re-measuring the vital signs and deciding if the RN should be informed, or instructing patients with low peripheral oxygen saturations to "take some deep breaths" and observing the response before deciding if the RN should be notified. Two BCTs (*Action planning* and *Prompts/cues*) will be delivered to modify beliefs (representing barriers) identified by HCAs and linked to the TDF domain *Memory, Attention and Decision Processes*. First, I hope to substitute decision making from HCAs with a more restrictive action plan that will be

developed during the intervention workshop. Second, desired escalation behaviour will be prompted in the ward context using signage attached to the vital signs monitoring equipment.

6.5 The components of the proposed preliminary behaviour change intervention

The output of my doctoral research is a preliminary behaviour change intervention that will be delivered to RNs and HCAs to drive more consistent implementation of NEWS and the associated escalation of care protocol. The intervention includes 12 BCTs that will be delivered through 18 applications. Six of the 18 applications included in the intervention were suggested by nominal group participants. The remaining 12 applications originated from the information package compiled by my supervisors and I ahead of the nominal groups. The applications that we proposed originated from several sources which are illustrated in Table 6.1. The inclusion of an educational component within the intervention will be justified and potential strategies for delivering the educational component discussed. Two applications of BCTs ('safety huddles' and 'safety champions') have a body of empirical literature underpinning their use in the context of patient safety. Consequently, the use of these specific applications will be discussed in greater depth and the literature related to these strategies synthesised.

Table 6.1 – origin of the different applications included in the draft behaviour change intervention

Behaviour Change Technique (BCT)	Application/s of the BCT	Origin of the application		
		Suggested by a nominal group participant	Proposed by the research team*	Original source/s for applications proposed by the research team*
Action planning	Develop "if…then" statements to link a cue to the desirable behaviour		✓	Byrne-Davis, Bull and Hart, 2019
Anticipated regret	Ask RNs/HCAs to consider the degree of regret that they might feel if the desirable behaviour was not enacted, and a patient came to harm		✓	Michie *et al.*, 2013
Comparative imagining of future outcomes	Prompt HCAs to imagine and compare likely or possible outcomes following immediate escalation of a deteriorating patient to the RN versus no escalation or delayed escalation		✓	Michie *et al.*, 2013
Identification of self as a role model	Ask RNs to picture themselves enacting the desirable behaviour/s and then ask them to consider who might be learning from their good practice		✓	Byrne-Davis, Bull and Hart, 2019
Information about others' approval	Show a video of senior and credible nursing staff describing the behaviours that they approve of		✓	Byrne-Davis, Bull and Hart, 2019

Behaviour Change Technique (BCT)	Application/s of the BCT	Origin of the application		
		Suggested by a nominal group participant	Proposed by the research team*	Original source/s for applications proposed by the research team*
	CCOT nurses to provide feedback to ward staff on their approval of appropriate escalation. Feedback should be given as soon after the escalation event as possible.	✓		
Prompts/cues	Attach laminated signs to vital signs monitoring equipment to prompt the desirable behaviour		✓	Michie *et al.*, 2013
Pros/Cons	Ask RNs/HCAs to list and compare pros and cons of enacting the desirable behaviour		✓	Michie *et al.*, 2013
Re-structuring the physical environment	Add vital signs monitoring equipment to the environment		✓	Byrne-Davis, Bull and Hart, 2019
	Add a visual marker on the floor to signal where the vital signs monitoring equipment should stand	✓		

Behaviour Change Technique (BCT)	Application/s of the BCT	Origin of the application		
		Suggested by a nominal group participant	Proposed by the research team*	Original source/s for applications proposed by the research team*
	Add clocks with second hands to the ward to enable monitoring of respiratory rate	✓		
	Add more digital thermometers with timers for 15s, 30s, 60s	✓		
Re-structuring the social environment	Set the expectation that HCAs attend ward safety huddles alongside RNs to facilitate escalation of deteriorating patients		✓	Brady *et al.*, 2013; Goldenhar *et al.*, 2013; Montague *et al.*, 2019; Franklin *et al.*, 2020; Pimentel *et al.*, 2021
	Use clinical cases during safety huddles as a stimulus for conversation	✓		
Salience of Consequences	Show videos of patients speaking emotively about the consequences of delayed escalation and timely escalation		✓	Byrne-Davis, Bull and Hart, 2019

Behaviour Change Technique (BCT)	Application/s of the BCT	Origin of the application		
		Suggested by a nominal group participant	Proposed by the research team*	Original source/s for applications proposed by the research team*
	Show videos of patients speaking emotively about the consequences of timely escalation	✓		
Social reward	Senior staff on the ward praise junior staff when they enact the desirable behaviour		✓	Michie *et al.*, 2013
Social Support and Encouragement	Deploy deteriorating patient champions (HCA and RN level) and ensure clear expectations/training		✓	Campbell, 2008; Jornsay and Garnett, 2014; Luton *et al.*, 2018; MacKay *et al.*, 2020

6.5.1 Knowledge-related barriers and strategies to address these barriers

Knowledge was identified as an important determinant of target behaviour in my research, with numerous barriers, enablers and competing beliefs in the domain (Smith et al., 2021). To address empirically deduced knowledge deficits (Smith et al., 2021), the draft intervention proposed includes an educational package addressing barriers identified from interviews (phase 2) (Smith et al., 2021). Knowledge is a pre-requisite to decisions individuals make and behaviours they enact (Ajzen et al., 2011). Whilst possession of accurate information is not independently associated with behaviour change (Ajzen et al., 2011; Kelly & Barker, 2016; Grimshaw et al., 2004), knowing what action is required, when and how, is necessary for desired behaviour to occur (Ajzen et al., 2011). To exemplify, if an individual who is motivated to measure respiratory rate knows the correct procedure for performing the task, then the probability that the desired behaviour will occur increases, particularly when the environment (social and/or physical) is also favourable (Michie, van Stralen & West, 2011).

COVID-19 has accelerated use of technology-enabled approaches for teaching and learning in both academic and healthcare settings (Harlan, Rosenzweig & Hoffmann, 2021; Vizcaya-Moreno & Pérez-Cañaveras, 2020). The current phase of the pandemic, where imposed social restrictions are reducing, provides opportunities to compare face-to-face with online modes of delivery (King et al., 2021). 'Blended learning' describes educational packages that include face-to-face and online activities that have been coherently woven together to promote active and student-centred learning (Dehghanzadeh & Jafaraghaee, 2018; Youhasan et al., 2021). One reported approach for blended learning is the use of a flipped classroom, where 'basic' knowledge (e.g. key principles) is acquired before class; leaving classroom time available for interactive activities that promote higher level thinking (e.g. critical evaluation and application of the same key principles) (Chen et al., 2018; Young & Seibenhener, 2018). Practically, this could involve providing learners with a series of digital resources (e.g. PowerPoint presentations with voiceover narration and/or videos) to work through pre-class, before structuring the classroom activities around group work with support from a knowledgeable facilitator (Harlan, Rosenzweig & Hoffmann,

2021; Youhasan et al., 2021; Khodaei et al., 2022; Young & Seibenhener, 2018). Within the published literature, it has been proposed that flipped classroom approaches improve problem-solving, communication, critical thinking, engagement, confidence, satisfaction, self-directedness (Youhasan et al., 2021), and metacognitive[12] awareness amongst learners (Khodaei et al., 2022). However, the body of work focusing on the use of flipped classroom approaches is heterogeneous and methodologically weak. Further, undergraduate nursing students were frequently sampled, making it unclear if these findings could be generalised to RNs and HCAs. This mode of delivery also requires access to technology making recipients susceptible to infrastructural barriers (e.g. lack of access to hardware, poor internet connectivity), and potential digital inequality (Forsetlund et al., 2021).

Use of a blended approach to deliver the educational elements could enable us to condense the workshop component of the intervention so that it is less time consuming. This may be advantageous as both RNs and HCAs identified high workload, competing priorities, and staff absence as challenges, within the workplace, during interviews (linked to the TDF domain *Environmental, Context and Resources)* (Smith et al., 2021). Similar constraints have been reported in other publications (Wood, Chaboyer & Carr, 2019; Olsen et al., 2019; Treacy & Stayt, 2019; Walker et al., 2021). The pragmatic appeal notwithstanding, the acceptability of a blended educational package and other intervention components, could be assessed further by embedding a process evaluation within a feasibility study (as described by Story *et al.*, 2002; Disbeschl *et al.*, 2021) (a programme of work planned for after my PhD).

