Impact of Non-Technical Skills on Performance and Effectiveness of a Rapid Response System

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PREFACE

In this thesis, a comprehensive clinical research program is presented for consideration of conferral of the degree of Doctor of Philosophy.

This was undertaken as a part-time Higher Degree by Research doctoral enrolment at the School of Public Health, The University of Adelaide under the supervision of Associate Professor Lynne Giles, Associate Professor Amy Salter and Professor Jonathan Karnon.

The research program comprised:

- conception and development;
- a literature review;
- two studies, conducted in parallel, centred around a common intervention;
- interpretation of study findings; and
- composition of this thesis.

This thesis is structured in a "Research by Publication" format. Five manuscripts are included herein, all of which have been published in peer-reviewed, medical journals. Citations and links to the full-text publications are provided.

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THESIS ABSTRACT

Background

The Rapid Response System (RRS) is a globally recognised hospital safety service that recognises and escalates inpatient clinical deterioration for management by a Rapid Response Team (RRT). Successful use of Non-Technical Skills (NTS) during RRT calls may facilitate and expedite resolution of clinical deteriorations.

Improving clinicians' use of NTS typically involves dedicated training which requires considerable time and financial resources, which are commonly not available. Therefore, this research was undertaken, aiming to promote use of NTS during RRT calls using a pragmatic approach with minimal resource requirements.

Methods

This research, presented herein as a PhD-by-publication, investigated the re-design of an existing RRS on the use of NTS during RRT calls. The re-design had three components: 1) shift-by-shift meetings of the RRT; 2) RRT role badges; and 3) a structured "hand-off" transition-of-care process at the end of calls.

A literature review was undertaken on NTS in context of an RRS to inform development of the re-design. Prior to implementation of the re-design (Phase 1), RRT Members and Users (ward staff that called the RRT) were surveyed regarding their experiences of RRT calls, and analysis of an RRS performance indicator: repeat RRT calls to the same patient during an admission, was conducted.

Following introduction of the RRS re-design (Phase 2), the survey of RRT Members and Users was repeated, and an interrupted time series analysis was performed to determine the effect of the re-design on the proportion of RRT attended patients going on to have repeat calls.

Results

Potentially preventable repeat calls (i.e. following an initial call that ended despite an ongoing breach of RRT calling triggers) were associated with increased risk of in-hospital mortality (odds ratio 4.80 [95% confidence interval (CI) 2.96 – 7.81)], by comparison to not having repeat RRT calls.

The RRS re-design was associated with improvements in both RRT Members' and Users' perceptions of NTS use during RRT calls. There were significant reductions in the proportion of RRT Members and Users reporting inter-personnel conflicts during calls following introduction of the re-design (26% less [95%CI -41% – -11%] and 14% less [95%CI -21% – -7%], respectively).

However, there was little evidence of a significant difference in the proportion of RRT-attended patients (per month) going on to have repeat calls (6% fewer [95%CI -15.1% – 3.1%]) or in the mean number of calls per admission for these patients (-0.07 calls [95%CI -0.23 – 0.08]).

Conclusions

This program of research showed that a pragmatic NTS-based re-design of an existing RRS was associated with statistically significant reductions in RRT Members' and Users' perceptions of conflicts during RRT calls; however, this did not extend to a significant reduction in repeat RRT calls.

Conflict between staff can exacerbate and/or be symptomatic of burnout. The results suggest that the RRS re-design had some beneficial effects on the working relationship between RRT Members and Users, which is promising as the well-being and resilience of clinicians is vital for sustainability of effective healthcare delivery.

This research provides an important precedent for other resource-limited hospitals by demonstrating that a low-cost quality improvement initiative could be implemented for an existing RRS. The RRS re-design has broad applicability, and potential for future iterative refinement.

CITATION LIST

Published papers in this Thesis are:

1. Chalwin RP, Flabouris A. Utility and assessment of non-technical skills for rapid response systems and medical emergency teams. Intern Med J 2013;43:962-969

2. Chalwin R, Flabouris A, Kapitola K, Dewick L. Perceptions of interactions between staff members calling, and those responding to, rapid response team activations for patient deterioration. Aust Health Rev 2016;40:364-370

3. Chalwin R, Giles L, Salter A, Kapitola K, Karnon J. Re-designing a rapid response system: effect on staff experiences and perceptions of rapid response team calls. BMC Health Serv Res 2020;20:480

4. Chalwin R, Giles L, Salter A, Eaton V, Kapitola K, Karnon J. Reasons for Repeat Rapid Response Team Calls, and Associations with In-Hospital Mortality. Jt Comm J Qual Patient Saf 2019;45:268-275

5. Chalwin R, Salter A, Karnon J, Eaton V, Giles L. Effect of a multi-faceted rapid response system re-design on repeat calling of the rapid response team. PLoS One 2022;17:e0265485

ABBREVIATIONS AND GLOSSARY OF TERMS USED IN THIS THESIS

This page presents abbreviations for terms used throughout this Thesis document, including the published papers within.

Definitions and/or descriptions of the terms used within this document are also provided to act as an accessible reference. Terms are shown in bold when used within definitions or descriptions of other terms to demonstrate their inter-dependency.

Abbreviation	Term	Definitions and Description
RRS	Rapid Response System	A hospital safety service that detects and responds to patient **Clinical Deterioration**. It has two clinical components, the **Afferent** and **Efferent Limbs**
	Afferent Limb	The detection component of the **RRS**, comprising recognition of **Clinical Deterioration** and escalation to the **Efferent Limb**
	Efferent Limb	The response component of the **RRS**, comprising the **RRT** attendance to the patient and the ongoing management of the patient by ward staff until resolution of the clinical deterioration that triggered the **RRT Call**
RRT	Rapid Response Team	The team of highly skilled clinicians that respond to escalation for clinical deterioration for hospitalised patients
MET	Medical Emergency Team	Nomenclature for the **RRT** in Australia, New Zealand and the United Kingdom
CAT	Cardiac Arrest Team	A **RRT** that only attends patients during cardiac and/or respiratory arrest
	Calling (the RRT)	Nomenclature for the act of escalation for **Clinical Deterioration**. This usually involves a phone call (hence "calling") to a hotline which alerts members of the **RRT** to attend **The Deteriorating Patient**
	RRT Call	Nomenclature for the period of attendance by the **RRT** at the bedside of **The Deteriorating Patient**

	Clinical Deterioration	The acute clinical emergency, manifested by worsening and potentially life-threatening physiological parameter(s), that is recognised and responded to by the **RRS**
	The Deteriorating Patient	Nomenclature for the patient experiencing the **Clinical Deterioration** that is recognised and responded to by the **RRS**
	RRT User	A descriptor used in this study for clinical staff that detect and escalate for **Clinical Deterioration**. They also take back clinical responsibility for patients remaining in the same location at the end of an **RRT Call**. Therefore, they are involved in both the **Afferent** and **Efferent Limbs** of the **RRS**
	RRT Member	A descriptor used in this study for clinicians that are rostered to the **RRT** and attend **RRT Calls**
NTS	Non-Technical Skills	A set of personal attributes, attitudes and behaviours that promote communication and cooperation within teams
CRM	Crisis Resource Management	Nomenclature for **NTS** within the clinical setting, particularly when used by the **RRT**
	Repeat RRT Call	A second, third or higher ordinal **RRT Call** occurring during a patient's hospital admission (i.e. the patient is attended more than once during their admission by the **RRT**)

PHD CANDIDATE DECLARATION

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint award of this degree.

I acknowledge that copyright of published works contained within this thesis resides with the copyright holder(s) of those works.

I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

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15th March 2022

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The clinical data custodians at Lyell McEwin Hospital, Mr Stephen Stone and Dr William Wilson, generously provided their time to assist developing the complex code required to extract necessary fields from hospital databases.

Lastly, Associate Professor Vicki Clifton of the Robinson Institute, University of Adelaide who inspired expansion and development of what was originally envisioned as an internal hospital quality improvement initiative into this doctoral research project.

Chapter 1: Introduction

1.1 OVERVIEW OF THE RAPID RESPONSE SYSTEM

In the broadest terms, the Rapid Response System (RRS) can be considered as an in-hospital Ambulance Service. That is, it rescues inpatients experiencing acute, unexpected and, often, life-threatening clinical problems [1-4].

1.1.1 An Era Before the RRS

The predecessor to the RRS was the Cardiac Arrest Team (CAT) [2,3,5-7]. This service, comprised of highly trained and skilled clinicians, would be activated to resuscitate inpatients subject to cardiac arrest.

Unfortunately, in-hospital cardiac arrest has been associated with very high mortality [8,9], with the majority of cardiac arrests occurring as the final event of a terminal clinical deterioration [9,10]. Cardiopulmonary Resuscitation (CPR) is often ineffective as, even if Return of Spontaneous Circulation can be achieved, the patient is still imperilled by the terminal clinical state that preceded their cardiac arrest. Therefore, delaying management of clinical deterioration until after onset of cardiac arrest was considered an insufficient mechanism to provide meaningful longer term clinical benefit to hospitalised patients [5,7,11-15].

1.1.2 Introduction of the RRS

In the early 1990s, evidence emerged indicating that the vast majority of in-hospital cardiac arrests could be anticipated [11]. Based on this information, the RRS was proposed wherein physiological antecedents of cardiac arrest would be identified and acted on pre-emptively [5,6]. The structure and operations of the RRS, as outlined in Section 1.1.4, were ratified at the First Consensus Conference on Medical Emergency Teams (held in June 2005) [7].

A series of retrospective analyses of patient physiology prior to cardiac arrest were undertaken from the late 1990s to early 2000s [10,13,16-18]. The results of these informed development of pre-defined physiological triggers, such as those shown in Table 1.1, that would form the triggers for an urgent clinical response.

Table 1.1: Exemplar physiological Clinical Deterioration criteria that would trigger an RRT Call.

Pulse Rate	Greater than or equal to 140 beats per minute
	Less than 40 beats per minute
Systolic Blood Pressure	Greater than or equal to 200mmHg
	Less than 90mmHg
Respiratory Rate	Greater than 30 breaths per minute
	Less than 8 breaths per minute
Pulse Oximetry (percentage saturation)	Less than 90%
Level of Consciousness	Only responding to physical or painful stimulus

1.1.3 Ethos of the RRS

The original proposed purpose for the RRS was to anticipate and prevent in-hospital cardiac arrest, with the aim of reducing mortality risk for inpatients with a perceived reversible condition [5]. Ward doctors and nurses observe patient physiology for markers of clinical deterioration that, if not corrected, are likely to result in cardiac arrest.

When detected, these clinical deteriorations prompt escalation of patient care to a team of highly skilled clinicians whose treatment aims to recover the patient to a safe and stable clinical status. Thereby the avoidable cardiac arrest is pre-empted and prevented through corrective clinical management [6,19].

However, not all in-hospital cardiac arrests can be anticipated or prevented. Therefore, the RRS has also assumed the workload of its predecessor (the CAT). In addition to the physiological triggers in Table 1.1, RRT calls are indicated for cardiac and/or respiratory arrest.

1.1.4 Structure of the RRS

The RRS addresses Clinical Deterioration through two operational clinical components [7]:

- the Afferent limb – the Detection component; and
- the Efferent limb – the Response component.

These limbs of the RRS are graphically represented in Figure 1.1, each having two sub-components:

1.1.4.1 Afferent Limb

Recognition: a number of physiological derangements or clinical states have been associated with impending in-hospital cardiac arrest if not addressed – the Clinical Deterioration [11,13,16-18]. Through the regular, or even continuous, monitoring of patient observations by ward staff, these warning signs for potential progression to cardiac arrest can be detected [5,20]. Some examples are shown in Table 1.1.

Escalation: when one or more of these physiological abnormal states is recognised, a mandatory escalation is required [2,20]. Thus, when reached, any of the physiological criteria (such as in Table 1.1) can be said to act as a Trigger for the Efferent Limb. When this occurs, the convention is for the Afferent Limb staff member to immediately phone a dedicated number that activates the Efferent Limb response, hence the terminology of the "Call" [2,5,7].

1.1.4.2 Efferent Limb

Rapid Response Team (RRT): the RRT is the group of clinicians who attend the escalated recognition of clinical deterioration [1-3,7]. In Australia and some other countries, the RRT is often titled the Medical Emergency Team due to historical convention [4,5].

The RRT is a self-sufficient, highly skilled clinical unit capable of managing any clinical catastrophe in any area of the hospital and, if necessary, safely transporting the patient to a suitable location, such as the Intensive Care Unit (ICU) [1-3], as the paramedics of an Ambulance Service would do in the community.

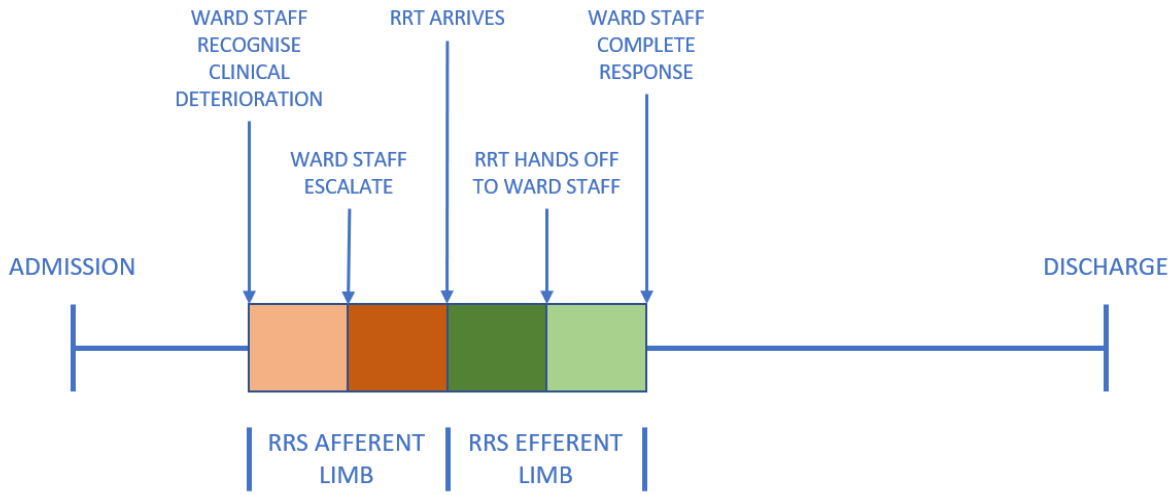
The goal of the team is the expeditious and simultaneous assessment and treatment of the deteriorating patient. Time is of the essence not just to stabilise and appropriately disposition the patient, but to also ensure RRT availability to attend further calls.

The Broader Response: if the clinical deterioration is successfully addressed during the RRT call, the patient may remain on their ward. In such instances, it is important to recognise that this patient has just triggered one or more physiological criteria associated with increased risk of in-hospital cardiac

arrest [17,18]. Therefore, ongoing monitoring and patient management are essential as part of efforts to prevent an avoidable cardiac arrest after departure of the RRT.

To ensure appropriate continuity of care, there must be an effective transition of clinical responsibility from the RRT to the ward care team [21,22]. By doing so, the Efferent Limb response may continue through measures such as increased frequency of observations and follow-up by the treating team in liaison with other clinical specialities as necessary.

Figure 1.1: Diagram of a simplified exemplar hospital admission with only one episode of clinical deterioration and full RRS involvement



1.1.5 RRS Staff Terminology

RRT Users: this describes the clinicians who recognise and escalate for clinical deterioration to the RRT. Typically, these clinicians will be the ward nurses and doctors caring for inpatients.

RRT Members: this describes the clinicians rostered to the RRT who respond to escalation for clinical deterioration by RRT Users.

These terms, as defined here, are used throughout the thesis and within the published results chapter papers.

1.1.6 Evidence Base for the Introduction of the RRS

Over the two and a half decades since its introduction [5], the RRS has been studied to assess whether its intended objective has been realised. The hypothesis was that forestalling avoidable cardiac arrests would translate into reduced in-hospital mortality or morbidity risks [6,13,16-18].

The MERIT study was the earliest and largest attempt to investigate this hypothesis. It was conducted as a multi-centre, cluster-randomised trial comparing rates of cardiac arrest, unexpected death or unplanned ICU admission between hospitals that were randomised to introduce (intervention) or not introduce (controls) an RRS [14]. After a four-month orientation period for staff education, hospitals in the intervention group implemented their RRS. Those in the control group continued normal practice, which in most centres meant persistence of an existing CAT.

Of disappointment to RRS proponents, MERIT found no significant differences in the incidence of cardiac arrest, unplanned ICU admission or in-hospital death (or composite thereof) between the

intervention and control groups at the end of the six-month study period [14]. Since then, the majority of reports of *de novo* implementation of an RRS have also found no alteration in mortality risk, including the recent large EPOCH trial [1-3,23,24]. However, these studies only described patient outcomes over the months following introduction of a novel RRS, typically in a single hospital, and have not been followed up with reporting of longer-term outcomes as those RRS matured.

Data pertaining to longer-term study outcomes would be helpful in evaluating the RRS as, in 2012, Tobin et al. noted reduced inpatient mortality when an RRS had been in place for at least two years [25]. This was corroborated in 2014, when Chen et al. reported sustained improvements in cardiac arrest rates and hospital mortality from 82 RRS across New South Wales over a ten-year period following introduction of an RRS [19].

Subsequent reviews by Salvatierra et al. and Lyons et al. suggested that in-hospital mortality may not be a useful metric for ascertaining the effectiveness of the RRS and proposed that other endpoints may be worth exploring [3,26]. For example, MERIT, EPOCH and other studies have consistently shown increased organisational vigilance for, and responsiveness to, clinical deterioration in acute hospitals with an RRS. This may have provided other (unmeasured) benefits to patients and staff such as:

- RRT assisted decision-making around patient treatment goals [1-5,27-36];
- improved quality of end-of-life care [3,37-40];
- increased clinical oversight for ward patients (other than those attended by the RRT) [27,29,36];
- clinical support to ward staff [36,41-44];
- improved liaison and relationship between critical care and general wards [35,38,45-48];
- reduction in ward staff stress [30,35,41-43,49,50]; and
- improved patient, family and/or proxy satisfaction [51-54].

1.1.7 Acceptance of the RRS

Despite the absence of conclusive evidence regarding clinical efficacy, most health organisations and governments have determined that the RRS is a necessary hospital patient safety measure [2-4,15,29-31,33,55]. In doing so, they have recognised the plausible value of the RRS to improving care delivery and patient management in an ethical manner, beyond the original objective of reducing the incidence of in-hospital cardiac arrest [3,30,31,33,36,56].

Today, the RRS is ubiquitous in developed nations' healthcare systems and thoroughly integrated into care models in acute hospitals [3,4,31]. The RRT, especially when operating as a critical care outreach service, is internationally regarded as an indispensable resource in providing and supporting aspects of care far beyond the initial proposed objective of rescuing patients from impending cardiac arrest [3,4,30,31,33,36,47,56-59]. It seems improbable that the healthcare industry could simply withdraw the RRS, so research has shifted more towards optimising and augmenting existing RRS rather than attempting to justifying existence of this service [3,4,29,31,33].

1.2 IMPROVEMENT OF THE RRS

As defined in the First Consensus Conference on Medical Emergency Teams report by what would become the International Society of Rapid Response Systems (iSRRS) [7], and ratified in 2016 by the joint statement of the College of Intensive Care Medicine and Intensive Care Society in Australian and New Zealand [4], an essential non-clinical component of the RRS is Governance (e.g. monitoring of RRS performance indicators such as incidence of in-hospital cardiac arrest [30]). These statements recommend RRS administrators audit operational activity, present data to a steering committee, and conduct improvement initiatives based on that committee's recommendations.

1.2.1 Increasing RRT Calling

A common approach aiming to improve RRS performance in the past has been to increase rates of RRT calling, based on a 2006 narrative review by Jones et al. that argued existence of a dose-effect relationship on patient safety [60]. Strategies attempted to the present time have included:

- adjusting or expanding physiological RRT calling triggers [20,34,61];
- adding non-physiological parameters to composite RRT calling triggers [62,63];
- automated or computerised algorithm assisted RRT calling [64,65];
- overcoming perceived barriers or unwillingness to call the RRT by clinicians [42,43,66]; and
- patient or family activated RRT calls [51-54].

While all have resulted in success in increasing RRT utilisation, no significant effect on in-hospital mortality was demonstrated. Furthermore, a recent study found that increasing RRT activity was not significantly associated with reductions of in-hospital cardiac arrest or mortality [67]. Unfortunately, none of the studies in this area explored other patient or organisational outcomes, so no conclusions regarding other potentially meaningful outcomes can be reached for this approach.

1.2.2 Reducing (the need for) RRT Calls

Other studies have attempted to pre-empt the need for an RRT call by addressing clinical deterioration before physiological derangement reaches pre-defined calling triggers. Strategies devised to achieve this have included:

- ICU Liaison or Outreach Services [27,36];
- implementing a team-based response to early deterioration [12];
- implementing an attending clinical unit response to early deterioration [44,56]; and
- protocolised therapies to pre-empt and prevent further deterioration to RRT call triggers (e.g.: standing orders for an intravenous fluid bolus in the event of mild hypotension) [59].

Given the physiological triggers for RRT calls (as in Table 1.1) have been associated with in-hospital cardiac arrest [5,6,10,11,13], it is plausible that preventing patients deteriorating to this point should confer additional benefit. However, no significant changes in outcomes (in-hospital cardiac arrest or death) have been reported to date.

1.2.3 Tiered Escalation and Response

Some studies have independently reported a triage-based "tiered" recognition and response re-structure to an existing RRS [44,47,56,68,69]. These RRS expanded the one-size-fits-all RRT response to a system that dispatched one out of two (or more) teams depending on the severity of patient deterioration.

A typical expanded model provides separate (i.e. tiered) responses for cardiac arrests (akin to the original CAT model) and all other calls (which the RRT would continue to attend) [47,68,69]. The justification for this arises from the differences in clinical skills required for management of cardiac arrest cases versus other patients that the RRS would respond to. An example is the ubiquitous requirement for advanced airway management (e.g. intubation) during CPR, whereas the overwhelming majority of other clinical deterioration conditions do not require this [70,71].

Of the publications on tiered RRS, only two reported patient outcomes. Kansal et al. noted a significant increase in RRT calling but no effect on hospital mortality or a composite outcome of cardiac arrest, unexpected death or unplanned ICU admission [69]. Aneman et al. reported a decrease in ICU mortality in patients admitted to the ICU from an RRT call following introduction of RRS tiers [68]. However, hospital mortality (including for those patients who had been admitted to the ICU) was not significantly changed.

1.2.4 Improving Efferent Limb Performance

As can be inferred from the number of strategies detailed above, considerable effort has been undertaken to improve the effectiveness of the Afferent Limb. By contrast, there have been fewer studies of the Efferent Limb of the RRS, for which improvement should be considered no less important.

Thus far, the vast majority of efforts to improve the RRS Efferent Limb have focused on training the RRT in cardiac arrest management, inheriting the approach taken with mandating accredited Advanced Life Support training for CATs [4,72-74] Studies of these training programs have focused on clinical skills improvement [72,73], and recommendations still emphasise cardiac arrest training for RRTs [30], despite the purpose of RRS being to pre-empt the need to perform CPR [3,19].

As RRS have matured, the incidence of in-hospital cardiac arrest has become progressively less common (typically around one to two percent of RRT calls per month) [3,8,26,28,67,71,75]. Further, the rescue from cardiac arrest hinges on provision of cardiopulmonary resuscitation and defibrillation (where indicated), thus clinical management can be standardised per, for example, the algorithms of the Australian Resuscitation Council [76].

By comparison, clinical deterioration as attended by the RRT is far more heterogenous, both in terms of clinical pattern and required management [14,16,24,28]. Defining "success" of the RRT call is less straightforward as, for example, patient survival from the call may not be achievable or the most appropriate outcome [37,39,40]. Some key performance indicators for the RRS have been proposed by the Australian Commission on Safety and Quality in Health Care (ACSQHC) and the iSRRS [30,77], however none specifically reflect conduct and management during RRT calls.

For example, the iSRRS paper proposes measuring the time interval between identification of the need for critical care interventions and their delivery, as well as the length of stay for patients attended by the RRT [77]. The former seems more dependent on availability of appropriately skilled team members than the performance of those skills, and the latter depends on many facets of care delivery and decision-making beyond the RRT call.

Therefore, in this quality improvement research, the objective was to design and implement an intervention targeted to the conduct of RRT calls and an outcome measure that could more specifically apply to those calls.

The RRT typically is rostered with experienced critical care clinicians who would already have highly developed clinical skills. At the time of commencing this research, the Department of Health (Government of South Australia), in keeping with ACSQHC recommendations, already mandated accredited Advanced Life Support skills availability within the RRT [30,78]. Thus, there seemed limited scope to further improve the existing level and set of clinical skills of an RRT.

By comparison, non-technical skills (NTS) had been little considered for the RRS [74]. Therefore, investigating the utility and improvement of NTS use during RRT calls seemed a novel and worthwhile initiative that might be applicable to all types of RRT calls, and will be fully explored in the following section.

1.3 NON-TECHNICAL SKILLS FOR THE RRS

This research presented in this thesis arose from a desire to improve the performance of a hospital RRS through promoting use of Non-Technical Skills (NTS). At this point, it is appropriate to outline the rationale behind this decision given the applicability of NTS to the RRS and, thus, how the project intervention arose.

1.3.1 Overview of Non-Technical Skills

NTS describe a set of personal attributes, attitudes and behaviours that facilitate alignment of purpose, coordination, communication and cooperation within teams [29,74,79-81]. In some respects, NTS can be thought of as a toolbox, from which clinicians can draw to improve their personal and professional performance.

NTS can be grouped into intra- and inter-personal domains [38], such as:

- leadership;
- communication;
- cooperation; and
- decision-making / planning.

The importance of NTS was first identified in industry, mainly aviation, following the realisation that most major incidents arose due to human error [82]. The relevance of NTS to clinical practice was subsequently recognised and NTS training has been introduced into many acute clinical areas such as emergency medicine, surgery and obstetrics [83-89]. NTS has been widely recognised as an important quality improvement mechanism that augments team-working and, by extension, should benefit patient safety [38,74,79,81].

When NTS are taught to cardiac arrest teams, significant improvements have been reported in use of those NTS, alongside improved performance of CPR, in simulated scenarios [47,72,73,90,91].

1.3.2 NTS Use to Improve an Existing RRS

Narrative reviews have proposed that NTS may have an important role during RRT calls [38,74,80]. Gillon et al. described the RRT call as a time of "clinical crisis" that induces significant psychological stress in RRT Members [74].

Studies of simulated emergency scenarios have shown that clinical skills and decisions are impaired when cardiac arrest teams are subject to time, clinical and logistic stressors [92-94]. Analyses of these simulated emergencies have identified NTS as the crucial factor. Effective utilisation of NTS has been associated with improved clinical competence and adherence to cardiac arrest algorithms [38,73,90,95].

Therefore, NTS would seem to be an ideal and essential skillset for RRS staff [74]. Successful use of NTS should augment interactions within the RRT and at the interface between clinical staff calling the RRT to attend a deteriorating patient and members of the RRT [38].

The unique characteristics of the RRS seem particularly amenable to benefit from successful use of NTS by RRT Members and Users [1-3,29,31,38,55,57,96]:

- the RRT is typically rostered from a large pool of clinical staff resulting in inconsistent and fluctuating team membership from shift-to-shift;
- RRT Members are typically not supernumerary;
    - they have other primary clinical duties within the hospital when rostered to the RRT;
    - those primary clinical roles have their own clinical priorities and demands to attend to, from which they are separated to attend RRT calls; and
    - thus, their primary roles could act as a distraction during RRT calls and impose pressure on the RRT to expedite completion of the call
    - for RRT Members rostered from the ICU, there may be incentive to keep a patient on the ward at the end of a call due to capacity shortages or to reduce their workload
- RRT Members come from separate clinical disciplines and only work together at RRT calls;
- RRT Members frequently do not know each other and/or have never worked together before attending RRT calls;

- RRT Members have no opportunity to establish rapport with each other prior to arriving at the first RRT call of that shift;
- RRT Members have no opportunity to agree roles and responsibilities prior to arriving at RRT calls;
- RRT Users calling the RRT often do not know members of the RRT, their level of skill or experience, or their role on the RRT;
- RRT Users still have to provide care for other patients in their clinical area and are not backfilled in those duties when remaining at an RRT call;
- RRT calls occur, by their nature, in clinical situations of extreme clinical and time pressure with little to no margin for error;
- the jurisdiction of clinical responsibility at RRT calls can be uncertain and contested if the patient's regular care team is present during calls; and
- the transition of clinical responsibility at the completion of RRT calls (when the patient remains in their current clinical area) may be uncertain, especially if the patient's regular care team was not present during that call.

Despite this applicability, there is scant mention of NTS in consensus statements for the RRS [4,7,30]. Further, there are no requirements, or even recommendations, for training or other efforts to improve use of NTS by RRS staff [30].

1.3.3 Improving NTS Use through Training

Improving clinicians' NTS use has historically been achieved through training programs [38,72-74,79,80]. Such programs can help team members to develop and refine their communication and cooperation skills through safe exposure to clinical and time pressures during simulated clinical scenarios. [72,73]

Promising effects on both clinical and non-clinical outcomes have been demonstrated in studies of NTS training in the simulation environment [38,73,95]. While simulation can be a powerful teaching tool [97], RRT and individual Member performance cannot be assumed to automatically extrapolate to workplaces [98]. Thus far, no study has been conducted to investigate the effects of an NTS training program for the RRS on patient outcomes. Therefore, despite the plausibility of NTS training for the RRS, no robust conclusions can be reached on its value to organisations, which constrains justification for its wider implementation.

A further barrier to implementation of NTS training programs for the RRS is the considerable resource requirement that is becoming ever more stretched over time. As noted earlier, the RRT is typically staffed from a large pool of clinical staff that could be rostered to a hospital RRS.

To train all clinical staff involved in RRT calls, or even just RRT Members, would require significant investment of funding and contingency to backfill these staff while attending training [4,35]. Furthermore, training requires frequent regular refresher sessions and, thus, ongoing funding support to be sustainable.

In resource limited healthcare, such as the public system in Australia, the implementation of a comprehensive, dedicated NTS training program for the RRS seems infeasible. Therefore, for this research, pragmatic options to promote NTS use by RRS clinicians without the need for training were explored.

1.3.4 Promoting NTS Use in the Absence of NTS Training

Previous publications have presented interventions that might improve NTS use by the RRS without the need for any dedicated training [69,99-103]. Of these, Beebe et al., Peebles et al., and Cant et al. proposed, but did not study, options to improve NTS use (including through post-call debrief) [100,102,103], Kansal et al. and Prince et al. included single NTS elements (start-of-call handover and RRT

Member identification, respectively) within large-scale reconfigurations of an RRS so did not identify the effect of the NTS element on outcomes [69,101], and Mardegan et al. only measured staff satisfaction of a start-of-call handover [99]. Furthermore, Prince et al. included a concurrent clinical skills training component as part of their study intervention [101].

A thorough exploration of the findings of these studies is presented in Section 3.4. However, in summary, none of these studies reached meaningful conclusions on the effects of NTS, or improvement in use thereof, by the RRS on organisational or patient outcomes. Therefore, the proposed research detailed in this thesis is novel in focusing on NTS use by RRT Members and Users during calls.

1.3.5 Ergonomics to Promote NTS Use

Development of the intervention for this research was informed by the concept of ergonomics, especially in its role as a pragmatic administrative control mechanism for risk management [104-107]. The conventional definitions of ergonomics have applied to prevention of physical injury; however, a broader scope has been proposed by Carayon et al. that also includes cognitive and psychological aspects [108,109].

Providing training for Afferent Limb staff would have taken the approach of attempting to modify and adapt staff attitudes and behaviours to better suit the RRS. By contrast, the ergonomic approach taken aimed to modify and adapt the RRS to better support RRT Members and Users during the "clinical crisis" of an RRT call [35,49,74]. Specifically, the intervention involved redesigning the RRS to intrinsically promote use of NTS by RRT Members and Users [35].

1.3.6 The RRS Re-design (as the Research Intervention)

The re-design comprised three components. These are briefly presented here, with detailed explanation provided in Chapter Three:

1. RRT meetings
2. RRT role badges
3. structured end-of-call handoff process

RRT Meetings: Short meetings of the RRT were held twice daily, at the overlap of the day and night shifts. These served as ice-breakers to encourage team bonding. The main agenda of the meetings was to enable RRT Member introduction and establish Members' initial roles on attending RRT calls. Doing this in advance of calls was designed to expedite management of deteriorating patients at RRT calls.

RRT Role Badges: RRT Members were supplied with badges indicating their designation on the RRT (e.g. Team Leader, RRT Nurse, and so on). This was designed to provide constant visual identification between RRT Members and for other clinical staff present at calls. The premise of the role badges was that interactions between staff would be more efficient through negating the need for checking or reinforcement of RRT roles.

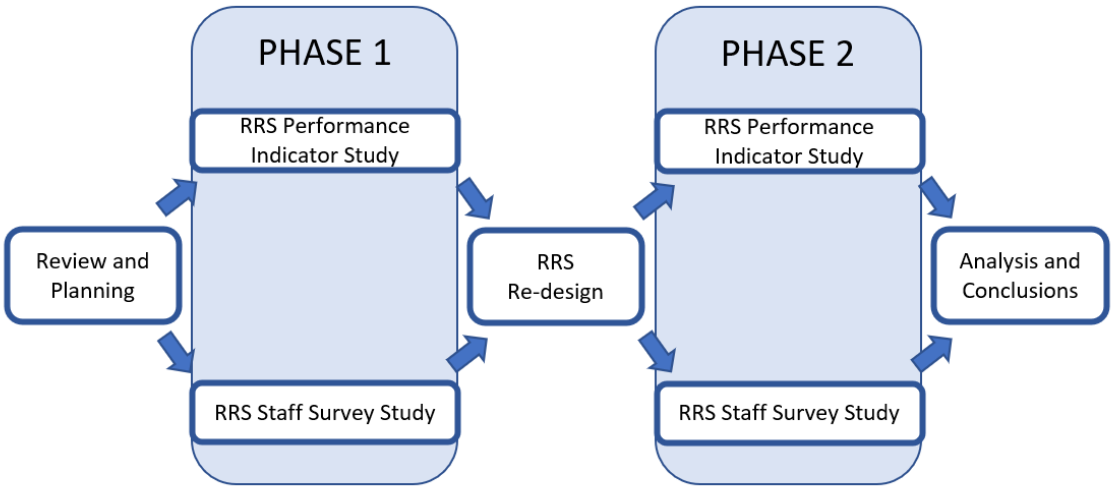
Structured End-of-Call Hand-Off: When patients stayed in the same clinical location at the end of an RRT call, a structured Hand-Off (i.e. formal transition of care responsibility) process was developed. This included a proforma that scripted clinical information relayed from the RRT to the Afferent Limb staff (typically ward nurses) who would be continuing care of that patient. The proforma also provided the opportunity for staff taking over care of the patient to clarify aspects of the plan and/or express any remaining clinical concerns (i.e. encouraged closed-loop communication). This element was designed to achieve a successful transition of care and obviate the need for the RRT to re-attend that patient due to incomplete resolution of the clinical deterioration.

1.4 THESIS OVERVIEW

As noted in the Preface, this Thesis is presented in the format for Doctor of Philosophy "by Publication", consistent with The University of Adelaide regulations for Higher Degrees by Research [110]. It reports findings from a set of studies that examined the effects of re-designing an existing RRS at a tertiary, metropolitan hospital.

The research employed a "before and after" design, punctuated by introduction of the RRS re-design that was outlined above (in Section 1.3.6). Figure 1.2 demonstrates the research graphically:

Figure 1.2: Diagram showing the research structure and study phases within it.



Five manuscripts, as shown in the Citation List, are included within this Thesis and are presented within the formatting and style of the Thesis document. Each is self-contained and referenced separately at the end of each article (i.e. discrete numbered reference lists for each publication).

These manuscripts have been peer-reviewed and published in Medline-indexed. Citations, Digital Object Identifiers and PubMed Identifiers are provided for each Paper chapter. PDFs of the published articles are available in Appendix H.

The structure and contents of the remaining chapters of this Thesis are as follows:

> **Chapter Two** contains **Paper 1**, a narrative Literature Review written in 2013 to explore the role of NTS for the RRS and methods that may improve NTS use. In the postscript, literature published between Paper 1 and writing this thesis is explored to bring the literature review up-to-date and provide rationale for the intervention presented in Chapter Three.
>
> **Chapter Three** explains the development and choice of the study intervention – the RRS re-design – and its components.
>
> **Chapter Four** contains **Paper 2**. This reports findings of the Phase 1 RRS Staff Survey (before the implementation of the study intervention).
>
> RRT Members and Users were surveyed for their experiences and perceptions of NTS use during calls. Separate questionnaires were used for Members and Users, though both contained some identical questions to gain insights from both sides of the RRT Member-User

interface. Full details of the development and conduct of these surveys is presented in the Preamble of Chapter Four (see Section 4.2).

Chapter Five contains **Paper 3**. This reports findings from the Phase 2 RRS Staff Survey conducted one year after implementation of the study intervention. The Member and User questionnaires, as presented in Chapter Four, were used (unchanged) for this study.

Data collected in the Phase 2 Staff Survey were compared against data collected at baseline (the Phase 1 surveys) and conclusions drawn about the effect of the intervention on staff perceptions and experiences of RRT calls.

Chapter Six contains **Paper 4**. This presents retrospective Phase 1 RRS data collected prior to implementation of the intervention.

An objective RRS Performance Indicator– the Repeat RRT Call – was used to indirectly assess RRS use of NTS. Repeat RRT Calls were defined as calls beyond an initial call during any patient's hospital admission (i.e. the second, third, and so on, call for that patient in that admission).

Some repeat calls would occur for discrete clinical deterioration events. Such repeat calls would not only be unavoidable but, rather, desirable as an indication of correct functioning of the RRS.

However, if the clinical concerns of RRT Users were not adequately addressed, or an ongoing plan devised for the patient by RRT Members was not communicated to Users, those Users would need to recall the RRT back to that patient. In this scenario, the resultant Repeat RRT Call may be potentially preventable by the RRS through effective use of NTS such as communication and cooperation.

A thorough exploration of Repeat RRT Calls (including the potentially preventable repeat calls) and the evidence base supporting its choice as a performance indicator is presented in the Preamble (Section 6.2) of Chapter 6.

Chapter Seven contains **Paper 5**. This reports the effect of the RRS intervention on the incidence of repeat RRT calls by comparing data from Phase 2 versus Phase 1. Conclusions are drawn on the potential benefits of the RRS re-design and NTS to patients and organisations.

Chapter Eight presents interpretation of the whole research project and the contribution of its component papers. It closes with conclusions and an outline of potential avenues for further development of the intervention and future research into the incorporation of NTS into the RRS.

References for Chapters One, Three and Eight. The Results Papers are individually referenced, per formatting for publication, at the ends of Chapters Two and Four to Seven (inclusive).

Appendices include materials used in the studies (such as the questionnaires) to support Chapters One and Three and links to PDFs of the published papers.

1.5 THESIS AIMS

The aims of the research program presented in this Thesis were distilled into an overarching research question:

> "Would a Non-Technical Skills (NTS) inspired re-design, without the need for staff training, improve interactions within an RRT and between RRT Users and Members during RRT calls, and reduce the incidence of (potentially preventable) repeat RRT calls?"

And the following composite research questions (addressed in the Results papers):

Paper 1. What is the existing evidence base on the role of NTS for the RRS?

Paper 2. What are RRS staff perceptions and experiences of interactions within the RRT and between RRT Users and Members during RRT calls (prior to re-design of the RRS)?

Paper 3. What is the relationship between (potentially preventable) repeat RRT calling and patient in-hospital mortality?

Paper 4. What is the effect of an RRS re-design on RRS staff perceptions and experiences of interactions within the RRT and between RRT Users and Members during RRT calls?

Paper 5. What is the effect of an RRS re-design on the incidence of (potentially preventable) repeat RRT calling?

1.6 PROJECT SUPERVISION

Initial enrolment was in the Discipline of Acute Care Medicine, Faculty of Health and Medical Sciences, The University of Adelaide in 2013 under the supervision of Associate Professor Athanasios Flabouris, Associate Professor Margaret Arstall and Associate Professor Josephine Thomas.

Three years later, enrolment was changed to the School of Public Health within the same Faculty. With this came a change of supervisors to Associate Professor Lynne Giles, Associate Professor Amy Salter and Professor Jonathan Karnon.

Chapter 2: Literature Review (Paper 1) – The Utility and Assessment of Non-Technical Skills for Rapid Response Systems and Medical Emergency Teams

2.1 CITATIONS

Chalwin RP, Flabouris A. Utility and assessment of non-technical skills for rapid response systems and medical emergency teams. Intern Med J 2013;43:962-969

2.1.1 Digital Object Identifier

10.1111/imj.12172

2.1.2 PubMed Identifier

23611153

2.2 PREAMBLE

The following paper was written and published in 2013 at the commencement of the research project.

It served to explore the role that Non-Technical Skills (NTS) may have during Rapid Response Team (RRT) calls. The background for this has been established in Chapter One: Introduction. This article will expand on themes already raised. It also discusses methods to optimise NTS use within the Rapid Response System as well as measure the success of NTS during calls.

Analogous articles for other disciplines have proposed and studied training as the preferred method for development of NTS by clinical teams [73,74,79,80]. The potential benefits to RRTs and other RRS staff from NTS training is discussed.

This article was published in an Australian journal so uses the terminology Medical Emergency Team in lieu of Rapid Response Team.

2.2.1 Presentation Style

The paper was written as a narrative review. There are disadvantages of the narrative review by comparison to the systematic review, such as the lack of a defined search strategy and not formally grading literature [111]. Through not following accepted guidelines for conducting systematic reviews, such as PRISMA, conclusions reached cannot be verified through reproduction of methodology.

However, there is a role for the narrative review when a topic is niche or there is no consensus method for evaluating it resulting in a heterogenous evidence base [112]. In this setting, following the explicit techniques of a systematic review may be impractical or restrict inclusion of historical or other relevant information that provide a comprehensive overview of the topic in question.

For this paper, the MEDLINE and EMBASE databases were queried for articles related to RRS and NTS, with no relevant comparative studies found. Further, the approaches taken in analogous articles

that either used training as the study intervention or were not conducted within an RRS, were not standardised or consistent. Due to this limited heterogeneous literature, and the use of NTS within a RRS being relatively novel (as noted in Section 1.2.4), a decision was made at that time to present a narrative review article to evaluate relevant research.

2.2.2 Research Question:

What is the existing evidence base on the role of NTS for the RRS?

2.3 STATEMENT OF AUTHORSHIP

2.3.1 Principal Author (Candidate)

2.3.1.1 Name:	Richard Chalwin
Contribution to the Paper:	Conception, planning, literature review, writing, drafting, proofing
Overall percentage (%):	75
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.
Signature:	Date: 22 Feb. 2022

2.3.2 Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);
ii. permission is granted for the candidate in include the publication in the thesis; and
iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

2.3.2.1 Name:	Arthas Flabouris
Contribution to the Paper:	Planning, drafting, proofing
Overall percentage (%):	25
Signature:	Date: 22 Feb. 2022

2.4 ABSTRACT

Efforts are ongoing to improve outcomes from cardiac arrest and medical emergencies. A promising quality improvement modality is use of Non-Technical Skills (NTS) training which aims to address human factors through improvements in performance of leadership, communication, situational awareness and decision-making. Originating in the airline industry, NTS training has been successfully introduced into anaesthesia, surgery, emergency medicine and other acute medical specialities.

Some aspects of NTS have already achieved acceptance for cardiac arrest teams. Leadership skills are emphasised in Advanced Life Support training and have shown favourable results when employed in simulated and clinical resuscitation scenarios. The application of NTS in Medical Emergency Teams (MET) as part of a Rapid Response System (RRS) attending medical emergencies is less certain; however observations of simulations have also shown promise.

This review highlights potential benefits of NTS competency for cardiac arrest teams and, more importantly, MET, due to the diversity of clinical scenarios encountered. Discussion covers methods to assess and refine NTS and NTS training to optimise performance in the clinical environment. Increasing attention should be applied to yielding meaningful patient and organisational outcomes from use of NTS. Similarly, implementation of any training course should receive appropriate scrutiny to refine team and institutional performance.

2.5 INTRODUCTION

Clinical emergencies are a common occurrence in acute medicine and critical care. Resolution of such a "crisis" hinges on expedited and targeted management. Federal Safety and Quality commissions in Australia and the United States currently endorse programs targeting recognition of and response to deteriorating patients as a key initiative to improve hospital outcomes. [1,2]

The importance of leadership and teamwork is becoming increasingly recognised during the response to clinical emergencies. [3-5] Historically, teamwork has not been emphasized in resuscitation training. [6] However, European and American Resuscitation Guidelines now recommend inclusion of this and other "non-technical" aspects in training to improve resuscitation outcomes.[7,8]

Non-technical skills (NTS) comprise a set of interpersonal and cognitive attributes that complement clinical skills and contribute to safe and efficient task performance [9]. Desirable leadership skills include clear instruction, delegation of tasks, inclusive decision-making and maintenance of situational awareness (i.e. remaining hands-off so an overview can be maintained). Specific NTS required by constituent team members include productive communication and co-operation. Obstacles to effective employment of NTS include a lack of clear leadership, communication breakdowns or absence of a common purpose within the team.

The concept of NTS training emerged within the aviation industry when human error was recognised as a leading cause of avoidable incidents, [9,10] and has since evolved from standalone seminars to become a fully integrated facet of flight crew training. [10,11] In this context, medicine is not that dissimilar from the aviation industry and as such, NTS training is being increasingly embraced by acute healthcare specialities such as anaesthesia, [12] surgery, [13] obstetrics, [14] paediatrics, [15] trauma, [16] emergency medicine, [17] critical care, [18] and aeromedicine. [10]

Rapid Response Systems (RRS) are designed to detect and respond to the deteriorating hospital patient. Medical Emergency Teams (MET) are a key component of any RRS and are tasked to respond to clinical emergencies that involve a deteriorating patient. Their membership, even if team skill set is pre-defined, may vary and so may impose an additional obstacle to team bonding. [19,20] It is precisely for such scenarios that clear leadership with allocation of roles and responsibilities and active use of NTS by team members may prove to be important.