Some participants reported being motivated, often strongly, to enact 'best practice' behaviours of the afferent limb according to local policy and procedure. Despite the relatively strong intention reported by RNs and HCAs to follow the local policy, knowledge about its existence and content were highly variable (Smith et al., 2021). This creates an interesting paradox, suggesting that whilst some staff were strongly motivated to act according to national and

[12] Metacognition relates to an awareness of one's own thought processes (Diamond-Fox & Bone, 2021).

organisational guidelines, their knowledge of both was limited. In the wider literature, a lack of awareness of the existence of policy and lack of familiarity with the content thereof have been cited as potential barriers to healthcare practitioners' adherence to clinical guidelines (Cabana & Kim, 2003; Cabana et al., 1999; Haw, Stubbs & Dickens, 2015; Grol & Grimshaw, 2003; Fasugba et al., 2021). Explanations for the lack of awareness of policy may stem for the nature of the documents themselves. From a documentary analysis of local deteriorating patient policies, it was highlighted that these documents are often large, unwieldy and written using language that is ambiguous and cannot be easily translated into action (Smith et al., 2019; Freathy et al., 2019). Findings from my PhD work suggest that nursing staff favour clear and concise information, supported by visual prompts (e.g. colour coding) that can be easily accessed and followed in a busy clinical environment (Smith et al., 2021). These findings are broadly consistent with other research findings that suggest nurses favour social interaction (e.g. discussion with a colleague perceived to be more expert), as opposed to accessing print or electronic-based sources which was reported to be a 'daunting' task due to the character and volume of the information (Marshall, West & Aitken, 2011; Walker et al., 2021). In order to make deteriorating patient policy accessible to nursing staff, those responsible for writing and disseminating these documents should ensure that content is presented in a suitable form for the intended audience, and that the language is adequately specific for enactment (Smith et al., 2019; Presseau et al., 2019; Michie & Johnston, 2004).

Barriers and enablers to the target behaviours were reported across numerous domains of behavioural determinants in my research suggesting that the mediators and moderators in this space are wide-ranging. The notion that healthcare practitioner behaviour change is determined by a range of barriers and enablers including, but not limited to, underpinning knowledge, is consistent with the findings of an alternate TDF study focusing on the recognition and response to deteriorating patients in the Australian context (Walker et al., 2021). Past strategies to address sub-optimal care and ALF have predominantly been educational and to a lesser extent skills-based training (Liaw et al., 2016; Duff et al., 2018; Connell et al., 2016; Saab et al., 2017). Whilst educational programmes have been seen to broadly improve health practitioner confidence and competence in recognising and responding to deteriorating patients, there is a paucity of studies

that have attempted to measure the impact of the education on staff behaviour in clinical practice or on patient outcomes (Connell *et al.*, 2016; Fuhrmann *et al.*, 2009). Despite compelling evidence that education-only approaches do not result in sustained behaviour change (O'Brien et al., 2007; Giguère et al., 2012; Forsetlund et al., 2009; Saab et al., 2017), these educational programmes appear to have been developed based on *tacit* assumptions that deficits in knowledge are the likely antecedents to ALF, and that addressing these deficits will result in a change in nursing staff behaviour. The tendency to focus on individual determinants of behaviour (i.e. deficits in clinicians' knowledge) over situational determinants (i.e. barriers related to the social or environmental context), may partly explain why ALF remains problematic despite the delivery of a range of different educational programmes over a prolonged period. My PhD findings suggest that education is only part of the picture for addressing ALF, and that a range of carefully selected and tailored strategies will be required to target this pervasive problem.

6.5.2 Delivering intervention components in different settings

The importance of context in the delivery of educational packages and other intervention strategies has been emphasised (Eddy, Jordan & Stephenson, 2016). In the intervention that I propose, BCTs will be delivered within and outside of the ward setting (see publication 3, figure 4). This design is broadly similar to other interventions developed using to the TDF to improve the translation of bronchiolitis guidelines (Haskell et al., 2021) and malnutrition screening tools (Jobber et al., 2021) into clinical practice. Participants in phase 3 of my research broadly favoured ward-based BCTs and applications over workshop-based strategies (reflected by NGT ranking data) (Smith et al., 2022). This preference by nursing staff for workplace development activities is consistent with findings from other published work (King et al., 2021). Despite these findings, I still plan to deliver aspects of the educational package and six BCTs within a workshop context. This decision is underpinned by findings of my own fieldwork, and the wider literature, which suggest that ward environments are unpredictable (Smith et al., 2020), that ward nursing staff often having competing priorities (Smith et al., 2021), and that interruptions and distractions are common in the ward setting (Freitas et al., 2021; Kellogg et al., 2021; Jones & Johnstone, 2017; Holden et al., 2011). Environments with these characteristics are unlikely to be conducive for delivering activities

where individuals will be prompted to carefully consider their behaviour/s (and the potential consequences thereof), to reflect on others' insights about their actions, and make plans for future behaviour (Michie et al., 2013). Whilst the available evidence is weak, there is also some suggestion that the use of workshops to deliver Continuing Professional Development (CPD) for healthcare practitioners improves uptake of desired clinical behaviour (Forsetlund et al., 2021).

Our decision to target mixed groups of RNs and HCAs for most workshop-based activities is supported by findings from a rapid review of studies focusing on the optimisation of CPD for nurses (King et al., 2021). Here, the authors reported that workplace transformation was more likely when CPD was multi-disciplinary (i.e. undertaken with co-workers from different roles). Findings of this review also underscore the importance of delivering some BCTs within the ward context. Results of the review imply that the translation of learning from CPD activities into the workplace is optimised when the culture of the clinical setting is believed to be positive, and when leaders are perceived as strong and visible (King et al., 2021). The overarching aim of several BCTs that I propose to deliver in the wards (*Restructuring the Physical Environment; Restructuring the Social Environment; Social Reward; Social Support or Encouragement; Information about Others' Approval*) will be to optimise the physical and social environment and/or create a positive and enabling culture for behaviour change to occur and for target behaviours to be enacted.

6.5.3 Re-structuring ward safety huddles

Safety huddles are meetings of clinical staff that typically take place within the clinical environment, have a focus on patient safety (Montague et al., 2019), are brief, often occur standing, can be multidisciplinary, and may be delivered using a structured and often rigid agenda (Montague et al., 2019; Stapley et al., 2018; Franklin et al., 2020; Pimentel et al., 2021). During focused ethnography in phase 1 (Smith et al., 2020), I directly observed safety huddles taking place on both clinical floors. The structure of these huddles were variable and nursing staff in attendance were not consistently provided with an opportunity to report patient deterioration; HCAs attended infrequently. These observations were corroborated by interview data (from phase 2), as both RNs and HCAs reported being unable to attend the safety huddle and/or expressed the belief

that safety huddles were not useful for reporting or receiving information about deteriorating patients (Smith et al., 2021). Similar findings have been reported from other qualitative research, where participants reported feeling unable to attend safety huddles due to high workload, or expressed the belief that they were ‘too junior’ or ‘not important enough’ to attend (Stapley et al., 2018). Hospital wards are often highly unpredictable environments in which interactions with patients and colleagues occur frequently and are often unplanned (Thomas, Donohue-Porter & Stein Fishbein, 2017; Walshe et al., 2021; McComb & Simpson, 2014; Endsley, 1995). Safety huddles provide a rare opportunity for nursing staff to interact during a planned event. Given social interaction between colleagues is a central element of the safety huddle, there is potential for social influence to occur within these brief meetings (Montague et al., 2019). Consequently, I proposed a re-structuring of the huddle as an application of the BCT *Re-structuring of the Social Environment.* This application of the BCT received the highest score from ranking exercises during nominal groups (in phase 3), suggesting it was perceived by some stakeholders to be acceptable and/or feasible (Smith et al., 2022).