The objective of this review is to outline the application and utility of NTS and NTS training for MET; and to explore the avenues for evaluating NTS training.

2.6 NTS IN RESUSCITATION

The role of leadership in resuscitation scenarios was identified early during the institution of cardiac arrest teams. [21] More recently, emphasis has been placed on broader team-building skills. [19,22] Studies across established critical care and emergency response teams have identified a number of key desirable attitudes and behaviours including leadership, motivated team-working, bi-directional communication, inclusive decision-making and avoidance of conflict. [23,24,25]

There has been increasing attention devoted towards ascertaining the importance of non-technical skills during resuscitation. [20,22,26] It is feasible that effective use of NTS will result in improved performance of clinical skills. [27] In select resuscitation scenarios, the appropriate management of clinical issues has been shown to correlate with team performance of NTS. [28,29] For example, a correlation between leadership skills and effectiveness of cardiopulmonary resuscitation, especially regarding timeliness of chest compressions and defibrillation, has been demonstrated; [21,23,30,31] as has a reduction in delays to initiation of resuscitative efforts, improved adherence to prescribed resuscitation algorithms, and expedited team decision-making. [6,21,25,32]

Thus, the emerging consensus seems to be generally positive, and aspects of NTS have been integrated into accredited resuscitation training systems. The United Kingdom and Australian Resuscitation Council Advanced Life Support provider courses, for example, encourage development of leadership skills and emphasise team interactions to optimise resuscitation efforts [33].

2.7 ASSESSING NTS

As more and more resources are allocated for NTS training, an important challenge will be to establish accurate and reliable measures to ascertain the "value-added" impact of NTS training. If cardiac arrest and medical emergency teams had a ubiquitous, consistent structure, training was standardised and investigator goals were homogeneous, a single assessment model could be used. However, differences do exist between service delivery and training needs as RRS are not uniform, even across centres within the same country, [34] and as such there is a range of assessment measures used to evaluate NTS. These and the associated trials of NTS performance relevant to cardiac arrest teams and MET are summarised in Table 1. The breadth of assessment tools utilised thus far may reflect the relative novelty of NTS training for MET and cardiac arrest teams, hence why no clear "gold standard" measure has yet emerged.

Table 1 – Assessment Tools of NTS and NTS training validated for evaluation of Medical Emergency or Cardiac Arrest Teams

Tool Name	Clinical Field	Subjects	NTS Domains	Scoring of NTS	Scoring of key clinical tasks
OSCAR [6]	Cardiac arrest	Proposal aimed at RRS	Communication, Cooperation, Coordination, Leadership, Monitoring	6 point scale (ineffective – effective)	Completed or not
Lighthouse Leadership (LBDQ) [21]	Cardiac arrest	Existing cardiac arrest team	Leadership	5 point scale (used never – always)	Completed or not
Modified LBDQ [23]	Cardiac arrest	Ad-hoc cardiac arrest team	Leadership	Competent or not-competent	Completed or not, time to complete
DeVita et al [24]	Medical Emergencies, including cardiac arrest	Existing team members of a RRS	Organisation, Data Transfer, Communication	Not assessed	Completed or not, time to complete, manikin "survival" or not
Teamwork Behavioural Rater [25]	Medical Emergencies	Existing intensive care team	Leadership and Team Co-ordination, Verbalising Situational Information, Mutual Performance Monitoring	7 point scale (undesirable – desirable behaviours)	Competent or not-competent
Wright et al [27]	Medical Emergencies	Ad-hoc team of medical students	Assertiveness, Decision-making, Situational Awareness, Leadership, Communication	5 point scale (unskilled – skilled)	Completed or not
Ottowa Global Rating Scale [28]	Medical Emergencies	Ad-hoc resident medical officer team	Leadership, Problem Solving, Situational Awareness, Resource Utilisation, Communication	7 point Likert scale	Not assessed
Ottowa Checklist [29]	Medical Emergencies	Ad-hoc resident medical officer team	Problem Solving, Situational Awareness, Resource Utilisation, Leadership, Communication	3 point scale (not used – used)	Not assessed
Fernandez Castelao et al [30]	Cardiac arrest	Ad-hoc cardiac arrest team	Leadership Verbalisation, Follower Verbalisation	Competent or not-competent	Completed or not, time to complete

LBDQ [31]	Cardiac arrest	Ad-hoc members of a cardiac arrest team	Leadership	5 point scale (used never – always)	Completed or not, time to complete
Marsch et al [32]	Cardiac arrest	Ad-hoc intensivist and nurse team	Task Distribution, Information Transfer, Leadership Behaviour, Conflicts	Not assessed	Completed or not, competent or not-competent
MHPTS [40]	Medical Emergencies	Ad-hoc resident and nurse team	Cooperation, Communication, Leadership, Situational Awareness, Decision Making	3 point scale (used never – consistently)	Not assessed
TEAM [41]	Medical Emergencies	Proposal for existing MET	Leadership, Teamwork, Task Management	5 point scale (used never – always)	Not assessed
CARDIOTEAM [45]	Cardiac arrest	Proposal aimed at RRS	Leadership, Coordination, Communication, Re-evaluation, Assertiveness, Task Management, Situational awareness	Not assessed	Completed or not, time to complete

OSCAR = Observational Skill-based Clinical Assessment tool for Resuscitation

LBDQ = Leadership Behavior Description Questionnaire

MHPTS = Mayo High Performance Team Score

TEAM = Team Emergency Assessment Measure

CARDIOTEAM = proprietary name for assessment tool

2.7.1 Objective Observation

Direct evaluation of NTS by independent assessors originates from the commercial aviation industry which commissioned the NOTECHS system to permit assessment of pilots during line-orientated flight training. [35] Their four targeted areas of Co-operation, Leadership, Situational Awareness and Decision Making formed the basis for development of the Anaesthetists Non-Technical Skills model. [36] Subsequently, many observational assessment tools have taken cues from these including Non-Technical Skills for Surgeons and the Observation Teamwork Assessment for Surgery in the theatre suite, [37,38] and Emergency Team Dynamics and the MedTEAMS program in the emergency department. [21,39]

NTS assessment by objective observation relies on inter-rater reliability and expert validation. There is no defined standard for an "expert" in non-technical skills and, thus, reliance upon a consensus approach. While many validation studies have specifically addressed inter-rater reliability and construct stability with generally positive results, [6,24,29,40,41] other authors have urged caution with the use of naïve assessors and suggest deployment of experienced evaluation groups. [42,43] Even with an apparently objective scoring system, investigators are prone to observer bias, such as leniency and the halo effect, with resultant difficulty in identifying areas in need of improvement. [44]

NTS assessment tools must be adapted to the individual characteristics of the service under scrutiny. An assessment method validated in one setting may not be generalizable to another, so establishment of a standardised international assessment system would be problematic. This crucial aspect, that one size does not fit all, was realised early on the evolution of Crisis Resource Management (CRM) in the aviation industry due to differences in cultural and behavioural norms internationally. [45]

The toughest hurdle to assessing the impact of NTS is isolating its specific contribution to performance or indirect outcomes. [8,20,22] This is best evaluated with direct measures such as objective observations by external assessors trained to concentrate on NTS and ignore all other activities. The credibility of such measures depends on expert assessor groups, with a high inter-rater agreement, who can reliably evaluate usage of NTS and outcomes from NTS training. [6,41,46]

None of these measures have any specific advantage over another being designed for ease-of-use. Each tool typically comprises a proprietary multiple point scale rating team employment of key NTS (ranging from "never" to "always") with common aspects of NTS consistent amongst evaluated parameters. The number of potential scoring options varied between 3 and 7, with the former affording simplicity at the cost of a reduction in precision versus the latter.

2.7.2 Assessment in the Simulated versus the Clinical Environment

Most existing, and proposed, assessment tools of NTS in RRS involve a simulated environment. [23-25,29] Advocates cite faithful reproduction of realistic emergencies, immersive simulation facilities and motivated facilitators as strong rationale for use of simulators. [14,39,47,48] They allow sufficient exposure to the realism of a medical emergency without risking patients and permit full control of the experience. Learning opportunities can be enhanced due to the ability to "freeze time" and vary manikin response to team requirements. Despite general acceptance, concerns have been raised regarding the ability of simulation to replicate actual patient encounters due to the lack of real consequences and reliance on participant cooperation. [49]

While most aviation assessments are performed in simulators, impartial observation has been conducted during flights to ensure NTS training is transferable into the "real world". [50] Despite logistical difficulties, observation of cardiac arrest teams at cardiac arrest attendance has similarly been achieved. The seminal "Lighthouse Leadership" paper required the investigators to arrange an elaborate method of videotaping resuscitation efforts at cardiac arrest calls. [21] Barriers to this

approach include the ethical issues associated with observation during cardiopulmonary resuscitation and the need for immediate availability of investigators. [20]

2.7.3 Team versus Individual Measures

Two approaches are available to assessors; score the overall conduct of the team or scrutinise performance on an individual level. Individual performance assessment is based on the premise that a team is only as strong as its component members. The Observational Skill-based Clinical Assessment tool for Resuscitation investigators took a direct approach by evaluating performance of defined tasks by specific members of a multi-disciplinary team. [6] A number of other investigations have also taken this approach, [28,29] with some emphasising the importance of clear and decisive leadership. [21,23,30,31]

The alternative standpoint is that of assessing composite team performance. This is likely to be more important than individual level assessment as it is likely to be more relevant to clinical practice. Assessment tools such as Team Emergency Assessment Measure and others score human factors in a non-specific manner requiring coherence of skills performance amongst team members. [25,32,39,45] While this allows for a more holistic approach, it also presents the potential for one or more under-performing individuals to detract from an otherwise competent team performance.

2.7.4 Attitudes to NTS training

One of the more frequently employed techniques for assessing "success" of NTS training is surveys for satisfaction with training, and assimilation of themes. This has been used extensively in domains such as aviation, [51,52] anaesthesia, [53,54] emergency medicine, [55] paediatrics, [15] and surgery. [56] The concept infers that user acceptance will increase retention and recall of training. Therefore, modern training courses make extensive use of educational psychology to improve the learning experience. [57] Surveys are also a useful mechanism to identify individuals less accepting of NTS principles, for whom further exploration of crisis management techniques may be desirable. [51]

Few surveys have evaluated attitudes to, and satisfaction with, NTS training for RRS. A retrospective mail-out questionnaire was presented to a multi-disciplinary participant group who encountered medical emergencies in their clinical practice. [58] The majority reported positive experiences with training that aided confidence in dealing with subsequent emergency encounters.

2.7.5 Benchmarking NTS against Clinical Performance Measures

NTS should not be regarded as an endpoint per se. Instead, it is a mechanism that has the potential to augment clinical performance. The benefits would stem from improvements in inter-personal communication and expedited decision-making. Such outcomes have been supported by an observational study of simulated medical case scenarios. [27] Positive correlations were noted between the frequency and quality of NTS use, and accuracy of clinical assessment and management. This preliminary data has been further verified in resuscitation scenarios. [23,30] Similar findings reported that the delivery of NTS training improved efficiency of naïve cardiac arrest teams. For example, significant reductions in delays and interruptions to chest compressions were noted even though the control groups had received additional cardio-pulmonary resuscitation training. [30]

With the association established, two proposed models consider the performance of required tasks as an analogy for NTS. The Observational Skill-based Clinical Assessment tool for Resuscitation system evaluates individual clinical skill sets by defined members of a multi-disciplinary resuscitation team as representative of Communication and Co-operation skills. [6] The CARDIOTEAM project has taken this a step further assigning an NTS principle to each step in the European Resuscitation Council algorithm. [45]

Therefore, assessment of clinical performance would seem to be a valuable mechanism of detecting any potential real-world benefit from NTS training. This also provides a reliable measure of NTS effectiveness by excluding the inherent subjectivity of team NTS performance observations.

2.8 RETENTION OF NTS

Like any newly learnt skill, it is reasonable to assume atrophy of NTS over time. The retention of NTS has not been well studied, though some projects have conducted extensive prospective evaluation, most notably the MedTEAMS initiative which surveyed participant attitudes at four and eight months post-training. [39] For cardiac arrest teams, a trial of leadership skills training has shown sustained improvements on repeat assessment conducted four months following initial training. [23] Tracking the retention of NTS, especially if standardised assessment methods are used, may be a possible mechanism to evaluate relative effectiveness of training programs. It also contributes evidence to indicate the required frequency of NTS training to maintain optimal performance.

2.9 ORGANISATIONAL AND COST BENEFITS OF NTS

Efficient team working and a culture of openness should create flow-on effects via improved patient outcomes that can be detected by hospital performance indicators. For example, the MedTEAMs project precipitated a change in institutional culture whereby increased team member cross-checking resulted in decreased rates of prescribing and therapeutic errors. [39]

The recent International Liaison Committee on Resuscitation (ILCOR) guidelines specify a number of RRS-associated outcome measures including cardiac arrest rates and mortality as indicative of a hospital's capacity to detect and respond to a deteriorating patient. [59] There is no requirement for these to be assessed in the context of NTS delivery. However it would be useful to do so, based upon the potential of NTS training to improve MET performance and thus positively influence clinically relevant hospital outcomes.

Cost benefits may be another desirable result from implementing non-technical skills training. However, studies exploring the economic benefits of NTS are few. The best data comes from a small trial assessing the cost-effectiveness of a NTS training course for improving appropriate use of damage control surgery. [60] The authors found that the financial gains to the hospital more than covered the outlay for training.

2.10 NTS IN THE ERA OF RRS AND MET

A MET, in comparison to a cardiac arrest team, will encounter a range of medical emergency "crises", in addition to cardiac arrests. This is because activation is based upon not just the observation of a cardiac arrest occurrence, but also observation of physiological triggers and staff concerns (the "worried" trigger). They do so on the basis that early recognition and protocolised resuscitation may increase survival.[61] When called, they deliver critical care type interventions during the majority of the occasions, and the time they spend attending patients who survive the call is approximately 30 minutes. [62]

A number of trials have specifically assessed performance of NTS, or the impact of NTS training in unexpected acute medical emergencies. [24,25,27-9] Trials that predominantly involved cardiac arrest teams, have revealed results that were generally positive, and linked enhanced manikin "survival" with competency in NTS. [23,26,31,32] Results from simulated emergencies have consistently shown that employment of NTS improves time efficiency and is associated with expedited decision-making. [21, 23-

[24] As MET, by comparison to a cardiac arrest team, attend increasingly diverse clinical scenarios, the potential benefits of a NTS associated enhancement in performance may be even more valuable. [22]

However, thus far, only one trial has specifically examined NTS training in an established RRS. [24] A comprehensive package of online learning material and didactic tutorials was delivered before engagement in practice involving clinical emergency scenarios. These were reinforced by facilitated debrief sessions to encourage participants to achieve insight to NTS performance. The results were impressive with significant improvements in completion of clinical tasks and manikin "survival". This is notable since all participants had ACLS accreditation prior to undertaking the NTS training course and shows the value of NTS when added to an existing clinical skill set.

A number of unanswered questions arise from this study; particularly regarding definition and allocation of specific roles and responsibilities for MET members. This extends beyond the establishment of a leader to recognise the benefits to operating efficiency if team members have defined tasks and targets. [6] Beyond this, a priori designation of member roles may further increase efficiency by eliminating the time currently devoted to team structuring on team arrival.

Within Australia, CRM courses that are specific to RRS are emerging. [63-65] Participants in such programs often report a positive response to training; however this may not necessarily translate into improved clinical outcomes.[50] As yet, there is no central governance and no national curriculum for any aspect of MET training.

2.11 NTS FOR RRS AND MET

Based upon the available information, it seems likely that NTS would be a useful skill set for MET, as it is already for other teams that are expected to encounter clinical emergencies. But before widespread endorsement can be realised, there are still outstanding issues to be addressed. Most importantly, the existing evidence base comes almost entirely from simulated scenarios, and from outside the ward environment.

Despite this, experience and knowledge of NTS training appears to be sufficiently mature that we can reasonably proceed to investigate the potential benefits that may be achieved within the MET working environment. Further research should be conducted to assess whether this knowledge can be extrapolated to patient and organisational outcomes. Ideally this should be undertaken through the conduct of real-time observational trials of MET performance on hospital wards, during an acute patient encounter. [21]

Study of actual practice must be methodologically robust so that meaningful outcomes can be detected. This highlights the need to identify which NTS elements and training methods are most productive, and the specific MET component behaviours that demonstrate proficiency in NTS within the ward environment. To do so will require further exploration of NTS, in for the context of RRS, and the validation of assessment measures for the evaluation of NTS implementation.

This review proposes the utility of NTS and training for teams responding to clinical emergencies and the potential avenues for evaluation of such NTS. Further development and evaluation of NTS training systems will provide information that will enable optimal dissemination of NTS to RRS in the future. There are a broad range of methods available to do so, but it still remains to be determined how to best select from, and utilise these methods.

2.12 CONCLUSIONS

NTS is a recognised skill set that augments clinical performance. NTS training has been successfully implemented in a number of medical disciplines with a generally favourable reception. Results from trials of team performance have been overwhelmingly positive. For resuscitation teams, training in leadership skills has been internationally endorsed and forms part of the syllabus for Advanced Life Support courses. However for RRS and MET, which in contrast, attend a diverse range of medical emergencies beyond that of the established cardiac arrest, it is important that NTS training reflects that diversity and increasingly complex demands. Equally importantly, investigation must shadow such training to better guide the evolution of NTS training and the potential patient benefits that it may offer.

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2.14 POSTSCRIPT

This narrative review was written early in candidature. At the time of writing, the plan had been to provide NTS training as the research intervention. Unfortunately, as noted in Chapter One (Section 1.3.4), training programs require significant resourcing and, therefore, this became infeasible.

Therefore, while this narrative review further establishes the argument for optimising use of NTS within the RRS, it did not explore methods of achieving this without training.

In the (almost) decade since publication of the paper presented as Chapter Two, the contribution of NTS to supplementing clinical skills has further established, and methods to optimise use of NTS honed [113,114]. However, over the same timeframe, within the sphere of RRS, there has been scant attention to NTS. To date, DeVita et al. [72], as was described in this chapter, remains the only comparator NTS study conducted on a RRT, and that was the simulation environment.

Thus, this postscript presents an update of the reviewed literature with a focus on the evidence around the key domains of NTS that relate to the design of the study intervention that is introduced in Chapter 3.

2.14.1 Leadership

The origin of RRT leadership dates to Cooper et al. published in 1999 [115] and, as noted in this chapter, has been validated in simulation studies [90,91,94]. Prineas et al. identified key leadership skills, of which some are relevant to RRT calls such as Command: "*the exercise of authority in the course of a … mission*" and Control: "*the wielding of resources in the course of performing a … series of tasks*" [114]. Like many other discussion papers on NTS, their recommendations for acquisition or refinement rely on training [38,80,83,86,96,103,113]. The argument is that innate leadership skills are rare. When present, individuals tend to exhibit either a mostly transactional (i.e. task focused) or mostly transformational (i.e. relationship focused) leadership style, whereas the best leaders learn to flexibly use both attributes as any situation demands [116].

Thus, in this doctoral research with training programs precluded because of funding and time constraints on participants, other approaches were necessary to identify the RRT leader and promote their role during calls. The simplest and most obvious means of team leader reinforcement is their visual identification. Gillon et al. proposed that the RRT leader should adopt a consistent position during RRT calls (see their Figure 2) [74].

Subsequent to publication of the narrative review in this chapter, Shah et al. and Prince et al. proposed conspicuous role identification cards to be donned by the leader during calls [101,117]. Shah et al. found significant improvements in team leader identification during simulated RRT calls (80.5% after vs 61.8% before introduction of the cards) whereas Prince et al. noted no difference, although this latter study addressed all team roles and did not focus on improving team leader identification.

In the absence of training or mentoring during RRT calls, there are limited options to improve leadership skills. The other viable technique, as proposed by Shah et al. [117], would be to provide a checklist or algorithm as an aide-memoire. However, such checklists rely on a consistent presentation and management of clinical events such as cardiac arrest. The heterogeneous nature of RRT calls, with some because of RRT Users' concern [57,118], require a far more nuanced approach that cannot be protocolised [74,119]. Thus, visual reinforcement of the team leader role is a practical approach to give confidence to the wearer and orient other call participants [96,102,114,116].

2.14.2 Communication

Prineas et al. identify communication as "*a means to provide knowledge, institute relationships, stablish predictable behaviour patterns, and as a vital component for leadership and team*

coordination" [114]. As such, effective use of communication skills is vital [50,120,121], such as through tools like Closed-Loop [122], a three-step method: the team leader gives an instruction, the directed team member verbally confirms that instruction, seeking clarification if necessary, before the team leader confirms or corrects the instruction, therein "closing the loop" [123].

However, as with leadership, while review and discussion papers sees to concur that communication skills are best acquired through training [79,98,113,124], an alternative approach would be to provide all participants at a RRT call with visual role markers [35,74,101]. This was the approach taken by Prince et al. [101], albeit in the context of a training intervention study, to expedite directed communication between necessary persons (e.g. between the RRT Leader and RRT Nurse for drug administration), rather than incur delays establishing personnel roles and responsibilities. However, as their study centred around a training program and did not specifically look for changes in staff perceptions of communication.

Consistency of communication is another potentially valuable approach with efficiency gains when all participants involved have aligned expectations [124,125]. Although not specifically designed for the RRS, structured clinical handover tools such as ISBAR seem suited to use at calls [50,81,99,122,125,126]. A narrative review of strategies to improve hospital service effectiveness by Buljac-Samardzic et al. [124] highlighted the use of communication "tools" such as ISBAR, alongside reviewing and redesigning organisational systems, as a viable method to improve efficiency. In the field of RRS, this has been explored by Kansal et al. and Mardegan et al. who incorporated a structured communication tool into their respective RRS [69,99]. Both tools aided RRT Users to relay patient information in a consistent format to an arriving RRT. Kansal et al. did not directly assess their handover tool whereas Mardegan queried Users' satisfaction, of which 57% expressed satisfaction with using the tool.

2.14.3 Cooperation

The interface of RRT Users and Members is uniquely complex within a typically siloed and hierarchical hospital system. As noted by Prineas et al. research consistently finds that workflow and inter-personnel interactions are augmented within teams with existing rapport [114]. With an ad-hoc and inconsistent staff participation in RRT calls, the "shared mental model" may be a more valuable area for promoting cooperation for the common purpose of patient management [120,122,127]. Cooperation is more challenging to improve without training as it often reflects the internal culture of the organisation [50,128-130]. Thus, where internal stressors affect staff morale and behaviours, frustrations could impair interactions during calls [49,131].

In the context of improving a RRS without availability of a training or organisation-wide intervention, the moments of transitions in patient care between Users and Members are a valuable opportunity to orient all present to the common purpose of patient care [21,22,120]. As outlined above, Mardegan et al. and Kansal et al. separately identified the importance of the arrival of the RRT as an opportunity to align RRT Members to Users' concerns [69,99]. Their respective structured handover tools (from Users to the arriving RRT Members) were designed to align all call attendees to the clinical concern, thereby mitigating Users' apprehension of calling and Members' doubts regarding indications for the call [43,45,46,132].

To date, no study or commentary has proposed a similar structured transition of care process at the end of calls. Alignment of Users' and Members' expectations for the RRT call, and especially for its completion, may improve successful transition of care. As noted in this Chapter and suggested by Calzavacca et al., deficits in the transition of care back to the initial treating team, especially where unresolved clinical concern persisted, could result in (potentially preventable) repeat calls to that patient [133].

2.14.4 Decision-Making/Planning

Another key factor in successful end-of-call resolution lies in the decisions and contingency plans made at completion of a call. As occurs in the Emergency Department [134,135], seniority of clinicians likely plays an important part in decision-making and planning, harnessing the experience that protocols and policies cannot replicate [31,136]. In 2018, Romig et al. reported improvements in patient survival and documentation of a clinical plan when ICU specialists attended RRT calls [137]. Unfortunately, adding ICU specialists to all RRTs is unlikely to be feasible due to the typical lack of their availability after-hours [31,57], despite studies consistently associating these after-hours calls with worse patient outcomes [138-142].

A potential solution in this scenario, with a pre-defined RRT, would be to leverage the experience of Members and Users by explicitly including all call participants in communication events (such as the transitions of care and the start and end of calls). Part of the ethos of Kansal and Mardegan was to empower experienced RRT Users to voice their concerns rather than the RRT, and especially its leader, dominating clinical discussions [69,99]. Their structured transition of care tools also prompted actions as a decision-assist tool. In this vein, Shah et al. included some clinical task prompts for the team leader, printed on the backside of their role identification card, to assist the initial phase of calls (e.g. to ensure intravenous access was achieved) [117]. This suggests that similar written prompts to verify patient safety and resolution of clinical concern could also be implemented for the end-of-call care transition. The potential of this strategy will be more fully explored in the following chapter.

2.14.5 Assessment of NTS

This chapter identified several potential methods for assessing NTS, with Table 1 listing the fourteen different observational tools available at the time of writing the literature review. All contain similar themes, mostly involving some or all of the NTS domains above, but there is no agreed standard to date [143]. The most commonly used tool is the Team Emergency Assessment Measure (TEAM®) [103,144], which has been validated in simulated and real emergency calls.

In 2017, Siems et al. used TEAM® in a before-and-after study evaluating the effect of a training course on use of NTS domains such as leadership, communication and planning [145]. They noted statistically significant improvements in TEAM ® scores for leadership and task management following delivery of the training course to RRT Members. This study is notable in reporting the first conduct of contemporaneous assessment of a team response to actual, rather than simulated, clinical deterioration since Cooper's video recording of cardiac arrest calls in 1999 [115].

Then, in 2021, Saunders et al. reported an evaluation of conducting in-field observations (also using TEAM® to assess NTS use during RRT calls) [146]. No intervention occurred so no comparator data were collected. However, this study did report feasibility for having observers attend RRT calls, albeit only during office hours due to resource limitations.

That only two papers have reported direct observation of NTS during RRT calls speaks to an inherent difficulty in undertaking such research. Even where resources are available to perform in-field observations of RRT calls, improvement in NTS use during calls cannot be assumed to provide benefit to patients or organisations. Thus, RRS research should also capture objective measures to assess the wider effect of any (NTS) improvement intervention [77,124,147]. However, while benchmarks for the RRS have been proposed [77], to date there remains no consensus on an objective marker of NTS success.

In the past decade, organisation level outcomes, such as incidence of adverse events, have been used to assess NTS interventions [59,69,77,148-150]. This approach was first proposed by the CONCORD research group whose hypothesis was that non-supernumerary RRT Members leaving their primary duties to attend calls would manifest as adverse events (e.g. unplanned ICU admission) from omitted or delayed care to their primarily allocated patients [151]. While a retrospective observational study did

not support that hypothesis [151], their larger-scale prospective trial reported a decreased incidence of adverse events when ICU-based members of the RRT were exempted from attending low-acuity calls [56].

2.14.6 Improvement without Training

Training remains the mainstay recommendation for improving the skills (both clinical and non-clinical) of the RRS [3,95,119,124,152,153]. However, the majority of RRS (in Australia and New Zealand) are not separately funded [4,29,57]. Instead, most draw their staff and budgets from other departments such as ICU and Internal Medicine [31]. While RRT training would be preferable and should be aimed for [4], the current state of resource limitation is likely to preclude delivery of training courses for RRT Members and Users. Although federal guidelines mandate provision of an RRS in Australian hospitals, there is no requirement for training beyond "at least one member of the RRT should have advanced life support skills" [33,154].

In this postscript, the original literature was updated to identify approaches to NTS development that did not require training. That no consistent approach has been used, and that many of the referenced papers contain proposals, but not investigation, of interventions suggests much progress is still required in this area of RRS improvement.

2.15 CLOSING

The continued paucity in evidence regarding the role and utility of NTS during RRT calls, and potential effects from improvement in use of NTS, almost a decade after commencing this research leaves a gap in knowledge in this area. Given that NTS has been identified as an efficacious patient safety mechanism in many allied medical (and non-medical) fields supports its relevance for the RRS, as detailed in Section 1.3.2. Therefore, the lack of published literature in this area highlights an untapped potential for research to address the effects of NTS use within the RRS.

The following chapter will elaborate the RRS re-design in preparation for the Results chapters (4 to 7 inclusive).

Chapter 3: The Research Intervention

3.1 PREAMBLE

This chapter will elaborate on the RRS re-design that was introduced and outlined in Chapter One, Section 1.3.6. In particular, detailed explanations and the evidence base for the re-design components will be presented.

3.2 BACKGROUND

The research presented in this thesis was conducted at the Lyell McEwin Hospital (LMH), an acute, tertiary, metropolitan hospital in the northern suburbs of Adelaide. The RRS at LMH had been initiated in June 2007. Therefore, by the time of introduction of the study intervention, the RRS could be considered mature, that is it had addressed any initiatory issues and was operating within expectations of the state Department of Health [154]. In 2016 and 2019, the RRS passed accreditation against the National Standards of the ACSQHC [30].

In the early 2010s, prior to commencement of this research, the RRS managers at LMH had received a number of internal complaints, reports of conflicts at RRT calls, and clinical incidents. These were investigated through RRS governance processes with focus groups of hospital staff to further elucidate some of the issues occurring during RRT calls.

The common theme seemed to be lapses in communication and cooperation during periods of clinical or time pressure at these RRT calls [35,48]. It is likely that under duress, clinicians would experience internal stress that manifested externally.

As noted in Chapter One (Section 1.3.2), promoting use of Non-Technical Skills (NTS) during RRT calls was considered to be one promising means of addressing these issues [38,74,103]. As also identified, NTS use would usually be improved through a dedicated training program, typically involving simulated clinical scenarios [38,73,79,80,84,103].

3.2.1 The Rapid Response System

The RRS at LMH has been introduced in 2009. From initiation, it had the four components recommended by the iSSRS consensus paper [7]. The afferent limb used track-and-trigger observation charts with pre-defined criteria for escalation to the RRT. RRT calling triggers, such as those shown in Table 1.1, remained unchanged throughout the entire period of performance data collection (i.e. July 2009 to June 2019).

LMH operated a single-tier RRT throughout this research. This team was available 24 hours a day with a consistent team membership as detailed in Table 3.1:

Table 3.1. RRT composition and Member Roles

RRT Member Role (as shown on Badges)	Primary Duty when not attending RRT calls
Team Leader	ICU Trainee
RRT Medical Officer	Internal Medicine Trainee
RRT Intern	Internal Medicine Intern
RRT Nurse	ICU Nurse
RRT Orderly	Hospital Pool Orderly
RRT Logistics	Hospital Coordinator

As noted in Section 1.2.4, the RRT team leader was required to have up-to-date Advanced Life Support credentials, and rostering to that role was contingent on possessing that credential. The RRT had an ICU specialist available, typically via phone, to provide advice on management or up-transfer of the patient at all hours.

The LMH RRS was administered by a (Nurse) Manager and overseen by a steering committee, chaired by the thesis author. Both were in these roles throughout the entire study period. The steering committee reviewed RRT call activity and addressed clinical incidents in liaison with the hospital's Safety and Quality unit, which was responsible for federal reporting of ACSQHC mandated performance indicator compliance [30,33].

No training for the RRT, or overall RRS, was provided before or during the study period. A training program was developed and proposed by the thesis author in early 2012. However, this did not prove feasible due to a lack of available funding or resourcing. Further, the rostering of RRT members from different departments presented difficulty finding a mutually convenient time for training, given that each representative department already had their own internal training commitments.

To summarise, except for the RRS re-design, the structure and operations of the RRS remained unchanged throughout the study period.

3.2.2 Initial Research Methodology

As mentioned previously, this research was first envisioned with an NTS *training* program as the intervention. Training program participants would be all RRT Members. Each participant would attend a day long initial course and then a half-day refresher yearly thereafter. The courses would be delivered as a combination of lectures and interactive clinical scenario simulations.

3.2.3 Revised Research Methodology

The delivery of a NTS training program was ultimately infeasible within the scope of this research due to resource, financial and time limitations as outlined above. Instead, a pragmatic approach was taken, replacing the training program with a re-design of the RRS that aimed to promote use of NTS during RRT calls, per the principles advocated by Buljac-Samardzic et al. [124].

3.3 DEVELOPMENT OF THE RRS RE-DESIGN

One avenue to achieve healthcare quality improvement in clinical settings is through mitigation of risks [104,107,109]. There is an established "Hierarchy of Hazard Control" safety mechanism that categorises these mitigation methods (from most to least effective: Elimination, Substitution, Engineering Control, Administrative Control, Personal Protective Equipment) [107]. Ideally a risk would be eliminated or substituted. However, in the clinical environment of the RRS, most measures to protect patients (or staff) from harm occur at the Administrative Control level. This is because the RRS responds to the unexpected and, in many cases, unavoidable clinical deterioration of acutely unwell patients. Individual patients' clinical courses are unpredictable and so, despite appropriate treatment, the risk of clinical deterioration posed by pathophysiology cannot be entirely eliminated or substituted.

In terms of patient risk from RRS involvement, while the recognition, escalation and response are protocolised, adherence and correct use of these elements are still prone to human error [38,48,74]. As an example, missed or delayed calling of the RRT is a recurring issue for RRS managers despite the well-publicised mandates for consistent, standardised escalation [42,43,66,132].

Therefore, the RRS relies heavily on education and, ideally, practical training to prevent missed opportunities to rescue deteriorating patients [4]. As already noted, providing training for the RRT proved infeasible and so an alternative strategy was enacted.

3.3.1 Ergonomics

As introduced in Section 1.3.5, the revised study design took inspiration from the concept of ergonomics, and particularly the psychological and cognitive aspects as described by Carayon et al. [82,104,105,108,109]. In broad terms, this approach aimed to adapt the RRS to its clinical staff rather than vice versa, the approach taken through training.

RRT calls are, by their nature, stressful events for RRT Members and Users [38,74]. The material on Non-Technical Skills in the context of an RRS in Section 1.3.2 presents the myriad reasons for this. It is, therefore, understandable that conscientious nurses and doctors will experience stress both physiologically and psychologically [47,49,74,155]. These natural human reactions increase susceptibility to unconstructive behaviours before, during, and after RRT calls.

The manifestation of these stressors was one possible cause for the reported difficulties and conflict during interactions within the RRT and between RRT Members and Users during calls. Therefore, the re-design was intended to modify the RRS to make it more supportive of RRT Members and Users [89,104,105]. Further, the re-design aimed to modify some behaviours at calls to improve interactions within the RRT and between RRT Members and Users.

A search was performed for existing NTS improvement initiatives. None were found that had been specifically designed for an RRS, but the Emergency Department (ED) focused TeamSTEPPS® appeared to be most pertinent to the workload and operations of an RRS [81].

3.3.2 TeamSTEPPS®

TeamSTEPPS® is a proprietary NTS improvement program, designed for ED Resuscitation Teams. It comprises a suite of training modules and operational tools that have been shown to improve use of NTS during management of high severity illness and trauma cases [81,122,156]. These include [157]:

- communication aids such as the structured SBAR (Situation, Background, Assessment, Recommendation) patient handover tool;
- communication events such as the Brief (a "*short session prior to start to share the plan, discuss team formation, assign roles and responsibilities, establish expectations and climate, anticipate outcomes and likely contingencies*") and the Huddle (an "*ad hoc meeting to re-establish situational awareness, reinforce plans already in place, and assess the need to adjust the plan*");
- situational awareness of patient safety such as through having clinicians monitor one other during error-prone tasks (e.g. drug formulation);
- mutual support such as assisting others to prevent task overloading; and
- challenging potential safety risks through graded escalation (see Appendix A).

Although not primarily intended for use by an RRS, there are commonalities between the temporal and clinical pressures of the ED resuscitation room and the bedside of the clinically deteriorating patient [35,74]. In particular, the "Brief" and "Huddle" tools of TeamSTEPPS® had relevance for the RRS and informed two of the study intervention components – **shift-by-shift RRT meetings** and the **end-of-RRT call Hand-Off procedure from RRT Members to Users** (for patients remaining on the ward) – respectively.

3.3.3 Roles and Responsibilities

The importance of defined roles and clinical responsibilities for RRT Members was first emphasised by Gillon et al [74]. The complexities of variable RRT composition and clinical pressures of RRT calls, outlined in Section 1.3.2, pointed to the need to pre-assign or at least identify roles for RRT members at calls. This informed the third study intervention component – **RRT Member role badges**.

3.4 RE-DESIGN COMPONENTS

3.4.1 RRT Meetings

3.4.1.1 Evidence Base

No studies exist to ascertain the effectiveness of the TeamSTEPPS® Brief (or derivatives thereof) by itself. Further, the TeamSTEPPS® system had not been studied previously within an RRS. However, the system as a whole had shown effectiveness in the ED setting, and this had led to its development into a proprietary NTS promotion tool more widely within healthcare [50].

Therefore, the inclusion of the RRT meetings component within the RRS re-design was based on plausibility and feasibility, requiring little time or resource to implement.

3.4.1.2 Structure and Delivery

Twice daily meetings, based on the Brief tool, were scheduled for RRT Members to coincide with the day and night shift changeovers. Since the nature of RRT calls does not permit pausing the response upon team arrival to a deteriorating patient, the meetings were scheduled for the beginning of each shift. This maximised the likelihood of facilitating this team bonding opportunity before the RRT had to attend the first call of their shift [35].

As noted in Chapter One, RRT Members do not characteristically have supernumerary roles [29,31,57]. Therefore, the meetings were designed to last no more than five minutes. The agenda of the meetings was provided to all RRT staff, with guidance notes available in the meeting location for reference. These are available in Appendices B and C respectively.

These meetings were chaired by the RRT Nurse (rostered from a small group of tenured ICU nurses, and so the least varying RRT Member) and included:

- RRT Member introductions and sharing of first names;
- allocation of team roles (and simultaneously the physical badge stating that role);
- allocation of duties or tasks to be commenced on initial arrival to a call; and
- sharing of logistic or organisational issues that might affect RRS operations.

Therefore, these meetings served as an 'icebreaker' for team-bonding prior to attending the first call of that shift The aim was also to expedite management of the clinical deterioration by mitigating the need to establish roles and responsibilities on arrival [35,74,100].

3.4.1.3 Relevance to Non-Technical Skills

In terms of domains of NTS, the meetings were designed to assist with [35,38,48,80]:

- leadership – cementing the role for that individual and the team to establish hierarchy and a chain of clinical responsibility;
- communication – establishing rapport between team members at an early juncture to encourage information sharing and interaction during RRT calls;

- cooperation – team-bonding and to establish roles and responsibilities in advance of attending clinically deteriorating patients; and
- decision-making – in parallel with Leadership, identifying how clinical decisions and plans will be made.

3.4.2 RRT Member Role Badges

3.4.2.1 Evidence Base

Lauridsen et al. surveyed cardiac arrest teams for pre-arrival role allocation [136]. They noted that 41% of RRTs did not have a pre-defined leader and most other roles were not defined in the majority of teams. However, this was a descriptive study and the authors did not make any recommendations about pre-defining RRT roles or draw any inferences about any potential benefits from doing so.

Prince et al. published results from a teamwork improvement program that focused on the roles and responsibilities aspect of RRT calls [101]. Their study involved several months of education and training to explain and reinforce RRT Member roles. As part of that study, RRT Members were required to wear lanyards during calls that visually identified roles.

Prince et al. evaluated their intervention through staff surveys. There was a significant improvement in Member expressed confidence (81% vs 65%, P<0.01) after the RRS improvement program. However, other findings around team leadership and communication within the RRT showed no significant change. Given the complex intervention that relied on concerted staff education, it is difficult to ascertain the specific effects of the RRT role lanyards on outcomes.

3.4.2.2 Structure and Delivery

As noted in Section 3.4.1.2, the RRT meetings also allowed for the allocation of badges for RRT Members. These were clip-on, bright red and stated the wearer's role in large block capital letters. They were designed to be clearly legible from across a patient room in line with Australian Standard AS1319-1994 which recommends 5mm vertical text height per metre viewing distance [158].

The intent was for these to be valuable to both RRT Users and Members. As noted in Chapter One (Section 1.3.2), the RRT can have a highly variable membership from shift-to-shift [4,29,31,57,74], so it was anticipated that Users may not have met Members prior to working together at an RRT call [35,38]. Thus, the badges would immediately and continuously identify each Member's role throughout the RRT call [101,136]. Therein, the badges could improve productivity through avoiding the need for RRT Users to allocate time discovering Members' roles [74,101].

Even within RRT Members' shifts, there is the potential for different clinicians to need to cover their roles. This may be due to competing clinical duties (as noted earlier, most RRTs are not supernumerary) or to permit meal and/or rest breaks for rostered RRT Members.

This may result in some RRT Members attending a call not having attended the RRT meeting for that shift. In such scenarios, it was intended that the RRT Role Badges would also serve a secondary function of identifying Members to each other when roles had not already been established because of changes to RRT Members within a shift.

The RRT composition identified by the Role Badges to all staff present at calls is shown in Table 3.1 above.

3.4.2.3 Relevance to Non-Technical Skills

In terms of domains of NTS, the badges were designed to assist with [35,38,48,80]:

- leadership – cementing the role for that individual and the team to establish hierarchy and a chain of clinical responsibility;

- communication – visual identification of roles to encourage appropriate information sharing and interaction during RRT calls between the correct individuals;
- cooperation –team bonding and reinforce roles (and responsibilities) when attending clinically deteriorating patients; and
- decision-making – in parallel with Leadership, identifying who would make clinical decisions and lead development of plans.

3.4.3 Structured Hand-Off Process

3.4.3.1 Evidence Base

There are no studies specifically examining the transition of care at the end of RRT calls, either in isolation or as part of a multi-faceted initiative. By contrast, there are two studies of paper-based handover tools that were used at the start of an RRT call (i.e. from RRT Users to Members when the latter arrive at the bedside of the Deteriorating Patient), from which findings might be extrapolated.

In 2012, Kansal et al. observed clinical endpoints before and after re-configuration of their RRS from a one-tier to a two-tier response (based on patient illness severity) and the addition of a new physiological observation chart [69]. The relevant component for this thesis was their introduction of a structured communication procedure from RRT Users to Members regarding the calling trigger breached and the nature of derangement of patient physiology.

These authors noted a 16% decrease in the frequency of a composite adverse outcome (expected cardiac arrest or unplanned admission to the ICU), although this change was not statistically significant. Further, due to the multi-faceted intervention, it was not possible to determine the extent to which the new communication tool was effective in isolation from other intervention components.

In 2013, Mardegan et al. reported results from their staff survey following introduction of an RRT activation datasheet [99]. This datasheet was specifically designed to aid information sharing from RRT Users to Members at the commencement of calls. Their proforma was introduced without any additional coaching or education, akin to the intervention presented in this thesis.

The majority (57%) of participants in the report by Mardegan et al. [99] agreed that having a proforma assisted RRT Users convey the nature of clinical deterioration to the arriving RRT. In that study, no pre-intervention data were collected to compare with post-introduction of the RRT activation datasheet. The only recommendation to improve RRT User satisfaction with the handover to the RRT that arose from this study was to provide NTS training for all RRS staff [99], which (as stated previously) was infeasible in this research.

As noted in Chapter One (Section 1.3.2), the issue of jurisdiction for clinical responsibility is the most fraught with risk for patients [21,159]. At the commencement of an RRT call, and especially on arrival of the RRT, leadership and clinical decision-making authority is assigned (usually by local protocol) to the RRT leader [31,48,74,103].

However, if the patient is to remain on the ward at the end of an RRT call, the transition of care responsibility is less clear [35]. Although the clinical deterioration will have been, at least in part, resolved, the patient is still vulnerable having just triggered one or more physiological abnormalities that are associated with in-hospital cardiac arrest [32].

As identified in Section 1.1.4.2, continuation of the RRT care plan after conclusion of a call can be considered part of the Efferent Limb response to the patient. It is typically delivered by the same RRT Users that just activated the RRT [32,35]. However, these RRT Users will usually be responsible for looking after multiple patients on their ward, so there is an onus on the RRT leader to ensure that the RRT call patient's ongoing care needs can be sustained on the ward [21,159]. In particular, the RRT leader

should ensure that RRT Users' clinical concerns have been thoroughly addressed and that those Users are comfortable continuing the Efferent Limb clinical plan (in addition to their other clinical duties) before the RRT departs from the call location.

One possible reason for the RRT being recalled back to the same patient is a suboptimal transition of care [32,35,48,133]. Thus, an end-of-call Hand-Off component was included in the RRS re-design for this study.

3.4.3.2 Structure and Delivery

A hardcopy checklist, along with guidance notes, were included with all RRT equipment kits taken to calls to facilitate the transition of care back to RRT Users. These are available in Appendices D and E respectively.

This proforma prompted:

- identification of personnel involved in the Hand-Off;
- a summary of the patient's clinical state and ongoing plan to be provided by the RRT's team-leader to the RRT Users taking back care of the patient;
- a contingency clinical plan should the patient deteriorate further; and
- the opportunity for the RRT Users resuming responsibility for clinical care for the patient to voice concerns and have them addressed by RRT Members.

This proforma served to structure and formalise information sharing at the point of the transition of care responsibility from RRT Members to Users. Less overtly, this gathering of clinicians was intended to clearly identify the moment of transition of care responsibility. Thus, there was also an implied transition of the leadership role from Members to Users, and need for ongoing use of NTS during that transition.

The final step of the Hand-Off was the requirement of a signature by a representative from both RRT Members and Users (i.e. ward staff calling the RRT and now accepting resumption of care responsibility). This signing of the paper checklist, to then be placed in the patient clinical record, further signalled the moment of transition of care.

More importantly, the signature of the RRT Users' representative was a condition for conclusion of the RRT call. Therefore, even if RRT Users lacked confidence to challenge RRT Members, they were empowered to alert any ongoing concerns about the patient simply by withholding signing.

Both RRT Members and Users were coached at the time of rollout of the RRS re-design to consider the signing process a valuable cross-checking safety mechanism for the benefit of the patient [21,35,159]. The ethos of the RRS in assisting advocation and protection for clinically deteriorating patients was reinforced to both groups in the rollout.

3.4.3.3 Relevance to Non-Technical Skills

In terms of domains of NTS, the RRT Member-to-User Hand-Off Process was designed to assist with [38,74,80]:

- leadership – clearly identifying the transition of clinical responsibility back to RRT Users;
- communication – encouraging appropriate information sharing and interaction during the transition of care between RRT Members and Users;
- cooperation – ensuring RRT User confidence and competence to continue care without needing to recall the RRT;
- decision-making – assurance of ongoing care responsibility and clinical planning after departure of the RRT.

3.4.4 Rationale for these Re-Design Components

As noted previously, there was no available additional funding for this research. This led to the selection of a non-training approach incorporating the above intervention components that were inherently low cost.

When the infeasibility of a formal training program became apparent, other potential intervention approaches were considered. For example, an online education and assessment program was contemplated that could be delivered alongside existing mandatory competencies that clinicians completed as part of compliance with National Standards requirements. However, this was deemed inefficient as changes in behaviour are far more effectively achieved through practical versus theoretical training [38,72-74,97,98].

The main impetus for deriving intervention components from the TeamSTEPPS® program, was that LMH had already implemented components of TeamSTEPPS® from 2011 to many areas of the hospital as a quality improvement initiative. For example, the operating theatres used the TimeOut tool (as described in TeamSTEPPS® supporting materials [50,157]) that pauses all work for identification of patients and staff present prior to starting surgical procedures. Indeed, this TimeOut tool was considered as a potential intervention component for this research. However, unlike elective surgical procedures, the management of clinically deteriorating patients cannot be deferred. It would be unethical to delay addressing life-threatening deterioration on RRT arrival to introduce all call participants. Rather, in such situations a primary survey needs to be completed before a full handover from RRT Users to Members can safely occur [119].

Although the RRS had not been part of the LMH TeamSTEPPS® initiative, for RRT Members and Users the concepts of the RRT Meetings and end-of-call Handoffs were sufficiently akin to the TeamSTEPPS® Briefing and Huddles (respectively) that detailed explanation and education was not necessary. This enabled a rapid rollout of the intervention without intensive dedication of resources that would not be feasible or available.

3.5 IMPLEMENTATION OF THE INTERVENTION

The intervention commenced on the 1st July 2014, having been fully conceived and developed over the preceding year

In preparation for implementation, the intervention components were publicised to RRT Members and Users over the preceding month. The author and the RRS Manager attended administrative meetings and education sessions of departments that rostered staff to the RRT (i.e. Internal Medicine, ICU and the Post-Graduate Education Unit), as well as the clinical wards on which the majority of RRT calls occurred. At these meetings, the intervention components were detailed with expectations and responsibilities for RRT Members and Users.

Emails were sent weekly to all LMH clinical staff (via the email account listed with Human Resources) over the month preceding 1st July 2014. These reinforced information about the intervention components and provided a countdown to implementation. Recipients were invited to submit clarifying questions by return email for answering in the following week's mailout.

Although information regarding the intervention was detailed, the rationale behind its components and the NTS improvement objective were not revealed. This information was intentionally withheld from hospital staff to reduce influencing results. Though, as with any open-label study, it was accepted that some degree of Hawthorne Effect would still occur [160].

On the 1st July 2014, for the first time, rostered RRT Members were paged to attend the inaugural RRT Meeting. At this meeting, badges were handed out and Members were reminded of details of the intervention components. End-of-call Handoff paperwork was placed on all RRT call equipment

trolleys and supplied to the rostered RRT Nurse. Thereafter, the intervention proceeded as detailed in Sections 3.4.1 thru 3.4.3 above.

For the first month of the intervention, either the thesis author and/or the RRS Manager attended RRT Meetings when present at LMH (typically for the morning meeting on weekdays) to facilitate and coach expected conduct of the meetings. During this initial month, the thesis author and/or the RRS Manager would also attend RRT calls when available to prompt wearing of role badges and to facilitate the end-of-call Handoffs (for calls resulting in the patient remaining on the ward).

At the end of July 2014, the facilitation of intervention components ceased. At this point, an email was sent to all rostered RRT Nurses encouraging them to take responsibility for correct conduct of the RRT Meetings and inviting them to report any concerns to the RRS Manager for addressing. Further, each clinical ward at LMH was invited to nominate a RRS Liaison Nurse who could relay any issues experienced by RRT Users with the Handoff process in their area to the RRS Manager for addressing.

3.6 CLOSING

The information presented in this Chapter described development of and rationale for the research intervention conducted during this PhD program.

The following Chapters will present the Results of the studies as published in separate papers. To summarise, these Results Chapters are:

Chapter	Paper	Description
4	2	Phase 1 (Pre-Intervention) Survey
5	3	Phase 2 (Post-Intervention) Survey
6	4	Phase 1 (Pre-Intervention) Repeat RRT Call data
7	5	Phase 2 (Post-Intervention) Repeat RRT Call data

Each of these papers will contain Methods which will reiterate the specific elements of the research methodology relevant to each reported study. Elaboration of the Methods is presented in the Preamble of each Chapter, as appropriate.

Chapter 4: Phase 1 Survey Results (Paper 2) – Perceptions of interactions between staff members calling, and those responding to, rapid response team activations for patient deterioration

4.1 CITATIONS

Chalwin R, Flabouris A, Kapitola K, Dewick L. Perceptions of interactions between staff members calling, and those responding to, rapid response team activations for patient deterioration. Aust Health Rev 2016;40:364-370

4.1.1 Digital Object Identifier

10.1071/AH15138

4.1.2 PubMed Identifier

29224610

4.2 PREAMBLE AND RESEARCH QUESTION

This was the second paper generated from the research project. It was written in the second half of 2015, presenting findings of the pre-intervention (Phase 1) survey. The research question addressed in this article was:

> "What are the prevailing perceptions and experiences of RRS staff attending RRT (Rapid Response Team) calls?"

An exploration of the development and conduct of the survey is presented here. This serves to supplement the Methodology of the published manuscripts which were necessarily concise to meet journal word count restrictions.

4.2.1 Member and User Approach

For this research, survey data were collected from both RRT Members and Users, whereas previously published studies had only involved RRT Users [41,45,46,99,132,161]. While these surveys of RRT Users collected useful data about conduct of the RRT, they overlooked potentially useful insights from RRT Members.

The RRS involves clinical staff throughout the hospital and requires them to work together effectively in moments of potential high stress during RRT calls. Successful management of the patient under their care is likely to be facilitated if RRT Members and Users can utilise NTS such as communication and cooperation [38,49,74,89]. Data from all interpersonal interactions at RRT calls were, thus, important

to gather. Therefore, for this research program RRT Members and Users were surveyed for perceptions and experiences of NTS use at:

- the interface between RRT Members (i.e. within the RRT); and
- the interface between RRT Members and Users.

Questionnaires were developed for each group. Both the RRT Member and User questionnaires addressed the same domains of NTS and queried perceptions and experiences of NTS use during RRT calls. The wording of questions differed between the two types of questionnaires, reflecting the different roles held by RRT Members and RRT Users.

4.2.2 Development of the Survey Tools

Previously used questionnaires were considered in the initial development of questions [45,46,161], but no existing instruments had addressed NTS use by RRT Members and Users during RRT calls at the time of development of this study. Jones et al. asked one relevant (Likert) question [45]: "I am reluctant to call a MET on my patients because I will be criticised if they are not that unwell". Their other questions related to logistics and initiation of the RRS. Bagshaw et al. used the survey tool from Jones et al. [46], and Benin conducted open interviews with RRT Users [161].

Therefore, in this absence of suitable validated survey tools, bespoke questionnaires were developed for RRT Users and, separately, for RRT Members. The questionnaires are presented in Appendices F and G, respectively.

The questionnaires were conceived by the thesis author and were intended to cover RRT Member and Users experience and perceptions of use of the NTS domains: leadership, communication, cooperation, and decision-making/planning during calls [38,83]. The Member and User questionnaires were also developed with consideration of the Role Badges and Handoff intervention components, hence containing questions relating to identification of RRT Members to Users and around the transition of care at the end of calls.

The questionnaires were refined through a series of six meetings with the initial principal supervisor (for which formal records were not retained). At these meetings, questions were added, removed, and modified to ensure targeting of one or more of the NTS domains. Some accepted principles of questionnaire design were employed [162,163], such as use of clear, simple language as far as possible, and keeping wording of questions neutral to avoid potentially influencing responses. However, no formal questionnaire development framework was used, such as the methodological approach proposed by Labaw [164].

Draft RRT Member and User questionnaires were both piloted, for convenience, with (the same) six ICU specialists who independently commented on language and design (for which records were not retained). These comments were used to correct leading or ambiguous language in questions, and to finalise the questionnaires that were disseminated to RRT Members and Users.

4.2.3 Survey Participants

For the surveys, study participants were LMH clinical staff. The RRT Member questionnaire was restricted to clinicians who had been rostered to the RRT during the 12 months prior to each survey phase. The RRT User questionnaire was available to all clinical staff who had worked at LMH for the 12 months prior to the survey.

Participation in the surveys was voluntary. Information about the survey was provided to participants (as shown on the front page of the questionnaires in Appendices F and G). No enticement or reward was offered, nor was there any disadvantage from declining to complete a survey. Participants remained anonymous with no personal identifiers collected.

4.2.4 Questionnaire Structure

Questions were grouped regarding RRT arrival in response to a call, during the call and completion of the call [119]. This reflected the RRS re-design with the RRT meetings having relevance to the start of a call, the RRT role badges during the call and the structured hand-off at call completion.

Neither the RRT Member nor the RRT User questionnaire captured personal identifiers. The RRT Member questionnaire requested data on participants' usual role on the RRT, how many years they had been in clinical practice and how long they had worked on an RRT. The RRT User questionnaire did not request any information about the respondents' experience.

Both questionnaires used 5-point Likert items to capture responses from Strongly Disagree to Strongly Agree for most questions. The RRT User questionnaire also queried experience of having recalled the RRT (during the preceding 12 months) along with the most common reason for having done so (e.g. the patient was still meeting RRT calling criteria).

At the end of both questionnaires, a free-text section allowed comments regarding experiences or perceptions of RRT calls. This section captured comments about any aspect of the RRT at respondents' discretion.

4.2.5 Conduct of the Survey

The pre-intervention survey was conducted over a two-month period just prior to introduction of the RRS re-design. Before this survey was conducted, information about it was circulated to all LMH clinical staff via email, disseminated by the LMH communications department. These emails were sent weekly for two weeks preceding start of the survey period and weekly during it.

The questionnaires were provided in hard copy to all clinical area within LMH such as wards and the radiology department. Questionnaires were left in rooms restricted to staff access only (e.g. ward tea-rooms). RRT Member questionnaires were also placed in the ICU meeting room used for the RRT meetings. Each location was provided with a sealed ballot-box for completed questionnaires. The questionnaires were also provided online via SurveyMonkey (a link was provided in emails sent to all clinical staff).

Clinical staff completing the survey were asked to only submit responses once (either on the hardcopy or electronically). Staff were also asked to complete both an RRT Member and RRT User questionnaire if they were rostered to the RRT but also needed to call the RRT (when not rostered to it).

At the end of the survey period, written survey responses, including free-text comments, were transcribed into separate electronic spreadsheets for RRT Members and RRT Users. This was merged with data collected by SurveyMonkey to become the RRT Member and User datasets for Paper 2.

4.3 STATEMENT OF AUTHORSHIP

4.3.1 Principal Author (Candidate)

4.3.1.1 Name:	Richard Chalwin
Contribution to the Paper:	Conception, planning, data analysis, data interpretation, writing, drafting, proofing
Overall percentage (%):	70
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.
Signature:	Date: 22 Feb. 2022

4.3.2 Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

iv. the candidate's stated contribution to the publication is accurate (as detailed above);

v. permission is granted for the candidate in include the publication in the thesis; and

vi. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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4.4 ABSTRACT

4.4.1 Objectives

To investigate experiences of staff interactions and non-technical skills (NTS) at Rapid Response Team (RRT) calls, and their association with repeat RRT calls.

4.4.2 Methods

Mixed methods surveying of RRT members, and staff who activate the RRT (RRT users) for their perceptions and attitudes regarding use of NTS during RRT calls. Responses within the survey were recorded as Likert items, ranked data and free comments. The latter were coded into nodes relating to one of four NTS domains: leadership, communication, cooperation and planning.

4.4.3 Results

Two hundred and ninety-seven (297, 32%) RRT users and 79 (73.8%) RRT members provided responses. Of RRT user respondents, 76.5% had activated the RRT at some point. Deficits in NTS at RRT calls were revealed with 36.9% of users not feeling involved during RRT calls and 24.7% of members perceiving that users were disinterested. Unresolved user clinical concerns, or persistence of RRT calling criteria, were reasons cited by 37.6% and 23% respectively of RRT users for reactivating a RRT to the same patient. Despite recollections of conflict at previous RRT calls, 92% of users would still reactivate the RRT. The commonest theme in the free comments related to deficiencies in cooperation (52.9%), communication (28.6%) and leadership (14.3%).

4.4.4 Conclusions

This survey of RRT users and members revealed problems with RRT users' and members' interactions at the time of a RRT call. Both users and members considered NTS to be important, but lacking. These findings support NTS training for RRT members and users.

4.5 KEY QUESTIONS

4.5.1 What is known about the topic?

Previous surveying has related experiences of criticism and conflict between clinical staff at Rapid Response Team (RRT) activations. This leads to reluctance to call the RRT when indicated with risks to patient safety especially if subsequent RRT activation is necessary. Training in non-technical skills (NTS) has improved clinician interactions in simulated emergencies, but the exact role of NTS during RRT calls has not yet been established.

4.5.2 What does this paper add?

This survey has examined experienced clinician's perceptions of the use of NTS at RRT calls and impact on subsequent calling. A key finding was a disparity between perceptions of how RRT members interact with those activating the RRT (RRT users) and their performance of NTS. This was reflected with unresolved RRT user clinical concern at the time of a call. In turn this influenced RRT users' attitudes and intentions to reactivate the RRT. Formal handover was considered desirable by both RRT users and members.

4.5.3 What are the implications for practitioners?

The interface between the RRT and those who call the RRT is crucial. This survey shows that RRT users desire to be included in management of the deteriorating patient and have their concerns addressed before completion of the RRT attendance. Failure to do so results in repeat activations to the same patient, with the potential for adverse patient outcomes. Training to include NTS, especially around handover, for RRT members may address this issue and should be further explored.

4.6 INTRODUCTION

Rapid Response Systems (RRS) have become a staple component of hospital safety and quality. Their implementation has been ratified in Australia, Canada, United Kingdom and the United States.[1-4]

Despite inconsistencies in the evidence for RRS, clinicians remain strongly supportive.[5-6] Surveys have shown that clinicians believe that availability of a Rapid Response Team (RRT) improves patient care, reduces their workload and acts as a safety net for deteriorating patients.[7-9] However, experiences of criticism for calling the RRT were also noted leading to ward staff reluctance to activate the RRT, [7, 8, 10] as well as conflicts and miscommunication between RRT and ward staff [9]. Such interface issues pose risks to patient safety when clinical deterioration is not escalated or responded to appropriately.[11-13] When staff concerns or criteria for activation remain unresolved reactivation of the RRT to the same patient is indicated. [14] Repeat RRT calling has been associated with increased patient risk. [14-17]

A potential solution is Crisis Resource Management training for RRTs which aims to increase competence, and use of non-technical skills (NTS) such as leadership, communication, team-working and decision-making. [18,19,20] Clinicians undertaking NTS training have experienced benefits to work practices and team behaviours,[21-23] and the insight and self-reflective learning it provides.[24, 25]

Therefore, a survey of staff who are part of a RRT and staff who activate the RRT was undertake to ascertain their experiences of RRT calls and patterns of repeat RRT calling. Specifically, their perceptions were sought of non-technical skills in shaping these interactions and how this may influence subsequent RRT calling.

4.7 METHODS

4.7.1 Study Design

Mixed methods, quantitative and qualitative, surveying was conducted as part of the IMPACT (Impact of Non-technical Skills Training on Performance and Effectiveness of a Medical Emergency Team) project (ClinicalTrials.gov: NCT01551160 and Australian New Zealand Clinical Trials Registry: ACTRN12612000280808) which aims to implement a NTS training program and assess its impact on RRS performance.

Staff rostered to the RRT (RRT member) and staff likely to activate the RRT (RRT user) in response to acutely deteriorating patients were surveyed for attitudes and perception relating to team-working and inter-disciplinary culture based on their experiences of interactions during RRT calls.

A series of themed sections covered the periods of RRT activation, attendance, and stand-down. Questions were designed to cover performance of four domains of NTS: leadership, communication, cooperation and planning. These included and expanded on questions 7 and 12, from the survey tool devised by Jones et al (2006) relating to fear of criticism for activating the RRT. [7]

Most responses were obtained on five level Likert items. Similar questions were posed to each group so perceptions of NTS could be cross-checked to improve the credibility of analyses.

One question, posed to RRT users, asked respondents to rank reasons for having recalled the RRT to the same patient from a list of seven potential indications (e.g. ongoing breach of RRT calling criteria), where 1 = most common and 7 = least common.

An open section for free comments was included at the bottom of the questionnaire. This invited respondents to elaborate on any of their responses to questions in the survey or express any issues not covered by those questions.

4.7.2 Study Setting

The Lyell McEwin Hospital, a 300 bed, university-affiliated, tertiary, metropolitan hospital located in Adelaide, South Australia which has comprehensive medical, surgical and critical care services. The Rapid Response System afferent limb comprises protocolised physiological monitoring with observations recorded on a proforma chart. RRT calls are activated based on standardised criteria for patient vital signs and staff concerns. [1] The efferent limb is a RRT whose composition was an intensive care trainee, an intensive care nurse, a general medical trainee, an intern and the hospital co-ordinator.

4.7.3 Data Collection

Surveying was performed as a snapshot over a 6 week period (May – June 2014), publicised via email and staff meetings, and invited all clinical staff to participate. Surveys were distributed as paper questionnaires and a SurveyMonkey® version was linked to in emails. Respondents were permitted to remain anonymous, but demographic data was requested regarding clinical working area, designation and number of years in practice.

4.7.4 Statistical Analysis

Likert item data were described as frequencies and percentages. Dichotomous unpaired categorical data was cross tabulated with a Pearson's Chi-square test. Logistic regression analysis was used to compare dichotomous with interdependent continuous variables. Ranked data were analysed by a Friedman test. Responses within grouped questions were subjected to factor analysis (principal component analysis with Varimax rotation). Thereafter Cronbach's alpha was calculated to assess internal consistency of the survey questionnaire. Comparison of Likert item responses were assessed for normalcy visually with histograms and Q-Q plots and analysed with independent samples t-tests where this was confirmed.[26] Statistical analyses were conducted with SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp).

Qualitative data from comments were transcribed and stored as individual text files. These were independently coded by both authors into nodes relating to experiences of achievement, or not, in one of four accepted core NTS domains (leadership, communication, cooperation and planning) [18,19,20] or suggestions in those domains. Disagreements were resolved by consensus based on the core principles of NTS. [20] Content analysis was explored frequency of referencing. NVivo qualitative data analysis software (QSR International Pty Ltd. Version 10 SP5, 2014) was used.

4.7.5 Ethical Considerations

This study was approved by The Human Research Ethics Committee (TQEH/LMH/MH) as part of the IMPACT trial (approval number: 2012069). Participation in the survey was entirely voluntary and consent was implicit by participants completing a response.

4.8 RESULTS

4.8.1 Quantitative Data from Survey Questions

4.8.1.1 RRT User Demographics

From 929 eligible RRT users, 297 (32.0%) responses were received. Of these, 232 (78.1%) were from nurses, 2 (0.7%) from allied health personnel, 21 (7.1%) from medical officers and 42 (14.1%) declined to reveal their designation. The median clinical experience was 7 years [3 – 18] in clinical practice.

4.8.1.2 RRT User Experiences

Of the RRT user respondents, 221 of 289 (76.5%) had activated the hospital RRT at least once, with 229 of 283 (80.9%) present during RRT attendance. This included 161 of 255 (63.1%) who felt RRT involved them in management of the patient and 166 of 254 (65.4%) who felt confident to speak up. Identification of RRT roles seemed lacking with only 70 of 257 (27.2%) agreeing that RRT members introduced themselves. and 170 of 257 (66.1%) not being able to identify the team leader. The majority of RRT users (275 of 285, 94%) welcomed a formalised handover from the RRT when patients were to remain in their clinical area.

4.8.1.3 RRT Member Demographics

From 107 eligible RRT members, 79 (73.8%) responses were received. Of these 21 (26.6%) were from RRT RNs (45.7% of eligible), 21 (19.6%) were from medical registrars (100% of eligible), 10 (9.3%) were from Intensive Care registrars (100% of eligible), 13 (12.1%) were from interns (56.5% of eligible) and 8 (7.5%) declined to indicate their designation. The median number of years of clinical experience on any clinical emergency team, including a RRT, was 3 years [1 – 6].

4.8.1.4 RRT Member Experiences

RRT members also identified issues, with 26 of 78 (33%) agreeing that the team did not routinely introduce themselves to ward staff. RRT internal team-working fared better with the majority of RRT members knowing others' roles and responsibilities (81.0% and 75.3% respectively) and reporting satisfaction with internal RRT communication (78.2%). However, 18 (24.7%) and 17 (23.3%) of 79 RRT member respondents felt that ward staff and home teams, respectively, expressed little interest when their patients were the subject of a RRT call. 27 of 79 (34.2%) identified that they did not receive adequate handover from those activating the RRT.

The full results expressed as percentage frequencies are contained in Appendix 1 for RRT users and Appendix 2 for RRT members.

4.8.1.5 Multiple RRT Calls

Of 220 RRT user respondents, 87 (39.5%) have recalled the RRT to the same patient. Nurses, in comparison to medical officers, were more inclined to recall the RRT, 85 of 203 (41.9%) and 2 of 17 (11.8%) (p=0. 02), respectively reporting this outcome. Logistic regression analysis showed that clinical experience did not have a significant influence on likelihood of initiating a repeat RRT call (p=0.72).

The reasons for making multiple RRT calls were ranked by RRT user respondents based on their experience. Ongoing breach of RRT physiological activation criteria was most commonly cited (mean rank 2.64) followed by the patient still meeting the "worried" calling criterion (mean rank 3.07), lack of a clinical plan following the initial call (mean rank 3.4), no contingency plan for subsequent deterioration (mean rank 3.52), resuscitation status not established (mean rank 3.6) and attending team not consulted about RRT call (mean rank 5.36). The "Other" response was the least common (mean rank 6.4) suggesting that the most important reasons were contained within the specific listed options. Overall there was a significant difference between rankings ($\chi 2$ 51.27, $p < 0.01$). This data is contained in Table 1.

Table 1 – Reasons for multiple RRT calling (N with % in parentheses)

Reason	Ranked 1st	Ranked 2nd	Ranked 3rd	Ranked 4th	Ranked 5th	Ranked 6th	Ranked 7th	Mean Rank
No plan handed over	15 (16.7)	11 (12.2)	17 (18.9)	19 (21.1)	14 (15.6)	8 (8.9)	6 (6.7)	3.4
Resuscitation status not clarified	10 (11.6)	14 (16.3)	21 (24.4)	18 (20.9)	13 (15.1)	5 (5.8)	5 (5.8)	3.6
Prior calling reason not resolved	25 (27.5)	21 (23.1)	15 (16.5)	12 (13.2)	9 (9.9)	4 (4.4)	5 (5.5)	3.07
Standard RRT calling criteria still breached	42 (43.3)	19 (19.6)	18 (18.6)	6 (6.2)	2 (2.1)	6 (6.2)	4 (4.1)	2.64
No plan for subsequent deterioration	13 (14.3)	15 (16.5)	23 (25.3)	13 (14.3)	18 (19.8)	4 (4.4)	5 (5.5)	3.52
Home team unaware of RRT call	2 (2.5)	6 (7.4)	7 (8.6)	6 (7.4)	11 (13.6)	40 (49.4)	9 (11.1)	5.36
Other reason	3 (12.5)	0 (0.0)	0 (0.0)	0 (0.0)	2 (8.3)	1 (4.2)	18 (75.0)	6.4

Of RRT user respondents, 54 of 204 (26.5%) felt discouraged from making a subsequent RRT call if the outcome of the prior RRT attendance had not addressed their original concerns. 35 of 201 (17.4%) respondents stated that this would engender some reluctance to also call the RRT to other patients. Despite this, 257 of 278 (92%) of respondents stated they were prepared to activate the RRT regardless of feelings of discomfort. This data is contained in Table 2.

Table 2 – Outcome of RRT not resolving the activating clinician's concerns (N with % in parentheses)

Outcome	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Re-activate RRT to the same patient	5 (1.8)	2 (0.7)	14 (5.0)	100 (36.0)	157 (56.5)
Complain to the RRT	12 (5.9)	33 (16.3)	64 (31.7)	66 (32.7)	27 (13.4)

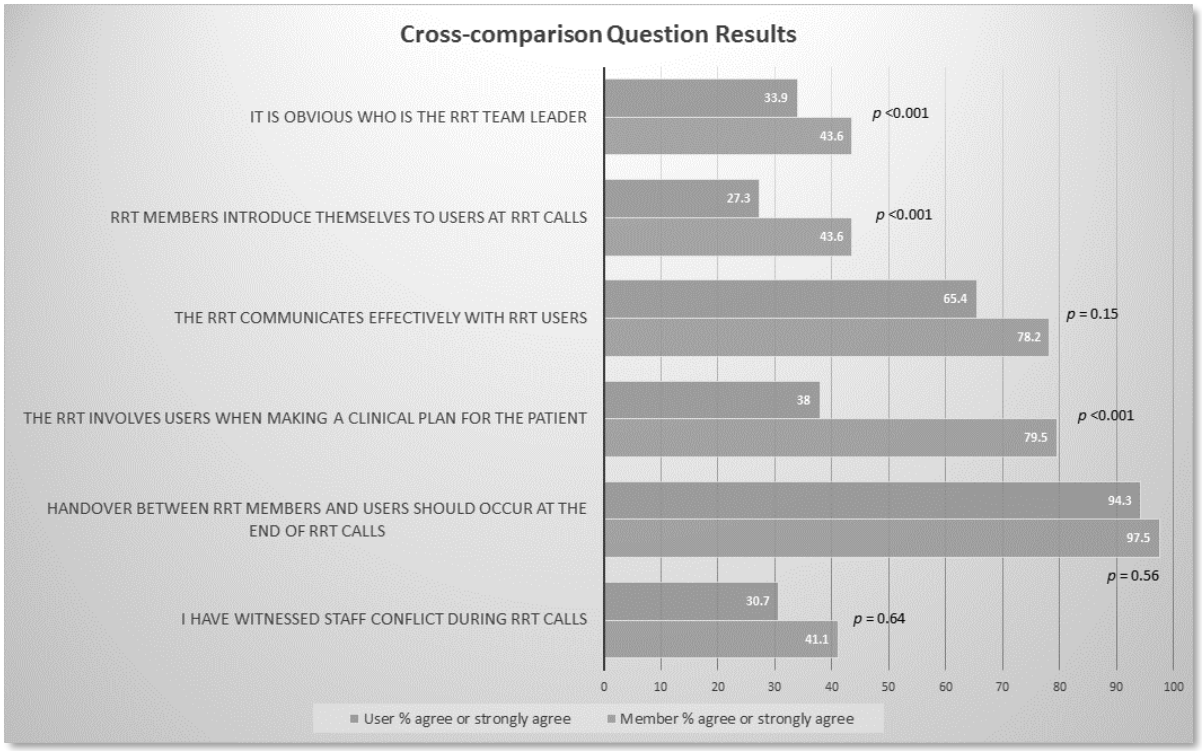
Call the home team instead	18 (8.9)	52 (25.6)	49 (24.1)	67 (33.0)	8.4 (17)
Notify the home team consultant	30 (15.4)	58 (29.7)	64 (32.8)	35 (17.9)	8 (4.1)
Feel discouraged from calling again on the same patient	59 (28.9)	58 (28.4)	33 (16.2)	42 (20.6)	12 (5.9)
Feel discouraged from calling on other patients	76 (37.8)	67 (33.3)	23 (11.4)	30 (14.9)	5 (2.5)

4.8.1.6 Comparison Data

Some questions were posed to both groups to elicit variances in perspectives on the same NTS domain. Almost half (43.6%) of RRT members felt they introduced themselves whereas the same percentage (43.6%) of RRT users disagreed ($p < 0.01$). Whilst 69% of RRT members felt it was clear who the team leader was, ward staff seemed less certain, with only 33.9% agreeing, ($p < 0.01$).

When it came to formulating a plan for patients remaining on the ward the variations were greater, with 62 of 78 (79.5%) RRT members reporting that ward staff were involved in the process, compared to 96 of 253 (38.0%) RRT users ($p < 0.01$). Communication amongst RRT members correlated better with 164 of 251 (65.3%) users and 61 of 78 (78.2%) of RRT members indicating that it was effective ($p = 0.15$). Both RRT users and members had witnessed conflicts during a RRT call (30.7% and 41.0% respectively, $p = 0.62$). Both groups showed good concordance and agreement that a formal handover between RRT members and users was important (97.4% and 94.3%, $p = 0.56$). This data is summarised in Figure 1.

Figure 1: Comparison Data



4.8.1.7 Data Validation

A 4-factor analysis of the RRT user data confirmed congruence within the sections of the survey relating to the initiation of a RRT call, during RRT attendance and the following RRT departure, so these were clustered for internal consistency analysis. By Cronbach's alpha this was confirmed with values of 0.775, 0.774 and 0.912 respectively.

4.8.1.8 Missing Items

The RRT user survey provided for a potential 7,425 individual data-points of which 1,139 (15.3%) were unfilled. The median number of missing responses per question was 44 [14 – 57] with a minimum of 12 and maximum of 102. In the RRT member survey only 81 potential data-points were not completed overall (3.7%). Some questions were answered by all respondents and the maximum number of missing responses per question was 10, median 1 [0 – 7].

4.8.2 Qualitative Data from Free Comments

4.8.2.1 RRT User Comment Content Analysis

Comments were provided by 34 (11.4%) RRT users. From these, 60 sections of text were coded (median 1 [1-3] per comment) into 68 nodes (median 2 [1-3]). Of these, 54 (79.4%) related prior experiences and the remainder (14, 20.6%) expressed suggestions for improvements around RRT performance of NTS.

The commonest user experience was of non-achievement of member-user cooperation (20, 37.0%), such as: "some [RRT] members … have been dismissive of nursing staff concerns about [the] patient". This was followed by non-achievement of member-user communication (15, 27.8%), such as "patient plans are often not discussed with the [ward] nursing staff" and non-achievement of plan development (12, 22.2%). Eight (23.5%) comments reported fear of criticism for calling, for example: "… there have been times that I have been apprehensive about calling [the RRT]".

In all there were five (9.3%) reports of NTS achievement, three (5.6%) for communication and two (3.7%) for cooperation.

4.8.2.2 RRT Member Comment Content Analysis

14 (17.7%) RRT members provided comments. These contained 21 sections that were coded (median 1 [1-2] per comment) into 24 nodes (median 2 [1-2]). These were mostly suggestions for NTS improvements (17, 70.8%). The commonest suggestion related to cooperation between the RRT and RRT user (9 references, 52.9%) with requests for admitting team involvement such as: "I believe that surgical patient [RRT calls] should be attended by a surgical registrar".

Of the seven experiences referenced, four (57.1%) were for non-achievement of cooperation, two (28.6%) for non-achievement of communication and one (14.3%) for non-achievement of leadership reporting experiencing: "… team leaders brushing off other [RRT] members opinions".

There were no comments or parts thereof that could be coded to experiences of achievement of NTS.

4.9 DISCUSSION

4.9.1 Summary of Key findings

In surveying RRT users' and members' attitudes and perceptions, involvement of users during a RRT call was frequent, and their experience was positive. There were however negative issues and these related to RRT member identification, communication and handover. Both RRT users and team members reported having experienced an uncomfortable interaction during a RRT call. RRT users reported feeling distanced and not involved sufficiently in decision-making by RRT members. In contrast RRT members perceived RRT users to be disinterested at the time of a RRT call. Persistence of RRT activation criteria, a failure to negotiate and communicate, a plan for subsequent patient deterioration, to address staff concerns, to ascertain resuscitation limits or to seek consensus with the admitting team were the most cited reasons for subsequent re-activation of the RRT.

4.9.2 Comparison with other studies

Multiple RRT calls to the same patient have been reported to occur in 10% to 22.5% of all RRT-attended patients,[14-17] and are associated with adverse patient outcomes.[14,16,17] The findings demonstrated that almost 40% of our RRT users reported having triggered more than one RRT call to the same patient. Ongoing breaches of RRT calling criteria or patient safety concerns were cited as leading triggers to recall the RRT. The latter arose because of failures in the way RRT members and users interacted at the time of a call. There was strong agreement from both RRT members and users for the need for a structured and effective handover process.

The relationship between a RRT members and users is one of complex co-dependency. Maintenance of good rapport is essential to optimise RRT calling and subsequent RRS performance. An inability to achieve this may lead to inefficient RRT activity due to unresolved clinical problems, risk to staff morale through dissatisfaction and conflicts, and potential for adverse patient outcomes.[11-13] The pressured working environment of clinical wards and the requirement to promptly recognise and respond to clinical deterioration,[1] pose a threat to the RRT member – user relationship. It was found that there was either a lack of, or inadequate, RRT user involvement in deciding upon patient care at the time of the RRT attendance. This was associated with a negative impact upon RRT users' impressions of the effectiveness of the RRT, and a discouragement from making a subsequent RRT call. Despite this, respondents still stated a willingness to reactivate the RRT.

Communication was perceived differently by RRT users and members. Communication amongst RRT members was viewed more effective than between RRT members and users. Effective communication, however is a key tenet of NTS in the context of "Crisis Resource Management".[14, 15] Communication strategies streamline patient care delivery, improve the signal-to-noise ratio and provide error mitigation through cross-checking and increased situational awareness.[27, 28] The fraught working environment of the RRT reinforces the need for effective communication.[29, 30]

These findings are in keeping with previous survey results,[7-10] and suggest there is a need for quality improvement in the way the RRT interacts, both as a team and with their users. In particular, patterns of multiple RRT calls should be evaluated regarding how they may be influenced by RRT user-member interactions, and strategies implemented to reduce their occurrence. Training in NTS, such as leadership, communication and team-working, is supported by these findings and could address the negative patterns of RRT member and user interactions [14,15,31,32]. This in turn has the potential to reduce multiple calls to the same patient. NTS training has already proven its effectiveness within other acute clinical domains including cardiac arrest teams, and thus should also benefit RRT. [14, 15]

4.9.3 Strengths and Weaknesses

Surveys such as this have their limitations.[31] The response rate for RRT users was less than a third, and the findings may not be generalizable to all RRT users. Responders with strong feelings may bias the results, as may the proportion of missing data-points due to incomplete responses. No inference was made regarding the reasons for these, but there is the risk of omitting useful data that may otherwise have altered the interpretation of our findings. A leading closed-question format was chosen to target specific study objectives. While efficient in nature, such a method of questioning does lower validity to broader application.

Despite these potential weaknesses, the availability of a free text section provided the opportunity for respondents to voice individual opinion. The application of identical questions to both RRT users and members allowed for better insights as to the likely state of the RRT user-member interface. Because of the importance and potential significance of RRTs to patient safety, even a survey response rate of 32% from RRS users can still be considered sufficient to develop conclusions. However small, in using parallel member-user surveying to analyse the RRS, this study is likely to be the first of its kind both nationally and internationally.

4.10 CONCLUSION

Effectiveness and quality of communication featured strongly for both RRT users and members in respect to how they interact at the time of a RRT call. In particular, the importance of staff identification, professional conduct, engagement in clinical decision making, and a formalised handover process. Where these were lacking, user satisfaction with RRT members was affected and had the potential to influence subsequent RRT calls, and thus the potential for patient harm and organisational inefficiency. Our findings support the need for quality improvement strategies that target RRT performance and the RRT member-user interface. NTS training may meet these needs and requires future exploration.

4.11 REFERENCES

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4.12 APPENDICES

4.12.1 Appendix 1 - RRT User Survey Results

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Number of responses
RRT members introduce themselves	12%	32%	29%	22%	5%	257
It is clear who is the RRT team-leader	7%	31%	28%	27%	7%	257
RRT invites me to state the reason for activation	1%	4%	8%	57%	30%	254
RRT acknowledges my rationale for activation	3%	10%	27%	48%	11%	254
RRT involve me during the call	2%	10%	25%	56%	7%	255
I feel confident speaking to RRT during calls	1%	12%	22%	50%	15%	254
RRT communicates well together	1%	6%	29%	54%	9%	249
I have witnessed conflict within RRT	9%	37%	23%	24%	7%	251
RRT works together to develop a plan	1%	7%	26%	58%	8%	251
RRT involves me in development of the plan	3%	19%	40%	34%	4%	253
At completion of RRT attendance, there is a plan	2%	11%	27%	53%	8%	253
At completion of a RRT attendance there should be a plan	2%	0%	1%	27%	70%	285

RRT should handover the plan before leaving	2%	0%	4%	27%	68%	282
I should be able to read and clarify the plan	2%	0%	1%	25%	72%	285
I should be able to ask RRT questions about the plan	2%	0%	5%	25%	69%	285
RRT should only leave after my concerns have been addressed	2%	0%	7%	35%	56%	285

4.12.2 Appendix 2 - RRT Member Survey Results

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Number of responses
RRT members introduce themselves	1%	32%	23%	33%	10%	78
It is clear who is the RRT team-leader	1%	12%	18%	52%	17%	77
I understand my role on the RRT	0%	3%	10%	58%	29%	79
I understand my responsibilities on the RRT	0%	1%	4%	64%	31%	78
The team leader delegates roles	0%	5%	23%	48%	24%	79
I understand the roles of other RRT members	1%	1%	16%	59%	22%	79
I understand the responsibilities of other RRT members	1%	5%	18%	53%	22%	77
RRT receives a handover from those activating	5%	29%	32%	29%	5%	79
Other members of RRT address my concerns	0%	4%	19%	66%	11%	79
RRT involves calling staff in development of the plan	0%	3%	18%	68%	12%	78
RRT communicates well together	0%	4%	18%	69%	9%	78
Nursing staff are unwilling to be involved during RRT attendance	3%	45%	27%	22%	3%	73
Medical staff are unwilling to be involved during RRT attendance	8%	44%	25%	21%	3%	73

I have witnessed conflict within RRT	8%	32%	19%	37%	4%	78
RRT should handover the plan before leaving	0	0	3%	44%	54%	78
RRT should not leave without handing over	0%	0%	5%	38%	57%	79
Communication skills are important during RRT calls	0%	0%	0%	23%	77%	79

4.13 POSTSCRIPT

As noted in the chapter Preamble (Section 4.2), the questionnaires used in this study were targeted at the NTS domains of leadership, communication, cooperation and decision-making/planning. However, these domains were not specifically highlighted in the reporting of results, nor was discussion focused on how participant perceptions related to these domains, especially in regard to areas for improvement.

Findings from exemplar questions that were posed to both study groups can be used to contextualise the NTS domains. This approach allows insights from, and comparison between, both sides of the Member-User interface. It also adds another dimension to relevant similarities and differences between RRT Users and Members. Relevant questions included:

1. "It is obvious who is the team leader at RRT calls". This statement targeted the leadership domain principally. There was a significant difference between Users' and Members' agreement (33.9% vs 43.6% respectively, $P<0.01$). This suggested a disparity in the perceived visibility of leadership with, not surprisingly, RRT Members having better awareness than Users. Even then, that less than half of Members perceived obvious leadership during RRT calls is noteworthy, especially given that 10 of the 107 respondents, as ICU registrars, were designated to hold the team leader role.
2. "RRT members introduce themselves to ward staff". This statement covers three NTS domains (leadership, communication and cooperation), with a significant difference between Users' and Members' perceptions (27.3% and 43.6%, respectively). With this question, there was also a notably low percentage reported by RRT Members that provides valuable insight into Members' own behaviour during calls.
3. "The RRT involves ward staff in development of the clinical plan". This statement queried communication and cooperation but was particularly focused on the NTS domain of decision-making and planning. Here, the greatest numerical difference was noted between Users' and Members' perceptions with 38.0% and 79.5% agreeing with the statement, respectively. The relatively high percentage of agreement by Members, by comparison to Users, suggested different experiences of the end of calls and Users' dissatisfaction with RRT Members' attention to their concerns before ending calls. The latter findings were further echoed by "ongoing calling criteria breaches at the end of calls" being the most cited reason reported as triggering repeat calls.

To summarise, the findings of this study flagged many areas for potential improvement during RRT calls and served as valuable baseline with which to compare findings from repeating the surveys after implementation of the intervention.

Chapter 5: Phase 2 Survey Results (Paper 3) – Re-designing a rapid response system: effect on staff experiences and perceptions of rapid response team calls

5.1 CITATIONS

Chalwin R, Giles L, Salter A, Kapitola K, Karnon J. Re-designing a rapid response system: effect on staff experiences and perceptions of rapid response team calls. BMC Health Serv Res 2020;20:480

5.1.1 Digital Object Identifier

10.1186/s12913-020-05260-z

5.1.2 PubMed Identifier

32471422

5.2 PREAMBLE AND RESEARCH QUESTION

This was the first of the post-intervention studies. This study addressed the research question:

> "What is the effect of an RRS re-design on RRS staff perceptions and experiences of attending RRT calls?"

The publication of this study reports staff experiences and perceptions of RRT calls that were collected by a survey conducted 12 months after introduction of the RRS re-design intervention. This interval permitted sufficient time for the intervention to become established and for all RRS staff to be exposed to it.

RRS Members and Users were specifically asked to consider only the prior 12 months in their responses. This aimed to ensure that the data collected reflected the effect of the intervention. These data were then compared against the responses from the pre-intervention survey (as reported in Paper 2).

5.2.1 Conduct of the Survey

The post-intervention survey occurred twelve months after introduction of the re-design. It also was conducted over two months and requested respondents to answer only based on their experiences over the preceding 12 months to capture their perceptions of RRT calls following the RRS re-design.

The RRT Member and User questionnaires were identical to those used in Phase 1. All aspects of conduct of Phase 1 surveys as described in Chapter 4 (Section 4.2) were repeated for this Phase 2 survey.

The data for both Phases for the RRT Member and User questionnaires were merged to become the dataset for Paper 3.

5.2.2 Objectives for the Survey

Repetition of the same survey methodology pre- and post- intervention was intended to evaluate the effect of that intervention in altering RRT Member and User perceptions and experiences of calls. As noted in Section 3.2.1, the RRS had no other changes except for addition of the intervention.

The survey, as highlighted in the previous chapter postscript (Section 4.13) addressed the NTS domains of leadership, communication, cooperation and decision-making/planning. The intervention is also detailed in this paper with each component being referenced to these NTS domains.

Thus, for example, a change in use of leadership skills during calls might be evidenced by difference in the User and/or Member agreement with the statement "It is obvious who is the Team Leader at RRT calls".

5.2.3 Isolation of the Effect of the Intervention

As outlined in Section 3.2.1, the RRS at LMH was intentionally unaltered throughout the study period. This consistency applied across all components of the RRS such as for:

- call triggers
- RRT composition (per Table 3.1)
- RRT leadership (i.e. always the ICU trainee doctor)
- skills mix of the RRT (i.e. at least 1 member – the team leader and/or RRT nurse – held Advanced Life Support provider accreditation)
- ICU Consultant availability and support (at any time of day or night)
- the level and capability of the ICU (which merely increased in size, but not casemix)
- level and capability of the hospital (which also increased in size but not casemix)
- RRS administration
- RRS governance (including policy and procedures which were updated only for compliance purposes with ACSQHC requirements [30])

Thus, the intervention and its components were the only noticeable change to the operations of RRT calls across the study period.

5.3 STATEMENT OF AUTHORSHIP

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Contribution to the Paper:	Conception, planning, data analysis, data interpretation, writing, drafting, proofing
Overall percentage (%):	65
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.
Signature:	Date: 22 Feb. 2022

5.3.2 Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Overall percentage (%):	10
Signature:	Date: 22 Feb. 2022

5.4 ABSTRACT

5.4.1 Background

Rapid Response Team (RRT) calls are clinical crises. Clinical and time pressures can hinder effective liaison between staff who call the RRT ('users') and those responding as part of the RRT ('members'). Non-technical skills (NTS) training has been shown to improve communication and cooperation but requires time and financial resources that may not be available in acute care hospitals. Rapid Response System (RRS) re-design, aiming to promote use of NTS, may provide an alternative approach to improving interactions within RRTs and between members and users.

5.4.2 Methods

Re-design of an existing mature RRS was undertaken in a tertiary, metropolitan hospital incorporating the addition of: 1) regular RRT meetings 2) RRT role badges and 3) a structured member-to-user patient care responsibility "hand-off" process. To compare experiences and perceptions of calls, users and members were surveyed pre and post re-design.

5.4.3 Results

Post re-design there were improvements in members' understanding of RRT roles (P=0.03) and responsibilities (P<0.01), and recollection of introducing themselves to users (P=0.02). For users, after the re-design, there were improvements in identification of the RRT leader (P<0.01), and in the development of clinical plans for patients remaining on the ward at the end of an RRT call (P<0.01). However, post-re-design, fewer users agreed that the structured hand-off was useful or that they should be involved in the process. Both members and users reported fewer experiences of conflict at RRT calls post-re-design (both P<0.01).

5.4.4 Conclusion

The RRS re-design yielded improvements in interactions between members in RRTs and between RRT members and users. However, some unintended consequences arose, particularly around user satisfaction with the structured hand-off. These findings suggest that refinement and improvement of the RRS is possible, but should be an ongoing iterative effort, ideally supported by staff training.

5.5 BACKGROUND

The Rapid Response System (RRS) is an integral patient safety mechanism within acute hospitals. It incorporates the afferent limb: a recognition and alert process for clinical deterioration, and the efferent limb: a team-based response to achieve appropriate and timely patient management.[1]

Staff for the afferent limb are typically ward clinicians under whose care patients are admitted. The efferent limb Rapid Response Team (RRT) comprises specialised clinicians from acute areas such as the Intensive Care Unit (ICU).[2] Optimal functioning of the RRS depends on collegial liaison between staff from these two components – those that call the RRT ('users') and those rostered to the RRT ('members').

The clinical and time stressors of RRT calls can threaten the working relationship between users and members. An impaired interface between RRT members and users may hinder successful resolution of RRT calls.[3,4] Unaddressed clinical deterioration and/or other patient wellbeing concerns may result in repeat activation of the RRT by the afferent limb. This potentially avoidable repeat calling has been associated with increased in-hospital mortality.[5]

Key non-technical skills (NTS) domains, such as communication and cooperation, play a significant role during RRT member-user interactions.[6,7] Effective use of these skills can be improved through delivery of NTS training to acute care clinicians.[8-11] Unfortunately, education programs require considerable time, logistic and financial resources to be effective, and thus are not always feasible to deliver to frontline hospital staff.