Several RNs and HCAs expressed the belief that the opinion of their colleagues influenced their behaviours, particularly in relation to how frequently they monitored patients’ vital signs and when they escalated care (Smith et al., 2021). For some RNs and HCAs, social influence was reported to be a powerful enabler of these desired behaviour/s, whilst others reported ambivalence about the influence of their colleagues or described challenging relationships in which they were dismissed or even mocked by peers for being too conscientious (Smith et al., 2021). In this context, encountering hostile and dismissive behaviour from colleagues (i.e. encountering negative social influence) was a potential barrier to staff enacting the desired afferent limb behaviour/s. In the wider literature, the broad term ‘unacceptable behaviour’ has been used to describe behaviours that encompass rudeness, bullying, harassment, or discrimination in the workplace (Cobb, 2017). When an individual is dismissed or encounters rudeness, this signals there is a problem in the environment, which can result in cognitive resources being re-allocated from existing tasks towards remedial strategies (Guo et al., 2022). Further, the heightened state of physiological arousal that may be induced by encountering unacceptable behaviour from a colleague, can narrow perception,

limit capacity for information processing, and result in reduced recall of prior knowledge and an impaired ability to make complex decisions (Porath & Erez, 2009). It has also been suggested that encountering unacceptable behaviour reduces an individual's willingness to share information (Sharifirad, 2016). Unacceptable behaviour may also affect team level performance; negatively impacting the quality of care by eroding the culture of reciprocal help between colleagues, and reducing the quality of clinical handovers (Kerber et al., 2015). A recurring theme is the detrimental impact that unacceptable behaviour can have on communication between healthcare practitioners (Guo et al., 2022; Alquwez, 2022).

As part of the proposed re-structuring of the safety huddle, an expectation will be set that HCAs attend the safety huddles alongside RNs. As part of the intervention package, a facilitator's guide/script will be developed that the senior nurse leading the meeting can use to deliver the safety huddle (as recommended by Stapley *et al.*, 2018). Use of a script should promote a consistent structure and increase intervention fidelity (Carroll et al., 2007). The content of the script will be informed by safety huddle literature (Edbrooke-Childs et al., 2017) and will focus on facilitation of the target behaviours where social influence was identified as an important determinant (Figure 6.1 illustrates the linkages between the TDF domains, BCTs, and target behaviours).

During fieldwork (in phase 1), I observed that safety huddles were commonly led by the nurse-in-charge of the ward or a senior RN. Interview participants from phase 2 reported their afferent limb behaviours were strongly influenced by colleagues perceived to be senior or more clinically experienced (Smith et al., 2021). Similar beliefs have been reported in other publications (Chua et al., 2017; Walker et al., 2021). Consequently, I will set the expectation (in the huddle guide/script) that the re-structured safety huddles should continue to be led by a senior nurse. It is my hypothesis that establishing more structured and inclusive safety huddles will minimise the frequency of the hostile and/or dismissive encounters that several RNs and HCAs reported (Smith et al., 2021), whilst enabling senior nurses to promote the relevant target behaviours (see Figure 6.1).

Behaviour Change Techniques → *(TDF domain used to select the BCT)*		**Information provision - training** *(K)*	**Social support or encouragement** *(SPRI, SI)*	**Salience of consequences** *(BaCon)*	**Pros/Cons** *(BaCon)*	**Anticipated regret** *(BaCon)*	**Comparative imagining of future outcomes** *(BaCon)*	**Action planning** *(G, MADP)*	**Prompts/cues** *(EC&R, MADP)*	**Re-structuring the physical environment** *(EC&R)*	**Re-structuring the social environment** *(EC&R, SI)*	**Information about others' approval** *(SI)*	**Identification of self as a role-model** *(SI)*	**Social reward** *(R, SI)*	**Number of BCTs linked to the target behaviour**
No.	**Summary of target behaviour** ↴														
1	Counting of respiratory rate	▨								▨					2
2	Recording vital signs directly into the EHR	▨			▨	▨									3
3	HCAs escalating care to the RN	▨	▨	▨	▨	▨	▨	▨	▨		▨			▨	10
4	RNs re-assessing the patient themselves	▨	▨							▨	▨				4
5	RNs escalating care to CCOT/medical team	▨	▨								▨	▨	▨	▨	6
6	Frequency of vital signs monitoring increased	▨	▨		▨	▨				▨	▨		▨		7
7	Further escalation to multiple responders if needed		▨												1

Key

▨	The BCT will be used to address barriers and enablers to the specified target behaviour/s.	**TDF domains**: *K - Knowledge, SPRI - Social Professional Role and Identity, SI - Social Influence, BaCon - Beliefs about Consequences, G-Goals, MADP - Memory, Attention and Decision Processes, EC&R - Environmental Context and Resources, R - Reinforcement*

Figure 6.1 – linkages between TDF domains, BCTs and the target behaviours

It is argued that safety huddles can enhance individual and team-level performance by improving situational awareness (Franklin et al., 2020). Whilst situational awareness has been defined, characterised, and theorised using multiple perspectives (Walshe et al., 2021), central to the concept is the perception of an individual or group about what is happening in the present, what might occur in the future (Walshe et al., 2021; Goldenhar et al., 2013), and what actions are, or may be, required (Leonard, Graham & Bonacum, 2004; Stapley et al., 2018). In the context of healthcare, where responsibilities are often distributed across different staff members, developing shared situational awareness is reported as beneficial for patient safety (Endsley, 1995; Walshe et al., 2021; Ede et al., 2021). In a scoping review of 158 publications including qualitative, quantitative, and mixed methods studies, safety huddles were found to have a positive impact in all but one study (Pimentel et al., 2021). Many of the included studies reported process-related outcomes (n=101/64%) (e.g. improved situational awareness and staff perception of safety), while fewer studies reported clinical outcomes (n=70/44%) (e.g. proportion of patients receiving timely evidence-based assessment or treatment) (Pimentel et al., 2021). Broadly, the findings of this review underscore the potential benefits of safety huddles as a mechanism to improve team performance, or perceived performance, of groups of healthcare practitioners and/or to improve clinical care for patients. Notwithstanding the broad signal of benefit from safety huddles, only 37% (n=59) of studies provided an explicit conceptual rationale for the reported huddle intervention. This finding might explain the authors' recommendation for more consistent use of theory in future safety huddle research (Pimentel et al., 2021). My PhD work exemplifies how safety huddles may be used to deliver precise intervention techniques selected using a theory-based approach.

Examples were found in the literature where safety huddles have been explicitly used to increase shared situational awareness amongst nursing staff about patients who are objectively deteriorating (e.g. have a raised EWS), and those who staff predict might deteriorate in the future (labelled as 'patients to watch' or simply 'watchers') (Goldenhar et al., 2013; Brady et al., 2013). Currently, targeted research reporting the benefits of safety huddles for recognising and responding to deteriorating patients has predominantly been carried out in paediatric ward areas (Stapley et al., 2018; Edbrooke-Childs et al., 2017; Goldenhar et al., 2013). Like children, a high

proportion of adults who deteriorate have physiological antecedents (Kause et al., 2004; Andersen et al., 2016; Hillman et al., 2001), and there is evidence that 'nurse worry' can predict deterioration in adult patients before the vital signs change (Douw et al., 2016; Romero-Brufau et al., 2019). Based on these overlaps, and the broader evidence-base where the benefits of safety huddles have been reported in a variety of clinical settings (Pimentel et al., 2021), there is an argument for transferring specific practices described within the paediatric literature into the adult setting until further evidence can be accumulated.

One factor found to promote sustainability of safety huddles was the inclusion of 'consistent reward and celebration' (Montague *et al.*, 2019 p1323). Whilst many of the RNs and HCAs I interviewed were equivocal about the impact of material rewards on their performance, several participants believed that receiving praise and acknowledgement from colleagues would positively influence their future behaviour. These enabling beliefs, linked to the TDF domains *Social Influences* and *Reinforcement* (Smith et al., 2021)*,* are consistent with findings of other research where cross-sectional surveys were used to examine the importance of praise and different types of reward to RNs (Sveinsdóttir, Ragnarsdóttir & Blöndal, 2016; Seitovirta et al., 2018). Findings from these studies suggest that RNs place slightly higher value on non-financial than financial rewards (Seitovirta et al., 2018), that praise and appreciation are valued forms of non-financial reward (Seitovirta et al., 2018; Sveinsdóttir, Ragnarsdóttir & Blöndal, 2016), and that RNs who are praised more often report greater job satisfaction, a more positive working culture, and greater commitment to their organisation (Sveinsdóttir, Ragnarsdóttir & Blöndal, 2016). In both studies only RNs were sampled, meaning that the findings may not be generalisable to HCAs. Further, with the reported methods (cross-sectional surveys), it was not possible for the researchers to demonstrate a causal relationship between intervention and outcome (e.g. praise and job satisfaction). Whilst these limitations are significant, in the absence of more robust research with experimental designs, these findings provide an early signal that purposeful praise (a simple and cost-free intervention) could be beneficial (Seitovirta et al., 2018; Sveinsdóttir, Ragnarsdóttir & Blöndal, 2016).