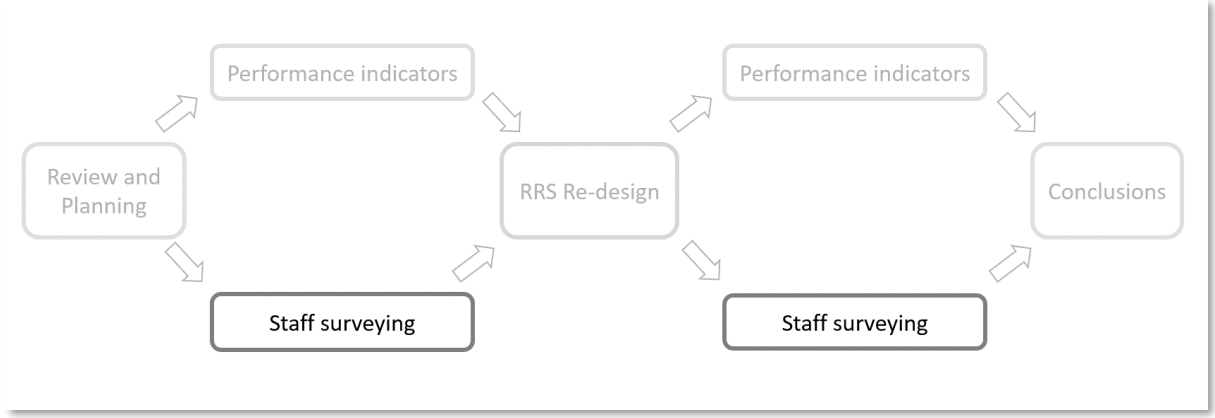
Given these constraints, an alternative approach is to incorporate design elements into the RRS that would promote effective communication and cooperation within the RRS without the need for dedicated training.[7,12,13] Previous studies with similar objectives have reported modification of individual aspects of the RRS, albeit without detailed investigation of their effects on system performance.[6,14-19] Therefore, the present study was conducted to describe and assess a multi-faceted re-design of an RRS which aimed to improve the quality of RRT member-member and member-user communication and cooperation.

5.6 METHODS

A pre-post survey was conducted as part of the *Impact of Non-Technical Skills on Performance and Effectiveness of a Medical Emergency Team* project (ClinicalTrials.gov: NCT01551160 – a diagram showing the structure of the overall project and the position of this study within it is shown in Figure 1), comparing clinical staff experiences and perceptions of RRT calls before and after the re-design of a hospital RRS.

Staff at a tertiary, university-affiliated hospital were eligible for inclusion if working in a clinical role during the study. Participants were divided into two groups, RRT members and RRT users.

FIGURE 1: Components of the RRS re-design project



Pre and post re-design hospital staff surveying, as compared in this study, is highlighted.

RRS = Rapid Response System

5.6.1 The RRS Re-Design

Incident reports and focus groups conducted at the investigating hospital prior to commencement of the project had highlighted issues around the quality of communication and cooperation during RRT calls, both at the member-user interface and within the RRT.

Insufficient financial and human resources were available at the investigating hospital to deliver an NTS training program for RRS staff. Therefore, a multi-faceted re-design of the existing mature RRS was undertaken instead, incorporating themes from the TeamSTEPPS® program and previously reported RRS improvement initiatives, to promote use of NTS without the need for training. [14,17,19,20]

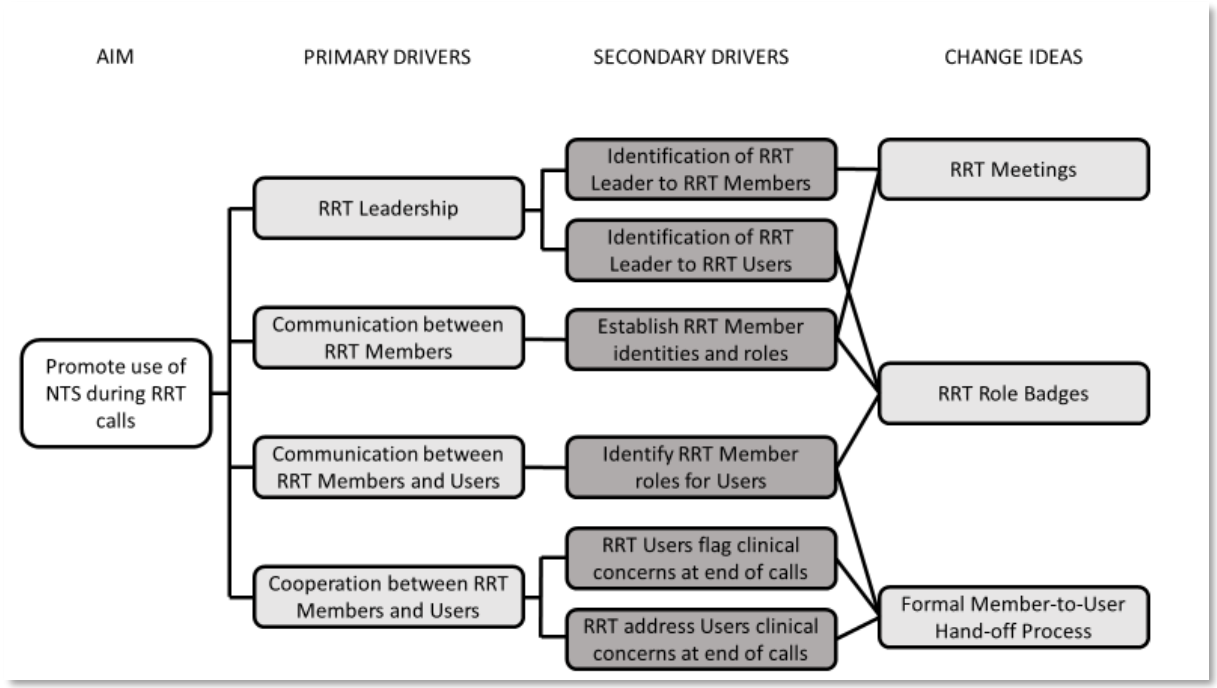
The objectives of the re-design were to encourage a better understanding of roles and responsibilities amongst RRT members, improve identification of those roles to afferent limb staff, and enhance communication both within the RRT and at the interface between team members and users.

The re-design incorporated three components:

1. Regular RRT meetings
2. Badges identifying RRT members' roles
3. A structured "hand-off" procedure from RRT members to users for patients remaining on the ward at the end of a call

The relationship of the primary and secondary drivers of these three re-design components are presented in Figure 2.

FIGURE 2: Driver Diagram depicting key drivers and components of the re-design



NTS = Non-Technical Skills, RRT = Rapid Response Team

5.6.1.1 Regular RRT meetings

The shift-by-shift changeover in RRT staffing was identified as a possible barrier to efficiency, [2,6,7] since time spent at calls establishing RRT members' roles and capabilities may delay assessment and resuscitation of patients. Therefore, regular "ice breaker" meetings for RRT staff were implemented.[17]

Meetings for RRT staff were scheduled twice daily, to coincide with staff changeovers between day and night shifts, so each team could convene before attending their first call. These meetings, typically lasting around five minutes, permitted members' introductions, and establishment of roles and initial responsibilities when attending calls, especially those of the team leader (see Appendix 1).[6,7,17,20]

5.6.1.2 Team Role Badges

Feedback from ward staff prior to the re-design suggested that RRT users frequently had difficulty ascertaining RRT membership and roles amongst clinical staff present at calls, with the team leader position particularly challenging to identify. Therefore, RRT role badges were included as part of the re-design to convey member designations to users (Team Leader – usually an ICU resident, RRT Nurse, Medicine Resident, Intern and Hospital Manager).[18]

Badges were distributed during the regular RRT meetings, with members required to wear them conspicuously during calls to ensure that RRT users and other staff could easily identify each member of the team, and their roles, at calls.

5.6.1.3 RRT members-to-users "hand-off" procedure

Prior to an RRT call, each patient's ward team have responsibility for leading care and clinical decision-making. During a call, this authority is temporarily adopted by the RRT to expedite management of the clinical crisis. However, if the patient is to remain on the ward at the end of their call, this clinical responsibility must be re-assumed by ward staff. Successful completion of the RRT call requires that this transfer of care is not only acknowledged by those on both sides of the member-user interface but is also appropriate. Most importantly, this needs careful consideration regarding whether the patient's ongoing management needs can be safely and effectively delivered by that ward team. [19,20]

Staff feedback prior to the redesign, and our previous research, [3] suggested that unresolved clinical concern at the end of calls was common, resulting in staff unease and, hence, repeat RRT calls. Ensuring resolution of RRT user concern is important as up to 18% of calls prior to the re-design were for the "worried" criterion rather than a predefined physiological trigger.[5]

Therefore, a structured verbal and written "hand-off" protocol was enacted when patients were to remain on their ward after a RRT call. (see Appendix 2). This included the requirement of a signature from a representative of the ward team re-assuming care responsibility to permit stand-down of the RRT, with the intention of encouraging users to voice any ongoing or unresolved clinical concerns before the RRT departed from the call.

5.6.2 Study Phases and Survey Instrument

The Phase 1 (pre) survey was carried out, following which the RRS re-design, described above, was implemented. One year later, the Phase 2 (post) survey was conducted.

For all survey questions, respondents were asked to recall their experiences and perceptions over the previous 12 months. Therefore, responses for each phase refer to the year preceding the completion of the survey instrument.

Two questionnaires were used: one for RRT members, the other for RRT users, relating to experiences of RRT calls and opinions on the member-user interface (see Appendices 3 and 4). Each group completed a different survey instrument, but the same questionnaire (within group) was repeated in Phase 1 and Phase 2 of the study.

5.6.3 Data Analysis

The effect of the re-design on experiences and perceptions was assessed by comparing Phase 1 and Phase 2 responses. No personal identifiers were collected in the questionnaires to ensure anonymity, so it was not possible to ascertain whether respondents had contributed data to both study phases. As a result, all quantitative data were considered unpaired.

For respondent characteristics, categorical variables are presented as frequencies and percentages and continuous variables are summarised with medians with interquartile ranges (IQRs). Between phase comparisons were conducted by Chi-square tests of association for categorical variables and Mann-Whitney U-tests for continuous variables.

For questionnaire items with Likert scale responses, data were re-coded into binary variables (strongly agree or agree, all other responses). Comparisons of the proportion of agree responses between the study phases for each question were assessed by Z-tests, and results reported as differences in proportions for Phase 2 – Phase 1 (d_{2-1}), with 95% confidence intervals (95% CI).

Statistical analyses were conducted with SPSS (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp). A P value of 0.05 or less was considered statistically

significant. No correction for multiple comparisons was made due to the exploratory nature of the study.

Free-text comments from the Phase 2 questionnaire were reviewed and coded if they referred to the RRS re-design. Comments were further categorised into positive (e.g. reporting improvements from the re-design), negative (e.g. identifying problems with the re-design) or suggestions for refinement or improvement. These results are summarised as frequencies.

5.7 RESULTS

5.7.1 RRT Members

There were 79 respondents in Phase 1 and 61 in Phase 2. RRT member roles were similarly represented in each phase except for internal medicine trainees (21 of 79 (26.6%) in Phase 1 vs 4 of 61 (6.6%) in Phase 2, P=0.06). The median number of years of experience as an RRT member was 3 years [IQR 1 – 6] for Phase 1 respondents versus 2 years [IQR 0.69 – 5.75] in Phase 2 (P=0.80).

A summary of all RRT members' questionnaire responses, showing comparisons between Phase 2 and Phase 1, is provided in Table 1. Relative to Phase 1, there was a higher proportion of agree responses in Phase 2 regarding whether the RRT members introduced themselves to users ($d_{2\text{-}1}$ 0.19 [95%CI 0.03 – 0.36] P=0.02), and understood other team members' roles $d_{2\text{-}1}$ 0.12 [95%CI 0.01 – 0.24] P=0.03) and responsibilities $d_{2\text{-}1}$ 0.22 [95%CI 0.09 – 0.34] P<0.01).

TABLE 1 – Members' Experiences and Perceptions of RRT Calls

	Phase 1 N (%) of agree responses	Phase 2 N (%) of agree responses	Differences in Proportions [95%CI]	P Value
RRT members introduce themselves to ward staff	34 (43.0%)	38 (62.3%)	0.19 [0.03 – 0.36]	0.02
It is obvious who is the Team Leader at RRT calls	53 (67.1%)	47 (77.0%)	0.10 [-0.05 – 0.25]	0.20
I understand my role as part of the RRT	69 (87.3%)	59 (96.7%)	0.09 [0.00 – 0.19]	0.05
I understand my responsibilities as part of the RRT	74 (93.7%)	60 (98.4%)	0.05 [-0.02 – 0.11]	0.17
The Team Leader delegates roles appropriately	57 (72.2%)	51 (83.6%)	0.11 [-0.03 – 0.25]	0.11
I understand the roles of other members of the RRT	64 (81.0%)	57 (93.4%)	0.12 [0.01 – 0.24]	0.03
I understand the responsibilities of other members of the RRT	58 (73.4%)	58 (95.1%)	0.22 [0.09 – 0.34]	<0.01
The RRT team always receives a handover from the ward team	27 (34.2%)	31 (50.8%)	0.17 [0.00 – 0.33]	0.05
Other members of the RRT listen to and address my queries and concerns	61 (77.2%)	54 (88.5%)	0.11 [-0.1 – 0.24]	0.08
The RRT involves ward staff in development of the clinical plan	62 (78.5%)	53 (86.9%)	0.08 [-0.04 – 0.21]	0.20
The RRT communicates well with other staff	61 (77.2%)	50 (82.0%)	0.05 [-0.09 – 0.18]	0.49
Ward staff who call the RRT are reluctant to be involved during calls	18 (22.8%)	12 (19.7%)	-0.03 [-0.17 – 0.11]	0.66
Attending teams are reluctant to be involved during calls on their patients	17 (21.5%)	16 (26.2%)	0.05 [-0.09 – 0.19]	0.51
I have witnessed conflicts during RRT calls	32 (40.5%)	9 (14.8%)	-0.26 [-0.41 – -0.11]	<0.01
The RRT should handover to ward staff before leaving	76 (96.2%)	55 (90.2%)	-0.06 [-0.14 – 0.02]	0.15
The RRT should not leave until they have an agreed plan with ward staff	75 (94.9%)	53 (86.9%)	-0.08 [-0.17 – 0.01]	0.09
Communication skills are important during RRT calls	79 (100%)	60 (98.4%)	-0.02 [-0.04 – 0.01]	0.25
The RRT works well together	68 (86.1%)	53 (86.9%)	0.01 [-0.11 – 0.12]	0.89

RRT = Rapid Response Team

Fewer respondents in Phase 2 had witnessed conflicts between staff at RRT calls over the previous year than respondents at Phase 1 (d_{2-1} -0.26 [95%CI -0.41 – -0.11] P<0.01).

For all other questions, the differences in proportions of participants who agreed or strongly agreed (versus not) were not statistically significant between study phases.

5.7.2 RRT Users

There were 297 RRT user respondents in Phase 1 and 302 respondents in Phase 2. RRT user clinical disciplines (e.g. doctor, nurse, allied health clinician) were similarly represented in each phase (P=0.11). The number of years of clinical practice reported by participants was also similar in the two phases.

Similar proportions of respondents had called an RRT in the 12 months prior to each survey (74.4% in Phase 1 vs 77.2% in Phase 2, P=0.57), but more respondents had been directly involved in RRT calls prior to Phase 2 than Phase 1 (86.1% vs 77.1%, P=0.02).

As detailed in Table 2, a higher proportion of respondents in Phase 2 agreed that the RRT leader's identity was obvious to users (d_{2-1} 0.21 [95%CI 0.12 – 0.29] P<0.01) and felt more confident speaking up during RRT calls (d_{2-1} 0.09 [95%CI 0.01 – 0.17] P=0.03), relative to respondents in Phase 1.

TABLE 2 – Users' Experiences and Perceptions of RRT Calls

	Phase 1 N (%) of agree responses	Phase 2 N (%) of agree responses	Differences in Proportions [95%CI]	P Value
RRT members introduce themselves to ward staff	70 (27.2%)	89 (32.1%)	0.05 [-0.03 – 0.13]	0.22
It is obvious who is the Team Leader at RRT calls	87 (33.9%)	151 (54.5%)	0.21 [0.12 – 0.29]	<0.01
The RRT invites me to state the reason for calling	219 (86.2%)	244 (89.4%)	0.03 [-0.02 – 0.09]	0.27
The RRT acknowledge my rationale for calling	152 (59.8%)	185 (67.8%)	0.08 [0.00 – 0.16]	0.06
The RRT team involve me in patient care during the call	161 (63.1%)	193 (70.2%)	0.07 [-0.01 – 0.15]	0.09
I feel confident speaking to the RRT during calls	166 (65.4%)	204 (74.2%)	0.09 [0.01 – 0.17]	0.03
The RRT communicates well with other staff	157 (63.1%)	191 (70.0%)	0.07 [-0.01 – 0.15]	0.09
I have witnessed conflicts during RRT calls	77 (30.7%)	45 (16.6%)	-0.14 [-0.21 – -0.07]	<0.01
When the patient remains on the ward there is a patient care plan	152 (60.1%)	186 (70.5%)	0.10 [0.02 – 0.19]	<0.01
The RRT team works together to develop a plan for the patient	164 (65.3%)	208 (76.8%)	0.11 [0.04 – 0.19]	<0.01
The RRT involves ward staff in development of the clinical plan	96 (37.9%)	147 (53.8%)	0.16 [0.07 – 0.24]	<0.01
The RRT should not leave until ward staff agree with their plan	261 (91.6%)	160 (58.2%)	-0.33 [-0.41 – -0.26]	<0.01
The RRT should document the clinical plan before leaving	275 (96.5%)	201 (72.8%)	-0.24 [-0.30 – -0.18]	<0.01
The RRT should handover to ward staff before leaving	266 (94.3%)	179 (64.6%)	-0.30 [-0.36 – -0.23]	<0.01
I should be able to read and understand the plan	276 (96.8%)	185 (67.0%)	-0.30 [-0.36 – -0.23]	<0.01
I should feel empowered to ask questions about the plan	267 (93.7%)	163 (59.3%)	-0.34 [-0.41 – -0.27]	<0.01
Poor communication results in recurrent RRT calls	233 (82.0%)	43 (15.8%)	-0.66 [-0.75 – -0.58]	<0.01

RRT = Rapid Response Team

Furthermore, a higher proportion of respondents at Phase 2 agreed that the RRT developed a clear clinical plan at calls ($d_{2\text{-}1}$ 0.11 [95%CI 0.04 – 0.19]), involved ward staff in the formulation of those plans ($d_{2\text{-}1}$ 0.16 [95%CI 0.07 – 0.24]) and ensured that a plan was in place before leaving patients on wards at the end of calls ($d_{2\text{-}1}$ 0.10 [95%CI 0.02 – 0.19]), all P<0.01.

Experiences of witnessing conflicts between staff at RRT calls were reported less frequently in Phase 2 than Phase 1 ($d_{2\text{-}1}$ -0.14 [95%CI -0.21 – -0.07] P<0.01).

Relative to Phase 1, fewer respondents in Phase 2 agreed that RRT plans should be documented, that ward staff should be invited to read these plans and that their consent should be sought before team departure ($d_{2\text{-}1}$ -0.24 [95%CI -0.30 – -0.18], -0.30 [95%CI -0.36 – -0.23] and -0.34 [95%CI -0.41 – -0.27] respectively, all P<0.01).

The proportion of respondents who re-called the RRT to the same patient decreased from 33.3% in Phase 1 to 27.2% in Phase 2, but the difference was not statistically significant (P=0.09). In both study phases, the two most commonly cited reasons were ongoing breaches of calling criteria and unresolved clinical concern that triggered the initial call.

5.7.3 Phase 2 Qualitative Data

5.7.3.1 RRT Members

Free-text comments were provided by 25 (41.0%) respondents. A total of 19 comments referred to the RRS re-design or its components.

Regarding the RRT meetings, there were five negative comments (e.g. “some [members] don’t always come”) and one suggestion (“have a board of [RRT] staff names and pictures”). For the team role badges there were two negative comments (“not all staff wear them”) and two suggestions for having “stickers rather than badges”. The handovers had two positive comments (e.g. “the contract [handover] is very good”) and one negative comment (“too much paperwork”).

There were three comments pertaining to the overall RRS re-design. Two specifically cited the re-design as having had a positive effect on the RRS (e.g. “communication skills have improved”), whereas the other reported the opposite (“very little [ward] team involvement”).

5.7.3.2 RRT Users

Free-text responses were provided by 56 (18.5%) users, with 48 comments relating to aspects of the RRS re-design.

The RRT role badges received three positive comments (e.g. “badges make [RRT member] identification easier”) and four negative ones (e.g. “team leader does not introduce other [RRT] members”). The handovers had three positive comments (e.g. “they leave everyone on the same page”), eight negative comments (e.g. “feel pressured to accept RRT plan”) and four suggestions for improvement (e.g. “handover directly to patient care nurse”).

Twelve user comments praised existing aspects of the re-design for improving interactions with the RRT (e.g. “better attitude and communication”). However, another twelve comments indicated further room for improvement (e.g. “no appreciation that calling is protocolised”).

5.8 DISCUSSION

5.8.1 Key Findings

This study demonstrated improvements in RRT member and user experiences during calls after implementation of a quality improvement re-design of the RRS aimed to facilitate enhanced communication and cooperation.

In particular, both members and users reported a significant decrease in their perceived incidence of conflicts between staff at RRT calls, and a trend towards fewer reports of users having needed to recall the RRT to the same patient, following the RRS re-design.

Despite these positive findings, some aspects of the re-design were less successful. The configuration of the structured hand-off process especially seems to have been problematic.

5.8.2 Components of the RRS Re-design

5.8.2.1 RRT Meetings

Improvements in RRT members' identification of their team leader and understanding of their own and others' responsibilities suggest that meetings assisted the RRT to establish individual duties prior to attending calls. It is also plausible that patients benefited from resultant expedited management of deterioration due to RRT role allocations having been established prior to attendance, rather than consuming valuable time during calls.[6,17]

Despite the potential benefits of meetings, there were some logistical hurdles. Nurses' and doctors' shift changeovers did not always coincide, meaning that occasionally teams would attend calls with members who had not participated in the most recent meeting. Similarly, when rostered RRT staff were on breaks, their substitutes would respond to calls having not attended a meeting.

5.8.2.2 Member Role Badges

There was an increase in users' identification of the RRT leader and members' recognition of each person's role within the team. These suggest that the badges helped to convey RRT member roles, thereby reducing users' perceptions of infrequent RRT member verbal introductions to other staff present at calls.

Benefits in efficiency and effectiveness of the management of simulated patient deterioration have been demonstrated when team leaders are easily identifiable.[6,7,21-23] However, the contribution of the badges is reliant on them being worn. One RRT member noted that "not all staff wear them" during calls. Some members may have disliked having their designation prominently displayed or inadvertently misplaced their badges.

5.8.2.3 Structured Hand-Off

The transition of care is fraught with potential risk. [24-26] Amongst these, the need to ensure continuity of clinical responsibility is essential to prevent omissions of, or delays to, decision-making. Commonly used tools for patient handover prompt communication of clinical detail, but do not necessarily prompt users to consider logistics around the transfer of responsibility between teams. [25] Furthermore, handover often does not mandate acknowledgement, documentation or dissemination of the individual or team taking over responsibility. [27,28]

Data before the redesign showed that almost a fifth of all RRT calls to patients were for staff concern. [5] These patients had an in-hospital mortality rate of just over eight percent, in comparison to a national median of less than one percent for hospital separations, [29] despite the absence of a physiological calling criterion being reached. From this it can be inferred that clinician gestalt and intuition should still be taken seriously, even when observations appear to be within normal ranges.

Therefore, the hand-off component of the re-design was carefully constructed and advertised to RRT members and users to encourage the latter group to escalate their concerns, even to the point of delaying completion of the call until satisfied with clinical outcome for the patient. When the transfer of care was by consensus, the hand-off process ensured clear documentation of the clinical team assuming responsibility for that patient's care beyond the end of the RRT call.

However, this seems to have been the least successful component of the re-design. User responses indicated that some hand-offs were unsatisfactory, took too long, or that users still felt obliged to accept the RRT's plan despite having unresolved concerns about patient welfare. This latter aspect suggests that some undesirable practices persisted, contrary to the ethos underpinning the re-design.

Interestingly, in Phase 1, RRT users were overwhelmingly in favour of a (re-designed) structured hand-off process. [3] While users apparently support the concept of a formalised transfer of clinical responsibility, [19] some aspects of the process implemented in this study did not appear to meet the needs of Phase 2 respondents. It seems likely that modification of a communication procedure may not, alone, be sufficient and that wider organisational cultural change is needed. [25]

There were indications that the re-designed hand-off process led to some improvements during member-user interactions. There was a significant increase in respondent agreement that users were involved in devising clinical plans for patients and that these plans were more thoroughly explained to them by the RRT.

5.8.2.4 Overall

The most striking findings were the proportionally large, and statistically significant, reductions in both users' and members' perceptions of inter-personnel conflicts at calls. Given the overarching purpose of the re-design was to optimise liaison and teamwork between users and members, these results reassure that the RRS, as a whole, matured to focus on cooperative patient care.

5.8.3 Strengths and Limitations

To the best of the authors' knowledge, this is the first study to develop and assess a multi-faceted RRS re-design specifically aiming to improve communication and cooperation without the need for NTS training.

The findings from this study should be interpreted with caveats. First, the study did not collect personal identifiers so data could not be analysed to assess intra-individual change. The incentive to participate afforded by anonymity was viewed as more important than the direct comparison of change within individuals. Second, collapsing of Likert scale variables reduced granular information but enabled analysis by proportions of agreement which was important for reporting and interpretation of findings.

Finally, it is recognised that assessment of the effectiveness of handovers or interventions to modify them have been identified as difficult to clearly elicit. [30,31] In this study of a multi-faceted quality improvement initiative, pragmatic methodology was employed due to a lack of available resources to conduct comprehensive qualitative data collection. Instead, surrogates of staff satisfaction with interactions during calls, such as perceptions of conflicts or needing to recall the RRT, were included as indicators of the broader effect of the initiative on communication and cooperation amongst members and users. More nuanced insights might have been achieved with qualitative data collected through personal interviews or focus groups and subsequent analyses, [32] but this was beyond the scope of the present study.

5.8.4 Lessons for the Future.

5.8.4.1 Modifying Existing Components

The improvement of the investigating hospital's RRS was always anticipated to be an evolving project, of which the design components implemented in this study were one part. In that regard, the evaluation of the re-design has provided useful information about the overall quality improvement process.

The RRT meetings in Phase 2 were reasonably successful. However, since not all members were always able to attend, where possible, a backup option is required. For instance, RRT rosters populated with personnel names, pictures and roles, could be made accessible through hospital intranet websites for those members unable to attend meetings. If resources allowed, this content could be hosted through a mobile app for ease of access by busy clinicians.

The badges also seem to have met their intended purpose, but they are easily misplaced and relatively expensive to replace. Stickers are logical substitutes that can be cheaply printed in bulk and adhered to clothing.

Stickers could also be created for RRT user roles and, along with RRT member stickers, be kept on RRT trolleys for easy access at calls. It is standard practice in Emergency Department resuscitation rooms that roles of all staff are clearly designated during trauma calls, so this should be easily extrapolated to deteriorating patient cases of the RRS.

The structured hand-off process was less successful than intended. Given users' perceptions of inconvenience, it may be reasonable to make it conditional rather than mandatory. Some RRT calls for simple, self-limiting problems (e.g. a vaso-vagal episode) could be easily flagged as not requiring detailed acknowledgement of resumption of patient responsibility by ward staff. By reserving the structured hand-off process for more complex cases, the true value in ensuring resolution of users' clinical concern may be realised.

Furthermore, the hand-off proforma assessed in this study included sections for clinical detail and plans. To prioritise its intended function, the proforma could be streamlined to simply record the acknowledgement by, as well as key contact details for, the specific clinical team taking over responsibility for patient care after RRT completion. This could focus all involved clinicians during the member-to-user communication on the importance of continuity of patient care, and further prevent the need for imminent RRT re-activation. [3,5]

5.8.4.2 Need for Training

Re-design of RRS structures and procedures can only achieve so much. Ultimately, a comprehensive initiative to improve RRT member and user communication and cooperation would require dedicated training, reinforced by refresher sessions. [6-13] The NTS required by teams involved in the care of deteriorating patients cannot be assumed or innately acquired. Thus, any RRS quality improvements initiatives should ideally include the provision of a "crisis resource management" multi-disciplinary training programme for all RRT members and users.[6-8,10]

5.9 CONCLUSIONS

This study showed that improvements in RRT member-user interactions during RRT calls can be attained through introduction of RRT meetings, designation badges and a structured hand-off process. However, it has also identified some challenges in re-designing the structure and procedures of an RRS and its components. This suggests that refinement and improvement of an RRS is possible, but should be seen as a continuously iterative process and supported by a staff education programme.

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5.11 POSTSCRIPT

This study presents the changes in RRT Members' and Users' perceptions of calls before and after implementation of the intervention. Findings were discussed in the context of the study intervention components, rather than NTS domains, as this paper was the first from this research to present that intervention.

Therefore, this postscript is added to focus on the broader objective of this thesis, that is to investigate the effect of the intervention on use of NTS during RRT calls.

Leadership skills appeared to be significantly improved with 54.5% of Users agreeing that the team leader role was obvious after the intervention versus 33.9% before its implementation ($P<0.01$). Communication improved across more than one question such as the 74.2% versus 65.4% (after vs before the intervention, respectively, $P=0.03$) of Users who felt confident speaking up during calls and the 15.8% versus 82.0% (after vs before the intervention, respectively, $P<0.01$) who had experienced poor communication between Members and Users that resulted in recalling of the RRT.

Similarly, the three questions relating to experiences of end of call decision-making and planning (i.e. when the patient remains on the ward there is a patient care plan, the RRT team works together to develop a plan for the patient, the RRT involves ward staff in development of the clinical plan) all showed statistically significant improvements for the User group. This is not to underplay the importance of the Members' experiences, but User frustrations over perceived unresolved clinical concern was the leading reported reason for having recalled the RRT. Thus, these improvements in Users' experiences after implementation of the intervention is a reassuring indicator that RRT Members behaviours and attitudes had been positively influenced.

Lastly, as noted in detail in the paper, the significant reduction in experiences of conflict at RRT call reported by both Members and Users suggests there was improved cooperation between these groups.

Therefore, despite the potential concerns regarding the Handoff component, the intervention was associated with improvements in experiences of RRT calls. Although NTS usage during calls was not recorded, it seems likely that improvements did occur. As noted previously, no other changes occurred to the RRS or more widely within LMH, so it is reasonable to conclude that at least come of the changes can be attributed to the intervention.

Chapter 6: Phase 1 Performance Indicator Results (Paper 4) – Reasons for Repeat Rapid Response Team Calls, and Associations with In-Hospital Mortality

6.1 CITATIONS

Chalwin R, Giles L, Salter A, Eaton V, Kapitola K, Karnon J. Reasons for Repeat Rapid Response Team Calls, and Associations with In-Hospital Mortality. Jt Comm J Qual Patient Saf 2019;45:268-275

6.1.1 Digital Object Identifier

10.1016/j.jcjq.2018.10.005

6.1.2 PubMed Identifier

30522833

6.2 PREAMBLE

This paper describes pre-intervention (Phase 1) RRS performance data. It addresses the research question:

> "Is there an association between potentially preventable repeat RRT calling and patient in-hospital mortality?"

The outcome was the Repeat RRT Call, that is the RRT attending the same patient more than once per admission, as introduced in Section 1.4.3. This paper also explores and draws conclusions about repeat RRT calling that may be potentially preventable by the RRT.

6.2.1 Selection of the Repeat RRT Call

A number of previously described RRS performance indicators were considered for this research as outlined in Section 1.2.4. These included the unexpected cardiac arrest (as used in the majority of RRS studies [2,3,19,24]), interval between the call occurring and the RRT arriving at the patient's bedside (as required by the Australian Commission for Quality and Safety in Health Care [30,33]), duration of the RRT call (analogous to the "scene time" of ambulance service cases [165,166]) or hospital length of stay (as recommended by the Subbe et al. on behalf of the iSSRS [77]). However, none of these sufficiently reflect the use (or not) of NTS, such as communication, at RRT calls.

As outlined in the Introduction (Section 1.4.3), appropriate use of NTS, such as communication and cooperation, between RRT Users and Members, especially to achieve satisfactory resolution of the clinical deterioration or concern that triggered the call, should prevent the need to recall the RRT back to that patient. Therefore, the occurrence of a repeat RRT call plausibly indicated some deficit in use of NTS during the prior call.

This plausibility was corroborated by the Phase 1 RRT User survey findings which showed that the commonest cited reasons for having recalled the RRT were persistence of calling criteria triggers or the staff clinical concern that had prompted the initial call. These results suggest that suboptimal cooperation and decision-making at the end of calls was resulting in inadequate resolution of the call trigger. This is especially relevant during calls for the "worried" criterion [118], in which there may not be an obvious physiological abnormality. For these calls, clinician gestalt must be recognised and acknowledged by the RRT rather than dismissed due to absent breach of a physiological criteria. Here, the role of NTS seems crucial to facilitate respectful leadership, open communication, affiliative cooperation, and shared decision-making between RRT Users and Members.

6.2.2 Evidence Base for the Repeat RRT Call

Patients subject to more than one RRT call during a hospital admission experience higher mortality than those patients only attended once by the RRT. This association between mortality and repeat calling was first identified by Calzavacca et al. in 2010 [133] and confirmed by Stelfox et al. four years later [167].

Calzavacca et al. reported 42.8% mortality in patients subject to repeat RRT calls versus 31.8% in those with a single call [133]. The repeat RRT call patients had similar characteristics but stayed in hospital longer and had more unplanned ICU admissions than single call patients. The authors concluded that confounding largely explained these results: repeat RRT calls (and unplanned ICU admissions) were indicative of sicker patients, rather than being causally linked to mortality. However, these authors did suggest that inadequate patient management or disposition by the RRT could also explain the repeat calls, and therefore by extension, the increased mortality risk.

That study finding was corroborated in 2014 by Stelfox et al. who found mortality of 34% in repeat RRT call patients compared to 23% in single call patients [167]. Again, the repeat RRT call patients had more unplanned ICU admissions (43% versus 13%) and longer mean hospital length of stay (31 vs 13 days). This paper further corroborated no strong predictors of repeat RRT calls that could be detected at the initial call. However, these authors flagged the importance of appropriate management of patients who remain on the ward at the end of their RRT call.

The findings of these two studies that focused on the relationship between repeat RRT calls and mortality risk were supported by secondary outcomes in two other papers. Kansal et al. noted 35.8% vs 18.5% mortality in repeat vs single RRT call patients, respectively [69]. Le Guen et al. reported 30.5% vs 23.8% mortality associated with repeat versus single RRT calls [75].

In each of these studies, the differences in mortality between the repeat and single call patients were statistically significant. Their conclusions were that, although repeat calling was not directly associated with mortality, the recalling of the RRT to the same patient could represent deficits in quality of care and proposed that initiatives be developed to mitigate repeat calling.

6.2.3 Potential Preventability of Repeat RRT Calls

Some repeat RRT calls may represent a subsequent clinical deterioration that has no relationship with the problem that triggered the first call [32,133,167]. The nature of hospitalised patients is that unexpected clinical events can occur at any time during an admission and such events could not have reasonably been foreseeable by the RRT at the time of the first call.

In this scenario, the repeat RRT call is a sign of an effective, functioning RRS that has appropriately recognised and responded to discrete clinical deteriorations.

However, there may be other repeat RRT calls that could have been avoided [32,48,133]. To date, there is no consensus definition of a potentially preventable repeat call. However, two examples, used in this research, are:

1. when the RRT completes a call and departs despite the patient still meeting one or more physiological criteria for RRT calling [32]
2. when the RRT completes a call and departs without addressing the clinical concerns of the staff who made the initial RRT call [35,48]

In these and similar scenarios, protocol mandates that RRT Users re-call the RRT back to that patient. It is possible that the repeat calls in these scenarios may have been prevented through effective use of NTS (e.g. verbalisation of RRT User ongoing clinical concern to RRT Members at the end of a call). Therefore, NTS have a plausible role in mitigation of these potentially preventable RRT calls.

6.2.4 The Potentially Preventable Repeat RRT Call

For the Phase 1 RRS performance indicator study (presented in this Chapter) outcomes were developed that would indicate missed opportunities by the RRS Efferent Limb to prevent a repeat RRT Call.

Calzavacca et al. and Stelfox et al. drew attention to two characteristics of repeat calls [133,167]:

- Temporal – the time interval between RRT calls to the same patient
- Trigger – the physiological or clinical cause for the RRT call

As noted in Stelfox et al. [167], the probability of a relationship between two RRT calls (for the same patient) could be reasonably assumed to be inversely proportional to the intervening time period. That is, the closer in time that the calls occur, the more likely the second resulted from some deficit in resolution of the first call.

As noted in Calzavacca et al. [133], it is reasonable to assume that, if a subsequent call is for the same reason as the prior call, there is a relationship between them. This assumption arises from the understanding that every RRT call indicates an underlying clinical problem. If the Afferent Limb successfully addresses that clinical problem, then there should be no need for further activation of the RRT for that problem. Therefore, if the RRT is recalled to that patient for the same reason as the first call, this suggests some deficit in resolution of the problem.

Based on this prior research [133,167], the two potentially preventable RRT call types developed for this research were defined as:

- Type 1 Potentially Preventable Repeat Call (T1-PRC): a repeat call following an initial call that ended despite ongoing breach of one or more RRT calling criteria (e.g., a patient who still had a systolic blood pressure < 90 mmHg at the completion of a call, who subsequently triggered a second call); and

- Type 2 Potentially Preventable Repeat Call (T2-PRC): a repeat call within 24 hours of an initial call and for the same recorded reason as the initial call.

These outcomes measures were novel to this research and, thus, not previously validated. Clinical plausibility was relied on to justify the potentially preventable labels.

For the Type 1 calls, inspiration was taken from reports of repeat calls due to the RRT leaving despite ongoing Users' concerns, as subsequently identified in the pre- and post-intervention survey papers. It was accepted that some instances of this may have been intentional, for example in a patient who was precluded from ICU admission but still appropriate for ongoing medical management on the ward, or a dying patient who the RRT re-attended to assist with end-of-life care [37,39]. There was a standing procedure at LMH during the study period that forestalled further RRT calls in these patient groups (V. Eaton, RRS Manager, personal communication, January 2020). Instead, these patients

became eligible for ICU or Internal Medicine trainee involvement on request that did not qualify as a RRT call.

For the Type 2 calls, the 24 hour (or less) period selected was extrapolated from afferent limb studies which set 24 hours (or greater) as the interval between clinical deterioration and a subsequent RRT call that indicated missed opportunity for timely escalation [11-13,16,42,66]. It is likely that some repeat calls within a very short time frame may have been needed to address new clinical information not available during the initial call (e.g. a chest radiograph). Conversely, some repeat calls after 24 hours may have occurred due to lapses in management at the initial call. However, with increasing interval between an initial and repeat call occurring, there would be increasing probability of the latter call being triggered by an unrelated clinical event. Thus, the 24-hour period was felt sufficiently short to mitigate likelihood of false positives and sufficiently long to capture drawn out re-deterioration from an incompletely resolved initial problem.

The most reliable method of detecting potentially preventable (vs not) repeat calls would have been detailed review of each instance. This would have yielded reliable data but was infeasible within this research.

6.2.5 Clinical Rationale for Addressing Repeat RRT Calling

When the RRT is recalled to the same patient due to incomplete resolution of the trigger for the previous call, there is the risk of patient harm [32]. This could occur due to increased duration of clinical deterioration consuming patient physiological reserve or precipitating significant clinical sequalae. It would, therefore, seem logical to address the clinical deterioration in a timely fashion in keeping with the original ethos for the RRS [5].

Conversely, when further RRT calls serve no clinical benefit to a certain patient, there may be potential risk to other patients since most hospitals do not roster multiple RRTs [29,31,57]. Therefore, when the RRT is attending a potentially preventable call, it is unavailable to attend a simultaneous call to another clinically deteriorating patient.

Further, most RRTs are not supernumerary [29,57]. That is, RRT members have primary clinical duties in other departments or disciplines. When a call is triggered, those RRT members must leave their current clinical activity to urgently attend the clinically deteriorating patient [56,151].

Therefore, as outlined above, minimising the incidence of potentially preventable repeat RRT calls (in patients who remain on the ward at the end of a RRT call) may have benefits for patients and the organisation [32,48].

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i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

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6.4 ABSTRACT

6.4.1 Background

Previous publications noted increased mortality risk in patients subject to repeat Rapid Response Team (RRT) calls. These patients were examined as a homogenous group, but there may be many reasons for repeat calls. Those potentially preventable by the Rapid Response System have not been investigated.

6.4.2 Methods

In a retrospective cohort study, patients with potentially preventable repeat calls were classified into two categories: Type 1, patients who had a repeat call following an initial call that ended despite the patient still triggering RRT calling criteria (T1-PRC), and Type 2, patients with a repeat call within 24 hours of an initial call and for the same reason (T2-PRC). In-hospital mortality for these patients and for those with repeat calls for all other reasons (ORC), were compared to patients with only a single call during their admission (SC).

6.4.3 Results

Mortality occurred in 31 (43.7%) T1-PRC, 13 (15.1%) T2-PRC, 56 (28.9%) ORC, and 289 (13.9%) SC patients. Univariate odds ratios, in comparison to SC patients, were 4.80 (95% CI 2.96–7.81, $p < 0.001$), 1.10 (0.60–2.02, $p = 0.75$), and 2.52 (1.80–3.52, $p < 0.001$) respectively. Mortality effects persisted for the T1-PRC and ORC groups after adjustment for patient, admission and initial call characteristics with odds ratios of 4.07 (2.36–7.01) $p < 0.001$ and 2.29 (1.57–3.34), $p < 0.001$ respectively.

6.4.4 Conclusions

This study identified that repeat calls following an initial call that ended with ongoing breach of predefined calling criteria were strongly associated with increased mortality. This highlights the risk to patients when the RRT leaves reversible clinical deterioration unresolved at the end of a call.

6.5 INTRODUCTION

The Rapid Response System (RRS) is an established hospital clinical service whose purpose is to recognize and respond to deteriorating patients in a timely manner.[1] The afferent limb of a RRS comprises detection of acute patient deterioration and graded escalation, including criteria-based calling of a Rapid Response Team (RRT).[1,2] The efferent limb typically involves attendance by the RRT to review and manage the deterioration, in liaison with staff activating that response.

In previous investigations, Calzavacca et al and Stelfox et al reported higher mortality in patients experiencing repeated RRT calls during their hospital admission compared with those patients with only a single call.[3,4] However, the reasons for this increased mortality risk and the contribution of other factors, aside from repeat calling, remain uncertain.

Repeat calling may indicate suboptimal performance by the RRS efferent limb.[3,5] This could include the RRT departing despite ongoing breach of calling criteria or ward teams not enacting clinical plans devised at RRT calls. [6,7] Any resultant repeat RRT calls would be potentially preventable by the RRS, and thus could represent deficits in care delivery that may expose patients to harm.

Other factors may also lead to repeat activation of the RRT, irrespective of quality of clinical management by the RRS. These could include subsequent deteriorations unrelated to the clinical issue that triggered the initial call or underlying patient comorbidity.[8–10]

To date, research concerned with repeat RRT calling has focused on patient and call characteristics and their association with in-hospital mortality.[3,4] The influence of RRS performance remains unexplored with regard to whether patient mortality may be modifiable by the RRT and ward team. Therefore, this study was conducted to examine the mortality risk associated with repeat calling that may or may not be preventable by the RRS.

6.6 MATERIALS AND METHODS

6.6.1 Design and Setting

This was a retrospective cohort study of patients attended by a hospital RRT between July 2009 and June 2014. The setting was the Lyell McEwin Hospital, a tertiary metropolitan hospital located in Adelaide, South Australia.

6.6.2 The Rapid Response System

All inpatients had vital signs assessed and documented per hospital observation and monitoring protocols. The RRT was activated for cardiac or respiratory arrests, if any predefined physiological criteria were breached, or for clinical concern (i.e., the “worried” criterion) (Sidebar 1).

Cardiac arrest

Respiratory arrest

Threatened or obstructed airway

Heart rate ≥ 140 bpm or < 40 bpm

Systolic blood pressure ≥ 200 mmHg or < 90 mmHg

Respiratory rate > 30 breaths per min or < 8 breaths per min

Pulse oximetry < 90%

Level of consciousness: only responding to physical or painful stimulus

Prolonged seizures

"Worried" or unresolved clinical concern

Sidebar 1: Rapid Response Team Activation Criteria

Calls occurred in general hospital wards, specialized wards with continuous monitoring (such as the coronary care unit), and non-ward areas (such as the radiology department).

The RRT comprised an intensive care unit (ICU) physician trainee, an ICU nurse, an internal medicine physician trainee, and an intern. An ICU specialist was available, on site or by phone, 24 hours a day to advise decision-making and appropriate disposition at the end of calls.

6.6.3 Subjects

All patients subject to at least one RRT call during the study period were identified from the hospital's RRS database. Those who died during their initial call, were transferred to ICU from their initial call, or were not admitted to the hospital were excluded. This yielded a study cohort of RRT attended patients who had the potential to trigger at least one repeat call.

Eligible patients were classified into four groups:

- Single Call (SC): those having no repeat RRT calls during their admission
- Type 1 Potentially Preventable Repeat Call (T1-PRC): those having a repeat call following an initial call that ended despite ongoing breach of one or more RRT calling criteria (e.g., a patient who still had a systolic blood pressure < 90 mmHg at the completion of a call, who subsequently triggered a second call).
- Type 2 Potentially Preventable Repeat Call (T2-PRC): those having a repeat call within 24 hours of an initial call and for the same recorded reason as the initial call
- Other Repeat Call (ORC): those whose repeat call was neither T1-PRC or T2-PRC (i.e., unlikely to be reasonably foreseeable or preventable by the RRS)

Patients with more than one repeat call during their admission or whose repeat call was both T1-PRC and T2-PRC were excluded from the analyses to ensure that all groups were mutually exclusive.