In the preliminary intervention protocol that I propose, the BCT *Social Reward* will be delivered during and outside of safety huddles through purposeful praise. During safety huddles, the senior nurse leading the huddle will thank and praise both RNs and HCAs when they raise concerns about a deteriorating patient (i.e. when they enact the behaviour of escalating care). To encourage the senior nurse to deliver social reward in this context, prompts will be incorporated into the facilitator's guide/script that will be developed as part of the intervention package and piloted during subsequent feasibility testing (a future study). Outside the safety huddle, RNs of all levels of seniority will be encouraged to praise HCAs when they approach them to escalate care. Consequently, RNs will deliver and receive the BCT *Social Reward*. To encourage RNs to deliver purposeful praise to HCAs, I anticipate preparing a presentation for delivery during the intervention workshop that will include persuasive content about the potential benefits of praise and positive validation on HCA behaviour. Similar strategies for preparing healthcare practitioners to deliver specified BCTs are reported in other published behaviour change interventions (Haskell et al., 2021).

Delivering social reward through purposeful praise only received a modest score for acceptability from nominal group participants. It is plausible that our stakeholders may have viewed social reward, delivered in this way, to be insincere and/or considered it to be an overly simplistic approach to a complex problem. However, as we did not evaluate why participants ranked the BCTs/applications as they did, we have no evidence to support this interpretation. Empirical evidence from TDF interviews suggest that *Reinforcement* was an important determinant of certain target behaviours, and that *Social Reward* was perceived positively by several RNs and HCAs (Smith et al., 2021). In light of these data, and the benefits of praise reported in the wider literature (Sveinsdóttir, Ragnarsdóttir & Blöndal, 2016; Seitovirta et al., 2018; Montague et al., 2019), the application of social reward through purposeful praise was included within the intervention, despite low scores from nominal group participants.

6.5.4 Introducing deteriorating patient champions on the wards to deliver specified BCTs

To operationalise the BCT *Social Support and Encouragement*, I propose to identify and train RNs and HCAs from the ward teams to become deteriorating patient champions. This potential strategy received favourable scores for acceptability and feasibility from stakeholders during nominal groups. In wider healthcare contexts, examples were found where 'safety champions' had been deployed to provide peer-level social support and advocacy to address deficiencies and inconsistencies in clinical care (Luton et al., 2018; Jornsay & Garnett, 2014; Campbell, 2008; Weingart et al., 2009; Flanagan et al., 2018). Originating from the management literature (Thompson, Estabrooks & Degner, 2006), safety champions have been described as individuals from within a community who strongly advocate for the adoption of an innovation (Campbell, 2008; Flanagan et al., 2018; Zavalkoff, Korah & Quach, 2015). Favourable characteristics of safety champions include being knowledgeable, passionate, enthusiastic, persuasive, and having a propensity for problem-solving (Flanagan et al., 2018; Luton et al., 2018; Thompson, Estabrooks & Degner, 2006)

During fieldwork, I frequently observed HCAs performing routine monitoring of vital signs (i.e. monitoring that occurred at a particular time irrespective of the patient's NEWS or clinical condition) and responsive monitoring of vital signs (i.e. targeted and/or more frequent monitoring of a vulnerable or deteriorating patient) (Smith et al., 2020). These findings are consistent with other research, where the central role of HCAs in monitoring vital signs on acute UK hospital wards has been reported (Ede et al., 2019). Whilst there were occasions where I observed RNs performing responsive monitoring, there were also occasions where I directly observed RNs delegating this task back to an HCA without checking on the patient themselves, despite having been informed by the HCA that the patient's vital signs were abnormal and/or the NEWS elevated (Smith et al., 2020). During subsequent interviews, competing views were expressed by RNs about the specific action of monitoring vital signs. Some RNs were emphatic that this was part of their role, whilst others reported that monitoring vital signs was a task that 'belonged to HCAs' or expressed the belief that HCAs should not require much input from RNs with this aspect of clinical care (Smith et

al., 2021). The discordant beliefs that we identified in relation to patient monitoring overlap with findings from an ethnographic study where some RNs expressed the view that monitoring patients was their responsibility, but were equally resigned that it would fall to HCAs (Mackintosh, Humphrey & Sandall, 2014). The beliefs that some interview participants expressed about the monitoring of vital signs were shaped by perceptions of their job role and were linked to the TDF domain *Social Professional Role and Identity* (Smith et al., 2021). Through the provision of social support and encouragement and positive social influence at the point of care, deteriorating patient champions will encourage RNs to perform responsive monitoring of vital signs and re-assessment of patients with an elevated NEWS. It is also expected that champions will promote other target behaviours linked to the TDF domains *Social Professional Role and Identity* and *Social Influences* (see Figure 6.1).

In several publications reporting the use of safety champions, individuals from within existing teams volunteered for the role (Campbell, 2008; Weingart et al., 2009; Luton et al., 2018). As the role requires a high degree of enthusiasm, use of a self-selection approach may be favourable as there is a greater chance of recruiting individuals who are highly motivated about the topic and innovation (Flanagan et al., 2018). Whilst self-selection is a commonly reported recruitment method for safety champions, an example was found where a more formal recruitment process was used to 'hire' a safety champion whose role was more explicitly linked to quality improvement (Zavalkoff, Korah & Quach, 2015). Whilst there is some degree of consensus about the personal characteristics of safety champions, it is far less clear what specific actions they should undertake as part of the role. This lack of clarity was highlighted from the findings of a literature review and concept analysis, where safety champions were compared to opinion leaders, facilitators, and change agents (Thompson, Estabrooks & Degner, 2006). From the review, the authors concluded that these different labels were frequently used in the literature to describe similar phenomena without providing clarity about their similarities and differences (Thompson, Estabrooks & Degner, 2006).

Notwithstanding the pragmatic appeal of safety champions, mixed findings have been reported from empirical work where the benefits of safety champions have been examined. From two studies with pre-post designs, the introduction of safety champions was found to increase the reporting of safety incidents in an oncology unit (Weingart et al., 2009), and reduce the incidence of hospital acquired pressure ulcers in a paediatric hospital (Luton et al., 2018). Whilst the introduction of safety champions resulted in a favourable reduction in the use of urinary catheters by clinicians in a paediatric ICU, the frequency of catheter-related urinary tract infection did not fall significantly (Zavalkoff, Korah & Quach, 2015). Likewise, the deployment of sepsis champions in an adult ICU resulted in an increase in compliance with a sepsis screening tool, but did not increase the number of patients receiving optimum sepsis treatment (Campbell, 2008). These findings could reflect a weakness of the safety champion as an intervention. However, they could also be explained by methodological weaknesses, where an insufficient evaluation of the problem resulted in the selection of a single intervention that was inadequate to facilitate the level of change required to improve measurable patient outcomes. Common to several of these papers reporting safety champions is a lack of detailed reporting of the intervention (i.e. how, when and where the champions operated; what they did, and with whom they worked) including what else may have been delivered alongside champions to bring about change (Luton et al., 2018; Weingart et al., 2009; Campbell, 2008; Jornsay & Garnett, 2014). This finding is consistent with reports from the wider literature where non-pharmacological interventions were often found to be poorly described (Hoffmann, Erueti & Glasziou, 2013). The lack of reporting within the body of literature makes it difficult to identify which specific techniques safety champions have delivered, difficult to theorise how these techniques might have affected recipient behaviour (i.e. identify possible mechanisms of action) (Johnston et al., 2021), and difficult to replicate effective interventions in different settings (Hoffmann, Erueti & Glasziou, 2013).

In the intervention I propose, it is anticipated that the deteriorating patient champions will broadly support the intended aims and outcomes of the intervention, whilst maintaining a more specific focus on the behaviours required to achieve these aims and outcomes. Similar approaches, where champions exerted their influence at different levels, have been reported in the

primary care setting (Shaw et al., 2012). It has been posited that a champions credibility is greater when they occupy the same professional role as the individuals they are trying to influence (Dopson et al., 2010). Consequently, both RN and HCA champions will be identified. From the five target behaviours where the TDF domains *Social, Professional Role and Identity* and *Social Influences* were reported determinants, one behaviour was enacted by RNs and HCAs, three behaviours were enacted exclusively by RNs, and one behaviour was enacted exclusively by HCAs (Smith et al., 2021, 2020). Appointing champions from the different staff groups (i.e. RNs and HCAs), provides an opportunity to tailor the delivery of the BCT *Social Support and Encouragement* as the different champions can support and encourage peers from their own professional group, to enact specific target behaviours relevant to their role. Ahead of future pilot work, a package of training and support will be developed for the champions to increase their understanding of the role and to ensure that they are equipped with the requisite knowledge and skills (Jornsay & Garnett, 2014; Campbell, 2008; Luton et al., 2018). Facilitating meetings for champions to share experiences and strategies has also been advocated within the literature (Luton et al., 2018). As part of the subsequent pilot work, I will explore the feasibility of bringing champions together for short meetings to discuss their progress, identify any barriers they are encountering, and share strategies for overcoming barriers. It is possible that bringing deteriorating patient champions together in this way will further increase reliability and sustainability. However, further empirical work will be required to substantiate this.

A relatively high frequency of RNs and HCAs expressed beliefs during an interview (in phase 2) that implied they had a strong intention to enact target behaviours (related to vital signs monitoring and escalation of care) and/or had established goals to carry these tasks out. Consequently, the TDF domains *Intentions* and *Goals* were rich in enabling beliefs. Some participants also reported using different strategies to increase the probability of target behaviours being enacted (linked to the TDF domain *Behavioural Regulation)* (Smith et al., 2021). Collectively, these data imply there are RNs and HCAs within the organisation who are more motivated, and/or have developed action plans to enact afferent limb behaviours in varying and potentially

challenging circumstances. It is possible that RNs and HCAs who hold these beliefs could have a positive influence on colleagues if they were operating as deteriorating patient champions.

In summary, findings from this programme of research have been reported and situated in the context of the Trust within which this research was conducted. System-level strategies to address inconsistencies in afferent limb behaviours reported from my work have been evaluated including the potential of health IT systems to eliminate certain actions from the chain of afferent limb behaviours. A rationale for developing an intervention that targets individual behaviour has been offered. As the main output of my PhD research, the content of the preliminary intervention has been discussed in depth. Where available, the wider body of published literature has been synthesised to evaluate specific intervention components and the different settings in which they will be delivered. Specifically, the educational component has been explored with a particular focus on the strengths and limitations of providing education as part of a behaviour change intervention, and the potential use of blended learning in this space. Further, the use of safety huddles and safety champions to deliver specified BCTs within the ward setting have been discussed drawing on the wider literature underpinning these approaches.

6.6 Strengths and limitations

My research makes a unique contribution to the international literature, as it is the first study where an implementation process (French et al., 2012) has been followed, and a theoretical framework of behaviour change (Cane, O'Connor & Michie, 2012) used to develop a complex intervention to improve responses to deteriorating patients. Use of a structured implementation process facilitated a highly systematic approach, whilst use of the TDF enabled expansive inquiry of potential determinants of afferent limb behaviours enacted by RNs and HCAs.

In phase 1 of my PhD work, seven target behaviours were selected from a longer list of 11 behaviours (Smith et al., 2020). Having a relatively long list of target behaviours made it challenging to ensure that the barriers and enablers to all target behaviours were explored adequately and consistently in every TDF domain during semi-structured interviews. The ideal

method would have been to pose at least one specific question for each target behaviour in every TDF domain (Atkins et al., 2017). Following this approach would have resulted in a topic guide with 98 questions (i.e. 7 questions × 14 TDF domains) excluding any follow-up prompts. The topic guides that I used included 30 high-level questions with follow-up prompts (range 1-6) in 12 of the 14 domains. My TDF interviews lasted an average of 54 minutes. It is plausible that an interview with 98 questions would have lasted considerably longer. Given participants were clinical staff it is unlikely that an interview of longer duration would have been acceptable. Consequently, I took a pragmatic approach and attempted to use high-level questions that overarched several target behaviours in the first instance. Thereafter, I followed up most questions with prompts linked to specific target behaviours. This broad approach to interview questioning is advocated as good practice within TDF guidance (Atkins et al., 2017). In some domains I anchored my high-level questions to specific target behaviours and did not question explicitly in other areas. For example, in the TDF domain *Skills* I posed questions related specifically to the measurement of vital signs (see appendices 7 and 8). These decisions were driven by my own clinical expertise, by the expertise of my supervisors, and – in some instances – the wider nursing literature. Whilst this approach helped to avoid an excessively long interview, it increased the likelihood that some behaviours were explored more comprehensively than others which may have influenced the prominence of some TDF domains and potentially the content of the preliminary intervention. Consequently, this is a limitation of my work. Broadly, my experience highlights some of the challenges of applying the TDF to examine complex clinical workflows involving multiple actors and interconnected behaviours. Where shortlisting to one or two target behaviours (the simpler and ideal course of action as advocated by Michie, Atkins & West, 2014) may not be straightforward, there is a lack of clear information for researchers about how to proceed. Arguably, this reflects a wider limitation within the TDF body of work.

In addition to creating challenges related to topic guide development, including a longer list of target behaviours had repercussions throughout the programme of work as it contributed to a more expansive corpus of data, a longer list of TDF domains, and a longer list of BCTs. Whilst the breadth and depth of information accumulated is a strength of this work, having such a large

dataset increased the risk of important information being overlooked during data analysis or during transitions from one phase of the project to the next. To reduce the likelihood of this, a robust audit trail was maintained across the programme of work. Practically, this included summarising the key outputs for each phase of the project in a consolidated document that was accessed by all members of the research at key project milestones (e.g. during consensus discussions) (see volume 2, appendix 13 for an example of such a document).

Whilst the use of structured observation has been advocated for identifying and specifying potential target behaviours for change (Atkins et al., 2017), there is a paucity of studies reporting the use of this method. My work highlights how observation may be used to identify and specify gaps between desired (i.e. policy-specified) behaviours and those enacted in a clinical setting. The detailed field notes and reflexive notes that I maintained during focused ethnography provided deeper insights into the context of the behaviours and influenced decision-making in subsequent phases of the project. For example, the decision to include re-structuring of safety huddles within the proposed preliminary intervention was partly informed by content analysis of field notes, where I had recorded observations from several safety huddles that were sub-optimal from a deteriorating patient perspective.

It is possible that my prolonged presence in the clinical areas during focused ethnography permitted individual RNs and HCAs to adjust to my presence (i.e. to habituate) (Pope, 2005; McCall, 2002). This may have reduced social desirability bias and increased the likelihood of participants reporting barriers and enablers more candidly during subsequent interviews. Whilst the different interviews (i.e. brief and semi-structured) had overlaps, they were sufficiently different (conducted at different times, in different contexts, using different questioning approaches) to provide a degree of methodological triangulation which increased the overall dependability of interview data (Elo et al., 2014).

Ward-level sampling decisions were informed by local (i.e. Trust-level) data and perceptions of key stakeholders immersed within the organisation (including the lead of the hospital's CCOT).

In phases 1 and 2, I collected data independently. Consequently, data within field notes represented only my perception of the phenomena of interest. A lack of investigator triangulation[13] at the point of data collection is a limitation of this work. To mitigate this, throughout the period of fieldwork (i.e. whilst phases 1 and 2 were ongoing) I had regular meetings with my supervisors. During these meetings, I described what I had observed and my interpretations of these events. This provided my supervisors with opportunities to validate or challenge my conclusions and to offer different perspectives on the data (Carter et al., 2014).

Focused ethnography was conducted on two floors (4 wards). Recruitment of TDF interview participants (RNs and HCAs) took place concurrently and in the same clinical areas. Consequently, I was able to recruit interview participants based on variations in directly observed clinical behaviours. The study design also permitted interview questions to be adjusted for individual participants based on the specific afferent limb behaviours I had observed them enacting in the ward setting. Collectively, these features of the study design were beneficial in maximising diversity within the sample and increasing opportunities to explore a range of different barriers and enablers.

In the formative stages of my project, the process of developing TDF interview topic guides was equally challenging and informative. On initial scrutiny of the framework, I found some of the TDF domain labels and their content difficult to interpret. Example domains that were particularly challenging to understand were *Behavioural Regulation* and *Reinforcement* (Cane, O'Connor & Michie, 2012; Atkins et al., 2017). To inform how I constructed questions for the topic guides, I looked to the literature where some example questions have been offered (see Michie, Atkins & West, 2014, p88). I found these examples to be of limited value given that they are generic (i.e. not anchored to any specific target behaviours). For these reasons, I believe that constructing sufficiently probing questions for the topic guide that adequately aligned to the relevant domains would have been extremely difficult without the input of a supervisor with expertise in health

[13] 'Investigator triangulation involves the participation of two or more researchers in the same study to provide multiple observations and conclusions' (Carter et al., 2014 p545).

psychology and experience of applying the TDF. These insights are consistent with reports from the wider literature, where the importance of practitioners being able to access individuals with knowledge and prior experience of the TDF has been emphasised (Atkins et al., 2017; Dyson & Cowdell, 2021). My experience also substantiates the argument that whilst the TDF is more straightforward than many of the theories from which it draws (Dyson & Cowdell, 2021; Michie et al., 2005), the framework and its associated materials may not be as widely accessible as some of its developers have claimed (Phillips et al., 2015). Consequently, its use by practitioners to examine implementation problems in clinical practice may be constrained by a lack of access to TDF literate collaborators.