6.6.4 Outcome Measure

The primary outcome was in-hospital mortality. Its relationship with each category of repeat calling was assessed initially in a univariate model, and then in an adjusted (multivariable) model that included patient demographics, comorbidities,[11] and hospital admission characteristics, as well as initial call characteristics, physiological parameters, and interventions.

6.6.5 Statistical Analysis

Descriptive data are presented as frequencies and percentages for categorical variables and medians with interquartile range (IQR) for quantitative variables. Univariate (with SC as the reference group) or multivariable logistic regression models were fit, and covariate effects reported as odds ratios (OR) with 95% confidence intervals (CI). All variables were included in the initial multivariable model and were retained in the final model if their associated *P* value was less than 0.05. SPSS Statistics for Windows (IBM Corporation, Version 24. Armonk, NY) was used for all analyses.

6.6.6 Ethics

This investigation forms part of a larger project, the Impact of Non-Technical Skills on Performance and Effectiveness of a Medical Emergency Team (ClinicalTrials.gov: NCT01551160) which has been approved by the Central Adelaide Local Health Network Human Research Ethics Committee. The present study was granted waiver from individual patient consent due to use of retrospective de-identified data.

6.7 RESULTS

6.7.1 Descriptive Data

RRT calls were triggered to 3700 patients over the study period, of whom 446 were not admitted to the hospital (outpatients, visitors, or staff members) and 36 were paediatric.

Of the 3218 adult inpatients subject to RRT calls, 109 died at their initial call and 536 were transferred to ICU from an initial call. There were 492 patients who went on to have repeat calls, of whom 122 (24.8%) were excluded due to having more than one repeat call and 23 were excluded due to having a repeat call that could be classified into both the T1-PRC and T2-PRC groups.

The remaining 2432 patients became the study cohort, composed of 2081 (85.6%) SC patients, 71 (2.9%) T1-PRC patients, 86 (3.5%) T2-PRC patients, and 194 (8.0%) ORC patients, who were included in subsequent analyses. The flow of patients is represented in Figure 1.

6.7.2 Univariate Mortality Analyses

6.7.2.1 Repeat Calling

In-hospital mortality occurred in 31 (43.7%) T1-PRC, 13 (15.1%) T2-PRC, and 56 (28.9%) ORC patients. When compared to SC patients, of whom 13.9% died, the mortality odds ratios were 4.80 (95% CI: 2.96–7.81, $p < 0.001$), 1.10 (95% CI: 0.60–2.02, $p = 0.75$), and 2.52 (95% CI: 1.80–3.52, $p < 0.001$), respectively, for T1-PRC, T2-PRC, and ORC patients (Table 1).

Table 1 Univariate Regressions for Mortality Associated with Repeat Call Type Patient Groups (Compared to the SC Group)

Patient Group	Number of Patients	Mortality	Odds Ratio (95% CI)	*P* value
SC	2081	289 (13.9%)	Reference	
T1-PRC	71	31 (43.7%)	4.81 (2.96–7.81)	<0.001
T2-PRC	86	13 (15.1%)	1.10 (0.60–2.02)	0.75
ORC	194	56 (28.9%)	2.52 (1.80–3.52)	<0.001

SC, single call; T1-PRC, type 1 potentially preventable repeat call; T2-PRC, type 2 potentially preventable repeat call; ORC, other repeat call; CI, confidence interval.

6.7.2.2 Patient Demographics

Patients not surviving were more likely to be male and older. Compared to elective surgical cases, patients admitted for non-elective surgery or under the cardiology, medical specialities, or internal medicine team had higher hospital mortality. There was no statistically significant association between Charlson Comorbidity Index and mortality (OR 0.99 [95%CI: 0.94–1.05], *P* = 0.82).

6.7.2.3 Initial Call Characteristics

In-hospital mortality occurred more often when the recorded reason for the initial call was low conscious state, tachycardia, hypotension, hypoxia, tachypnoea, or cardiac arrest (where the patient survived the call itself), in comparison to patients whose initial call was for "worried". Mortality was also associated with calls occurring on monitored or general hospital wards (compared to non-clinical areas), outside standard consulting hours (8:00 am to 6:00 pm Monday to Friday), longer interval between admission and call, and longer call duration.

The need for an airway intervention, such as insertion of a nasopharyngeal tube, was associated with higher in-hospital mortality, even when not delivered as part of cardiopulmonary resuscitation (OR 2.40 [95%CI: 1.23–4.66] *P* = 0.02). However, administration of oxygen, an intravenous fluid bolus, or non-invasive ventilation had no significant relationship with vital status at hospital discharge (see Table 2).

Table 2 Univariate Initial Call Characteristics Associated with Hospital Mortality

	Non-Survivors	Survivors	Odds Ratio (95% CI)	*P* value
Location:				
Non-ward area	4 (3.1%)	125 (96.9%)	reference	
Monitored ward	55 (13.2%)	363 (86.8%)	4.74 (1.68–13.33)	0.003
General ward	325 (17.5%)	1537 (82.5%)	6.61 (2.42–18.01)	<0.001
Reason for call:				
Worried	36 (8.2%)	401 (91.8%)	reference	
Systolic blood pressure ≥200	1 (7.7%)	12 (92.3%)	0.93 (0.12–7.34)	0.94
Prolonged seizure	9 (8.6%)	96 (91.4%)	1.04 (0.49–2.24)	0.91
Heart rate <40	5 (9.4%)	48 (90.6%)	1.16 (0.44–3.10)	0.77
Airway compromise	4 (10.5%)	34 (89.5%)	1.31 (0.44–3.90)	0.63
Low conscious state	83 (13.2%)	547 (86.8%)	1.69 (1.12–2.55)	0.01
Heart rate ≥140	22 (14.2%)	133 (85.8%)	1.84 (1.05–3.24)	0.03
Systolic blood pressure <90 mmHg	65 (15.2%)	364 (84.8%)	1.99 (1.29–3.06)	0.002
Respiratory rate <8	4 (20.0%)	16 (80.0%)	2.79 (0.88–8.77)	0.08
Respiratory rate >30	53 (25.2%)	157 (74.8%)	3.76 (2.37–5.97)	0.001
Cardiac arrest	10 (27.0%)	27 (73.0%)	4.13 (1.85–9.20)	<0.001
Pulse oximetry <90%	97 (31.8%)	208 (68.2%)	5.20 (3.42–7.89)	<0.001
Call outside standard hours	193 (18.6%)	844 (81.4%)	1.40 (1.13–1.74)	0.003
Airway intervention	13 (31.0%)	29 (69.0%)	2.40 (1.23–4.66)	0.02
Non-invasive ventilation	11 (22.9%)	37 (77.1%)	1.58 (0.80–3.12)	0.23
Oxygen therapy	256 (16.5%)	1300 (83.5%)	1.10 (0.88–1.38)	0.42
Intravenous fluid bolus	91 (14.1%)	553 (85.9%)	0.82 (0.64–1.06)	0.15
Arrival calling criteria breach				
Heart rate	36 (18.7%)	157 (81.3%)	1.23 (0.84–1.79)	0.31
Respiratory rate	71 (25.2%)	211 (74.8%)	1.94 (1.45–2.60)	<0.001
Systolic blood pressure	75 (18.8%)	325 (81.3%)	1.26 (0.96–1.67)	0.10
Pulse oximetry	94 (33.1%)	190 (66.9%)	3.11 (2.36–4.10)	<0.001
Number of call arrival criteria breaches				
0	466 (20.7%)	1786 (79.3%)	reference	
1	315 (23.8%)	1009 (76.2%)	1.20 (1.02–1.41)	0.03
2	129 (37.2%)	218 (62.8%)	2.27 (1.78–2.88)	<0.001
3 or more	32 (43.8%)	41 (56.2%)	2.99 (1.86–4.80)	<0.001
End calling criteria breach				
Heart rate	13 (18.1%)	59 (81.9%)	1.16 (0.63–2.14)	0.62
Respiratory rate	41 (27.9%)	106 (72.1%)	2.15 (1.48–3.14)	<0.001
Systolic blood pressure	37 (29.8%)	87 (70.2%)	2.36 (1.58–3.53)	<0.001
Pulse oximetry	33 (44.0%)	42 (56.0%)	4.42 (2.76–7.06)	<0.001
Number of end of call criteria breaches				
0	283 (72.8%)	1772 (86.7%)	reference	
1	88 (22.6%)	251 (12.3%)	2.20 (1.67–2.89)	<0.001
2 or more	18 (4.6%)	20 (0.8%)	6.63 (3.38–13.02)	<0.001
Interval to initial call in days*	3.0 (1.3– 7.9)	1.9 (1.0– 4.4)	1.02 (1.01–1.03)	0.002
Call duration in minutes*	30 (19– 40)	25 (16– 35)	1.01 (1.00–1.02)	0.002

*Numerical data shown as median (interquartile range).

6.7.2.4 Initial Call Physiological Parameters

Patients who later died in hospital had higher pulse and respiratory rates and lower oxygen saturation, systolic blood pressure, and consciousness level, both at RRT arrival and at the end of RRT calls. Mortality was also associated with ongoing breach of one and two or more of any of the standard calling criteria at the end of a call (OR 2.20 [95%CI: 1.67–2.89], $P < 0.001$ and 6.63 [95% CI: 3.38–13.02], $P<0.001$, respectively).

6.7.3 Multivariable Regression Analysis

When adjusted for all covariates as detailed above, the mortality odds ratios were slightly attenuated for T1-PRC patients and ORC patients (4.07 [95% CI: 2.36–7.01], $P < 0.001$ and 2.29 [95% CI: 1.57–3.34], $P < 0.001$, respectively), and slightly increased for T2-PRC patients (1.29 [95% CI: 0.67–2.50], $P = 0.45$).

Other variables retained in the final model included age; male gender; admission under a cardiology, medical specialities, or internal medicine team (compared to admission for elective surgery); and initial call characteristics, including number of days since admission; recorded call reason being tachypnoea, hypotension, hypoxia or cardiac arrest; oxygen saturation <90% on team arrival; and requirement for an airway intervention (Table 3).

Table 3 Variables Retained in the Final Multivariable Logistic Regression Model for In-Hospital Mortality

Variables	Variable Reference Category	Odds Ratio (95% CI)	*P* value
Repeat call patient types:	Single call patients		
T1-PRC patients		4.07 (2.36–7.01)	<0.001
T2-PRC patients		1.29 (0.67–2.50)	0.45
ORC patients		2.29 (1.57–3.34)	<0.001
Age	n/a	1.04 (1.03–1.05)	<0.001
Male gender	Female gender	1.29 (1.01–1.65)	0.05
Attending team:	Elective surgery patients		
Psychiatry		1.49 (0.33–6.65)	0.60
Emergency surgery		2.60 (0.97–7.02)	0.06
Cardiology		4.63 (1.61–13.34)	0.004
Medical specialities		7.94 (2.90–21.72)	<0.001
Internal medicine		7.14 (2.83–17.97)	<0.001
Initial call location:	Low acuity or non-clinical area		
Monitoring ward		2.43 (0.81–7.31)	0.11
General ward		3.40 (1.21–9.55)	0.02
Initial call reason:	"Worried" criterion		
Systolic blood pressure ≥200		0.85 (0.10–7.17)	0.88
Prolonged seizure		1.19 (0.52–2.72)	0.69
Heart rate <40		0.93 (0.32–2.69)	0.89
Airway compromise		0.96 (0.26–3.59)	0.95
Low conscious state		1.29 (0.82–2.04)	0.27
Heart rate ≥140		1.67 (0.90–3.10)	0.10
Systolic blood pressure <90		1.78 (1.10–2.88)	0.02
Respiratory rate <8		2.60 (0.72–9.38)	0.15
Respiratory rate >30		2.43 (1.45–4.07)	0.001
Cardiac arrest		4.97 (2.00–12.38)	0.001
Pulse oximetry <90%		2.59 (1.60–4.21)	<0.001
Number of days between admission and initial call	n/a	1.02 (1.01–1.04)	0.001
Pulse oximetry <90% on team arrival to initial call	Pulse oximetry ≥90% on team arrival	1.86 (1.32–2.61)	<0.001
Airway intervention performed at initial call	Airway intervention not performed at initial call	3.57 (1.65–7.73)	0.001

T1-PRC, type 1 potentially preventable repeat call; T2-PRC, type 2 potentially preventable repeat call; ORC, other repeat call (i.e., repeat call that was not T1-PRC or T2-PRC); CI, confidence interval.

6.8 DISCUSSION

6.8.1 Key Findings

This study explored different reasons for repeat calls and shows that these should not be viewed as a homogenous entity. Mortality was associated with type 1 potentially preventable and other type repeat calls, but not type 2 potentially preventable calls, even when adjusted for a wide range of patient and other factors.

6.8.2 Potentially Preventable Repeat Calls

6.8.2.1 Type 1

Increased in-hospital mortality was observed when repeat calls followed an initial call that ended despite ongoing breach of one or more RRT calling criteria. It is possible that some of these calls reflected chronic tolerated abnormalities, such as mild hypoxaemia in airways disease.[12] However, the fact that the effect on mortality persisted in a multivariable model, indicates an association between this type of potentially preventable repeat call and mortality that cannot be explained by physiological or other risk factors.

In keeping with the original ethos for the RRS, this finding reinforces the established risks from leaving acute physiological deterioration untreated.[13–16] Abnormal physiology that is refractory to corrective efforts at the RRT call should prompt reassessment of the patient and evaluation of management options.[17,18] Some instances of repeat calling in this study may have arisen due to inexperience of clinicians attending calls. It is notable that mortality was associated with calls occurring outside office hours, when junior staff are typically rostered. While consultants were always available for advice, hospital protocols did not mandate their involvement for all calls. Unfortunately, data was not available to ascertain how often they were called.

Another potential explanation for these repeat calls could be patients with recognized irreversible deterioration, such as the terminal phase of a terminal illness. This may have been acknowledged at their initial call, resulting in physiological abnormalities being reasonably left unresolved. In this scenario, it may be worth reconsidering further RRT involvement at the initial call, as subsequent repeat calls do not seem to benefit patients in such circumstances.[10] Furthermore, these additional repeat calls impose an organizational resource burden that may affect RRS responsiveness and distract RRT staff from other duties.[19]

6.8.2.2 Type 2

The other postulated surrogate marker of RRS efferent limb performance was not significantly related to in-hospital mortality in univariate or adjusted analyses. It is possible that these repeat calls arose from underappreciation by the RRS of the pathology that manifested as the initial call trigger. Incomplete resolution of this disease process, either at the call or subsequently by ward teams, could result in recurrence of that call trigger.

Given that repeat calling has been previously associated with mortality, it is of interest that this group had no increased risk. This suggests that the additional patient reviews by experienced RRT staff at the repeat calls likely conferred an improvement in care delivery. They may also have mitigated any potential harm from recurrence or persistence of the clinical issue that triggered an initial call. However, this is an inefficient substitute for careful scrutiny for underlying conditions by the RRS and devising of thorough care plans in liaison with ward teams at the time of the initial RRT call.

6.8.3 Other Repeat Calls

This group aggregated the repeat calls that the RRS could not be reasonably expected to prevent. As such, it represents a diverse range of patients who experienced repeated clinical deterioration during their admission. Not surprisingly, this group had higher mortality than single call patients congruent with the findings of previous studies on repeat calling.[3,4]

6.8.4 Strengths and Limitations

This study represents a comprehensive examination of a large cohort of patients, with findings in keeping with previous studies, reinforcing an association between in-hospital mortality and repeat calling. Patient and call characteristics associated with mortality have been examined and reported previously.[3,4] However, to date the involvement of the RRS in repeat calling and the potential for resultant mortality has only been raised as a concept. This study is the first to develop repeat call indicators for RRS performance and assess their association with mortality.

The study cohort was constrained to exclude patients who had no possibility of triggering repeat calls, and any effects on mortality from care delivered in the ICU. This permitted robust analyses to provide insights into the effects of RRS performance on mortality.

Patients who had more than one repeat call were also excluded, and it is possible that doing so reduced the study power. However, this exclusion was necessary as most of these patients had repeat calls that were of different types. To maintain mutually exclusive groups and ensure robust mortality risk assessment would have required creating six additional study groups with different combinations of repeat call types. This would make interpretation of results more difficult, especially for RRS managers looking to apply them to clinical practice.

The nature of the analyses only permit association to be inferred; the establishment of true cause and effect would require a prospective investigation. In-hospital mortality can be affected by many variables, and while useful inferences can be drawn from this database, the possibility that some unavailable or unmeasured factors have also influenced outcomes cannot be discounted. For example, due to the regression analysis methodology, it was not possible to include repeat call characteristics in the multivariable models (the single call patients would lack data for these variables, leading to their automatic censoring by the statistical package). So, any effect on mortality from repeat call afferent limb factors (including delayed detection of deterioration) in the repeat call groups cannot be reasonably determined within the scope of this study.

Unfortunately, data on treatment limitation or not-for-resuscitation orders were not available in the database, nor was data captured regarding patients who were managed under an end-of-life care plan either at or after RRT calls. However, protocols at the investigating hospital preclude further RRT calling in patients under an end-of-life plan. Therefore, it is reasonable to presume that patients receiving repeat calls were assessed as having a reversible deterioration at their initial call.

Finally, although data was not available on ICU capacity at the time of calls, hospital protocol mandated that patients accepted for admission would be taken there regardless of bed availability. In such instances, the RRT would continue care of the patient in the ICU while staffing resources were sought. Therefore, it can be reasonably assumed that no T1-PRC patients occurred due to ICU logistical limitations.

6.8.5 Potential Lessons

Repeat RRT calling appears commonplace and associated with in-hospital mortality. The findings of this study suggest that such mortality is, at least in part, a reflection of RRS efferent limb performance. From a clinical effectiveness perspective, reversible clinical deterioration should not be left unresolved as these patients had the highest mortality risk of all groups subject to repeat calls.

Since these are vulnerable patients, routine involvement of a critical care specialist would seem to be indicated to guide decision-making and ensure appropriate oversight.[20] Furthermore, a safe, albeit

resource-demanding, practice would be to err toward admitting such patients to an area of higher acuity, such as an ICU.

There may be circumstances in which it is appropriate to leave patients on wards despite incomplete resolution of clinical deterioration. However, this decision should not be made lightly as it requires development of a comprehensive management plan in liaison with senior members of ward teams to ensure continuity of care after departure of the RRT. It is reasonable to consider this consensus management plan as an extension of the RRS efferent limb. The onus is on both the RRT and the ward staff to ensure effective handover of required clinical tasks and goals. This should include a review of the frequency of physiological monitoring to prevent delays to detection of any subsequent deterioration.[17,18]

If the resource exists, ongoing care and subsequent follow-up can be supported by outreach or liaison services based out of an ICU.[21] These provide an important role in bringing experience and expertise to wards to potentially avoid the need for up-transfer while maintaining high levels of patient care and safety.

From an organizational efficiency perspective, the potentially preventable repeat calls represent an avoidable operational and logistic burden, especially as most RRS are not directly funded and have non-supernumerary staffing.[22] Clinical incidents due to RRT members being diverted from their routine duties to attend calls have not been demonstrated. [19] However, such interruptions and distractions to workflow are undesirable and may still present a potential risk to other patients.

Finally, repeat calls may be a symptom of staff frustration especially where there may be a perception that the concerns of those activating a RRT have not been acknowledged or addressed.[6,7] Thus, to some extent, addressing RRT-related factors such as nontechnical skills to improve communication and cooperation may reduce the occurrence of avoidable repeat calls.[23,24]

6.9 CONCLUSIONS

This study has shown that repeat calls following an initial call that ends with the patient still triggering physiological calling criteria are associated with in-hospital mortality. This presents an opportunity for the RRT to make efforts to reduce repeat calling by ensuring that reversible clinical deterioration is resolved at the end of calls. Doing so would be of benefit to patients by recognizing the associated mortality risk, and to the organization through improved RRS responsiveness.

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Chapter 7: Phase 2 Performance Indicator Results (Paper 5) – Effect of a multi-faceted Rapid Response System re-design on repeat calling of the Rapid Response Team

7.1 CITATIONS

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35324935

7.2 PREAMBLE AND RESEARCH QUESTION

This is the second and final post-intervention paper in this thesis. It addresses the research question:

> "What effect will an RRS re-design have on repeat RRT calling?"

The article describes the effect of the RRS re-design intervention on objective RRS performance. The outcome of interest is repeat RRT calling. As noted in Paper 3, repeat RRT calls are associated with patient mortality risk. Further, they pose an organisational resourcing burden.

Therefore, this paper served to interest RRS managers in presenting potential benefits to RRT availability. That is, while the RRT is attending a call, it is unavailable to attend other patients. If concurrent calls occur, and the hospital has only one RRT, then the operational capacity of the RRS is exceeded. This is problematic for several reasons including the resource burden of needing to roster a second team, the delay to response if creating a 'scratch' RRT or the potential impairment in response if dividing the lone RRT.

If potentially preventable RRS activity, for example repeat RRT calls, can be reduced, this may obviate the above dilemma.

7.2.1 Isolation of the Effect of the Intervention

As outlined in Section 3.2.1 and detailed in the Preamble to the post-intervention surveys paper (Section 5.2.3), the RRS was not changed throughout the entire study period (July 2009 to June 2019) aside from subtle governance updates that would not have been noticeable to RRT Users and Members.

Thus, the findings of this study can be attributed to the intervention even in the absence of direct measurement of use of NTS during RRT calls.

7.3 STATEMENT OF AUTHORSHIP

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i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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7.4 ABSTRACT

7.4.1 Background

Repeat Rapid Response Team (RRT) calls are associated with increased in-hospital mortality risk and pose an organisation-level resource burden. Use of Non-Technical Skills (NTS) at calls has the potential to reduce potentially preventable repeat calling. NTS are usually improved through training, although this consumes time and financial resources. Re-designing the Rapid Response System (RRS) to promote use of NTS may provide a feasible alternative.

7.4.2 Methods

A pre-post observational study was undertaken to assess the effect of an RRS re-design that aimed to promote use of NTS during RRT calls. The primary outcome was the proportion of admissions each month subject to repeat RRT calling, and the average number of repeat calls per admission each month was the secondary outcome of interest. Univariate and multivariable interrupted time series analyses compared outcomes between the two study phases.

7.4.3 Results

The proportion of admissions with repeat calls each month increased across both phases of the study period, but the increase was lower in the post re-design phase (change in regression slope -0.12 (standard error 0.07) post versus pre re-design). The multivariable model predicted a 6% reduction (95% confidence interval -15.1 – 3.1; P=0.19) in the proportion of admissions having repeat calls at the end of the post redesign phase study compared to the predicted proportion in the absence of the re-design.

The average number of calls per admission was also predicted to decrease in the post re-design phase, with an estimated difference of -0.07 calls per admission (equivalent to one fewer repeat call per 14 patients who had RRT calls) at the end of the post re-design phase (95% confidence interval -0.23 – 0.08, P=0.35).

7.4.4 Conclusion

This study of an RRS re-design showed modest, but not statistically significant, reductions in the proportion of admissions with repeat calls and the mean number of repeat calls per admission. Given the economic and workforce capacity issues that all health care systems now face, even small improvements in the RRS may have lasting impact across the organisation. For the potential interest of RRS managers, this paper presents a pragmatic, low-cost initiative intended to enhance communication and cooperation at RRT calls.

7.5 INTRODUCTION

Over the past quarter century, the Rapid Response Team (RRT) has evolved from a conceptual advancement of the response to in-hospital cardiac arrest to become a ubiquitous patient safety mechanism [1,2]. Throughout this time, studies, and reviews of Rapid Response System (RRS) activity have consistently demonstrated increasing rates of RRT calling, as RRS mature and the hospitals they are based within become busier [2-5].

In some respects, this suggests desirable awareness and utilisation of a patient safety mechanism. Indeed, the increase in RRS usage within an organisation has been associated with improved patient survival statistics [3,6,7]. However, increasing RRS activity poses a logistical and resourcing burden for hospitals, as most RRTs tend to not be supernumerary, with staff rostered from other substantive roles [4,8,9]. Although adverse effects have not yet been attributed to team members leaving other duties to attend RRT calls [10], the potential exists for these to occur. This risk could be magnified during concurrent RRT calls as resources are typically not available to provide a full response to more than one call simultaneously [9].

Against this background of increasing activity, the RRS should seek efficiencies to facilitate RRT capacity to promptly attend all unexpected clinical deteriorations. One avenue could be through reduction of potentially preventable repeat calling, that is the RRT attending a patient more than once due to inadequate resolution of an initial call, especially when the repeat call closely follows the first. In a previous study, we found increased mortality risk in patients re-attended by the RRT within 24 hours of a previous completed call in which clinical issues remained unresolved [11].

Deficits in non-technical skills (NTS), such as communication and cooperation, at RRT calls have been identified as a risk factor for potentially preventable repeat calling [11-13]. Effective employment of NTS are crucial due to the inherent time and clinical pressures imposed by the deteriorating patient [14,15]. Ideally, NTS would be augmented by delivery of specialised, simulated scenario training for RRTs [14, 16]. However, such training requires taking staff away from clinical duties, which is often not feasible in resource-limited hospitals.

Therefore, a comprehensive, multi-faceted RRS re-design aimed to enhance use of NTS at RRT calls, without the need for dedicated training or additional funding, was implemented. The re-design drew on themes from the TeamSTEPPS® program [17,18], and previous research which described RRS improvement initiatives [14,19-21]. The present study uses Interrupted Time Series analysis to investigate the effects of the re-design of an existing RRS.

7.6 METHODS

This was a pre-post intervention study assessing the proportion of patients who had repeat RRT calls before and after implementation of a RRS re-design. Data were collected over a five-year period prior to the re-design and another five years after its implementation. The present study was part of the Impact of Non-Technical Skills on Performance and Effectiveness of a Medical Emergency Team (IMPACT) research program (ClinicalTrials.gov: NCT01551160), components of which have already been reported [11-13].

7.6.1 Participants

Patients attended by the RRT at a tertiary, outer metropolitan hospital between 1st July 2009 and 30th June 2019 were identified from RRS records. Those who were not admitted to the hospital (e.g. day procedures, outpatients, or visitors) and patients under 18 years of age were ineligible for inclusion.

The cohort of in-patient admissions who were attended by the RRT were divided into two groups: those attended by the RRT more than once during an admission (the 'Repeat Call' group) and those with only one RRT call.

Clinical staff were classified into two groups: those rostered to attend calls as part of the RRT ('members'), and those who recognise clinical deterioration and call the RRT ('users').

7.6.2 Intervention

The RRS re-design incorporated three components, described in detail previously [13]. These components targeted the key NTS domains of leadership, communication, and co-operation both within the RRT and between RRT members and users.

1. Regular RRT meetings

Short meetings for RRT members, designed to address Leadership and Cooperation within the team, were scheduled to occur at the beginning of each shift. The primary purpose of these meetings was to pre-emptively establish each team member's role and initial task at RRT calls. This approach was designed to avoid spending valuable time doing this at a deteriorating patient's bedside.

2. Team Role Badges

Each member of the RRT was required to wear a badge indicating their role while attending calls. This was designed to reinforce the team Leadership role as well as facilitate non-verbal Communication of all role designations to RRT members and users present at calls.

3. RRT members-to-users "hand-off" procedure

A structured verbal and written process, aiming to improve Communication and Cooperation between RRT members and users, was introduced for RRT calls ending with the patient remaining on their ward. This formalised the transfer of primary clinical responsibility from the RRT back to the ward team. In particular, the hand-off process encouraged RRT users to voice any ongoing clinical concerns and have them addressed before the RRT departed.

7.6.3 Study Phases

There were two phases of data collection, punctuated by the implementation of the RRS re-design as detailed above. Phase 1 comprised five years (July 2009 – June 2014) and Phase 2 a further five-year period (July 2014 – June 2019). The data presented in this paper were collected retrospectively, extracted at the end of the study from the hospital's RRS and in-patient electronic databases.

Aside from the re-design described above, the configuration and operations of the RRS did not change over the entire study period (i.e. Phase 1 and 2). In particular, the RRT activation criteria, composition of the RRT and provision of Critical Care services at the investigating hospital remained the same throughout.

7.6.4 Outcome Measures

RRT call data, obtained from the hospital RRS database, were aggregated at the per-patient-admission level. Variables were then created to indicate if each admission contained repeat calls, or not, and the count of those repeat calls.

The admission-level data were then collapsed by study month, derived from the date of hospital entry, with month 1 representing July 2009, through to month 120 in June 2019. A variable was created to indicate study phase (Phase 1: months 1 – 60, Phase 2: months 61 – 120).

The primary outcome in this study was the proportion of admissions with repeat RRT calls from all admissions with at least one RRT call (per month). This was chosen as an indicator of potentially preventable RRS activity that could be measured throughout both study phases.

The secondary outcome was the mean number of RRT calls per admission (from all admissions with at least one RRT call) to investigate aggregate RRT call load on the hospital.

7.6.5 Other Variables

Demographic data, captured at time of admission, included age, gender, Indigenous identification and socioeconomic status (expressed as a binary variable for Socio-Economic Indexes for Australia (SEIFA) decile of three or less versus greater than three, derived from the 2016 Postal Area Index of Relative Socio-economic Advantage and Disadvantage) [22]. Hospital admission data included elective vs non-elective admission, Charlson Co-Morbidity Index (CCI) and in-patient length of stay (LOS). Counts of hospital admissions during each month of the study were derived from the hospital activity database.

These variables were similarly aggregated by month to account for variations in hospital activity and casemix over the study period. For each study month, the number of admissions, and the percentage of admissions corresponding to male gender, Indigenous identification, SEIFA ≤ 3, and non-elective admissions were derived. The mean age, CCI, and hospital LOS were also calculated for each study month.

7.6.6 Data Analysis

Monthly hospital activity and aggregated patient demographics were compared between study phases using Mann-Whitney U-tests.

The effect of the re-design was assessed by Interrupted Time Series (ITS) methodology as described by Bernal et al [23]. In general terms, ITS analyses use segmented regression to compare the observed effect of an intervention, introduced at a defined time point, on an outcome to the effect predicted in the absence of the intervention [24,25]. ITS quantified the impact of the RRS re-design on the outcomes of interest through the change in coefficients of the fitted regression line at the point of introducing the re-design.

Non-seasonal Auto Regressive Integrated Moving Average (ARIMA) models with a first-order auto-correlation were fit for each outcome variable [26]. Study month was used as the time metric in all models. Initially, simple models were fit that considered only time (study month), phase and the interaction of time and phase (i.e. a different intercept and slope corresponding to the post-intervention phase compared to the pre-intervention phase were allowed for in the regression model – see Figure 2 in Bernal et al [23]). Subsequently, multivariable models that included hospital admission rates, patient demographics and admission characteristics were fit to adjust for any variations between months in hospital activity and casemix over the study phases. The final multivariable model retained variables with a corresponding P-value < 0.1. Sensitivity analyses were also undertaken to examine the impact of potential outliers [27].

Predicted changes in the percentage of repeat call admissions and mean number of calls per admission were derived for each year using the approach outlined in Wagner et al [28]. In this way, the cumulative annual changes in the outcome measures that were attributable to the RRS design were estimated.

Model fit was assessed by the stationary R2 value, where values closer to 1 are indicative of better fit, and the Ljung-Box Q statistic, which indicates if there is a marked lack of fit of the corresponding ARIMA model. [29] Durbin's alternative statistic was used to assess the extent of auto-correlation in the statistical models [30].

Statistical analyses were conducted with SPSS (IBM Corp. Released 2019. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp), with the exception of Durbin's alternative statistic, which was calculated using Stata (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC).

7.6.7 Ethics

This study was approved by the Central Adelaide Health Network Human Research Committee (approval number: 2012069).

The need for patient signed consent was waived on the grounds that data used in this study were already collected electronically for hospital quality assurance purposes, no unique patient identifiers were included in the study database, and all individual patient level variables were aggregated by study month prior to analysis and reporting.

7.7 RESULTS

The RRS database provided records for 9754 patients who were attended by the RRT during the study period. From these, 93 paediatric patients and 122 visitors, staff or outpatients were excluded as being ineligible. A further 12 in-patients for whom the database had incomplete records were also excluded. Of the remaining 9527 patient admissions, 3073 occurred in Phase 1 and 6454 in Phase 2. The hospital in-patient database recorded 188016 admissions during Phase 1 and 240910 in Phase 2.

In Phase 2, by comparison to Phase 1, there were more mean hospital admissions per month (4015 [SD 419.7] vs 3134 [SD 222.0], P<0.01) and a greater percentage of those hospital admissions were attended by the RRT (2.6% [standard deviation (SD) 0.5] versus 1.6% [SD 0.4], P<0.01).

Compared to Phase 1, in Phase 2 there were shorter mean in-patient LOS (10.9 days [SD 1.6] vs 12.9 [SD 3.0], P<0.01), lower mean patient age (67.4 [SD 2.0] vs 68.6 [SD 2.8], P<0.01), lower percentage of patients with low socioeconomic status (68.2% [SD 7.0%] vs 79.7% [SD 6.4%], P<0.01) and lower mean CCI (4.5 [SD 0.3] vs 4.8 [SD 0.46], P<0.01). Hospital activity and patient demographic data are summarised by year of the study in Table 1.

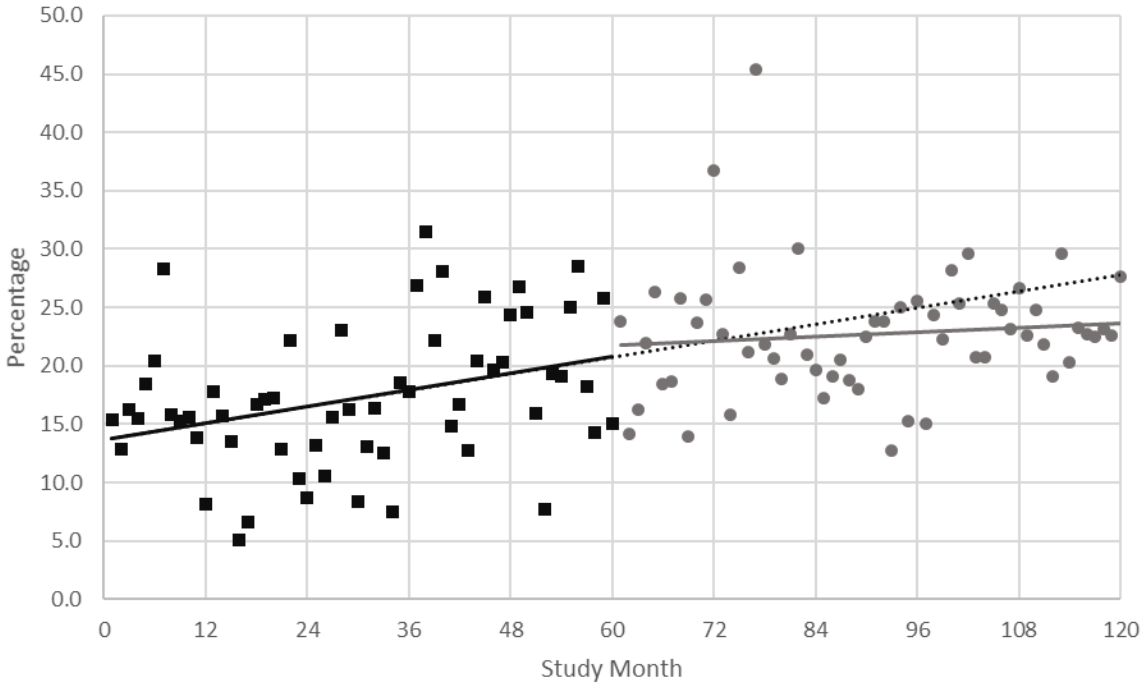
Study Year	Count of All Admissions	Count of RRT Call Admissions	LOS Mean (SD)	Age Mean (SD)	Male Mean % (SD)	Indigenous Mean % (SD)	Low SEIFA Mean % (SD)	CCI Mean (SD)	Non-Elective Mean % (SD)
1	34238	507	14.4 (4.2)	67.8 (3.3)	48.7 (6.2)	0.9 (1.3)	81.7 (6.7)	4.7 (0.4)	90.8 (3.1)
2	36087	506	14.0 (3.0)	69.1 (2.8)	52.3 (9.4)	1.8 (2.0)	79.0 (6.7)	4.9 (0.5)	94.4 (2.7)
3	37785	578	11.7 (2.1)	68.9 (2.6)	51.4 (7.4)	3.0 (1.8)	82.3 (4.5)	4.8 (0.5)	93.4 (3.0)
4	39441	666	12.1 (2.2)	68.0 (3.1)	50.8 (8.7)	2.6 (1.7)	78.4 (8.2)	4.6 (0.5)	94.9 (3.2)
5	40465	816	12.6 (2.5)	69.3 (2.4)	47.9 (5.2)	1.7 (1.4)	77.0 (5.0)	4.9 (0.4)	92.9 (2.9)
Phase 1 overall	188016	3073	12.9 (3.0)	68.6 (2.8)	50.2 (7.5)	2.0 (1.8)	79.7 (6.4)	4.8 (0.5)	93.3 (3.2)
6	41098	887	11.0 (0.6)	67.2 (2.5)	52.1 (6.6)	2.4 (2.1)	74.5 (5.5)	4.7 (0.4)	92.4 (2.7)
7	45307	1174	9.9 (1.5)	65.8 (2.1)	45.7 (5.0)	1.9 (1.2)	72.4 (6.4)	4.3 (0.3)	92.0 (2.8)
8	49009	1223	11.6 (2.0)	67.8 (1.6)	49.5 (5.2)	2.0 (1.6)	65.5 (5.6)	4.4 (0.2)	94.6 (2.6)
9	52123	1541	11.5 (1.8)	68.2 (1.6)	49.7 (4.8)	3.1 (1.7)	66.6 (4.9)	4.6 (0.2)	93.2 (3.3)
10	53373	1629	10.7 (1.3)	67.9 (1.5)	49.3 (5.3)	3.6 (1.8)	61.8 (4.5)	4.6 (0.3)	93.4 (1.9)
Phase 2 overall	240910	6454	10.9 (1.6)	67.4 (2.0)	49.3 (5.6)	2.6 (1.7)	68.2 (7.0)	4.5 (0.3)	93.1 (2.7)

Table 1: Hospital activity and demographic data (for patients having RRT calls) by study year. RRT = Rapid Response Team, SD = standard deviation, LOS = length of stay, SEIFA = socio-economic indexes for Australia, CCI = Charlson co-morbidity index.

7.7.1 Primary Outcome

The ARIMA univariate model estimated the slope as 0.115 (standard error (SE) 0.047) in Phase 1, and 0.029 (SE 0.047) in Phase 2, indicating an observed change in slope between phases of -0.087 (SE 0.067), as shown in Fig 1.

Fig 1. Percentage of repeat call admissions per month representing the ARIMA univariate model. Phase 1 monthly observed data in black squares, with slope illustrated by the solid black line. Phase 2 monthly observed data in grey circles, with slope illustrated by the solid grey line. The slope in Phase 1 is extended into Phase 2 and represented by the dotted black line for comparison with Phase 2 observed data.

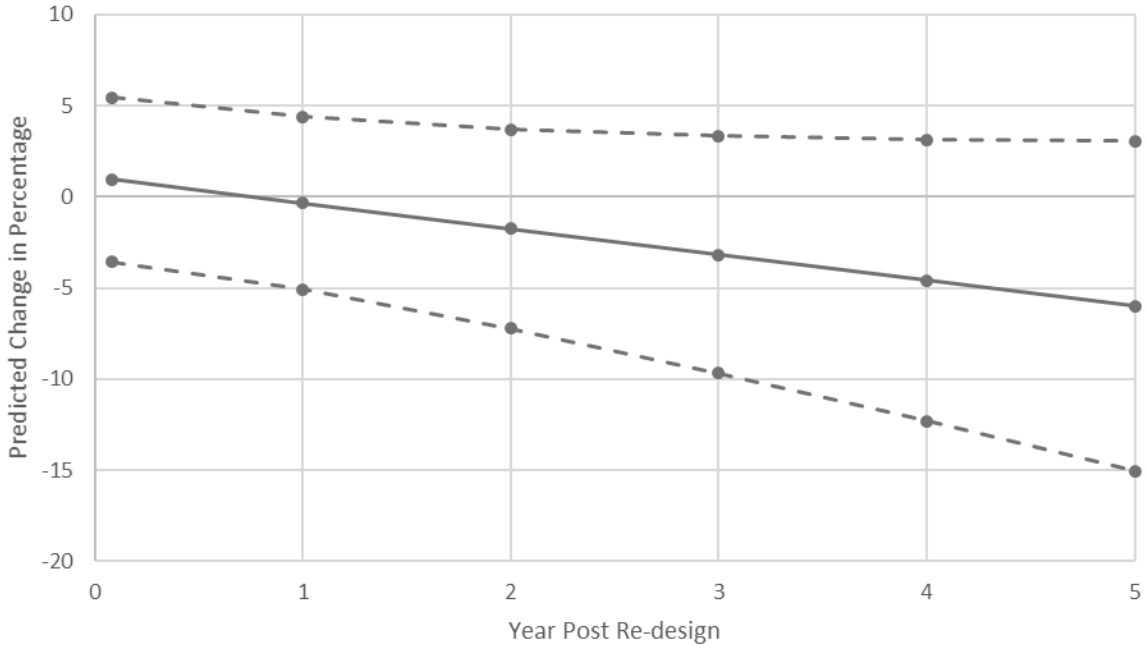


Similar results were found for the final multivariable model, in which proportion of non-elective admissions and average hospital LOS were also retained as covariates. In this model, the change in slope due to the re-design was estimated to be -0.118 (SE 0.067).

The final multivariable model estimated a 6% decrease (95% confidence interval (CI)

-15.1 – 3.1, P=0.19) in the proportion of RRT attended patients triggering repeat calls (per month) by the fifth-year post-implementation of RRS re-design. The estimated cumulative change in the observed percentage of repeat call admissions in Phase 2, compared to the percentage predicted if the re-design had not been implemented, is shown in Fig 2.

Fig 2. Final Multivariable Model. Cumulative predicted change in percentage of repeat call admissions (per month) associated with the RRS re-design, with 95% confidence intervals.



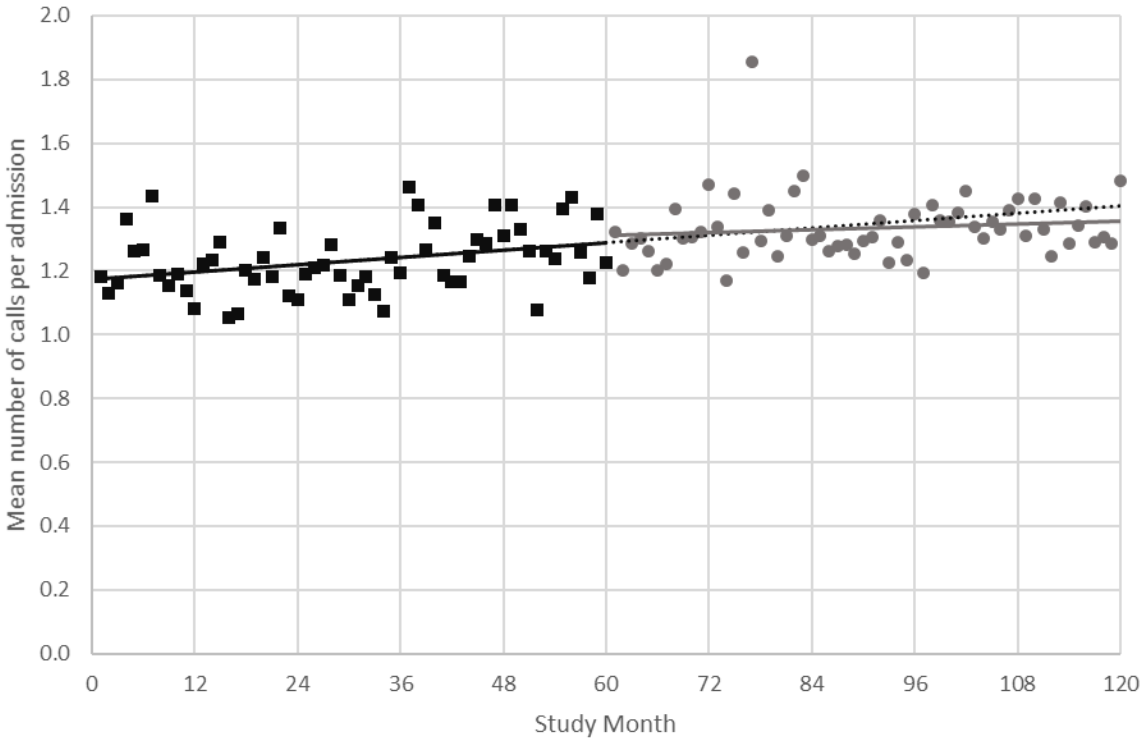
Durbin's alternative test statistics were 2.35 on 1 df (P=0.12) and 2.13 on 1 df (P=0.14) for the univariate and multivariable models, respectively, and the stationary R2 values were 0.26 for the univariate and 0.30 for the multivariable models, respectively. The Ljung-Box Q statistic indicated there was no significant lack of fit observed for the univariate (15.77 on 17 df; P=0.54), nor for the multivariable model (Q=20.83 on 17 df; P=0.23). Taken together, these statistics suggest reasonable fit of the ITS models.

Given the unusual observation in November 2015 (study month 77), a sensitivity analysis was conducted excluding this value. This analysis resulted in slightly attenuated regression coefficients for the univariate (-0.068 [SE 0.064] vs -0.087 [SE 0.067]) and multivariable models (-0.094 [SE 0.065] vs -0.118 [SE 0.067]), and a modest alteration of the estimated change in percentage of patients having repeat calls versus predicted to -4.9% (95% CI -13.7 – 3.8, P=0.27) as shown in S1 Fig.