I conducted pilot interviews using draft topic guides. Transcribed quotes from audio-recorded pilot interviews were used to identify questions that appeared to confuse and/or mislead the participant, to refine questions in the topic guides, and to populate the coding manual with illustrative quotes which were discussed and debated with supervisors (including health psychologists). Using the pilot data in this way was time consuming but highly productive as it allowed me to deepen my understanding of the TDF domains and the content thereof, whilst developing and refining research materials. For that reason, I argue that this process represents a further strength of the methods, and I would recommend these approaches particularly for researchers inexperienced in using the TDF.

Whilst a proportion of human behaviour is driven by conscious reflection and careful decision-making, other behaviours are cued by the environment and enacted without effort or deliberation (Presseau et al., 2014b). To code determinants (i.e. barriers and enablers) of specified behaviour/s from a TDF-informed interview, participants needed to be conscious of what influenced their behaviour and able to articulate these influences when questioned. Given that only a proportion of human behaviour is driven by conscious, effortful and deliberative reasoning (Presseau et al., 2014b; Nilsen et al., 2012), it is plausible that some participants may not have been conscious of what was influencing all their behaviours or able to describe these influences in a way that was codable by the research team (i.e. could be linked to the TDF domains). To

exemplify this argument, there is evidence that emotion can affect healthcare practitioners' clinical decision making and subsequent behaviour (Kozlowski et al., 2017). In my research, the TDF domain *Emotions* met criteria of only moderate importance and therefore was not used to drive the selection of BCTs (Smith et al., 2021, 2022). Based on findings from the empirical literature, it is possible that some of my participants were unaware of the impact of their emotions and/or did not feel able to acknowledge them openly (Kozlowski et al., 2017). Consequently, I may not have garnered a true picture of the importance of emotions as a determinant of afferent limb behaviour. The inability to consistently access 'the truth' during a TDF interview reflects a broader methodological limitation as it could result in some determinants being missed and potentially not targeted with suitable intervention components.

To ensure reliable coding of interview data, a detailed coding manual was developed and revised during double coding activities and subsequent consensus discussions. Whilst there is precedent with the TDF literature for developing coding manuals (Roberts et al., 2017; Presseau et al., 2017), it is my assertion that the process my supervisors and I followed in developing and revising the manual (see section 4.6.1.2) was particularly robust. Prior to my supervisors and I agreeing on a definitive coding manual (i.e. the version that I used to code interview transcripts independently) (volume 2, appendix 9), 13 different versions were reviewed and revised by me and my supervisors (JJF, LMA, MC) representing the comprehensive and iterative nature of the process. Despite having a comprehensive manual, reaching full agreement between independent coders in the linking quotes (or parts of quotes) to TDF domains was challenging. This is reflected by low percentage agreement between independent coders following deductive analysis of the first transcript, where full agreement in the linking of quotes (n=36) to TDF domains only occurred on 11 (31%) occasions, and partial agreement[14] occurred on 23 (64%) occasions (prior to consensus discussions). Reconciling disagreement and achieving 60% full agreement between coders (Atkins et al., 2017) (the agreed threshold for proceeding to independent coding) required considerable

[14] Partial agreement was typically reported when a quote had been linked to multiple TDF domains by both coders, and there was agreement in the coding for one TDF domain (minimum) but disagreement in other domain/s.

time and resources. To exemplify, my primary supervisor and I each spent approximately 18 hours independently coding three transcripts and a further eight hours discussing and debating coding decisions. In the final consensus meeting, a second supervisor (MC – a health psychologist) was also present to help reconcile disagreements. The procedure that we followed represents 'best practice' from published TDF guidance (Atkins et al., 2017) and is therefore a strength of this research. However, our experiences highlight a further challenge for practitioners applying the TDF.

Two patient advisors were consulted when the study was designed and agreed to be involved throughout the programme of work (see section 4.4). However, only one advisor remained involved until completion (the other advisor stopped responding to email communication shortly after data collection began). The patient advisor who remained involved offered valuable, often unique, insights into research materials and reports used to disseminate findings in different settings and for different audiences. Consistent input from an engaged patient advisor at all stages of the project is a strength of this work. However, having a larger and more diverse service-user group would have been preferable to ensure a broader range of perspectives. As the preliminary intervention I have developed targets healthcare staff rather than patients, I elected not to include service-users within data collection activities (e.g. as participants in the nominal groups in phase 3). As such, service-users acted as 'endorses' rather than 'co-producers' of the materials and research outputs including the preliminary intervention itself (Hewison, Gale & Shapiro, 2012; Martin, 2010). In phase 1 of this project target behaviours were specified and labelled according to Action, Actor, Context, Target, and Time (Presseau et al., 2019). Whilst RNs and/or HCAs were the *actors* of all target behaviours, for five of the seven behaviours the patient was the *secondary target* (i.e. the recipient of a particular action who was not required to enact anything themselves) (Smith et al., 2021) underscoring the centrality of patients to the behaviours of interest. In light of this, and wider recommendations that service users be actively involved in the design, execution, analysis, and dissemination of research (National Institute for Health Research (NIHR) Research Development Service, 2018; Gray-Burrows et al., 2018) the lack of service user participation in key research activities is a limitation of my work. For my doctoral work, I attempted to recruit patient

advisors who had experienced clinical deterioration and serious illness. Patients recovering from critical illness are a potentially vulnerable cohort with numerous potential sequelae affecting their physical and/or mental health, and cognitive function (Pauley & Walsh, 2022). The potential vulnerability of this group of patients may partly explain why I found it so challenging to access, recruit, and retain patient advisors with these characteristics. To strengthen the 'patient voice' in subsequent work, my goal will be to form a larger and more diverse service-user group and facilitate the participation of service-users in all research activities. To achieve this, I will consider recruiting service-users who have experienced hospital care but may not have experienced clinical deterioration or critical illness. I anticipate that expanding the eligibility criteria in this way will lead to more fruitful service-user recruitment and potentially a richer and more diverse stakeholder contribution.

6.7 Recommendations

6.7.1 Recommendations for research

The level of detail in the reporting of intervention content has been identified as highly variable and often inadequate to facilitate replication (Hoffmann et al., 2014). In a sample of 137 published non-drug related interventions, only 39% were reported as being adequately described (Hoffmann, Erueti & Glasziou, 2013). Using expert consensus methods, Hoffman et al (2014) created a checklist to guide reporting of intervention content. The Template for Intervention Description and Replication (TIDieR) checklist was originally developed to guide reporting of interventions for the purpose of trials and other evaluative study designs (Hoffmann et al., 2014). More recently, four additions to TIDieR checklist were proposed to improve reporting of the potentially complex interaction between context and intervention delivery in applied healthcare research (Cotterill et al., 2018). I have developed the first iteration of a draft intervention manual for the preliminary behaviour change intervention that I propose (see volume 2, appendix 30) broadly structured in accordance with the TIDieR checklist (Hoffmann et al., 2014), and the modifications proposed by Cotterill et al (2018). The content of this draft manual should be expanded upon and revised iteratively during subsequent feasibility testing.

The MRC framework for developing and evaluating complex interventions recognises feasibility testing as an important step in the process following development or identification of the intervention (Skivington et al., 2021). I plan to design a feasibility study for the intervention that I have developed. Feasibility studies have been defined as 'those that aim to assess whether a future study, project or development can be done' (Eldridge *et al.*, 2016 p16). Consequently, feasibility studies often involve piloting of the proposed methods for evaluating an intervention (e.g. carrying out a scaled-down version of a randomised control trial) (Eldridge et al., 2016; Avery et al., 2017) and may involve concurrent process evaluation. Process evaluation in this context could involve piloting, refining and/or tailoring of the intervention itself, assessment of the potential cost of the intervention (i.e. through economic evaluation), and further evaluation of the acceptability of the intervention to those who will deliver it and the potential recipients (Skivington et al., 2021; Disbeschl et al., 2021; Sekhon, Cartwright & Francis, 2017). Part of the feasibility study would be to identify the most appropriate outcome measures to use during subsequent evaluation, thereby addressing the final guiding question from the implementation process proposed by French et al (2012): *How can behaviour change be measured and understood?*

It has been posited that acceptability is a necessary but not sufficient condition for an intervention to be effective (Sekhon, Cartwright & Francis, 2017). In my work, acceptability of different intervention components to stakeholders was broadly assessed using NGT methods (in phase 3) (Smith et al., 2022). These findings contributed to decision-making about the content of the proposed intervention. Given its importance, there is an argument for intervention acceptability to be examined further, more expansively and systematically, during feasibility testing (Skivington et al., 2021). The Theoretical Framework of Acceptability (TFA) was developed to inform evaluations of intervention acceptability (Sekhon, Cartwright & Francis, 2017). Questionnaires structured according to the seven constructs of the TFA *(affective attitude, burden, ethicality, intervention coherence, opportunity costs, perceived effectiveness, and self-efficacy)* were compiled

using a 5-step pre-validation method (Sekhon, Cartwright & Francis, 2022). The TFA constructs and questionnaires could be used to evaluate the acceptability of my proposed intervention as part of a broader feasibility testing programme.