7.7.2 Secondary Outcome

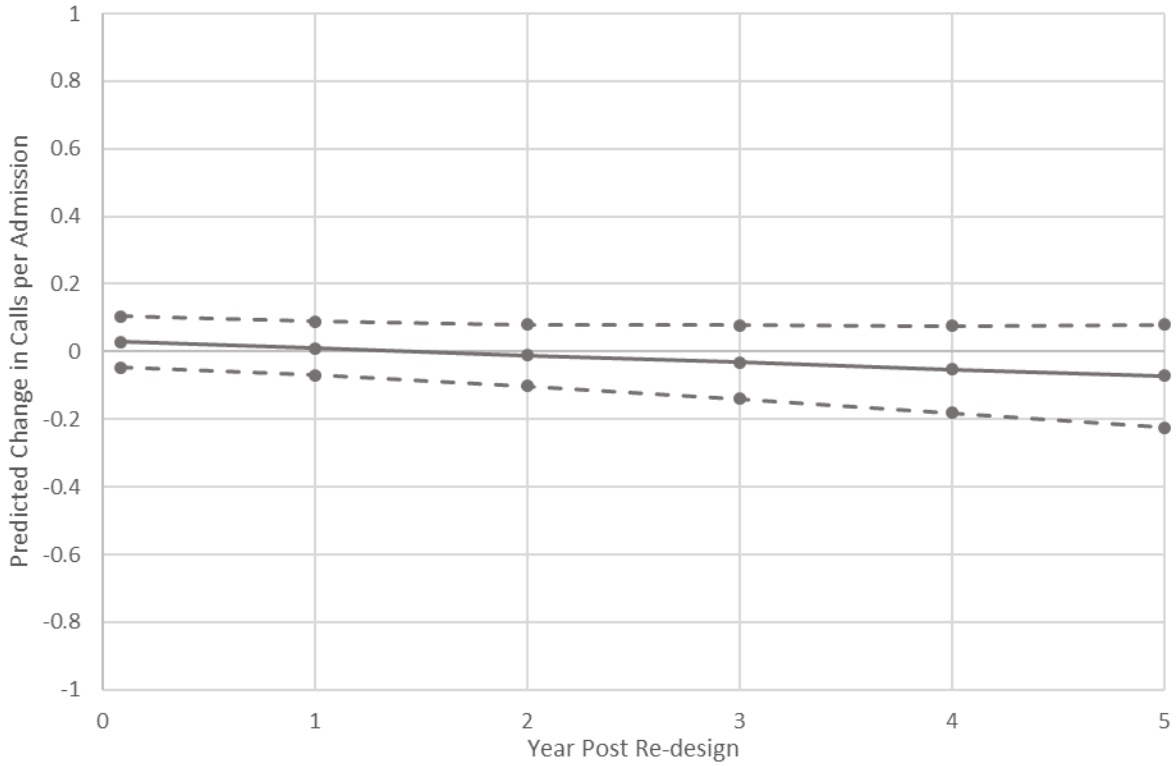
The change in regression coefficient for the mean number of calls per admission in Phase 2 compared to Phase 1 associated with implementation of the re-design was -0.001 (SE 0.001) in the ARIMA univariate model. Fig 3 shows the observed data for Phase 1 and Phase 2.

Fig 3. Mean number of calls per admission by study month for the ARIMA univariate model. Phase 1 observed data in black squares, with slope illustrated by the solid black line. Phase 2 observed data in grey circles, with slope illustrated by the solid grey line. The Phase 1 slope is extended into Phase 2 and represented by the dotted black line for comparison with Phase 2 observed data.



At the end of the Phase 2, the final multivariable model, retaining hospital LOS, showed a predicted difference of -0.07 (95%CI -0.23 – 0.08) calls per admission (P=0.35) as shown in Fig 4.

Fig 4. Final Multivariable Model. Cumulative predicted change in calls per admission associated with the RRS re-design, with 95% confidence intervals.



The fit statistics from the ITS models for the calls per admission were similar to those observed in the analysis of the primary outcome, again suggesting reasonable fit. Durbin's alternative test statistics were 0.68 on 1 df (P=0.41) and 0.58 on 1 df (P=0.45) for the univariate and multivariable models, respectively. The stationary R2 values were 0.26 for the univariate and 0.30 for the multivariable models. The Ljung-Box Q statistic indicated there was no significant lack of fit for the univariate (12.83 on 17 df; P=0.75), nor for the multivariable model (Q=15.82 on 17 df; P=0.54).

A sensitivity analysis excluding the unusual November 2015 observation led to results that were essentially unchanged, with the pre-post regression coefficient change in slope of -0.001 [SE 0.001] and 0.07 fewer predicted calls per admission (95%CI -0.21 – 0.07, P=0.34), as presented in the final multivariable model in S2 Fig.

7.8 DISCUSSION

7.8.1 Key Findings

Following a multi-faceted RRS re-design, modest, but not statistically significant, reductions were estimated in the percentage of RRT-attended patients having repeat calls and the average number of repeat RRT calls per patient, with changes in hospital activity and patient demographics accounted for in the statistical analyses. The observed reduction saw six percent fewer RRT attended patients going on to have repeat calls (per month). In the context of a median 30-minute call duration [12], this would be equivalent to a reduction in RRS activity of three hours per 100 patients attended by the RRT.

7.8.2 Interpretation of Results

Notably, the investigating hospital saw markedly increased activity throughout the study period. This partly explains the disparity in the number of subjects between the two study Phases. However, there was also a statistically significant increase in the percentage of admissions subject to RRT calls in Phase 2 versus Phase 1. Reviews of RRS operational activity observations have reported that increases in RRT calling over time following introduction of an RRS are commonplace [1-7]. A likely cause is familiarity and acceptability that reduce barriers to calling as the RRS matures.

In this study, the changes in hospital activity and patient demographics were accounted for in the multivariable Interrupted Time Series analyses. The estimated reduction in proportion of patients experiencing a repeat call following the RRS re-design has potential implications for patient mortality. A previous publication from this research program and two other studies corroborated the association between repeat calling and mortality [12,31,32].

7.8.3 Implications of Results

For organisations, there are two important potential benefits to operational efficiency from exploring potentially avoidable repeat calling. First, RRTs tend to draw resources from other acute clinical unit rosters, such as ICU and Internal Medicine, rather than have their own supernumerary staffing [8,9]. Therefore, even modest reductions in potentially avoidable re-calling of the RRT allow staff more time to attend to their primary rostered clinical duties.

Second, as RRS activity increases, there is a proportionate potential for concurrent RRT calls. Most RRS only roster a single RRT [8,9], which presents a risk to simultaneously deteriorating patients from delayed or incomplete attendance by an RRT. Thus, attempts to reduce the likelihood of avoidable repeat calls may help to ensure constant RRS capability to attend clinical deterioration promptly and effectively.

7.8.4 Contribution to Evidence Base

The literature on re-designing the RRS to improve use of NTS during RRT calls is scant. Most published articles reinforce simulation training as the gold standard mechanism to achieve this [14,15]. Staff training is labour and cost intensive, so alternative strategies need to be explored.

Kansal et al. evaluated streamlining information sharing by ward staff to the RRT on their arrival to calls, alongside other restructuring of their respective RRS [19]. Although they did report reductions in rates of unexpected deaths and other adverse patient outcomes after re-designing the RRS, these authors could not ascribe the role of the enhanced handover as the sole reason for these improvements due to changes to a tiered RRS response taking place at the same time.

Prince et al. and Mardegan et al. described changes to operations of the RRT during calls [20,21]. Prince et al. focused on visual identification of team member roles during cardiac arrest calls which was incorporated into simulation training for the RRT. These authors noted perceived improvements in communication during RRT calls, although no pre-training data were collected. This reflects improvements in perceptions and experiences of interactions during RRT calls we found in a previous publication from this research program [13]. Mardegan et al. only described staff satisfaction after introduction of a RRT call checklist that facilitated handover from ward staff to the RRT on their arrival to calls. While staff were positive in general about each of these interventions, no effects on patient outcomes were presented in either study [20,21].

The present study reports implementation of a multi-faceted RRS re-design that aimed to promote use of NTS during RRT calls. While not statistically significant, the results may still be worthy of consideration at an organisational level, especially given the negligible barriers or overheads to implementing the three components of this RRS re-design.

7.8.5 Strengths and Limitations

To the best of our knowledge, this is the first description of objective RRS performance outcomes measured around implementation of a Non-Technical Skills focused system re-design.

The Interrupted Time Series approach is particularly helpful for studying organisation-level interventions where randomised controlled trials are infeasible [23-25]. Its use in this study allowed us to investigate the effect of the re-design on the outcomes and accounted for temporal trends and variations [28]. The analysis also demonstrated that the effect of the re-design in reducing rates of repeat calling was sustained throughout Phase 2, with no evidence of attrition of benefit.

As with any pragmatic study, there are limitations. First, we acknowledge the absence of results regarding RRS compliance with the components of the re-design, or usage of NTS during RRT calls. Due to limited financial resources for the study, it was not possible to employ observers to objectively record attendance at RRT meetings, wearing of badges or usage of NTS during RRT calls, and adherence to the required hand-off process at RRT call completions.

Second, although a range of demographic and hospital activity co-variates were included in the analyses and the configuration of RRS did not otherwise alter during the entire study period, it is still possible that some other unmeasured factors, such as seniority of RRT clinicians, could have influenced the findings.

Finally, some repeat calls may indicate a correctly functioning RRS responding to clinically discrete deteriorations. However, this study focused on the wider resourcing implication for organisations, and so did not separate these from the preventable calls. All repeat calls present a potential logistical and staffing burden on hospitals, so that even modest improvements, such as observed here, may confer benefits to the organisation.

7.8.6 Future Scope for Re-designing the RRS

The RRS re-design used in this study was developed with the understanding that further iteration and re-evaluation would be worthwhile. Some potential revisions to the re-design, such as role stickers, rather than badges, and electronic availability of RRT rosters, have already been proposed in a previous publication from this research program [13].

Further to those, a natural addition to the RRS would be debriefs for the RRT and other hospital staff involved in calls [33,34]. This could take one of two forms: “hot debrief” conducted immediately after completion of each RRT call or “cold debrief” in which cases are reviewed later at scheduled meetings [34]. There are challenges in implementing either of these debrief methods. Hot debrief depends on RRT members, and possibly also ward staff, involved in that call remaining available to attend. For ad-hoc RRTs rostered from other clinical roles, this may be infeasible [8,9]. The scheduled, delayed nature of cold debrief provides more opportunity for RRT members to plan their attendance and avoid conflicts with other clinical duties, so may be easier to implement, but all RRT members are unlikely to be rostered to work at the scheduled time of the cold debrief [34].

7.8.7 Context within the IMPACT research project

As outlined earlier, this study was conducted as part of a larger research project. In a parallel survey study of perceptions and experiences of NTS use during RRT calls of RRT members and those calling the RRT (users), this RRS re-design was associated with significant reductions in reported experience of conflict [13]. Furthermore, both in quantitative data and free-text comments, improvements in leadership, communication and cooperation between RRT members and users during RRT calls were reported following introduction of the re-design.

Thus, the apparent lack of effect of the RRS re-design on the proportion of admissions with repeat RRT calls and the mean number of RRT calls per admission raises the question of whether organisational change did not occur, or whether a potential improvement (as suggested by the survey findings) was not captured by the outcomes used here. Therefore, as part of future research, identification and use of other outcome measures that are more sensitive to NTS performance during RRT calls should be explored.

7.9 CONCLUSIONS

This study reports a multi-faceted RRS re-design which was associated with a modest, but not statistically significant, reduction in the percentage of patients per month having repeat calls and the average number of repeat calls per admission.

In an era of economic and health workforce constraints, even small potential improvements may still have relevance to organisations. This RRS re-design (and assessment thereof) has scope for further refinement, and may be of interest to RRS clinicians and managers seeking to implement their own pragmatic, low-cost quality improvement initiatives.

7.10 ACKNOWLEDGEMENTS

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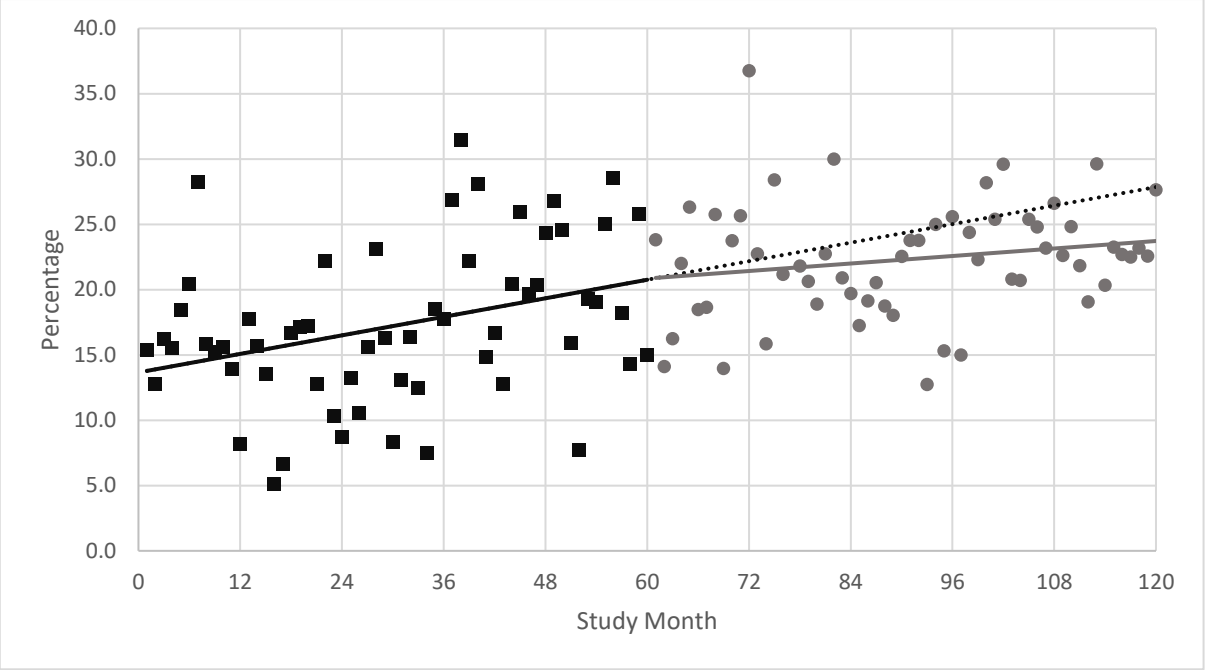
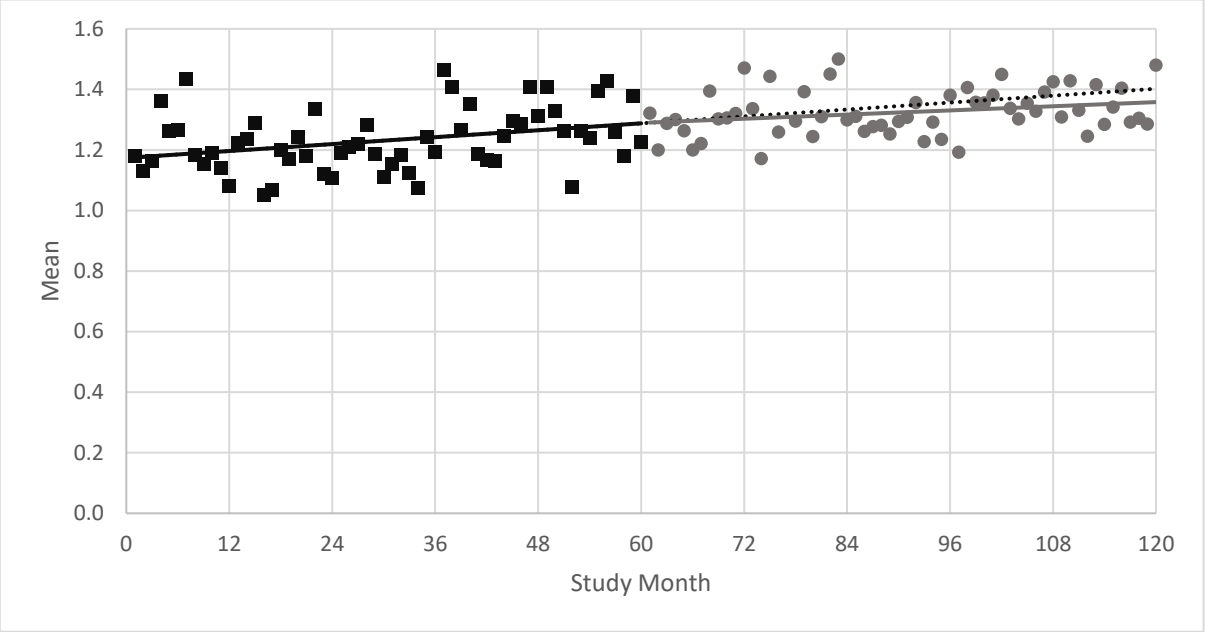
7.12 SUPPORTING INFORMATION



S1 Fig. Percentage of repeat call admissions per month representing the ARIMA univariate model with outlier detection enabled. Phase 1 observed data shown as black squares, with trend shown as the solid black line. Phase 2 observed data shown as grey circles, with trend shown as the solid grey line. The Phase 1 trend is extended into Phase 2 as the dotted black line for comparison with Phase 2 observed data. Observation for study month 77 (November 2015) was identified as an outlier and excluded for this sensitivity analysis.



S2 Fig. Mean number of calls per admission by study month for the ARIMA univariate model with outlier detection enabled. Phase 1 observed data shown as black squares, with trend shown as the solid black line. Phase 2 observed data shown as in grey circles, with trend shown as the solid grey line. The Phase 1 trend is extended into Phase 2 as the dotted black line for comparison with Phase 2 observed data. Observation for study month 77 (November 2015) was identified as outlier and excluded for this sensitivity analysis.

Chapter 8: Discussion and Conclusions

8.1 PREAMBLE

This thesis has presented a comprehensive yet pragmatic research program, conducted within an operational hospital RRS. Discussion and conclusions for the individual study phases and data types are contained in the relevant papers (as Chapters 4 to 7). This final chapter will synthesise the findings from those papers to provide an overarching summary of the research program.

8.2 SUMMARY OF KEY STUDY FINDINGS

Paper 1 (Chapter 2) concluded that although the role of NTS, and training in NTS, had not been established directly for the RRS, there was sufficient evidence from similar disciplines and clinical environments from which to extrapolate. Thus, plausibility was proposed for patient and organisational benefits from successful use of NTS during RRT calls.

Paper 2 (Chapter 4) identified that communication and cooperation issues occurred during RRT calls particularly between RRT Members and Users, and that these issues could result in unresolved clinical concern at the end of calls. Such events were cited as reasons for repeat RRT calls, which could potentially have been prevented through use of NTS.

Paper 3 (Chapter 5) found that the RRS re-design, as described in Chapter 3, was associated with improvements in RRT Member and User experience of some domains of NTS use during RRT calls (such as leadership, communication and awareness of roles/responsibilities). Most notably, both groups reported significant reductions in perceptions of conflicts during calls following introduction of the RRS re-design.

Paper 4 (Chapter 6) corroborated the previously identified relationship between repeat RRT calling and in-hospital mortality. It added to the existing evidence base by demonstrating mortality risk specifically associated with repeat calls due to unresolved clinical deterioration. Thus, a patient-centric argument was established for seeking to reduce repeat calls that might be potentially preventable by the RRT.

Paper 5 (Chapter 7) noted a modest, but not statistically significant, reduction in the incidence of repeat RRT calling following implementation of the re-design.

8.3 INTERPRETATION OF STUDY FINDINGS

Even in the context of a modest effect of the RRS re-design on repeat calling, the decrease in perceptions of inter-personnel conflict during calls following the re-design suggests an important improvement occurred in the professional relationships within the RRT, and between RRT Members and Users. Given the inherent stressful working environment of the RRT call, any improvement in staff interactions is desirable for the wellbeing of staff. As noted in Section 3.3.1, the internal stress experienced by clinicians in the pressured and unpredictable scenario of an RRT call can be manifested externally as unproductive behaviours [35,82,168-170].

Certainly the non-supernumerary nature of the RRT could be a source of some conflict during RRT calls. As demonstrated in Table 3.1, the RRT at LMH was not supernumerary, in keeping with other

Australian RRTs [4,29,31,57]. The dual roles may impose stress from the competing workload and responsibilities of Members' primary duties which await them and could potentially coerce expedited resolution of the call. Additionally, for Members rostered from the ICU, there may be an (unconscious) incentive to leave a precarious patient on the ward at the end of a call, thereby reducing the workload of that ICU.

The Phase 2 survey indicated that improved cooperation and shared decision-making occurred around the end of calls. As noted in the postscript for that paper (Section 5.11), the findings of Users' perceptions of their involvement and counsel around clinical planning for patients who would remain on the ward suggested improvements in the NTS domains of cooperation, communication and decision-making/planning occurred.

Thus, in the setting of a RRS for which changing the RRT composition was not feasible (due to the low experience level of Internal Medicine trainees then rostered to the RRT), the intervention may have assisted with:

- a shared goal of patient management and planning (rather than the RRT providing sub-optimal assistance due to any perceived need to prioritise primary duties)
- clearer and earlier identification of concerns User-Member to expedite management and resolution
- appropriate delegation of responsibility so some or all RRT Members could leave where appropriate (to attend their other duties) with lower risk of repeat calling (due to inadequate/incomplete clinical planning or lack of identification of an ongoing care provider to call).

The previously flagged significant reductions in perceptions of conflict point to a healthier working relationship amongst RRT Members and Users.

Conflict or confrontation can induce or exacerbate anxiety or depression for clinicians, especially if there are repeated exposures [168]. The resultant phenomenon of burnout has been an increasingly recognised issue within healthcare human resources, especially over the extended COVID-19 pandemic with additional caseload and PPE requirements for front-line clinical staff such as RRT Members [171-174].

No studies have specifically examined the burden of burnout or low morale within the RRS. However, RRT Members are required to maintain high standards of care delivery, while under considerable time and clinical pressure, and with little margin for error, so would seem at high risk for burnout [35,49,74,131].

Presenteeism (i.e. reduced productivity when staff work at less than normal capability) within the RRT could pose a threat to the quality of healthcare delivered during calls and, thus, is worth addressing wherever possible [175-178]. Therefore, any benefits that the RRS re-design may have provided for RRS staff wellbeing and morale could be important if these benefit then mediated positive effects on patient safety and organisational efficiency [49]. In an era of high clinical demand co-existent with stretched healthcare resources, any potential benefits are worthwhile, especially if achievable from a low-cost intervention such as the RRS re-design presented in this thesis.

8.4 LESSONS LEARNED AND STRENGTHS

Positive aspects and shortcomings of the thesis component studies are presented in the respective Results chapters (Chapters 4 – 7), so will not be revisited here. Rather, this section considers the strengths and limitations of the research program overall.

8.4.1 Lessons Learned

First: a more robust approach to development of the surveys would have been desirable. As noted in Section 4.2.2, a validated framework for development of the questionnaires was not employed. Although many aspects of development of the surveys may have been appropriate, the absence of a framework or documentation of the development process undermine their validity to some degree. For any future research in this area, a structured approach could be used to identify objectives and design questionnaires with consideration to respondents [162,164].

The surveys captured (mostly) quantitative data which may have been richer if a qualitative approach was also used [163]. Qualitative data could have been collected through open written responses or semi-structured interviews, as used by Benin et al. to evaluate their RRS [161]. However, the quantitative approach used in this doctoral research was pragmatic and less burdensome for participants.

Second: the repeat call RRS performance indicator proved straightforward to capture (along with other RRS and patient data). However, data were not collected on RRS compliance with components of the intervention or regarding performance of NTS during RRT calls. Thus, it is not clear to what degree the (modest) change in incidence of repeat calls (post- vs pre-intervention) reflects changes in NTS use following the re-design. The potential for future studies to evaluate repeat calling, alongside other potential indicators of NTS use during RRT calls, is explored in Section 8.5.2 (Future Research Opportunities).

Third: The rationale for selecting the repeat RRT call, and the potentially preventable derivatives thereof, has been presented in the Preamble to Chapter 6. However, it is possible that another RRS performance indicator, some examples of which were outlined in Section 1.2.4, may better reflect use of NTS during RRT calls (versus repeat calls). However, to date, no other indicator has been proposed that focuses on evaluation of NTS use during calls [4,77,78]. For example, the commonly cited "unexpected cardiac arrest" is more representative of afferent limb performance, hence the many studies of antecedents and delays to escalation [5,6,10-13,16-18].

Other potentially useful outcomes for consideration were not available in the RRS database. For example, unplanned ICU admissions (including those following an RRT call) have been proposed and studied previously [14,16,47,56,69,118]. Akin to the (unplanned) repeat RRT call, these non-elective ICU admissions may also reflect suboptimal resolution at an initial call [77]. The LMH RRS database only captured RRT calls with unplanned ICU admissions not recorded or available electronically.

Future research could simultaneously evaluate many potential RRS performance indicators alongside repeat calling (also explored in Section 8.5.2) to develop and validate a robust measure.

Fourth: this was a single centre investigation, and so findings may not be generalisable to other RRS. Further, the research spanned a ten-year period. Although the RRS was not altered (other than the re-design) throughout the study, it is possible that system- or institutional-level changes occurred that were not captured.

For example, seniority of RRT members was not captured for inclusion as a covariate in the adjusted multivariable model in Chapter 7. Although the effect of RRT Members' clinical experience on patient outcomes has not been investigated, analogous studies in the ED setting have shown that survival in trauma patients correlated with seniority of care providers [134,135].

To minimise the impact of these limitations, the RRS re-design presented in this thesis could be implemented across multiple hospitals and evaluated with a cluster-randomised controlled trial. This approach would allow stratification by patient and hospital level characteristics, providing a more precise estimate of the effect of the RRS re-design. Conclusions derived from a multi-centre study may be more reliable and have broader applicability for other (similar) RRS.

8.4.2 Strengths

First: the research presented in this thesis adds to our understanding of the RRS. It is original in focusing on the role of NTS within the RRS and, particularly the use of NTS during RRT calls. It is also novel in seeking to improve NTS use during RRT calls through low-cost and sustainable ergonomic mechanisms.

As acknowledged above, indirect measurement of NTS use was employed, and data were not captured on actual use of NTS at calls during the study period. However, it is notable that there are only three papers presenting data from observation of RRT calls. The first was Cooper et al. from 1999 [115], with the other two being Siems et al. from 2017 and Saunders et al. from 2021 [145,146]. The long gap between Cooper et al. and Siems et al., during which RRS were mandated in Australian hospitals from 2014 onwards, speaks to difficulties in conducting this type of research. Were observations of RRT calls readily achievable, it is reasonable to assume that other researchers would have attempted to reproduce or expand on Cooper's work.

Some of the complexity lies in the methodology of these three studies [115,145,146]. Cooper video-taped cardiac arrest calls for later analysis [115]. This may be problematic to repeat today with a need to balance privacy concerns against progressing research, especially since gaining consent from deteriorating patients prospectively would be impractical [179,180]. Both Siems and Saunders only observed RRT calls during office hours when research staff were available. To conduct a robust study, the unexpected nature of RRT calls would necessitate availability of research project staff at all hours, especially since adverse patient events are more likely following out-of-hours calls [138,139,141,142].

In the absence of resources to conduct observations at any time of day, this research took an approach of pragmatism [124,181,182]. In doing so, the findings and discussion presented are valuable steps in progressing an area of research from which improvements can be considered.

Second: this research addressed an important question for organisations given the promise that NTS has shown in analogous clinical areas and industry. The statistically significant reductions in perceptions of conflict during RRT calls (following introduction of the RRS) are of noteworthy benefit to Lyell McEwin Hospital in terms of potential improvements in workplace culture, as detailed in Section 8.3.

Third: the changes to the RRS from the re-design were straightforward to implement and minimally intrusive for RRS staff and the hospital. Even the most potentially disruptive component, the RRT meetings, only required five minutes of time from each shift to minimise interruption of RRT Members' normal clinical duties. Thus, pragmatic re-design of an RRS should have broad appeal to RRS managers as it is suitable for implementation in a wide range of hospital configurations, jurisdictions and resourcing.

Fourth: the RRS re-design presented in this thesis has substantial scope for iteration. Some potential options for re-configuration of the LMH RRS, have been presented in the post-intervention Results chapters (5 and 7). Further discussion on development of the RRS re-design is presented below (in Section 8.5.3).

8.4.3 Refinement of Methodology

As noted extensively throughout the thesis, there were limitations to achievable methodology due to resourcing constraints. However, considering subsequently published literature, as presented in the postscript to Chapter 2, it may have been possible to overcome these in this research.

8.4.3.1 The effect of implementing RRS Re-design components on use of NTS during calls

Direct observations of RRT calls were not done in this research due to lack of availability of researchers outside office hours, and inconsistent availability during office hours. Thus, not all RRT calls would have data recorded and so, rather than risk collection of potentially unreliable data, observations were not done at all.

However, as demonstrated by Siems et al. and Saunders et al., it is feasible to undertake convenience sampling when researchers are available [145,146]. Although doing so presents a potential selection bias, taking this approach may have offered a reasonable compromise between accommodating resource limitations and providing data on use of NTS before and after re-designing an RRS.

8.4.3.2 Compliance with RRS Re-design components

Although data regarding compliance with the intervention components were not collected for this research, it should be feasible in future iterations. The RRT Meetings and Structured Hand-offs were driven by hard-copy checklists, completion of which could be reviewed by researchers. This would provide useful data to establish the relationship between the RRS re-design components and changes in use of NTS during calls.

As an exemplar, Mardegan et al. undertook convenience sampling of their RRT call datasheets for 100 patients subject to calls during May 2013. They found 91 patients had datasheets completed, of which 87 (95.6%) had the handoff from RRT Users to arriving Members recorded. Thus, capture of compliance with this component may have been feasible.

8.4.3.3 Importance of an objective performance indicator

The use in this research of an objective measure is supported by Subbe et al. [77]. They present the consensus of the iSSRS for measures of RRS performance with an aim to "*identify metrics that permit teams to monitor quality in their own institution and to assess the performance of interventions related to their RRS over time*". While none of their proposed metrics were ideally suited to this research, hence the development of a bespoke measure (the repeat RRT call), it underpins that outcomes must be appreciable to patients (e.g. as hospital survival [8,19,183]), organisations (e.g. as incidence of adverse events [56,151]) and the wider society (e.g. as cost-effectiveness).

Thus the inclusion of an objective outcome in this research, in lieu of undertaking in-field observations, was an important and valuable feature.

8.4.3.4 Surveys of Staff Wellbeing

The question regarding experiences of conflict during RRT calls proved invaluable for establishing an organisational benefit from re-designing the RRS [35]. As discussed extensively in Section 8.3, an effect of the intervention on staff morale and wellbeing was an interesting finding. However, this was extrapolated from one question and this finding would have been more robust if more questions had been included to query respondents' wellbeing and morale.

Publications subsequent to development of the questionnaires have flagged the importance of stress at RRT calls, both for Users summoning the team and for Members addressing time-critical clinical deterioration [49,120,130,131,169,173]. Thus, the inclusion of more questions to elicit the effect of the

intervention on internally perceived and externally manifested stress would provide rich additional data to support the objective organisational outcomes discussed above.

8.5 FUTURE RESEARCH OPPORTUNITIES

8.5.1 Use of Existing Data

For the Phase 2 RRS Performance Indicator paper (Chapter 7), ten years' of RRT call records were extracted from the LMH RRS database. This equated to almost ten thousand data records with 120 fields. In the future, this large and rich dataset could be explored further and cross-linked with other hospital databases to examine the effect of the RRS re-design on other patient outcomes, such as an unplanned ICU admission within 24 hours of a completed RRT call (following which the patient remained on their ward). This clinical event potentially represents a missed opportunity to admit the patient to the ICU from the RRT call [184,185]. Although unplanned ICU admissions proximal to completed RRT calls have not yet been investigated (either in this thesis or the broader literature), increased morbidity and mortality has been associated with delayed admission to ICU from the ED [186,187]. Delayed admissions to ICU following RRT calls may be analogous to the (potentially preventable) repeat calls and, thus, may also be representative of decision-making (as a domain of NTS) during RRT calls.

Alternatively, the dataset could be used for the development of predictive models for use by the RRS. The origin of RRT call triggers was based on prediction of clinical deterioration that, if uncorrected, would result in potentially preventable cardiac arrest [5,12]. Therefore, the development of predictive tools to assist decision-making, for example: on appropriate patient follow-up or disposition to reduce likelihood of repeat RRT calling, would be a logical extension.

Precedents exist for use of predictive tools by the RRS. A research group at the Mayo Clinic have reported a predictive model and risk score for likelihood of a patient triggering an RRT call within twelve hours of admission to the ward from the ED [188,189]. A similar model was developed by Ng et al. for use at the time of discharge from the ICU to identify patients at risk of subsequent clinical deterioration (based on a composite outcome of an RRT call, unexpected cardiac arrest or unplanned re-admission to the ICU) [190].

These predictive studies were all single centre investigations and addressed a different timepoint in the patient admission journey. As such, they may not be directly applicable to the (potentially preventable) repeat call outcome presented in this thesis. However, the imperative to improve efficiency and efficacy of the RRS prompts consideration of RRT decision-assist tools for use at the end of calls.

A tool developed from a predictive model, following methodology such as described by Royston et al. and Pavlou et al. [191,192], may be extremely helpful for an RRT in determining patients for whom transfer to the ICU might be more suitable rather than being left on the ward. As noted in the findings of Chapter 5, potentially preventable calls where the patient remained on the ward despite ongoing criteria breaches were associated with increased in-hospital mortality [32]. Therefore, a predictive model and tool to identify patients at greatest risk of potentially preventable calls may be beneficial to the RRS and is worthy of investigation.

8.5.2 Electronic Data Collection

One potential mechanism to facilitate the collection of data concerning use of the re-design elements in RRT calls without the need for funding observers would be through contemporaneous documentation of RRT Meeting and Hand-Off steps on an electronic device. In 2018 (i.e. three years

after onset of study Phase 2), LMH installed a hospital-wide wireless network. This permits access to the hospital intranet and file storage for authorised mobile and portable devices.

Therefore, further evaluation of the RRS re-design could use a dedicated mobile device (e.g. an iPad®) that is pre-configured for study data capture. This device could be entrusted to the RRT Nurse role (as the most consistent Member) and be handed from incumbent to incumbent (on shift changeover) as already occurs for their RRT call pager. Just as the paper proforma was intended to act as guidance for the Hand-Off events, the data entry (and collection) software could present a series of questions and/or prompts, in keeping with the principle of ergonomics underpinning the RRS re-design [105,108].

The electronic data capture device would require a user-friendly interface that guided clinicians through the steps of the re-design components. This would circumvent the need to coach new RRT Members on the RRS re-design through presentation of an intuitive tool that facilitated the RRT Meetings (in addition to the end-of-call Hand-Off events). Software like this could also assist with standardisation of the conduct of the RRT Meetings and Hand-Offs. As precedent for utility by the RRS, electronic checklists are routinely used in the aviation industry to ensure compliance with safety procedures [106,107,193,194].

8.5.3 Evolution of the RRS Re-Design

In the Phase 2 studies (i.e. Chapters 5 and 7), some avenues for improvements to the RRS beyond the studied research intervention were identified. To summarise here, those recommendations were to:

1. use stickers rather than badges for the RRT role identification [35];
2. make the formal Hand-Off process conditional rather than automatic [35];
3. hold a debriefing session after calls;
4. publish RRT rosters on the hospital intranet [35].

One of these recommendations: **RRT Member role stickers** was enacted at LMH in 2019, after completion of the study. This was a straightforward and cost-superior alternative (to the badges) with negligible barrier to implementation. These were distributed at the RRT Meetings, with spares available on each RRT equipment trolley. The RRT Nurses took responsibility for ensuring the wearing of these stickers by all RRT Members present at calls.

As noted in the Discussion of the Phase 2 Survey (Chapter 5), of all the RRS re-design components, the structured Hand-Off process was the most problematic. In free-text comments, some RRT Users reported finding the Hand-Off laborious and time-consuming. By their nature, some clinical deterioration events will be brief and self-limiting, such as the vaso-vagal syncope [195]. For these RRT calls, the role of the Hand-Off is often considered of questionable benefit and may become inconvenient in delaying RRT Users (and Members) returning to their other clinical duties. Therefore, a more efficient and appealing alternative could be a **Conditional Hand-Off**. That is, the structured Hand-Off process (including the proforma) would be reserved for select cases rather than required for all calls as mandated in the RRS re-design studied here.

Determination of guidelines for the nature of RRT calls that may, and may not, benefit from the structured Hand-Off process would involve broad consultation with RRT Users and Members. A degree of discretion could also be applied to enable RRT Members and Users at a call to decide on the value of a Hand-Off for each call that is absent a pre-defined indication. This would ideally encourage RRT Users to seek a Hand-Off where it would be of benefit to them and the patient for whom they will be resuming responsibility of care. In doing so, they would gain additional agency in the end-of-call decision-making and their advocacy for patients.

Despite the potential gains, making the Hand-Off discretionary would pose the risk of eroding cooperation (as a domain of NTS) between RRT Members and Users. This could occur if differences in interpretation of indications for a Hand-Off arise amongst RRT Members and/or between RRT Members and Users. In such situations, RRS policy could stipulate proceeding with a Hand-Off as the default, especially if lack of consensus exists. Alternatively, the electronic data capture tool (as detailed above) could provide a decision-assist tool to determine whether a Hand-Off is indicated (or not). The overarching ethos of the RRS re-design components is to benefit staff as well as patients, so regular reinforcement to RRT Members and Users regarding the potential advantage of reducing potentially preventable repeat calls (i.e. their workload) may also sustain the culture of common purpose amongst all RRS staff

Debriefing was proposed in Chapter 7 as a potential method to learn from experience and reinforce team building after the stress of the often complex and clinically demanding RRT Call. In that paper, the potential utility of "hot" and "cold" debrief for the RRS (that is, respectively, debriefing immediately after a call and debriefing later on in a meeting format, respectively [196]) were introduced. The utility of debrief has been established for cardiac arrest teams to improve adherence to and timeliness of algorithm-driven clinical management [197,198] . However, debriefing has also been promoted to improve use of NTS during cardiac arrest calls, for example: incorporation of a hot debrief after simulated clinical scenarios at United Kingdom Resuscitation Advanced Life Support courses [199].

A form of cold debriefing already occurs within most RRS including LMH, in the form of a Steering Committee that reviews summary RRT activity and incidents post-hoc, typically monthly. Given that the RRT is rostered from a large pool of staff with other substantive positions [29,57], cold debriefing individual cases would likely be impractical. This is due to the inherent difficulty in ensuring availability of RRT Members to participate in reviews of calls they attended. Rather, cold debriefing would risk becoming a largely unproductive exercise due to the loss of nuance in clinical records (if involved Members were not present) and/or the recall bias inherent with increasing elapsed time between a call and its retrospective review and debrief.

Instead, the hot debrief would seem a more viable option. This has recently been proposed within the RRS by Aponte-Patel et al. and Conoscenti et al [200,201]. Both research teams surveyed members of their RRT after introduction of a post-call debrief and found high levels of agreement that hot debrief was useful (83% and 85%, respectively). The main barrier to addition of a debrief component into the RRS re-design would be the non-supernumerary nature of the RRT at LMH (and more generally across Australia [29,57]). That is, RRT Members and Users present at a call typically need to reattend their primary clinical duties as soon as practically possible after completion of an RRT call.

Therefore, a reasonable compromise would be to reserve a **Conditional Hot Debriefing** for selected complex calls. The established scenario is the cardiac arrest call for which broad consensus supports debriefing [196]. Focus groups of RRT Members and Users, facilitated by RRS managers, could develop a pre-defined list of calls for which debrief should follow. One reasonable indicator for debrief would be transfer of the patient to ICU from the call (i.e. a complex clinical deterioration that could not be resolved in situ). In such situations, all RRT Members and Users participating in that call could accompany the patient and, after handing over care to ICU staff, attend a short debrief to check call participants' wellbeing, as well as provide an opportunity for self-reflection on NTS performance during the call [196,202].

Transitioning the RRT Meetings to online would be another logical step that would be flexible and have minimal overheads to implementation and is pertinent during COVID-19 pandemic response measures that discourage avoidable in-person meetings [203,204]. This could include **electronic availability of RRT rostering** to all hospital staff and a **Virtual RRT Meeting** to permit attendance at the shift-by-shift RRT Meetings without the need for staff to be co-located. LMH recently introduced

Microsoft Teams® as a hospital-wide collaborative and productivity facility. This is available to all staff via their organisation account with the service available on portable devices (including personal mobile phones) as well as hospital computer terminals. Therefore, it would be relatively straightforward to implement the electronic rostering and virtual meetings.

As noted in Section 1.3.2, the RRT at LMH consists of clinicians from many hospital departments (ICU, Internal Medicine, the Intern pool) who have other primary clinical roles. Although the RRT Meetings were only scheduled to last five minutes, the total attendance time may be much longer if Members are working far from the meeting venue at the scheduled meeting time. Therefore, being able to attend virtually may incentivise and motivate RRT Members' attendance by minimising interruption of their primary duties [121,205]. Further, use of a digital platform would naturally lend to implementation of an electronic checklist-based assistance tool for conducting the RRT Meetings. Web conferencing facilities, such as Teams®, by default display a timer for the length of the meeting. This timer could plausibly be re-configured to a five-minute countdown as an additional prompt to encourage participant discussions during the RRT Meetings to remain concise and on topic.

The proposed portable electronic device for use by the RRT could also provide a checklist and/or guidance notes for the **Conditional Hand-Off** and **Debriefing**. This would help to support the RRT in maintaining a consistent, systematic approach and supportive culture during Hand-Offs and debriefs. Such strategies may also have benefits for RRT Members' and Users' well-being and professional development [49,74,172,202].

A future study could revise the current RRS re-design as a second intervention and repeat the surveys and RRS performance indicator measurement in a third study phase. Given that no additional funding (above existing RRS budgets and staffing) was required to conduct the surveys and performance indicator data collection presented herein, conduct of a third phase should require little additional resourcing beyond the re-design revision.

The suggested revisions, as detailed above, remain in keeping with the ethos of the current re-design in being minimally disruptive to the operational RRS at LMH and having a low implementation timeframe or financial overhead.

8.6 TRANSLATING RESEARCH INTO PRACTICE

As noted throughout this thesis, a pragmatic approach was used in this research program. Evaluation of alternative methods at LMH, such as the training course from Prince et al. or extensive RRS re-configuration from Kansal et al., would have required considerable resources and time to conduct, so were beyond the scope of what was possible in this research program. Rather than view the approach presented in this thesis as a limitation, it demonstrates that a meaningful intervention can be implemented in the absence of a dedicated funding and/or resource allocation. The low-cost, low-barrier nature of the RRS re-design, therefore, has broad potential application, including in developing nations and in periods of intense demand and pressure such as a pandemic.

The re-design, and its underpinning principles, have been described in this thesis and the component Results chapters. Therefore, other hospitals and researchers can replicate the RRS re-design or use it as inspiration for their own pragmatic interventions. In that regard, the methods described in this thesis provide a feasible foundation for translating research into practice [206,207].

A key aspect of translational health research is transferability and generalisability: that is, whether the intervention has applicability to and potential utility for other RRS [206-209]. The RRS re-design presented in this thesis required no additional equipment or personnel, or separate funding. The time taken to complete the RRT meetings and end-of-call Hand-Offs was minimal, and the negligible

printing costs of the Hand-Off proformas and RRT role stickers was easily absorbed within existing RRS budget lines. Thus, replication or validation of the re-design should be feasible within even small or resource-limited hospitals.

The quantitative data presented in Chapter 7 suggests that the (effect of the) re-design was sustained throughout the five years of Phase 2. This serves as some reassurance for another important aspect of research translation, namely the crucial steps of adoption, implementation and maintenance (as proposed by Glasgow et al. [147]) faced by others seeking to replicate a health intervention.

8.7 CLOSING

This thesis has presented the rationale, methodology and results of a pragmatic, multi-faceted, NTS-based intervention for an operational RRS. Development and implementation of this re-design intervention has been more robustly evaluated than typically occurs for health services improvement initiatives. The planning, implementation and evaluation of a RRS re-design presented herein serves as a solid foundation for ongoing research efforts aiming to improve the performance of an RRS.

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This is the bibliography for Chapters One, Three and Eight. References for the included papers (Chapters Two and Four to Seven incl.) are at the end of their respective chapters.

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Appendices

APPENDIX A: TEAMSTEPPS® TWO CHALLENGE RULE

Two-Challenge Rule

Empowers all team members to "*stop the line*" if they sense or discover an essential safety breach.

When an initial assertive statement is ignored:

- It is your responsibility to assertively voice concern at least *two times* to ensure that it has been heard.
- The team member being challenged must acknowledge that concern has been heard.
- If the safety issue still hasn't been addressed:
  - Take a stronger course of action.
  - Utilize supervisor or chain of command.