The idea that behaviour is driven by two systems of cognitive processing (i.e. a reflective system and an automatic system) that operate in parallel, underpin dual process theories (Presseau et al., 2014b; Nilsen et al., 2012). In accordance with these theories, behaviours enacted in familiar and unchanging settings are more likely to occur when internal and external cues activate automatic processes. In comparison, behaviours that occur in novel or unfamiliar settings are more likely to result from reflective processing (Potthoff et al., 2019; Nilsen et al., 2012). As the cognitive control shifts from the reflective system towards the automatic system, habit becomes a stronger predictor of behaviour than intention (Nilsen et al., 2012). Participants of my research described using the NEWS alongside other clinical information to inform decision-making (Smith et al., 2021). Given imperfections of current track-and-trigger tools (including NEWS), information processing and decision-making by RNs is an important determinant of behaviour in this space. Despite this, there is limited research focusing in depth on the decision processes that drive behaviours of the afferent limb. Conducting research to explore behaviours of the afferent limb through a dual process theory 'lens' (Nilsen et al., 2012; Presseau et al., 2014b) could expand understanding of the cognitive processes that drive these behaviours. Further investigation in this area could also clarify the role that habit plays and permit reporting of the extent to which it drives specific behaviour/s of the afferent limb (Potthoff et al., 2019; Nilsen et al., 2012; Presseau et al., 2014a). If habit was found to have a role, findings of this work could be used to select further intervention components specifically aimed at modifying habit; that is, constructing habits that are useful and/or substituting habits associated with unwanted behaviour (Presseau et al., 2014a).

The Nursing Associate (NA) role was introduced within the UK to bridge the gap between registered nurses and healthcare assistants in the delivery of patient centered care (Health Education England, n.d.). As part of the NA role, Nursing and Midwifery Council standards state

that NAs should be proficient in the measurement and interpretation of vital signs, and be able to escalate care when there is evidence that a patient is deteriorating (Nursing and Midwifery Council (NMC), 2018b). As such, it is very likely that nursing associates will enact some – if not all - the target afferent limb behaviours conventionally carried out by HCAs and/or RNs. Within the broader patient safety literature, there is a clear signal that having hospital wards staffed with an adequate number of RNs impacts favourably on patient mortality, and that HCAs are not effective substitutes for RNs (Zaranko et al., 2022). At present, less is known about the impact of substituting RNs with NAs. As the number of NAs in clinical practice expands, opportunities will arise for further empirical work to explore the impact of NAs on the nursing workforce, and specifically the implications for patient safety including their role within the rapid response system. In the Trust that I conducted my research, NAs are being implemented slowly but were not established when I was conducting data collection (hence why they were not sampled). Moving forward, I will need to consider the suitability of the preliminary intervention for NAs and potentially tailor intervention components to ensure that they are appropriate and acceptable for individuals occupying the NA role.

Internationally, there is increasing interest in the response to deteriorating patients that occurs at ward-level before the RRT is activated (Sprogis et al., 2021b, 2021a). For patients with mild to moderate abnormalities in vital signs, some escalation of care protocols (including the protocol linked to NEWS) direct nursing staff to escalate care to local responders, leaving activation of the RRT reserved for patients with more severely deranged vital signs (Bingham et al., 2015; Frost et al., 2015; Sprogis et al., 2021b; Royal College of Physicians, 2017; Sprogis et al., 2021a). Broadly, this has been described as a ‘tiered system’ (Sprogis et al., 2021b, 2021a). Within tiered systems, ward-level responders may include senior nurses, junior and middle-grade doctors from the patient’s medical team, or ward-based advanced practitioners (Williams et al., 2022; Bingham et al., 2015; Frost et al., 2015; Sprogis et al., 2021b, 2021a). From the wider international literature it is evident that ward-based doctors are key stakeholders within the RRS. Whilst there is a body of literature reporting the barriers and enablers to junior doctors responding to, and managing, deteriorating patients (Radeschi et al., 2015; Stewart, 2008; Callaghan et al., 2017; Chua et al., 2019a), no reports were found where theory or a theoretical framework (like the TDF)

had been applied to systematically examine medical staff behaviour or the determinants thereof. Conducting further research with a sample of junior and middle-grade doctors, using a similar design to the programme of work reported in this thesis, could expand our understanding further and potentially permit the development of a theory-based intervention targeting medical staff. Findings of this work could provide opportunities to identify elements of an intervention that could be multi-disciplinary.

6.7.2 Recommendations for policy and clinical practice

In preparation for the programme of research reported in this thesis, preparatory work was conducted in the form of a documentary analysis of local deteriorating patient policies (see section 1.6). This included an analysis of the policy document from the Trust within which my research was conducted. Broadly, findings of this documentary analysis were that local deteriorating patient policies are often large, unwieldy, and that content is frequently vague, ambiguous, and/or potentially difficult for clinicians to follow (Smith et al., 2019). More specifically, statements within policy documents directing afferent limb behaviour often lacked clear specification of the context (when and where the behaviour should occur), timing (over what period the behaviour should be enacted), and/or the actor (the person/s responsible for enacting the behaviour) (Smith et al., 2019). Similar findings regarding a lack of clarity and specificity within deteriorating patient policy documents have been reported in other published international work (Freathy et al., 2019; Sprogis et al., 2021a; Walker et al., 2021). Findings from my PhD work signal a high level of inconsistency in RN's and HCA's knowledge about local deteriorating patient policy in relation to the existence of policy, the content of the document, and the procedure for accessing the policy as a source of information from within the ward setting (Smith et al., 2021). Together, findings of my preparatory work and PhD research imply that policies are often not well written for the intended audience (i.e. healthcare practitioners), and that nursing staff are ambivalent about the existence of these documents or their use in guiding their actions in clinical practice. Consequently, my recommendations are two-fold. First, I suggest that managers and leaders responsible for drafting local policies carefully consider how policy documents are written. In relation to writing specific statements to direct behaviour, the AACTT (which abbreviates Action, Actor, Context, Target,

Time) (Presseau et al., 2019) framework could be used to construct statements that are specific and therefore actionable by clinical staff (Michie & Johnston, 2004; Grol et al., 1998). We have offered examples of how this may be achieved in our publication (Smith et al., 2019). Engaging patient-facing clinicians in the policy writing process (e.g. as key stakeholders or co-producers of the document) could help ensure the content and layout of the policy is acceptable to the end-user (Hewison, Gale & Shapiro, 2012). Second, opportunities need to be taken to raise awareness of deteriorating patient policy at ward level including providing information about how the document can be accessed in the ward setting. Information should be provided on the similarities and differences between the NEWS escalation of care protocol (i.e. the quick reference guide linked to NEWS and visible on the EHR) and the local policy document, as well as how these sources of information are related. Senior nursing staff and ward managers are well positioned to undertake these activities using forums such ward meetings, clinical handovers, and huddles to provide information. I also anticipate providing this information as part of the educational component of the proposed intervention.

When scrutinising the NEWS2 implementation guideline (Royal College of Physicians, 2017) and specifically searching for the term ‘healthcare assistant’ (or synonyms including ‘healthcare support worker’ and ‘nursing assistant’) I found that the term had only been used once (within an appendix) across the entire 53-page document. In comparison, the term ‘registered nurse’ had been used on nine separate occasions. Similar findings were evident when I examined the local deteriorating patient policy from the Trust where this research was conducted (the term healthcare assistant had not been used at all, whilst the term ‘registered nurse’ had been used on nine occasions). Findings from phase 1 of my research, and from the wider body of literature, underscore the central role of HCAs within the RRS (Smith et al., 2020; Ede et al., 2019; Mackintosh, Humphrey & Sandall, 2014). Despite this, their role as key ‘actors’ within the afferent limb is poorly reflected in guidelines and policies at both national and local levels (Smith et al., 2019). As of June 2022, there were approximately 47,000 RN vacancies within England; the highest nursing vacancy rate on record for the past five years (NHS Digital, 2022). On this basis, it is very likely that a significant proportion of direct patient care will continue to be delivered by HCAs

and by individuals occupying emerging roles such as the nursing associate (Health Education England, n.d.). On this basis, I would recommend that policy writers at all levels work to address the invisibility of HCAs by detailing their contribution to patient care more explicitly. As well as ensuring healthcare policies accurately reflect the realities of clinical practice, this level of acknowledgement will be required to plan and initiate further strategies for developing the nursing workforce (Hewko et al., 2015).

RN and HCA participants of my research expressed mixed beliefs about the predictive performance of NEWS in identifying deteriorating patients. Whilst some participants reported that the NEWS provides an accurate reflection of patient acuity, other participants were more guarded about its accuracy. This may partly explain why numerous participants (including RNs and HCAs) reported using additional clinical information alongside NEWS to inform decision-making and subsequent action (Smith et al., 2021). Within the implementation guideline for NEWS2 it is stated that the tool should 'not be a barrier or an alternative to skilled clinical judgement' (Royal College of Physicians, 2017 p32). This inclusion within the national guideline underscores the importance of good clinical reasoning and decision making, particularly in circumstances where the NEWS may over or under-represent patient acuity (Royal College of Physicians, 2017). Despite the acknowledged importance of clinical decision making, and the evidence from my research that it is a determinant of RN's and HCA's afferent limb behaviour/s, local deteriorating patient policies provide little clarity for clinicians about the specific circumstances in which decision-making may be employed, who the decision-maker/s should be, or what alternate actions may be taken and by whom (Smith et al., 2019; Sprogis et al., 2021a). Moving forward, it may be beneficial for local (i.e. organisation-level) clinical leaders and policy-writers to consider which specific behaviours of the afferent limb are obligatory (i.e. should always be performed), and where there are alternate behaviours that may be enacted based on decision-making by a specified actor. Writing this more explicitly into policy, could help to prevent members of the team making decision beyond their scope of practice (e.g. HCAs deciding to delay escalation of care to a RN) and further legitimise decision-making by suitable clinicians in appropriate circumstances.

6.7.3 Recommendations for education

From the wider literature it is evident that educational strategies are commonly used for addressing deficiencies and inconsistencies in nursing care (Francis & Johnston, 2010). More specifically, there is evidence of a range of educational approaches being used to address the problem of afferent limb failure (Duff et al., 2018; Liaw et al., 2016; Connell et al., 2016; Saab et al., 2017). Findings of my research suggest that RNs and HCAs may have knowledge gaps in the following areas: the correct procedure for certain tasks (e.g. measurement of respiratory rate); an understanding of how and why a patient's physiology (and therefore vital signs) may change in states of acute illness; how the NEWS corresponds to the patient's level of risk and what actions are required at the different thresholds; and the overlaps and differences between the first and second versions of NEWS (i.e. between NEWS and NEWS2) (Smith et al., 2021). These knowledge deficits could be addressed by providing clinical staff with correct information delivered by a credible facilitator (e.g. a member of the organisations CCOT or equivalent). To address these knowledge deficits it is possible that recipients will require the opportunity to learn and re-learn essential information, and that the package of training will need to be repeated (Theilen et al., 2013). There is some evidence that using blended learning and 'flipped classroom' approaches may increase critical thinking and metacognition in learners (Youhasan et al., 2021; Khodaei et al., 2022) and may be beneficial in this context. It may also be advantageous for those who design and deliver education to consider tailoring educational packages to target knowledge gaps of staff within their own organisation (Baker et al., 2015). One way to achieve this might be to use varying sources of information (e.g. incident reports from SAEs, engagement with relevant clinical stakeholders) to better understand where gaps exist and to use these identified knowledge gaps to construct educational resources.

In the UK, the most recent standards from the NMC for pre-registration nursing education emphasise the need for RNs to have the knowledge and skills required to perform clinical assessment of various body systems (Nursing and Midwifery Council (NMC), 2018a). This includes performing physical assessment techniques (e.g. chest auscultation) not previously taught to

undergraduate nursing students in the UK. Within the same standards, the importance of robust physical assessment has been linked to effective recognition of a deteriorating patient (Nursing and Midwifery Council (NMC), 2018a). Equipping graduate nurses with the skills to perform these techniques could increase the quantity and complexity of the clinical data collected when assessing an acutely ill patient (Osborne et al., 2015; Chua et al., 2019b). Given the importance of RN decision-making in the deteriorating patient space, it is my recommendation that undergraduate and graduate RNs receive education (in Higher Education Institutions and/or clinical practice) on different models and frameworks for clinical reasoning alongside physical assessment techniques. Increasing nurses knowledge in this area could help ensure that decision making processes are robust, that RNs are aware of the decision processes they used, and can describe what shaped their decisions and how they were made (Levett-Jones et al., 2010; Osborne et al., 2015; Diamond-Fox & Bone, 2021).

Whilst educational approaches should remain part of the picture for optimising the care of deteriorating patients, clinicians and health service managers should be extremely cautious about advocating for entirely education-based strategies for addressing ALF. This cautionary note is informed by the span of determinants to behaviours of the afferent limb reported in my work. Specifically, barriers and enablers were identified across all 14 domains of the TDF, with 9 domains meeting criteria of high importance and a further 4 domains meeting criteria of moderate importance (Smith et al., 2021). Given the range of determinants, it is highly unlikely that education alone would be adequate to address the complex problem of ALF.

6.8 Conclusion

In conclusion, an implementation process, and a theoretical framework of behaviour change, was used to guide the development of a preliminary intervention to improve recognition of, and response to, deteriorating patients by RNs and HCAs in the acute ward setting. Phase 1 findings highlight inappropriate clinical responses (behaviours) enacted in the ward setting that do not align with those reported in deteriorating patient policy. These results were used to report and specify the afferent limb behaviours that will be targeted by the intervention. In phase 2, barriers to, and

enablers of, the target behaviours were linked to all 14 domains of the TDF representing the span of possible determinants. Nine of the TDF domains were found to represent the most important barriers and enablers. These 9 TDF domains were linked to specific BCTs that experts believe could be appropriate for changing behaviours when barriers and enablers to those behaviours have been identified in the specified domains. In phase 3, the long list of 50 BCTs was shortlisted based on acceptability (to nursing staff) and feasibility (for application within an acute hospital ward). The shortlist of 14 BCTs derived from this initial task was shortlisted further using information acquired from nominal groups held with healthcare leaders, senior clinicians, and ward-based nursing staff. The proposed preliminary intervention includes an education package and 12 BCTs that will be delivered through two broad modes of delivery (in a face-to-face workshop and in the acute ward environment), using 18 discreet applications (concrete strategies for operationalising techniques). Six of the 18 applications included in the intervention were suggested by nominal group participants. Ten of the remaining applications were derived from materials developed by experts in implementation science and behaviour change. Two further applications (safety huddles and safety champions) were informed by published empirical work. All applications attempt to change the determinants of the seven target behaviours of the afferent limb that are performed inappropriately by nursing staff.

To the best of my knowledge, this is the first report of a theory-based intervention, targeting behaviours of the afferent limb of the RRS, to be published internationally (study protocols notwithstanding). An important step within the broader process of designing, evaluating, and implementing complex interventions is to design a feasibility study. I anticipate that this will include two broad components: a pilot of the study design that will be used to evaluate the intervention, and a process evaluation to refine the intervention itself. The process evaluation element will involve development and piloting materials, testing the various intervention components in the ‘real-world’ setting, and exploring further the acceptability of the intervention to those who deliver it and its recipients. Throughout this process, the intervention manual (volume 2, appendix 30) will be populated with further content and revised iteratively.

Within the nursing profession, there has been a tendency to target complex and enduring problems solely with knowledge and/or skills-based training (Francis & Johnston, 2010). Whilst tailored educational packages are likely to remain part of the solution to ALF, it is unlikely that these strategies alone will be adequate to facilitate the desired behaviours from RNs and HCAs and mitigate ALF. The programme of work reported in this thesis highlights the range of behaviours that are not enacted in accordance with policy and possible determinants to these behaviours. The span of target behaviours and reported determinants is mirrored by the complexity of the proposed intervention which incorporates multiple components, tailored for delivery in different settings, targeting several behaviours enacted by different healthcare practitioners.

7 References

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