CUS

Assertive statements:

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https://www.ahrq.gov/teamstepps/instructor/essentials/pocketguide.html#twochall

RRT Meeting Agenda

1. Welcome
2. Introductions
3. Badge Checks
4. Establish team roles and initial duties / tasks
5. Logistic and organisational issues
6. Break

RRT Meeting Guidance Notes

A TeamSTEPPS based intervention to improve team working and communication

Objectives:

1. Establish team member roles and responsibilities
2. Build team rapport

Operational Guidance

1. The brief should take no more than 5 minutes
2. An agenda is provided (see attached)
3. Discussion of clinical matters or patient cases is discouraged

Agenda Items

1. Welcome – facilitator or team member should announce the brief and welcome the team
2. Introductions – invite all team members to state their name, designation and BLS or ALS provider status. Team members are encouraged to welcome one another and use this as an opportunity to build rapport. Even where team members know one another, the formal introduction is still strongly encouraged
3. Badge Checks – all members should visibly wear the provided RRT service badge indicating their designation and role within the RRT. Badges should be handed over with the RRT pager at shift changeover
4. Establish team roles and initial duties / tasks
    a. A team leader should be nominated. In most circumstances this will be the ICU registrar. However it may be reasonable for another team member to assume the leadership role if experience and competencies permit
    b. A back-up team leader should be nominated in the event that the initial team leader is required to become task-focused or cannot remain at the patient bedside
    c. Other team roles should be established including the default tasks to be taken by each member on initial attendance at the patient bedside. For example: the intern could fetch the notes and check the past history and resuscitation status
5. Logistic and organisational issues – any access or equipment issues should be disclosed to ensure timely attendance by all team members and prevent discrepancies
6. Break – team members return to current rostered activities with thanks from briefing facilitator or briefing chair

APPENDIX D: RRT HAND-OFF CHECKLIST

RRT Hand-Off Contract

CallID: _____ Date: _____ Time: _____ AM/PM

Role	Present	Name
ICU Reg	YES / NO	
Med Reg	YES / NO	
MET Nurse	YES / NO	
Home Team / Cover Dr	YES / NO	
Ward Nurse	YES / NO	
Other	YES / NO	

Clinical Handover (tick when completed):

Identity	Situation	Background	Assessment	Recommend

Ward Team Read-back (tick when completed):

Read-back of plan	Contingency plan	Resus Status	Happy with plan

Signatures:

_____ _____

RRT Leader Ward Doctor / Nurse

RRT Hand-Off Guidance Notes

A TeamSTEPPS based intervention to improve team working and communication

Objectives:

1. Ensure effective clinical handover of patient from RRT back to ward team
2. Prevent requirement for repeat RRT call due to unresolved issues

Operational Guidance

1. The huddle should take no more than 5 minutes
2. An agenda is provided (see attached)
3. Formal clinical handover of the patient should follow the ISBAR format
4. Ward staff should read-back to the RRT, raise any queries and indicate satisfaction level with taking back patient care
5. RRT should not depart the location until the patient care team is satisfied

Agenda Items

1. Welcome – facilitator or RRT leader should announce the huddle and introduce RRT to the ward team
2. ISBAR Clinical Handover – should be delivered by a member of the RRT to the ward team. This should follow the NALHN guidelines on the ISBAR format (Identity, Situation, Background, Assessment and Recommendations). The aim should be to provide a comprehensive plan to the ward staff and address any potential contingency situations. Handover of any treatment limitation or resuscitation orders are essential
3. Read-back by a member of the bed card, cover and/or ward nursing team – this aims to ensure that the plan has been fully understood by the ward team who will take back care of the patient from the RRT. At this point any queries should be raised and any concerns addressed. Establishing contingency plans in the event of subsequent deterioration or change in clinical status is important. The ward staff should also indicate their level of satisfaction with the current plan and willingness to follow it.
4. Signatures – this is the formal point of return of clinical responsibility from RRT back to the ward staff. The RRT leader and the ward staff member accepting the patient should both sign on the contract to indicate successful completion of the huddle
5. Break – all team members return to current rostered activities with thanks from the facilitator or RRT leader

RRT User Perception Questionnaire

Dear Colleague,

You have been asked to complete this survey because you may have already activated a RRT call or may need to in the future as part of your role in the hospital.

It is important to hear the opinions of those who actually activate and attend RRT calls. If you have experienced issues with the RRT team or RRT service, please let us know. That way, improvements can be targeted to do the most good.

One area of interest to Lyell McEwin Hospital is the way that teams work together and the way in which they communicate, both within the team and to other colleagues. Many of the questions in the survey will address this.

This is a short survey and should take no more than 10 minutes to complete. Please provide an answer to each question. There is also an opportunity at the end of the survey for you to provide us with your thoughts and suggestions.

PLEASE NOTE:

This is an anonymous survey. You are not required to provide your name or any other identifying information. So feel free to be completely honest!

RRT CALL PROJECT TEAM

Usual Ward _____Designation or Role _____No. of years since grad._____

1	Over the past year, have you ever called a RRT CALL please circle	**Yes**	**No**
2	Over the past year, have you ever been involved in a RRT CALL please circle	**Yes**	**No**

IF THE ANSWER IS NO TO BOTH QUESTIONS PLEASE GO TO QUESTION 16
If either answer is yes start at question 3

	Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	When the RRT team Arrives					
3	The RRT team members introduce themselves					
4	It is clear who the Team Leader at RRT calls is.					
5	The RRT team invites me to state the reason for activating RRT					
6	The RRT team acknowledge my rationale for calling RRT					

	Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	During the RRT call					
7	The RRT team involve me in patient care during the RRT call					
8	I feel confident speaking to the team during RRT calls					
9	The RRT team communicates well with other staff					
10	I have witnessed conflicts during RRT calls					

	Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	At the completion of the RRT call					
11	The RRT team works together to develop a plan for the patient					
12	Ward staff are involved in the development of the plan for the patient					
13	When the patient remains on the ward there is a formal plan for the patients care					
14	When patients have remained on the ward after a RRT call, I have had to recall the RRT team back to see the same patient (Please Circle) **YES** **NO**					

If **YES** please circle why, and rank from most to least common (1 = most common, 7 least common)

	A No clear plan for the patient
	B Resus status or treatment limitation orders were not clarified
	C The reason for calling the previous RRT was not resolved
	D The patient still was still meeting standard RRT calling criteria
	E No contingency plan had been made in case that patient reached RRT criteria again
	F Home team not informed by RRT / unaware of patient remaining on the ward
	G Other - please explain _____- _____

	Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	General Questions about the RRT team / call					
16	When the patient remains on the ward at the end of a RRT call, there should be a documented plan for the patients care					
17	A handover between the RRT and ward staff should be held for patients remaining on the ward at the end of a RRT call					
18	I should be able to read and understand the plan formulated by the RRT team before they leave the ward					
19	I should feel empowered to ask questions about the plan before the RRT team leaves					
20	Poor communication results in recurrent RRT calls on the same patient					
21	The RRT team should only leave after all of the ward staff concerns have been addressed					

22	ISBAR should be the preferred format for clinical handovers.					
23	I am comfortable using ISBAR for handover					

	Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
24	If the RRT team leave without my concerns for the patient being resolved and another RRT is necessary for that patient, I would:					
	Call another RRT					
	Complain to the RRT team					
	Call the home team instead					
	Call the bed card consultant instead					
	Feel discouraged from calling another RRT on the same patient					
	Feel discouraged from calling RRT on other patients					

Do you have any other concerns / comments that would be helpful to improve communications with the RRT team

_____

_____

_____

APPENDIX G: RRT MEMBER QUESTIONNAIRE

RRT Member Perception Questionnaire

Dear Colleague,

You have been asked to complete this survey because you have been, or are currently, rostered to attend RRT calls as part of the Medical Emergency Team response.

It is important to hear the opinions of those who actually attend RRT calls. If you have noticed issues with the way that the RRT team or RRT service works, please let us know. That way, improvements can be targeted to do the most good.

One area of interest to Lyell McEwin Hospital is the way that teams work together and the way in which they communicate, both within the team and to other colleagues. Many of the questions in this survey will address this.

This is a short survey and should take no more than 10 minutes to complete. Please provide an answer to each question. There is also an opportunity at the end of the survey for you to provide us with your thoughts and suggestions.

PLEASE NOTE:

This is an anonymous survey. You are not required to provide your name or any other identifying information. So feel free to be completely honest!

RRT SERVICE PROJECT TEAM

What is your role or designation on the RRT team? (please circle)

ICU Registrar Medical Registrar Intern RRT Nurse Duty Nurse Coordinator

Number of years in clinical practice? …… Of these, how many at LMH? ……

Number of months or years on RRT? ……

	Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	Currently, when the RRT team arrives					
1	RRT Team members introduce themselves to ward staff					
2	It is obvious who is the team leader at RRT calls					
3	I understand my role as part of the RRT team					
4	I understand my responsibilities as part of the RRT team					
5	The Team Leader delegates roles appropriately					
6	I understand the roles of other members of the RRT call team					
7	I understand the responsibilities of other members of the RRT team					
8	The RRT team always receives a handover from the ward team					
	Question	**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
	Over the past year, my experiences during RRT calls are					
9	Other members of the RRT listen to and address my queries and concerns					
10	The RRT involves ward staff during development of the plan for patient care.					
9	The RRT team communicates well with other staff					
9a	Ward staff who call RRT are reluctant to be involved during RRT calls					
9b	Home teams are reluctant to be involved during RRT calls on their patients					
10	I have witnessed conflicts during calls					

	Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	At the completion of the RRT call					
12	A representative/ leader of RRT should handover to ward staff before leaving					
13	The ISBAR format is used for clinical handover by the RRT team to ward staff					
14	I am familiar with the ISBAR format for clinical handover					
15	The RRT team did not leave the ward until they have an agreed plan with the ward staff					
	Question	**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
	My perceptions about the RRT team					
16	Communication skills are important during RRT calls					
17	I feel confident using the ISBAR format for clinical handover					
18	The RRT team works well together regardless of how difficult the clinical situation is					
	Question	**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
	Please rate the following suggestions to help the RRT team improve performance:					
19	Meet at the start of a shift to introduce team members and establish the team leader and other team member roles					
20	Have a debrief at the conclusion of every RRT call					
21	Receive a handover from the previous shift RRT team					
23	Follow-up all RRT calls during a shift before the team goes off duty					
22	Hold regular hospital-wide audit for all patients attended by RRT					
23	Participate in team-work and communication skills training					
24	Participate in simulated RRT scenario training					

Do you have other suggestions that would help the RRT team improve their performance?

Thank you for your time. If you would like provide more feedback and are happy to be contacted, please provide a phone number or email address:

APPENDIX H: PUBLISHER PDFS OF PAPERS INCLUDED IN THIS THESIS

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INTERNAL MEDICINE JOURNAL

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REVIEW

Utility and assessment of non-technical skills for rapid response systems and medical emergency teams

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Key words
medical emergency team, rapid response system, crisis resource management, non-technical skills, quality improvement.

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Abstract

Efforts are ongoing to improve outcomes from cardiac arrest and medical emergencies. A promising quality improvement modality is use of non-technical skills (NTS) that aim to address human factors through improvements in performance of leadership, communication, situational awareness and decision-making. Originating in the airline industry, NTS training has been successfully introduced into anaesthesia, surgery, emergency medicine and other acute medical specialities. Some aspects of NTS have already achieved acceptance for cardiac arrest teams. Leadership skills are emphasised in advanced life support training and have shown favourable results when employed in simulated and clinical resuscitation scenarios. The application of NTS in medical emergency teams as part of a rapid response system attending medical emergencies is less certain; however, observations of simulations have also shown promise. This review highlights the potential benefits of NTS competency for cardiac arrest teams and, more importantly, medical emergency teams because of the diversity of clinical scenarios encountered. Discussion covers methods to assess and refine NTS and NTS training to optimise performance in the clinical environment. Increasing attention should be applied to yielding meaningful patient and organisational outcomes from use of NTS. Similarly, implementation of any training course should receive appropriate scrutiny to refine team and institutional performance.

Introduction

Clinical emergencies are a common occurrence in acute medicine and critical care. Resolution of such a 'crisis' hinges on expedited and targeted management. Federal Safety and Quality commissions in Australia and the United States currently endorse programmes targeting recognition of and response to deteriorating patients as a key initiative to improve hospital outcomes.[1,2]

The importance of leadership and teamwork is becoming increasingly recognised during the response to clinical emergencies.[3–5] Historically, teamwork has not been emphasised in resuscitation training.[6] However, European and American Resuscitation Guidelines now recommend inclusion of this and other 'non-technical' aspects in training to improve resuscitation outcomes.[7,8]

Non-technical skills (NTS) comprise a set of interpersonal and cognitive attributes that complement clinical skills and contribute to safe and efficient task performance.[9] Desirable leadership skills include clear instruction, delegation of tasks, inclusive decision-making and maintenance of situational awareness (i.e. remaining hands off so an overview can be maintained). Specific NTS required by constituent team members include productive communication and cooperation. Obstacles to effective employment of NTS include a lack of clear leadership, communication breakdowns or absence of a common purpose within the team.

The concept of NTS training emerged within the aviation industry when human error was recognised as a leading cause of avoidable incidents[9,10] and has since evolved from standalone seminars to become a fully integrated facet of flight crew training.[10,11] In this context, medicine is not that dissimilar from the aviation industry, and as such, NTS training is being increasingly embraced by acute healthcare specialities such as anaesthesia,[12] surgery,[13] obstetrics,[14] paediatrics,[15] trauma,[16] emergency medicine,[17] critical care,[18] and aeromedicine.[10]

Rapid response systems (RRS) are designed to detect and respond to the deteriorating hospital patient. Medical emergency teams (MET) are a key component of any

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RRS and are tasked to respond to clinical emergencies that involve a deteriorating patient. Their membership, even if team skill set is predefined, may vary and so may impose an additional obstacle to team bonding.[19,20] It is precisely for such scenarios that clear leadership with allocation of roles and responsibilities and active use of NTS by team members may prove to be important.

The objective of this review is to outline the application and utility of NTS and NTS training for MET, and to explore the avenues for evaluating NTS training.

Current use of NTS in resuscitation

The role of leadership in resuscitation scenarios was identified early during the institution of cardiac arrest teams.[21] More recently, emphasis has been placed on broader team-building skills.[19,22] Studies across established critical care and emergency response teams have identified a number of key desirable attitudes and behaviours including leadership, motivated team-working, bi-directional communication, inclusive decision-making and avoidance of conflict.[23–25]

There has been increasing attention devoted towards ascertaining the importance of NTS during resuscitation.[20,22,26] It is feasible that effective use of NTS will result in improved performance of clinical skills.[27] In select resuscitation scenarios, the appropriate management of clinical issues has been shown to correlate with team performance of NTS.[28,29] For example, a correlation between leadership skills and effectiveness of cardiopulmonary resuscitation, especially regarding timeliness of chest compressions and defibrillation, has been demonstrated;[21,23,30,31] as has a reduction in delays to initiation of resuscitative efforts, improved adherence to prescribed resuscitation algorithms and expedited team decision-making.[6,21,25,32]

Thus, the emerging consensus seems to be generally positive, and aspects of NTS have been integrated into accredited resuscitation training systems. The United Kingdom and Australian Resuscitation Council Advanced Life Support provider courses, for example, encourage development of leadership skills and emphasise team interactions to optimise resuscitation efforts.[33]

Assessing NTS

As more and more resources are allocated for NTS training, an important challenge will be to establish accurate and reliable measures so as to ascertain the 'value-added' impact of NTS training. If cardiac arrest and MET had a ubiquitous, consistent structure, training was standardised and investigator goals were homogeneous, a single assessment model could be used. However, differences do exist between service delivery and training needs as RRS are not uniform, even across centres within the same country,[34] and as such, there is a range of assessment measures used to evaluate NTS. These and the associated trials of NTS performance relevant to cardiac arrest teams and MET are summarised in Table 1. The breadth of assessment tools utilised thus far may reflect the relative novelty of NTS training for MET and cardiac arrest teams, hence why no clear 'gold standard' measure has yet emerged.

Objective observation

Direct evaluation of NTS by independent assessors originates from the commercial aviation industry that commissioned the NOTECHS system to permit assessment of pilots during line-orientated flight training.[35] Their four targeted areas of cooperation, leadership, situational awareness and decision-making formed the basis for development of the Anaesthetists NTS model.[36] Subsequently, many observational assessment tools have taken cues from these including NTS for Surgeons and the Observation Teamwork Assessment for Surgery in the theatre suite,[37,38] and Emergency Team Dynamics and the MedTEAMS programme in the emergency department.[21,39]

NTS assessment by objective observation relies on interrater reliability and expert validation. There is no defined standard for an 'expert' in NTS and thus reliance on a consensus approach. While many validation studies have specifically addressed interrater reliability and construct stability with generally positive results,[6,24,29,40,41] other authors have urged caution with the use of naïve assessors and suggest deployment of experienced evaluation groups.[42,43] Even with an apparently objective scoring system, investigators are prone to observer bias, such as leniency and the halo effect, with resultant difficulty in identifying areas in need of improvement.[44]

NTS assessment tools must be adapted to the individual characteristics of the service under scrutiny. An assessment method validated in one setting may not be generalisable to another, so establishment of a standardised international assessment system would be problematic. This crucial aspect, that one size does not fit all, was realised early on the evolution of crisis resource management (CRM) in the aviation industry because of differences in cultural and behavioural norms internationally.[45]

The toughest hurdle to assessing the impact of NTS is isolating its specific contribution to performance or indirect outcomes.[8,20,22] This is best evaluated with direct measures such as objective observations by external assessors trained to concentrate on NTS and ignore all other activities. The credibility of such measures depends

Table 1 Assessment tools of NTS and NTS training validated for evaluation of medical emergency or cardiac arrest teams

Tool name	Clinical field	Subjects	NTS domains	Scoring of NTS	Scoring of key clinical tasks
OSCAR[6]	Cardiac arrest	Proposal aimed at RRS	Communication, cooperation, coordination, leadership, monitoring	6-point scale (ineffective – effective)	Completed or not
Lighthouse Leadership (LBDQ)[21]	Cardiac arrest	Existing cardiac arrest team	Leadership	5-point scale (used never – always)	Completed or not
Modified LBDQ[23]	Cardiac arrest	Ad-hoc cardiac arrest team	Leadership	Competent or not-competent	Completed or not, time to complete
DeVita *et al*.[24]	Medical emergencies, including cardiac arrest	Existing team members of a RRS	Organisation, data transfer, communication	Not assessed	Completed or not, time to complete, manikin 'survival' or not
Teamwork Behavioural Rater[25]	Medical emergencies	Existing intensive care team	Leadership and team coordination, verbalising Situational information, mutual performance monitoring	7-point scale (undesirable – desirable behaviours)	Competent or not-competent
Wright *et al*.[27]	Medical emergencies	Ad-hoc team of medical students	Assertiveness, decision-making, situational awareness, leadership, communication	5-point scale (unskilled – skilled)	Completed or not
Ottowa Global Rating Scale[28]	Medical emergencies	Ad-hoc resident medical officer team	Leadership, problem solving, situational awareness, resource utilisation, communication	7-point Likert scale	Not assessed
Ottowa Checklist[29]	Medical emergencies	Ad-hoc resident medical officer team	Problem solving, situational awareness, resource utilisation, leadership, communication	3-point scale (not used – used)	Not assessed
Fernandez Castelao *et al*.[30]	Cardiac arrest	Ad-hoc cardiac arrest team	Leadership verbalisation, follower verbalisation	Competent or not competent	Completed or not, time to complete
LBDQ[31]	Cardiac arrest	Ad-hoc members of a cardiac arrest team	Leadership	5-point scale (used never – always)	Completed or not, time to complete
Marsch *et al*.[32]	Cardiac arrest	Ad-hoc intensivist and nurse team	Task distribution, information transfer, leadership behaviour, conflicts	Not assessed	Completed or not, competent or not-competent
MHPTS[40]	Medical emergencies	Ad-hoc resident and nurse team	Cooperation, communication, leadership, situational awareness, decision making	3-point scale (used never – consistently)	Not assessed
TEAM[41]	Medical emergencies	Proposal for existing MET	Leadership, teamwork, task management	5-point scale (used never – always)	Not assessed
CARDIOTEAM[45]	Cardiac arrest	Proposal aimed at RRS	Leadership, coordination, communication, re-evaluation, assertiveness, task management, situational awareness	Not assessed	Completed or not, time to complete

CARDIOTEAM, proprietary name for assessment tool; LBDQ, Leadership Behaviour Description Questionnaire; MHPTS, Mayo High Performance Team Score; OSCAR, Observational Skill-based Clinical Assessment tool for Resuscitation; TEAM, Team Emergency Assessment Measure.

on expert assessor groups, with a high interrater agreement, who can reliably evaluate usage of NTS and outcomes from NTS training.[6,41,46]

None of these measures has any specific advantage over another being designed for ease-of-use. Each tool typically comprises a proprietary multiple point scale rating team employment of key NTS (ranging from 'never' to 'always') with common aspects of NTS consistent among evaluated parameters. The number of potential scoring options varied between 3 and 7, with the former affording simplicity at the cost of a reduction in precision versus the latter.

Assessment in the simulated versus the clinical environment

Most existing, and proposed, assessment tools of NTS in RRS involve a simulated environment.[23–25,29] Advocates cite faithful reproduction of realistic emergencies, immersive simulation facilities and motivated facilitators as strong rationale for use of simulators.[14,39,47,48] They allow sufficient exposure to the realism of a medical emergency without risking patients and permit full control of the experience. Learning opportunities can be enhanced due to the ability to 'freeze time' and vary manikin response to team requirements. Despite general acceptance, concerns have been raised regarding the ability of simulation to replicate actual patient encounters because of the lack of real consequences and reliance on participant cooperation.[49]

While most aviation assessments are performed in simulators, impartial observation has been conducted during flights to ensure that NTS training is transferable into the 'real world'.[50] Despite logistical difficulties, observation of cardiac arrest teams at cardiac arrest attendance has similarly been achieved. The seminal 'Lighthouse Leadership' paper required the investigators to arrange an elaborate method of videotaping resuscitation efforts at cardiac arrest calls.[21] Barriers to this approach include the ethical issues associated with observation during cardiopulmonary resuscitation and the need for immediate availability of investigators.[20]

Team versus individual measures

Two approaches are available to assessors: score the overall conduct of the team or scrutinise performance on an individual level. Individual performance assessment is based on the premise that a team is only as strong as its component members. The Observational Skill-based Clinical Assessment Tool for Resuscitation (OSCAR) Investigators took a direct approach by evaluating performance of defined tasks by specific members of a multidisciplinary team.[6] Several other investigations have also taken this approach,[28,29] with some emphasising the importance of clear and decisive leadership.[21,23,30,31]

The alternative standpoint is that of assessing composite team performance. This is likely to be more important than individual level assessment as it is likely to be more relevant to clinical practice. Assessment tools such as Team Emergency Assessment Measure and others score human factors in a non-specific manner requiring coherence of skills performance among team members.[25,32,39,45] While this allows for a more holistic approach, it also presents the potential for one or more underperforming individuals to detract from an otherwise competent team performance.

Attitudes to NTS training

One of the more frequently employed techniques for assessing 'success' of NTS training is surveys for satisfaction with training and assimilation of themes. This has been used extensively in domains such as aviation,[51,52] anaesthesia,[53,54] emergency medicine,[55] paediatrics[15] and surgery.[56] The concept infers that user acceptance will increase retention and recall of training. Therefore, modern training courses make extensive use of educational psychology to improve the learning experience.[57] Surveys are also a useful mechanism to identify individuals less accepting of NTS principles, for whom further exploration of crisis management techniques may be desirable.[51]

Few surveys have evaluated attitudes to, and satisfaction with, NTS training for RRS. A retrospective mail-out questionnaire was presented to a multidisciplinary participant group who encountered medical emergencies in their clinical practice.[58] The majority reported positive experiences with training that aided confidence in dealing with subsequent emergency encounters.

Benchmarking NTS against clinical performance measures

NTS should not be regarded as an end-point per se. Instead, it is a mechanism that has the potential to augment clinical performance. The benefits would stem from improvements in interpersonal communication and expedited decision-making. Such outcomes have been supported by an observational study of simulated medical case scenarios.[27] Positive correlations were noted between the frequency and quality of NTS use, and accuracy of clinical assessment and management. These preliminary data have been further verified in resuscitation scenarios.[23,30] Similar findings reported that the delivery of NTS training improved efficiency of naïve cardiac

arrest teams. For example, significant reductions in delays and interruptions to chest compressions were noted even though the control groups had received additional cardiopulmonary resuscitation training.[30]

With the association established, two proposed models consider the performance of required tasks as an analogy for NTS. The OSCAR system evaluates individual clinical skill sets by defined members of a multidisciplinary resuscitation team as representative of communication and co-operation skills.[6] The CARDIOTEAM project has taken this a step further assigning a NTS principle to each step in the European Resuscitation Council algorithm.[45]

Therefore, assessment of clinical performance would seem to be a valuable mechanism of detecting any potential real-world benefit from NTS training. This also provides a reliable measure of NTS effectiveness by excluding the inherent subjectivity of team NTS performance observations.

Retention of NTS

Like any newly learnt skill, it is reasonable to assume atrophy of NTS over time. The retention of NTS has not been well studied, although some projects have conducted extensive prospective evaluation, most notably the MedTEAMS initiative that surveyed participant attitudes at 4 and 8 months post-training.[39] For cardiac arrest teams, a trial of leadership skills training has shown sustained improvements on repeat assessment conducted 4 months following initial training.[23] Tracking the retention of NTS, especially if standardised assessment methods are used, may be a possible mechanism to evaluate relative effectiveness of training programmes. It also contributes evidence to indicate the required frequency of NTS training so as to maintain optimal performance.

Organisational and cost–benefits of NTS

Efficient team working and a culture of openness should create flow-on effects through improved patient outcomes that can be detected by hospital performance indicators. For example, the MedTEAMs project precipitated a change in institutional culture, whereby increased team member cross-checking resulted in decreased rates of prescribing and therapeutic errors.[39]

The recent International Liaison Committee on Resuscitation guidelines specifies a number of RRS-associated outcome measures including cardiac arrest rates and mortality as indicative of a hospital's capacity to detect and respond to a deteriorating patient.[59] There is no requirement for these to be assessed in the context of NTS delivery. However it would be useful to do so based on the potential of NTS training to improve MET performance and thus positively influence clinically relevant hospital outcomes.

Cost–benefits may be another desirable result from implementing NTS training. However, studies exploring the economic benefits of NTS are few. The best data come from a small trial assessing the cost-effectiveness of a NTS training course for improving appropriate use of damage control surgery.[60] The authors found that the financial gains to the hospital more than covered the outlay for training.

NTS in the era of RRS and MET

A MET, in comparison with a cardiac arrest team, will encounter a range of medical emergency 'crises', in addition to cardiac arrests. This is because activation is based on not just the observation of a cardiac arrest occurrence but also observation of physiological triggers and staff concerns (the 'worried' trigger). They do so on the basis that early recognition and protocolised resuscitation may increase survival.[61] When called, MET deliver critical care type interventions during the majority of attendances, and the time spent attending patients who survive the call is approximately 30 min.[62]

Several trials have specifically assessed performance of NTS or the impact of NTS training in unexpected acute medical emergencies.[24,25,27–29] Trials that predominantly involved cardiac arrest teams have revealed results that were generally positive and linked enhanced manikin 'survival' with competency in NTS.[23,26,31,32] Results from simulated emergencies have consistently shown that employment of NTS improves time efficiency and is associated with expedited decision-making.[21,23,24] As MET, by comparison with a cardiac arrest team, attend increasingly diverse clinical scenarios, the potential benefits of a NTS-associated enhancement in performance may be even more valuable.[22]

However, thus far, only one trial has specifically examined NTS training in an established RRS.[24] A comprehensive package of online learning material and didactic tutorials was delivered before engagement in practice involving clinical emergency scenarios. These were reinforced by facilitated debrief sessions to encourage participants to achieve insight to NTS performance. The results were impressive with significant improvements in completion of clinical tasks and manikin 'survival'. This is notable because all participants had Advanced Life Support accreditation prior to undertaking the NTS training course, and this shows the value of NTS when added to an existing clinical skill set.

Several unanswered questions arise from this study, particularly regarding definition and allocation of specific roles and responsibilities for MET members. This extends beyond the establishment of a leader to recognise the benefits to operating efficiency if team members have defined tasks and targets.[6] Beyond this, a priori designation of member roles may further increase efficiency by eliminating the time currently devoted to team structuring on team arrival.

Within Australia, CRM courses that are specific to RRS are emerging.[63,64] Participants in such programmes often report a positive response to training; however, this may not necessarily translate into improved clinical outcomes.[50] As yet, there is no central governance and no national curriculum for any aspect of MET training.

NTS for RRS and MET

Based on the available information, it seems likely that NTS would be a useful skill set for MET, as it is already for other teams that are expected to encounter clinical emergencies. But before widespread endorsement can be realised, there are still outstanding issues to be addressed. Most importantly, the existing evidence base comes almost entirely from simulated scenarios and from outside the ward environment.

Despite this, experience and knowledge of NTS training appears to be sufficiently mature that we can reasonably proceed to investigate the potential benefits that may be achieved within the MET working environment. Further research should be conducted so as to assess whether this knowledge can be extrapolated to patient and organisational outcomes. Ideally, this should be undertaken through the conduct of real-time observational trials of MET performance on hospital wards during an acute patient encounter.[21]

Study of actual practice must be methodologically robust so that meaningful outcomes can be detected. This highlights the need to identify which NTS elements and training methods are most productive and the specific MET component behaviours that demonstrate proficiency in NTS within the ward environment. To do so will require further exploration of NTS, in the context of RRS, and the validation of assessment measures for the evaluation of NTS implementation.

This review proposes the utility of NTS and training for teams responding to clinical emergencies and the potential avenues for evaluation of such NTS. Further development and evaluation of NTS training systems will provide information that will enable optimal dissemination of NTS to RRS in the future. There is a broad range of methods available to do so, but it still remains to be determined how best to select from and utilise these methods.

Conclusions

NTS is a recognised skill set that augments clinical performance. NTS training has been successfully implemented in a number of medical disciplines with a generally favourable reception. Results from trials of team performance have been overwhelmingly positive. For resuscitation teams, training in leadership skills has been internationally endorsed and forms part of the syllabus for Advanced Life Support courses. However, for RRS and MET, which in contrast, attend a diverse range of medical emergencies beyond that of the established cardiac arrest, it is important that NTS training reflects that diversity and increasingly complex demands. Equally importantly, investigation must shadow such training so as to better guide the evolution of NTS training and the potential patient benefits that it may offer.

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Perceptions of interactions between staff members calling, and those responding to, rapid response team activations for patient deterioration*

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Abstract

Objectives. The aim of the present study was to investigate experiences of staff interactions and non-technical skills (NTS) at rapid response team (RRT) calls, and their association with repeat RRT calls.

Methods. Mixed-methods surveys were conducted of RRT members and staff who activate the RRT (RRT users) for their perceptions and attitudes regarding the use of NTS during RRT calls. Responses within the survey were recorded as Likert items, ranked data and free comments. The latter were coded into nodes relating to one of four NTS domains: leadership, communication, cooperation and planning.

Results. Two hundred and ninety-seven (32%) RRT users and 79 (73.8%) RRT members provided responses. Of the RRT user respondents, 76.5% had activated the RRT at some point. Deficits in NTS at RRT calls were revealed, with 36.9% of users not feeling involved during RRT calls and 24.7% of members perceiving that users were disinterested. Unresolved user clinical concerns, or persistence of RRT calling criteria, were reasons cited by 37.6% and 23%, respectively, of RRT users for reactivating an RRT to the same patient. Despite recollections of conflict at previous RRT calls, 92% of users would still reactivate the RRT. The most common theme in the free comments related to deficiencies in cooperation (52.9%), communication (28.6%) and leadership (14.3%).

Conclusions. This survey of RRT users and members revealed problems with RRT users' and members' interactions at the time of an RRT call. Both users and members considered NTS to be important, but lacking. These findings support NTS training for RRT members and users.

What is known about the topic? Previous surveying has related experiences of criticism and conflict between clinical staff at RRT activations. This leads to reluctance to call the RRT when indicated, with risks to patient safety, especially if subsequent RRT activation is necessary. Training in NTS has improved clinician interactions in simulated emergencies, but the exact role of NTS during RRT calls has not yet been established.

What does this paper add? The present survey examined experienced clinicians' perceptions of the use of NTS at RRT calls and the effect on subsequent calling. A key finding was a disparity between perceptions of how RRT members interact with those activating the RRT (RRT users) and their performance of NTS. This was reflected with unresolved RRT user clinical concern at the time of a call. In turn, this affected RRT users' attitudes and intentions to reactivate the RRT. Formal handover was considered desirable by both RRT users and members.

What are the implications for practitioners? The interface between the RRT and those who call the RRT is crucial. This survey shows that RRT users desire to be included in the management of the deteriorating patient and have their concerns

*This study has been registered with ClinicalTrials.gov (ID NCT01551160) and the Australian New Zealand Clinical Trials Registry (ID ACTRN12612000280808).

addressed before completion of RRT attendance. Failure to do so results in repeat activations to the same patient, with the potential for adverse patient outcomes. Training to include NTS, especially around handover, for RRT members may address this issue and should be explored further.

Additional keywords: crisis resource management, non-technical skills, rapid response system.

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Introduction

Rapid response systems (RRS) have become a staple component of hospital safety and quality. Their implementation has been ratified in Australia, Canada, the UK and the US.[1–4]

Despite inconsistencies in the evidence for RRS, clinicians remain strongly supportive.[5–6] Surveys have shown that clinicians believe that availability of a rapid response team (RRT) improves patient care, reduces clinician workload and acts as a safety net for deteriorating patients.[7–9] However, experiences of criticism for calling the RRT were also noted, leading to the reluctance of ward staff to activate the RRT,[7,8,10] as well as conflicts and miscommunication between RRT and ward staff.[9] Such interface issues pose risks to patient safety when clinical deterioration is not escalated or responded to appropriately.[11–13] When staff concerns or criteria for activation remain unresolved, reactivation of the RRT to the same patient is indicated.[14] Repeat RRT calling has been associated with increased patient risk.[14–17]

A potential solution is crisis resource management training for RRTs, which aims to increase competence, and the use of non-technical skills (NTS), such as leadership, communication, team working and decision making.[18–20] Clinicians undertaking NTS training have experienced benefits to work practices and team behaviours,[21–23] as well as the insight and self-reflective learning it provides.[24,25]

Therefore, a survey of staff who are part of an RRT and staff who activate the RRT was undertaken to ascertain experiences of RRT calls and patterns of repeat RRT calling. Specifically, perceptions were sought of NTS in shaping these interactions and how this may affect subsequent RRT calling.

Methods

Study design

Mixed-methods (quantitative and qualitative) surveying was conducted as part of the IMPACT (Impact of Non-technical Skills Training on Performance and Effectiveness of a Medical Emergency Team) project (ClinicalTrials.gov ID NCT01551160; Australian New Zealand Clinical Trials Registry ID ACTRN12612000280808), the aim of which was to implement an NTS training program and assess its effect on RRS performance.

Staff rostered to the RRT (RRT member) and staff likely to activate the RRT (RRT user) in response to acutely deteriorating patients were surveyed for attitudes and perceptions relating to team working and interdisciplinary culture based on their experiences of interactions during RRT calls.

A series of themed sections covered the periods of RRT activation, attendance and stand-down. Questions were designed to cover performance of four domains of NTS: leadership, communication, cooperation and planning. These included and expanded on Questions 7 and 12, from the survey tool devised by Jones *et al*.[7] relating to fear of criticism for activating the RRT.

Most responses were obtained on five-level Likert items. Similar questions were posed to each group so perceptions of NTS could be cross-checked to improve the credibility of analyses.

One question posed to RRT users asked respondents to rank reasons for having recalled the RRT to the same patient from a list of seven potential indications (e.g. ongoing breach of RRT calling criteria), where 1 = most common and 7 = least common.

An open section for free comments was included at the bottom of the questionnaire. This invited respondents to elaborate on any of their responses to questions in the survey or express any issues not covered by the questions.

Study setting

The study setting was the Lyell McEwin Hospital, a 300-bed university-affiliated tertiary metropolitan hospital located in Adelaide, South Australia, that has comprehensive medical, surgical and critical care services. The RRS afferent limb comprises protocolised physiological monitoring, with observations recorded on a pro forma chart. RRT calls are activated based on standardised criteria for patient vital signs and staff concerns.[1] The efferent limb is an RRT comprising an intensive care trainee, an intensive care nurse, a general medical trainee, an intern and the hospital coordinator.

Data collection

Surveying was performed as a snapshot over a 6-week period (May–June 2014), publicised via email and staff meetings, inviting all clinical staff to participate. Surveys were distributed as paper questionnaires and a SurveyMonkey version was linked to emails. Respondents were permitted to remain anonymous, but demographic data was requested regarding clinical working area, designation and number of years in practice.

Statistical analysis

Likert item data are described as frequencies and percentages. Dichotomous unpaired categorical data were cross-tabulated with a Pearson's Chi-squared test. Logistic regression analysis was used to compare dichotomous with interdependent continuous variables. Ranked data were analysed by a Friedman test. Responses within grouped questions were subjected to factor analysis (principal component analysis with Varimax rotation). Thereafter, Cronbach's α was calculated to assess internal consistency of the survey questionnaire. Comparisons of Likert item responses were assessed for normalcy visually with histograms and Q-Q plots and analysed with independent samples *t*-tests where this was confirmed.[26] Statistical analyses were conducted

using SPSS Version 22.0 (IBM SPSS Statistics for Windows, Armonk, NY, USA).

Qualitative data from comments were transcribed and stored as individual text files. These were coded independently by RC and AF into nodes relating to experiences of achievement, or not, in one of four accepted core NTS domains (leadership, communication, cooperation and planning)[18–20] or suggestions in those domains. Disagreements were resolved by consensus based on the core principles of NTS.[20] Content analysis explored frequency of referencing using NVivo Version 10 qualitative data analysis software (QSR International, Melbourne, Vic., Australia).

Ethical considerations

This study was approved by The Human Research Ethics Committee (TQEH/LMH/MH) as part of the IMPACT trial (Approval no. 2012069). Participation in the survey was entirely voluntary and consent was implicit by participants completing a response.

Results

Quantitative data from survey questions

RRT user demographics

From 929 eligible RRT users, 297 (32.0%) responses were received. Of these, 232 (78.1%) were from nurses, 2 (0.7%) from allied health personnel and 21 (7.1%) from medical officers; 42 (14.1%) declined to reveal their designation. The median clinical experience was 7 years (interquartile range (IQR) 3–18 years) in clinical practice.

RRT user experiences

Of the RRT user respondents, 221 of 289 (76.5%) had activated the hospital RRT at least once, with 229 of 283 (80.9%) present during RRT attendance. This included 161 of 255 (63.1%) who felt RRT involved them in management of the patient and 166 of 254 (65.4%) who felt confident to speak up. Identification of RRT roles seemed lacking, with only 70 of 257 (27.2%) agreeing that RRT members introduced themselves and 170 of 257 (66.1%) not being able to identify the team leader. Most RRT users (275/285; 94%) welcomed a formalised handover from the RRT when patients were to remain in their clinical area.

RRT member demographics

From 107 eligible RRT members, 79 (73.8%) responses were received. Of these 21 (26.6%) were from RRT nurses (45.7% of eligible), 21 (19.6%) were from medical registrars (100% of eligible), 10 (9.3%) were from intensive care registrars (100% of eligible) and 13 (12.1%) were from interns (56.5% of eligible); eight (7.5%) declined to indicate their designation. The median number of years of clinical experience on any clinical emergency team, including an RRT, was 3 years (IQR 1–6 years).

RRT member experiences

RRT members also identified issues, with 26 of 78 (33%) agreeing that the team did not routinely introduce themselves to ward staff. RRT internal team working fared better, with the majority of RRT members knowing the roles and responsibilities of others in the team (81.0% and 75.3%, respectively) and reporting satisfaction with internal RRT communication (78.2%). However, 18 (24.7%) and 17 (23.3%) of 79 RRT member respondents felt that ward staff and home teams, respectively, expressed little interest when their patients were the subject of an RRT call. Twenty-seven of 79 (34.2%) identified that they did not receive adequate handover from those activating the RRT.

The full results, expressed as percentage frequencies, are contained in Appendix 1 for RRT users and Appendix 2 for RRT members.

Multiple RRT calls

Of 220 RRT user respondents, 87 (39.5%) have recalled the RRT to the same patient. Of those reporting this outcome, nurses were more inclined to recall the RRT than medical officers (85/203 (41.9%) vs 2/17 (11.8%), respectively; $P = 0.02$). Logistic regression analysis showed that clinical experience did not have a significant effect on the likelihood of initiating a repeat RRT call ($P = 0.72$).

The reasons for making multiple RRT calls were ranked by RRT user respondents based on their experience. Ongoing breach of RRT physiological activation criteria was most commonly cited (mean rank 2.64), followed by the patient still meeting the 'worried' calling criterion (mean rank 3.07), lack of a clinical plan following the initial call (mean rank 3.4), no contingency plan for subsequent deterioration (mean rank 3.52), resuscitation status not established (mean rank 3.6) and attending team not consulted about RRT call (mean rank 5.36). The 'Other' response was the least common (mean rank 6.4), suggesting that the most important reasons were contained within the specific listed options. Overall, there was a significant difference between rankings (χ^2 51.27, $P < 0.01$). These data are presented in Table 1.

Of RRT user respondents, 54 of 204 (26.5%) felt discouraged from making a subsequent RRT call if the outcome of the prior RRT attendance had not addressed their original concerns. Thirty-five of 201 (17.4%) respondents stated that this would engender some reluctance to also call the RRT for other patients. Despite this, 257 of 278 (92%) respondents stated they were prepared to activate the RRT regardless of feelings of discomfort. These data are presented in Table 2.

Comparison data

Some questions were posed to both groups to elicit variances in perspectives on the same NTS domain. Almost half (43.6%) of RRT members felt they introduced themselves, whereas the same percentage (43.6%) of RRT users disagreed ($P < 0.01$). Although 69% of RRT members felt it was clear who the team leader was, ward staff seemed less certain, with only 33.9% agreeing ($P < 0.01$).

When it came to formulating a plan for patients remaining on the ward, the variations were greater, with 62 of 78 (79.5%) RRT members reporting that ward staff were involved in the process, compared with 96 of 253 (38.0%) RRT users ($P < 0.01$). Communication among RRT members correlated better, with 164 of 251 (65.3%) users and 61 of 78 (78.2%) RRT members indicating that it was effective ($P = 0.15$). Both RRT users and members had witnessed conflicts during an RRT call (30.7% and 41.0%, respectively; $P = 0.62$). Both groups showed good concordance

and agreement that a formal handover between RRT members and users was important (97.4% and 94.3%, respectively; $P = 0.56$). These data are summarised in Fig. 1.

Data validation

A four-factor analysis of the RRT user data confirmed congruence within the sections of the survey relating to the initiation of an RRT call, during RRT attendance and the following RRT departure, so these were clustered for internal consistency analysis. This was confirmed by Cronbach's α, with values of 0.775, 0.774 and 0.912, respectively.

Missing items

The RRT user survey provided for a potential 7425 individual data points, of which 1139 (15.3%) were unfilled. The median number of missing responses per question was 44 (IQR 14–57),

Table 1. Reasons for multiple rapid response team (RRT) calling
Data show the number of respondents in each group, with percentages in parentheses

Reason	Rank							Mean rank
	1	2	3	4	5	6	7	
No plan handed over	15 (16.7)	11 (12.2)	17 (18.9)	19 (21.1)	14 (15.6)	8 (8.9)	6 (6.7)	3.4
Resuscitation status not clarified	10 (11.6)	14 (16.3)	21 (24.4)	18 (20.9)	13 (15.1)	5 (5.8)	5 (5.8)	3.6
Prior calling reason not resolved	25 (27.5)	21 (23.1)	15 (16.5)	12 (13.2)	9 (9.9)	4 (4.4)	5 (5.5)	3.07
Standard RRT calling criteria still breached	42 (43.3)	19 (19.6)	18 (18.6)	6 (6.2)	2 (2.1)	6 (6.2)	4 (4.1)	2.64
No plan for subsequent deterioration	13 (14.3)	15 (16.5)	23 (25.3)	13 (14.3)	18 (19.8)	4 (4.4)	5 (5.5)	3.52
Home team unaware of RRT call	2 (2.5)	6 (7.4)	7 (8.6)	6 (7.4)	11 (13.6)	40 (49.4)	9 (11.1)	5.36
Other reason	3 (12.5)	0 (0.0)	0 (0.0)	0 (0.0)	2 (8.3)	1 (4.2)	18 (75.0)	6.4

Table 2. Outcome of rapid response team (RRT) not resolving the activating clinician's concerns
Data show the number of respondents in each group, with percentages in parentheses

Outcome	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Reactivate RRT to the same patient	5 (1.8)	2 (0.7)	14 (5.0)	100 (36.0)	157 (56.5)
Complain to the RRT	12 (5.9)	33 (16.3)	64 (31.7)	66 (32.7)	27 (13.4)
Call the home team instead	18 (8.9)	52 (25.6)	49 (24.1)	67 (33.0)	8.4 (17)
Notify the home team consultant	30 (15.4)	58 (29.7)	64 (32.8)	35 (17.9)	8 (4.1)
Feel discouraged from calling again on the same patient	59 (28.9)	58 (28.4)	33 (16.2)	42 (20.6)	12 (5.9)
Feel discouraged from calling on other patients	76 (37.8)	67 (33.3)	23 (11.4)	30 (14.9)	5 (2.5)

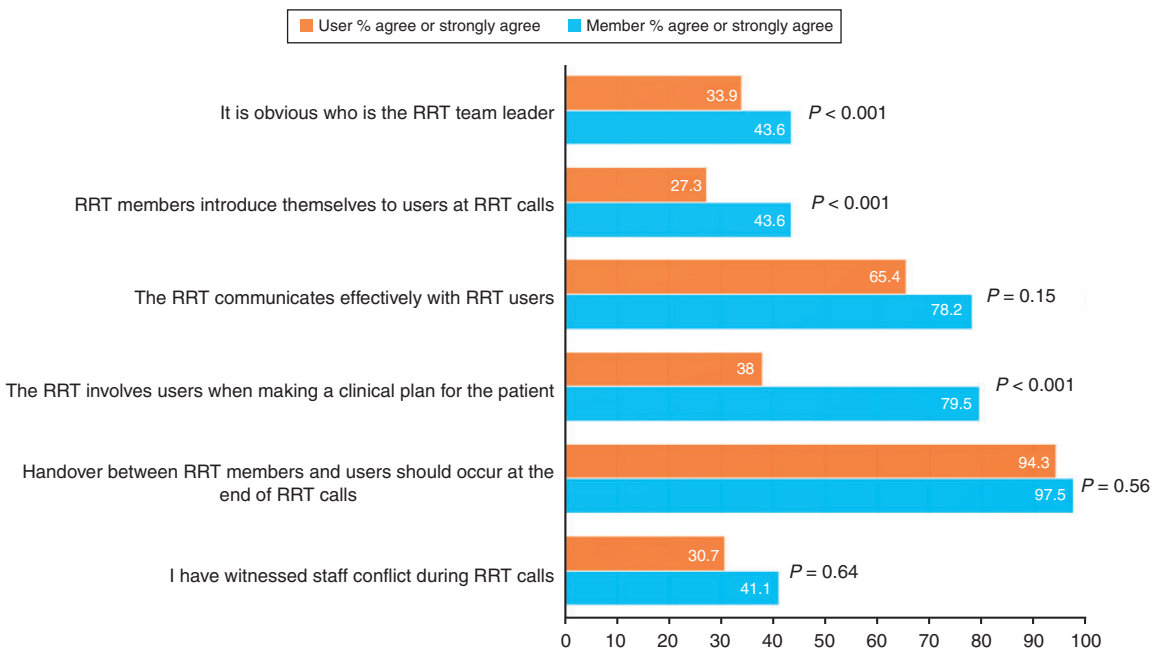

Fig. 1. Cross-comparison of question results. RRT, rapid response team.

with a minimum of 12 and a maximum of 102. In the RRT member survey, only 81 potential data points were not completed overall (3.7%). Some questions were answered by all respondents, and the maximum number of missing responses per question was 10 (median 1, IQR 0–7).

Qualitative data from free comments

RRT user comment content analysis

Comments were provided by 34 (11.4%) RRT users. From these, 60 sections of text were coded (median 1, IQR 1–3, per comment) into 68 nodes (median 2, IQR 1–3). Of these, 54 (79.4%) related prior experiences, whereas the remainder (14; 20.6%) expressed suggestions for improvements around RRT performance of NTS.

The most common user experience was of non-achievement of member-user cooperation (20; 37.0%), such as 'some [RRT] members. . .have been dismissive of nursing staff concerns about [the] patient'. This was followed by non-achievement of member-user communication (15; 27.8%), such as 'patient plans are often not discussed with the [ward] nursing staff', and non-achievement of plan development (12; 22.2%). Eight (23.5%) comments reported fear of criticism for calling; for example, '. . .there have been times that I have been apprehensive about calling [the RRT]'.

In all, there were five (9.3%) reports of NTS achievement, three (5.6%) for communication and two (3.7%) for cooperation.

RRT member comment content analysis

Fourteen (17.7%) RRT members provided comments. These contained 21 sections that were coded (median 1, IQR 1–2, per comment) into 24 nodes (median 2, IQR 1–2). These were mostly suggestions for NTS improvements (17; 70.8%). The most common suggestion related to cooperation between the RRT and RRT user (nine references; 52.9%), with requests for admitting team involvement, such as 'I believe that surgical patient [RRT calls] should be attended by a surgical registrar'.

Of the seven experiences referenced, four (57.1%) were for non-achievement of cooperation, two (28.6%) for non-achievement of communication and one (14.3%) for non-achievement of leadership, reporting experiencing '. . .team leaders brushing off other [RRT] members' opinions'.

There were no comments or parts thereof that could be coded to experiences of achievement of NTS.

Discussion

Summary of key findings

In surveying RRT users' and members' attitudes and perceptions, involvement of users during an RRT call was frequent and their experience was positive. However, there were negative issues and these related to RRT member identification, communication and handover. Both RRT users and team members reported having experienced an uncomfortable interaction during an RRT call. RRT users reported feeling distanced and not involved sufficiently in decision making by RRT members. In contrast, RRT members perceived RRT users to be disinterested at the time of an RRT call. Persistence of RRT activation criteria, a failure to negotiate and communicate a plan for subsequent patient deterioration, to address staff concerns, to ascertain resuscitation limits or to seek consensus with the admitting team were the most cited reasons for subsequent reactivation of the RRT.

Comparison with other studies

Multiple RRT calls to the same patient have been reported to occur in 10%–22.5% of all RRT-attended patients[14–17] and are associated with adverse patient outcomes.[14,16,17] The findings of the present study demonstrated that almost 40% of RRT users reported having triggered more than one RRT call to the same patient. Ongoing breaches of RRT calling criteria or patient safety concerns were cited as leading triggers to recall the RRT. The latter arose because of failures in the way RRT members and users interacted at the time of a call. There was strong agreement from both RRT members and users for the need for a structured and effective handover process.

The relationship between RRT members and users is one of complex codependency. Maintenance of good rapport is essential to optimise RRT calling and subsequent RRS performance. An inability to achieve this may lead to inefficient RRT activity because of unresolved clinical problems, risk to staff morale through dissatisfaction and conflicts, and potential for adverse patient outcomes.[11–13] The pressured working environment of clinical wards and the requirement to promptly recognise and respond to clinical deterioration[1] pose a threat to the RRT member–user relationship. The present study found that there was either a lack of, or inadequate, RRT user involvement in deciding upon patient care at the time of RRT attendance. This was associated with a negative effect on RRT users' impressions of the effectiveness of the RRT, and a discouragement from making a subsequent RRT call. Despite this, respondents still stated a willingness to reactivate the RRT.

Communication was perceived differently by RRT users and members. Communication among RRT members was viewed more effective than between RRT members and users. However, effective communication is a key tenet of NTS in the context of 'crisis resource management'.[14,15] Communication strategies streamline patient care delivery, improve the signal-to-noise ratio and provide error mitigation through cross-checking and increased situational awareness.[27,28] The fraught working environment of the RRT reinforces the need for effective communication.[29,30]

These findings are in keeping with previous survey results,[7–10] and suggest there is a need for quality improvement in the way the RRT interacts, both as a team and with their users. In particular, patterns of multiple RRT calls should be evaluated regarding how they may be affected by RRT user–member interactions, and strategies implemented to reduce their occurrence. Training in NTS, such as leadership, communication and team working, is supported by these findings and could address the negative patterns of RRT member and user interactions.[14,15,29,30] This, in turn, has the potential to reduce multiple calls to the same patient. NTS training has already proven its effectiveness within other acute clinical domains, including cardiac arrest teams, and thus should also benefit RRT.[14,15]

Strengths and weaknesses

Surveys such as that conducted in the present study have their limitations.[31] The response rate for RRT users was less than

one-third, and the findings may not be generalisable to all RRT users. Responders with strong feelings may bias the results, as may the proportion of missing data points because of incomplete responses. No inference was made regarding the reasons for these, but there is the risk of omitting useful data that may otherwise have altered the interpretation of our findings. A leading closed-question format was chosen to target specific study objectives. Although efficient in nature, such a method of questioning does lower validity to broader application.

Despite these potential weaknesses, the availability of a free text section provided the opportunity for respondents to voice individual opinion. The application of identical questions to both RRT users and members allowed for better insights as to the likely state of the RRT user–member interface. Because of the importance and potential significance of RRTs to patient safety, even a survey response rate of 32% from RRS users can still be considered sufficient to develop conclusions. However small, in using parallel member–user surveying to analyse the RRS, the present study is likely to be the first of its kind both nationally and internationally.

Conclusion

Effectiveness and quality of communication featured strongly for both RRT users and members with regard to how they interact at the time of an RRT call, in particular the importance of staff identification, professional conduct, engagement in clinical decision making and a formalised handover process. Where these were lacking, user satisfaction with RRT members was affected and had the potential to influence subsequent RRT calls, thus creating the potential for patient harm and organisational inefficiency. The findings of the present study support the need for quality improvement strategies that target RRT performance and the RRT member–user interface. NTS training may meet these needs, and requires future exploration.

Competing interests

None.

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Appendix 1. Rapid response team (RRT) user survey results

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	No. responses
RRT members introduce themselves	12%	32%	29%	22%	5%	257
It is clear who is the RRT team leader	7%	31%	28%	27%	7%	257
RRT invites me to state the reason for activation	1%	4%	8%	57%	30%	254
RRT acknowledges my rationale for activation	3%	10%	27%	48%	11%	254
RRT involve me during the call	2%	10%	25%	56%	7%	255
I feel confident speaking to RRT during calls	1%	12%	22%	50%	15%	254
RRT communicates well together	1%	6%	29%	54%	9%	249
I have witnessed conflict within RRT	9%	37%	23%	24%	7%	251
RRT works together to develop a plan	1%	7%	26%	58%	8%	251
RRT involves me in development of the plan	3%	19%	40%	34%	4%	253
At completion of RRT attendance, there is a plan	2%	11%	27%	53%	8%	253
At completion of a RRT attendance there should be a plan	2%	0%	1%	27%	70%	285
RRT should handover the plan before leaving	2%	0%	4%	27%	68%	282
I should be able to read and clarify the plan	2%	0%	1%	25%	72%	285
I should be able to ask RRT questions about the plan	2%	0%	5%	25%	69%	285
RRT should only leave after my concerns have been addressed	2%	0%	7%	35%	56%	285

Appendix 2. Rapid response team (RRT) member survey results

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	No. responses
RRT members introduce themselves	1%	32%	23%	33%	10%	78
It is clear who is the RRT team leader	1%	12%	18%	52%	17%	77
I understand my role on the RRT	0%	3%	10%	58%	29%	79
I understand my responsibilities on the RRT	0%	1%	4%	64%	31%	78
The team leader delegates roles	0%	5%	23%	48%	24%	79
I understand the roles of other RRT members	1%	1%	16%	59%	22%	79
I understand the responsibilities of other RRT members	1%	5%	18%	53%	22%	77
RRT receives a handover from those activating	5%	29%	32%	29%	5%	79
Other members of RRT address my concerns	0%	4%	19%	66%	11%	79
RRT involves calling staff in development of the plan	0%	3%	18%	68%	12%	78
RRT communicates well together	0%	4%	18%	69%	9%	78
Nursing staff are unwilling to be involved during RRT attendance	3%	45%	27%	22%	3%	73
Medical staff are unwilling to be involved during RRT attendance	8%	44%	25%	21%	3%	73
I have witnessed conflict within RRT	8%	32%	19%	37%	4%	78
RRT should handover the plan before leaving	0	0	3%	44%	54%	78
RRT should not leave without handing over	0%	0%	5%	38%	57%	79
Communication skills are important during RRT calls	0%	0%	0%	23%	77%	79

BMC Health Services Research

RESEARCH ARTICLE Open Access

Re-designing a rapid response system: effect on staff experiences and perceptions of rapid response team calls

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Abstract

Background: Rapid Response Team (RRT) calls are clinical crises. Clinical and time pressures can hinder effective liaison between staff who call the RRT ('users') and those responding as part of the RRT ('members'). Non-technical skills (NTS) training has been shown to improve communication and cooperation but requires time and financial resources that may not be available in acute care hospitals. Rapid Response System (RRS) re-design, aiming to promote use of NTS, may provide an alternative approach to improving interactions within RRTs and between members and users.

Methods: Re-design of an existing mature RRS was undertaken in a tertiary, metropolitan hospital incorporating the addition of: 1) regular RRT meetings 2) RRT role badges and 3) a structured member-to-user patient care responsibility "hand-off" process. To compare experiences and perceptions of calls, users and members were surveyed pre and post re-design.

Results: Post re-design there were improvements in members' understanding of RRT roles ($P = 0.03$) and responsibilities ($P < 0.01$), and recollection of introducing themselves to users ($P = 0.02$). For users, after the re-design, there were improvements in identification of the RRT leader ($P < 0.01$), and in the development of clinical plans for patients remaining on the ward at the end of an RRT call ($P < 0.01$). However, post-re-design, fewer users agreed that the structured hand-off was useful or that they should be involved in the process. Both members and users reported fewer experiences of conflict at RRT calls post-re-design (both $P < 0.01$).

Conclusion: The RRS re-design yielded improvements in interactions between members in RRTs and between RRT members and users. However, some unintended consequences arose, particularly around user satisfaction with the structured hand-off. These findings suggest that refinement and improvement of the RRS is possible, but should be an ongoing iterative effort, ideally supported by staff training.

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Keywords: Hospital rapid response team, Quality improvement, Interdisciplinary communication

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Background

The Rapid Response System (RRS) is an integral patient safety mechanism within acute hospitals. It incorporates the afferent limb: a recognition and alert process for clinical deterioration, and the efferent limb: a team-based response to achieve appropriate and timely patient management [1].

Staff for the afferent limb are typically ward clinicians under whose care patients are admitted. The efferent limb Rapid Response Team (RRT) comprises specialised clinicians from acute areas such as the Intensive Care Unit (ICU) [2]. Optimal functioning of the RRS depends on collegial liaison between staff from these two components – those that call the RRT ('users') and those rostered to the RRT ('members').

The clinical and time stressors of RRT calls can threaten the working relationship between users and members. An impaired interface between RRT members and users may hinder successful resolution of RRT calls [3, 4]. Unaddressed clinical deterioration and/or other patient wellbeing concerns may result in repeat activation of the RRT by the afferent limb. This potentially avoidable repeat calling has been associated with increased in-hospital mortality [5].

Key non-technical skills (NTS) domains, such as communication and cooperation, play a significant role during RRT member-user interactions [6, 7]. Effective use of these skills can be improved through delivery of NTS training to acute care clinicians [8–11]. Unfortunately, education programs require considerable time, logistic and financial resources to be effective, and thus are not always feasible to deliver to frontline hospital staff.

Given these constraints, an alternative approach is to incorporate design elements into the RRS that would promote effective communication and cooperation within the RRS without the need for dedicated training [7, 12, 13]. Previous studies with similar objectives have reported modification of individual aspects of the RRS, albeit without detailed investigation of their effects on system performance [6, 14–19]. Therefore, the present study was conducted to describe and assess a multi-faceted re-design of an RRS which aimed to improve the quality of RRT member-member and member-user communication and cooperation.

Methods

A pre-post survey was conducted as part of the *Impact of Non-Technical Skills on Performance and Effectiveness of a Medical Emergency Team* project (ClinicalTrials.gov: NCT01551160 – a diagram showing the structure of the overall project and the position of this study within it is shown in Fig. 1), comparing clinical staff experiences and perceptions of RRT calls before and after the re-design of a hospital RRS.

Staff at a tertiary, university-affiliated hospital were eligible for inclusion if working in a clinical role during the study. Participants were divided into two groups, RRT members and RRT users.

The RRS re-design

Incident reports and focus groups conducted at the investigating hospital prior to commencement of the project had highlighted issues around the quality of communication and cooperation during RRT calls, both at the member-user interface and within the RRT.

Insufficient financial and human resources were available at the investigating hospital to deliver an NTS training program for RRS staff. Therefore, a multi-faceted re-design of the existing mature RRS was undertaken instead, incorporating themes from the TeamSTEPPS® program and previously reported RRS improvement initiatives, to promote use of NTS without the need for training [14, 17, 19, 20].

The objectives of the re-design were to encourage a better understanding of roles and responsibilities amongst RRT members, improve identification of those roles to afferent limb staff, and enhance communication both within the RRT and at the interface between team members and users.

The re-design incorporated three components:

1. Regular RRT meetings
2. Badges identifying RRT members' roles

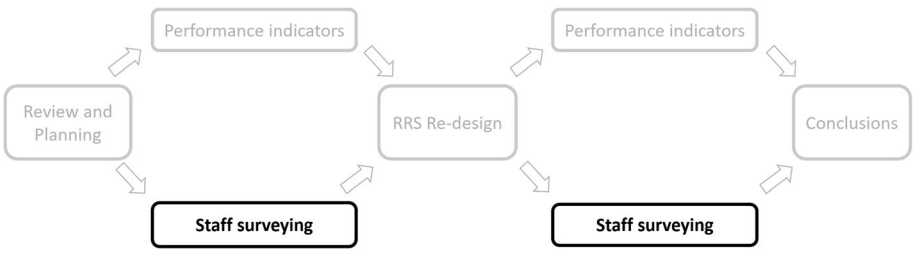

Fig. 1 Components of the RRS re-design project. Pre and post re-design hospital staff surveying, as compared in this study, is highlighted. RRS = Rapid Response System

3. A structured "hand-off" procedure from RRT members to users for patients remaining on the ward at the end of a call

The relationship of the primary and secondary drivers of these three re-design components are presented in Fig. 2.

Regular RRT meetings

The shift-by-shift changeover in RRT staffing was identified as a possible barrier to efficiency [2, 6, 7], since time spent at calls establishing RRT members' roles and capabilities may delay assessment and resuscitation of patients. Therefore, regular "ice breaker" meetings for RRT staff were implemented [17].

Meetings for RRT staff were scheduled twice daily, to coincide with staff changeovers between day and night shifts, so each team could convene before attending their first call. These meetings, typically lasting around 5 minutes, permitted members' introductions, and establishment of roles and initial responsibilities when attending calls, especially those of the team leader (see Additional file 1) [6, 7, 17, 20].

Team role badges

Feedback from ward staff prior to the re-design suggested that RRT users frequently had difficulty ascertaining RRT membership and roles amongst clinical staff present at calls, with the team leader position particularly challenging to identify. Therefore, RRT role badges were included as part of the re-design to convey member designations to users (Team Leader – usually an ICU resident, RRT Nurse, Medicine Resident, Intern and Hospital Manager) [18].

Badges were distributed during the regular RRT meetings, with members required to wear them conspicuously during calls to ensure that RRT users and other staff could easily identify each member of the team, and their roles, at calls.

RRT members-to-users" hand-off" procedure

Prior to an RRT call, each patient's ward team have responsibility for leading care and clinical decision-making. During a call, this authority is temporarily adopted by the RRT to expedite management of the clinical crisis. However, if the patient is to remain on the ward at the end of their call, this clinical responsibility must be re-assumed by ward staff. Successful completion of the RRT call requires that this transfer of care is not only acknowledged by those on both sides of the member-user interface but is also appropriate. Most importantly, this needs careful consideration regarding whether the patient's ongoing management needs can be safely and effectively delivered by that ward team [19, 20].

Staff feedback prior to the redesign, and our previous research [3], suggested that unresolved clinical concern at the end of calls was common, resulting in staff unease and, hence, repeat RRT calls. Ensuring resolution of RRT user concern is important as up to 18% of calls prior to the re-design were for the "worried" criterion rather than a predefined physiological trigger [5].

Therefore, a structured verbal and written" hand-off" protocol was enacted when patients were to remain on their ward after a RRT call. (see Additional file 2). This included the requirement of a signature from a representative of the ward team re-assuming care responsibility to permit stand-down of the RRT, with the intention of encouraging users to voice any ongoing or unresolved clinical concerns before the RRT departed from the call.

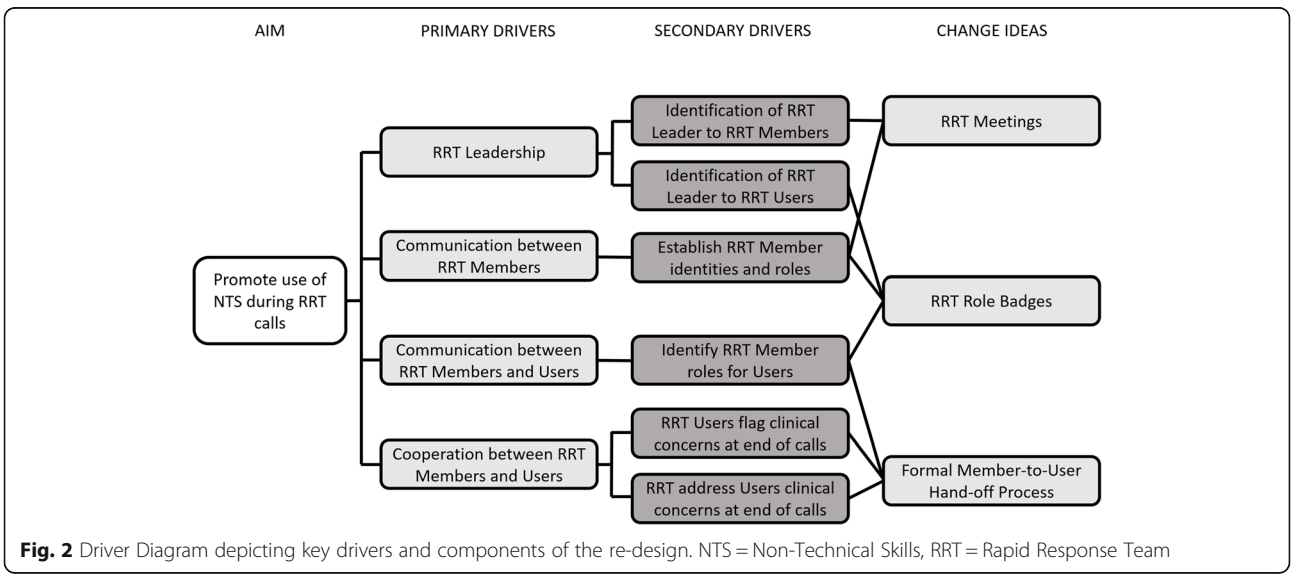

Fig. 2 Driver Diagram depicting key drivers and components of the re-design. NTS = Non-Technical Skills, RRT = Rapid Response Team

Study phases and survey instrument

The Phase 1 (pre) survey was carried out, following which the RRS re-design, described above, was implemented. One year later, the Phase 2 (post) survey was conducted.

For all survey questions, respondents were asked to recall their experiences and perceptions over the previous 12 months. Therefore, responses for each phase refer to the year preceding the completion of the survey instrument.

Two questionnaires were used: one for RRT members, the other for RRT users, relating to experiences of RRT calls and opinions on the member-user interface (see Additional files 3 and 4). Each group completed a different survey instrument, but the same questionnaire (within group) was repeated in Phase 1 and Phase 2 of the study.

Data analysis

The effect of the re-design on experiences and perceptions was assessed by comparing Phase 1 and Phase 2 responses. No personal identifiers were collected in the questionnaires to ensure anonymity, so it was not possible to ascertain whether respondents had contributed data to both study phases. As a result, all quantitative data were considered unpaired.

For respondent characteristics, categorical variables are presented as frequencies and percentages and continuous variables are summarised with medians with interquartile ranges (IQRs). Between phase comparisons were conducted by Chi-square tests of association for categorical variables and Mann-Whitney U-tests for continuous variables.

For questionnaire items with Likert scale responses, data were re-coded into binary variables (strongly agree or agree, all other responses). Comparisons of the proportion of agree responses between the study phases for each question were assessed by Z-tests, and results reported as differences in proportions for Phase 2 − Phase 1 (δ2–1), with 95% confidence intervals (95% CI).

Statistical analyses were conducted with SPSS (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp). A P value of 0.05 or less was considered statistically significant. No correction for multiple comparisons was made due to the exploratory nature of the study.

Free-text comments from the Phase 2 questionnaire were reviewed and coded if they referred to the RRS re-design. Comments were further categorised into positive (e.g. reporting improvements from the re-design), negative (e.g. identifying problems with the re-design) or suggestions for refinement or improvement. These results are summarised as frequencies.

Results

RRT members

There were 79 respondents in Phase 1 and 61 in Phase 2. RRT member roles were similarly represented in each phase except for internal medicine trainees (21 of 79 (26.6%) in Phase 1 vs 4 of 61 (6.6%) in Phase 2, $P = 0.06$). The median number of years of experience as an RRT member was 3 years [IQR 1–6] for Phase 1 respondents versus 2 years [IQR 0.69–5.75] in Phase 2 ($P = 0.80$).

A summary of all RRT members' questionnaire responses, showing comparisons between Phase 2 and Phase 1, is provided in Table 1. Relative to Phase 1, there was a higher proportion of agree responses in Phase 2 regarding whether the RRT members introduced themselves to users (δ_{2-1} 0.19 [95%CI 0.03–0.36] $P = 0.02$), and understood other team members' roles (δ_{2-1} 0.12 [95%CI 0.01–0.24] $P = 0.03$) and responsibilities (δ_{2-1} 0.22 [95%CI 0.09–0.34] $P < 0.01$).

Fewer respondents in Phase 2 had witnessed conflicts between staff at RRT calls over the previous year than respondents at Phase 1 (δ_{2-1}-0.26 [95%CI -0.41 – -0.11] $P < 0.01$).

For all other questions, the differences in proportions of participants who agreed or strongly agreed (versus not) were not statistically significant between study phases.

RRT users

There were 297 RRT user respondents in Phase 1 and 302 respondents in Phase 2. RRT user clinical disciplines (e.g. doctor, nurse, allied health clinician) were similarly represented in each phase ($P = 0.11$). The number of years of clinical practice reported by participants was also similar in the two phases.

Similar proportions of respondents had called an RRT in the 12 months prior to each survey (74.4% in Phase 1 vs 77.2% in Phase 2, $P = 0.57$), but more respondents had been directly involved in RRT calls prior to Phase 2 than Phase 1 (86.1% vs 77.1%, $P = 0.02$).

As detailed in Table 2, a higher proportion of respondents in Phase 2 agreed that the RRT leader's identity was obvious to users (δ_{2-1} 0.21 [95%CI 0.12–0.29] $P <$ 0.01) and felt more confident speaking up during RRT calls (δ_{2-1} 0.09 [95%CI 0.01–0.17] $P = 0.03$), relative to respondents in Phase 1.

Furthermore, a higher proportion of respondents at Phase 2 agreed that the RRT developed a clear clinical plan at calls (δ_{2-1} 0.11 [95%CI 0.04–0.19]), involved ward staff in the formulation of those plans (δ_{2-1} 0.16 [95%CI 0.07–0.24]) and ensured that a plan was in place before leaving patients on wards at the end of calls (δ_{2-1} 0.10 [95%CI 0.02–0.19]), all $P < 0.01$.

Table 1 Members' experiences and perceptions of RRT calls

	Phase 1 N (%) of agree responses	Phase 2 N (%) of agree responses	Differences in Proportions [95%CI]	*P* Value
RRT members introduce themselves to ward staff	34 (43.0%)	38 (62.3%)	0.19 [0.03 – 0.36]	0.02
It is obvious who is the Team Leader at RRT calls	53 (67.1%)	47 (77.0%)	0.10 [-0.05 – 0.25]	0.20
I understand my role as part of the RRT	69 (87.3%)	59 (96.7%)	0.09 [0.00 – 0.19]	0.05
I understand my responsibilities as part of the RRT	74 (93.7%)	60 (98.4%)	0.05 [-0.02 – 0.11]	0.17
The Team Leader delegates roles appropriately	57 (72.2%)	51 (83.6%)	0.11 [-0.03 – 0.25]	0.11
I understand the roles of other members of the RRT	64 (81.0%)	57 (93.4%)	0.12 [0.01 – 0.24]	0.03
I understand the responsibilities of other members of the RRT	58 (73.4%)	58 (95.1%)	0.22 [0.09 – 0.34]	<0.01
The RRT team always receives a handover from the ward team	27 (34.2%)	31 (50.8%)	0.17 [0.00 – 0.33]	0.05
Other members of the RRT listen to and address my queries and concerns	61 (77.2%)	54 (88.5%)	0.11 [-0.1 – 0.24]	0.08
The RRT involves ward staff in development of the clinical plan	62 (78.5%)	53 (86.9%)	0.08 [-0.04 – 0.21]	0.20
The RRT communicates well with other staff	61 (77.2%)	50 (82.0%)	0.05 [-0.09 – 0.18]	0.49
Ward staff who call the RRT are reluctant to be involved during calls	18 (22.8%)	12 (19.7%)	-0.03 [-0.17 – 0.11]	0.66
Attending teams are reluctant to be involved during calls on their patients	17 (21.5%)	16 (26.2%)	0.05 [-0.09 – 0.19]	0.51
I have witnessed conflicts during RRT calls	32 (40.5%)	9 (14.8%)	-0.26 [-0.41 – -0.11]	<0.01
The RRT should handover to ward staff before leaving	76 (96.2%)	55 (90.2%)	-0.06 [-0.14 – 0.02]	0.15
The RRT should not leave until they have an agreed plan with ward staff	75 (94.9%)	53 (86.9%)	-0.08 [-0.17 – 0.01]	0.09
Communication skills are important during RRT calls	79 (100%)	60 (98.4%)	-0.02 [-0.04 – 0.01]	0.25
The RRT works well together	68 (86.1%)	53 (86.9%)	0.01 [-0.11 – 0.12]	0.89

RRT Rapid Response Team

Experiences of witnessing conflicts between staff at RRT calls were reported less frequently in Phase 2 than Phase 1 (δ_{2-1} -0.14 [– 0.21 – -0.07] $P < 0.01$).

Relative to Phase 1, fewer respondents in Phase 2 agreed that RRT plans should be documented, that ward staff should be invited to read these plans and that their consent should be sought before team departure (δ_{2-1} -0.24 [95%CI -0.30 – – 0.18], – 0.30 [95%CI -0.36 – – 0.23] and – 0.34 [95%CI -0.41 – – 0.27] respectively, all $P < 0.01$).

The proportion of respondents who re-called the RRT to the same patient decreased from 33.3% in Phase 1 to 27.2% in Phase 2, but the difference was not statistically significant ($P = 0.09$). In both study phases, the two most commonly cited reasons were ongoing breaches of calling criteria and unresolved clinical concern that triggered the initial call.

Phase 2 qualitative data

RRT members

Free-text comments were provided by 25 (41.0%) respondents. A total of 19 comments referred to the RRS re-design or its components.

Regarding the RRT meetings, there were five negative comments (e.g. "some [members] don't always come") and one suggestion ("have a board of [RRT] staff names and pictures"). For the team role badges there were two negative comments ("not all staff wear them") and two suggestions for having "stickers rather than badges". The handovers had two positive comments (e.g. "the contract [handover] is very good") and one negative comment ("too much paperwork").

There were three comments pertaining to the overall RRS re-design. Two specifically cited the re-design as having had a positive effect on the RRS (e.g. "communication skills have improved"), whereas the other reported the opposite ("very little [ward] team involvement").

RRT users

Free-text responses were provided by 56 (18.5%) users, with 48 comments relating to aspects of the RRS re-design.

The RRT role badges received three positive comments (e.g. "badges make [RRT member] identification easier") and four negative ones (e.g. "team leader does not introduce other [RRT] members"). The handovers had three positive comments (e.g. "they leave everyone

Table 2 Users' experiences and perceptions of RRT calls

	Phase 1 N (%) of agree responses	Phase 2 N (%) of agree responses	Differences in Proportions [95%CI]	*P* Value
RRT members introduce themselves to ward staff	70 (27.2%)	89 (32.1%)	0.05 [-0.03 – 0.13]	0.22
It is obvious who is the Team Leader at RRT calls	87 (33.9%)	151 (54.5%)	0.21 [0.12 – 0.29]	<0.01
The RRT invites me to state the reason for calling	219 (86.2%)	244 (89.4%)	0.03 [-0.02 – 0.09]	0.27
The RRT acknowledge my rationale for calling	152 (59.8%)	185 (67.8%)	0.08 [0.00 – 0.16]	0.06
The RRT team involve me in patient care during the call	161 (63.1%)	193 (70.2%)	0.07 [-0.01 – 0.15]	0.09
I feel confident speaking to the RRT during calls	166 (65.4%)	204 (74.2%)	0.09 [0.01 – 0.17]	0.03
The RRT communicates well with other staff	157 (63.1%)	191 (70.0%)	0.07 [-0.01 – 0.15]	0.09
I have witnessed conflicts during RRT calls	77 (30.7%)	45 (16.6%)	-0.14 [-0.21 – -0.07]	<0.01
When the patient remains on the ward there is a patient care plan	152 (60.1%)	186 (70.5%)	0.10 [0.02 – 0.19]	<0.01
The RRT team works together to develop a plan for the patient	164 (65.3%)	208 (76.8%)	0.11 [0.04 – 0.19]	<0.01
The RRT involves ward staff in development of the clinical plan	96 (37.9%)	147 (53.8%)	0.16 [0.07 – 0.24]	<0.01
The RRT should not leave until ward staff agree with their plan	261 (91.6%)	160 (58.2%)	-0.33 [-0.41 – -0.26]	<0.01
The RRT should document the clinical plan before leaving	275 (96.5%)	201 (72.8%)	-0.24 [-0.30 – -0.18]	<0.01
The RRT should handover to ward staff before leaving	266 (94.3%)	179 (64.6%)	-0.30 [-0.36 – -0.23]	<0.01
I should be able to read and understand the plan	276 (96.8%)	185 (67.0%)	-0.30 [-0.36 – -0.23]	<0.01
I should feel empowered to ask questions about the plan	267 (93.7%)	163 (59.3%)	-0.34 [-0.41 – -0.27]	<0.01
Poor communication results in recurrent RRT calls	233 (82.0%)	43 (15.8%)	-0.66 [-0.75 – -0.58]	<0.01

RRT Rapid Response Team

on the same page"), eight negative comments (e.g. "feel pressured to accept RRT plan") and four suggestions for improvement (e.g. "handover directly to patient care nurse").

Twelve user comments praised existing aspects of the re-design for improving interactions with the RRT (e.g. "better attitude and communication"). However, another 12 comments indicated further room for improvement (e.g. "no appreciation that calling is protocolised").

Discussion

Key findings

This study demonstrated improvements in RRT member and user experiences during calls after implementation of a quality improvement re-design of the RRS aimed to facilitate enhanced communication and cooperation.

In particular, both members and users reported a significant decrease in their perceived incidence of conflicts between staff at RRT calls, and a trend towards fewer reports of users having needed to recall the RRT to the same patient, following the RRS re-design.

Despite these positive findings, some aspects of the re-design were less successful. The configuration of the structured hand-off process especially seems to have been problematic.

Components of the RRS re-design

RRT meetings

Improvements in RRT members' identification of their team leader and understanding of their own and others' responsibilities suggest that meetings assisted the RRT to establish individual duties prior to attending calls. It is also plausible that patients benefited from resultant expedited management of deterioration due to RRT role allocations having been established prior to attendance, rather than consuming valuable time during calls [6, 17].

Despite the potential benefits of meetings, there were some logistical hurdles. Nurses' and doctors' shift changeovers did not always coincide, meaning that occasionally teams would attend calls with members who had not participated in the most recent meeting. Similarly, when rostered RRT staff were on breaks, their substitutes would respond to calls having not attended a meeting.

Member role badges

There was an increase in users' identification of the RRT leader and members' recognition of each person's role within the team. These suggest that the badges helped to convey RRT member roles, thereby reducing users' perceptions of infrequent RRT member verbal introductions to other staff present at calls.

Benefits in efficiency and effectiveness of the management of simulated patient deterioration have been demonstrated when team leaders are easily identifiable [6, 7, 21–23]. However, the contribution of the badges is reliant on them being worn. One RRT member noted that "not all staff wear them" during calls. Some members may have disliked having their designation prominently displayed or inadvertently misplaced their badges.

Structured hand-off

The transition of care is fraught with potential risk [24–26]. Amongst these, the need to ensure continuity of clinical responsibility is essential to prevent omissions of, or delays to, decision-making. Commonly used tools for patient handover prompt communication of clinical detail, but do not necessarily prompt users to consider logistics around the transfer of responsibility between teams [25]. Furthermore, handover often does not mandate acknowledgement, documentation or dissemination of the individual or team taking over responsibility [27, 28].

Data before the redesign showed that almost a fifth of all RRT calls to patients were for staff concern [5]. These patients had an in-hospital mortality rate of just over 8 %, in comparison to a national median of less than 1 % for hospital separations [29], despite the absence of a physiological calling criterion being reached. From this it can be inferred that clinician gestalt and intuition should still be taken seriously, even when observations appear to be within normal ranges.

Therefore, the hand-off component of the re-design was carefully constructed and advertised to RRT members and users to encourage the latter group to escalate their concerns, even to the point of delaying completion of the call until satisfied with clinical outcome for the patient. When the transfer of care was by consensus, the hand-off process ensured clear documentation of the clinical team assuming responsibility for that patient's care beyond the end of the RRT call.

However, this seems to have been the least successful component of the re-design. User responses indicated that some hand-offs were unsatisfactory, took too long, or that users still felt obliged to accept the RRT's plan despite having unresolved concerns about patient welfare. This latter aspect suggests that some undesirable practices persisted, contrary to the ethos underpinning the re-design.

Interestingly, in Phase 1, RRT users were overwhelmingly in favour of a (re-designed) structured hand-off process [3]. While users apparently support the concept of a formalised transfer of clinical responsibility [19], some aspects of the process implemented in this study did not appear to meet the needs of Phase 2 respondents. It seems likely that modification of a communication procedure may not, alone, be sufficient and that wider organisational cultural change is needed [25].

There were indications that the re-designed hand-off process led to some improvements during member-user interactions. There was a significant increase in respondent agreement that users were involved in devising clinical plans for patients and that these plans were more thoroughly explained to them by the RRT.

Overall

The most striking findings were the proportionally large, and statistically significant, reductions in both users' and members' perceptions of inter-personnel conflicts at calls. Given the overarching purpose of the re-design was to optimise liaison and teamwork between users and members, these results reassure that the RRS, as a whole, matured to focus on cooperative patient care.

Strengths and limitations

To the best of the authors' knowledge, this is the first study to develop and assess a multi-faceted RRS re-design specifically aiming to improve communication and cooperation without the need for NTS training.

The findings from this study should be interpreted with caveats. First, the study did not collect personal identifiers so data could not be analysed to assess intra-individual change. The incentive to participate afforded by anonymity was viewed as more important than the direct comparison of change within individuals. Second, collapsing of Likert scale variables reduced granular information but enabled analysis by proportions of agreement which was important for reporting and interpretation of findings.

Finally, it is recognised that assessment of the effectiveness of handovers or interventions to modify them have been identified as difficult to clearly elicit [30, 31]. In this study of a multi-faceted quality improvement initiative, pragmatic methodology was employed due to a lack of available resources to conduct comprehensive qualitative data collection. Instead, surrogates of staff satisfaction with interactions during calls, such as perceptions of conflicts or needing to recall the RRT, were included as indicators of the broader effect of the initiative on communication and cooperation amongst members and users. More nuanced insights might have been achieved with qualitative data collected through personal interviews or focus groups and subsequent analyses [32], but this was beyond the scope of the present study.

Lessons for the future

Modifying existing components

The improvement of the investigating hospital's RRS was always anticipated to be an evolving project, of which

the design components implemented in this study were one part. In that regard, the evaluation of the re-design has provided useful information about the overall quality improvement process.

The RRT meetings in Phase 2 were reasonably successful. However, since not all members were always able to attend, where possible, a backup option is required. For instance, RRT rosters populated with personnel names, pictures and roles, could be made accessible through hospital intranet websites for those members unable to attend meetings. If resources allowed, this content could be hosted through a mobile app for ease of access by busy clinicians.

The badges also seem to have met their intended purpose, but they are easily misplaced and relatively expensive to replace. Stickers are logical substitutes that can be cheaply printed in bulk and adhered to clothing.

Stickers could also be created for RRT user roles and, along with RRT member stickers, be kept on RRT trolleys for easy access at calls. It is standard practice in Emergency Department resuscitation rooms that roles of all staff are clearly designated during trauma calls, so this should be easily extrapolated to deteriorating patient cases of the RRS.

The structured hand-off process was less successful than intended. Given users' perceptions of inconvenience, it may be reasonable to make it conditional rather than mandatory. Some RRT calls for simple, self-limiting problems (e.g. a vaso-vagal episode) could be easily flagged as not requiring detailed acknowledgement of resumption of patient responsibility by ward staff. By reserving the structured hand-off process for more complex cases, the true value in ensuring resolution of users' clinical concern may be realised.

Furthermore, the hand-off proforma assessed in this study included sections for clinical detail and plans. To prioritise its intended function, the proforma could be streamlined to simply record the acknowledgement by, as well as key contact details for, the specific clinical team taking over responsibility for patient care after RRT completion. This could focus all involved clinicians during the member-to-user communication on the importance of continuity of patient care, and further prevent the need for imminent RRT re-activation [3, 5].

Need for training

Re-design of RRS structures and procedures can only achieve so much. Ultimately, a comprehensive initiative to improve RRT member and user communication and cooperation would require dedicated training, reinforced by refresher sessions [6–13]. The NTS required by teams involved in the care of deteriorating patients cannot be assumed or innately acquired. Thus, any RRS quality improvements initiatives should ideally include the provision of a "crisis resource management" multidisciplinary training programme for all RRT members and users [6–8, 10].

Conclusions

This study showed that improvements in RRT member-user interactions during RRT calls can be attained through introduction of RRT meetings, designation badges and a structured hand-off process. However, it has also identified some challenges in re-designing the structure and procedures of an RRS and its components. This suggests that refinement and improvement of an RRS is possible, but should be seen as a continuously iterative process and supported by a staff education programme.

Supplementary information

Supplementary information accompanies this paper at https://doi.org/10.1186/s12913-020-05260-z.

Additional file 1. Rapid Response Team meeting checklist.
Additional file 2. Rapid Response Team call handover tool.
Additional file 3. Rapid Response Team member survey tool.
Additional file 4. Rapid Response Team user survey tool.

Abbreviations

RRS: Rapid Response System; RRT: Rapid Response Team; ICU: Intensive Care Unit; NTS: Non-Technical Skills

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None.

Authors' contributions

RC – conception, study design, data analysis and interpretation, preparation and revision of the manuscript, approval and acceptance of accountability for the final submission; LG – study design, data analysis and interpretation, revision of the manuscript, approval and acceptance of accountability for the final submission; AS – study design, data analysis and interpretation, revision of the manuscript, approval and acceptance of accountability for the final submission; KK – data acquisition and analysis, preparation and revision of the manuscript, approval and acceptance of accountability for the final submission; JK – study design, data analysis and interpretation, revision of the manuscript, approval and acceptance of accountability for the final submission. All of the above listed authors have read and approved the manuscript.

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Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available under the terms and conditions of Ethics Committee approval but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study was approved by the Central Adelaide Health Network Human Research Committee, Level 3, Roma Mitchell House, 136 North Terrace, Adelaide, SA 5000, Australia (approval number: 2012069).

All participants were provided with information regarding the study aims and methodology. No personal identifiers were collected. Participation was entirely voluntary, with no incentivisation for completing a survey nor penalty for not doing so.
The need for signed consent was waived by the Central Adelaide Health Network Human Research Committee on the grounds that completion of a questionnaire implied consent to use the data provided and that a separate document stating this was not required.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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Reasons for Repeat Rapid Response Team Calls, and Associations with In-Hospital Mortality

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Background: Previous publications noted increased mortality risk in patients subject to repeat rapid response team (RRT) calls. These patients were examined as a homogenous group, but there may be many reasons for repeat calls. Those potentially preventable by the rapid response system have not been investigated.

Methods: In a retrospective cohort study, patients with potentially preventable repeat calls were classified into two categories: type 1 (patients who had a repeat call following an initial call that ended despite the patient still triggering RRT calling criteria [T1-PRC]) and type 2 (patients with a repeat call within 24 hours of an initial call and for the same reason [T2-PRC]). In-hospital mortality for these patients and for those with repeat calls for all other reasons (ORC) were compared to patients with only a single call during their admission (SC).

Results: Mortality occurred in 31 (43.7%) T1-PRC, 13 (15.1%) T2-PRC, 56 (28.9%) ORC, and 289 (13.9%) SC patients. Univariate odds ratios (ORs), in comparison to SC patients, were 4.81 (95% confidence interval [CI]: 2.96–7.81; $p < 0.001$), 1.10 (95% CI: 0.60–2.02; $p = 0.75$), and 2.52 (95% CI: 1.80–3.52; $p < 0.001$), respectively. Mortality effects persisted for the T1-PRC and ORC groups after adjustment for patient, admission, and initial call characteristics with ORs of 4.07 (95% CI: 2.36–7.01; $p < 0.001$) and 2.29 (95% CI: 1.57–3.34; $p < 0.001$), respectively.

Conclusion: This study found that repeat calls following an initial call that ended with ongoing breach of predefined calling criteria were strongly associated with increased mortality. This highlights the risk to patients when the RRT leaves reversible clinical deterioration unresolved at the end of a call.

The rapid response system (RRS) is an established hospital clinical service whose purpose is to recognize and respond to deteriorating patients in a timely manner.[1] The afferent limb of an RRS comprises detection of acute patient deterioration and graded escalation, including criteria-based calling of a rapid response team (RRT).[1,2] The efferent limb typically involves attendance by the RRT to review and manage the deterioration, in liaison with staff activating that response.

In previous investigations, Calzavacca et al. and Stelfox et al. reported higher mortality in patients experiencing repeated RRT calls during their hospital admission compared with those patients with only a single call.[3,4] However, the reasons for this increased mortality risk and the contribution of other factors, aside from repeat calling, remain uncertain. Repeat calling may indicate suboptimal performance by the RRS efferent limb.[3,5] This could include the RRT departing despite ongoing breach of calling criteria or ward teams not enacting clinical plans devised at RRT calls.[6,7] Any resultant repeat RRT calls would be potentially preventable by the RRS and thus could represent deficits in care delivery that may expose patients to harm.

Other factors may also lead to repeat activation of the RRT, irrespective of quality of clinical management by the RRS. These could include subsequent deteriorations unrelated to the clinical issue that triggered the initial call or underlying patient comorbidity.[8–10] To date, research concerned with repeat RRT calling has focused on patient and call characteristics and their association with in-hospital mortality.[3,4] The influence of RRS performance remains unexplored with regard to whether patient mortality may be modifiable by the RRT and ward team. Therefore, this study was conducted to examine the mortality risk associated with repeat calling that may or may not be preventable by the RRS.

METHODS

Design and Setting

This was a retrospective cohort study of patients attended by a hospital RRT between July 2009 and June 2014. The setting was the Lyell McEwin Hospital, a tertiary metropolitan hospital located in Adelaide, South Australia.

The Rapid Response System

All inpatients had vital signs assessed and documented per hospital observation and monitoring protocols. The RRT was activated for cardiac or respiratory arrests, if any predefined physiological criteria were breached, or for clinical concern (that is, the "worried" criterion) (Sidebar 1). Calls occurred in general hospital wards, specialized wards with

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continuous monitoring (such as the coronary care unit), and non-ward areas (such as the radiology department). The RRT comprised an ICU physician trainee, an ICU nurse, an internal medicine physician trainee, and an intern. An ICU specialist was available, on-site or by phone, 24 hours a day to advise decision making and appropriate disposition at the end of calls.

Sidebar 1. Rapid Response Team Activation Criteria

Cardiac arrest
Respiratory arrest
Threatened or obstructed airway
Heart rate ≥ 140 bpm or < 40 bpm
Systolic blood pressure ≥ 200 mmHg or < 90 mmHg
Respiratory rate > 30 breaths per min or < 8 breaths per min
Pulse oximetry < 90%
Level of consciousness: responding only to physical or painful stimulus
Prolonged seizures
"Worried" or unresolved clinical concern

Subjects

All patients subject to at least one RRT call during the study period were identified from the hospital's RRS database. Those who died during their initial call, were transferred to the ICU from their initial call, or were not admitted to the hospital were excluded. This yielded a study cohort of RRT–attended patients who had the potential to trigger at least one repeat call. Eligible patients were classified into four groups:

- Single Call (SC): those having no repeat RRT calls during their admission
- Type 1 Potentially Preventable Repeat Call (T1-PRC): those having a repeat call following an initial call that ended despite ongoing breach of one or more RRT calling criteria (for example, a patient who still had a systolic blood pressure < 90 mmHg at the completion of a call, who subsequently triggered a second call)
- Type 2 Potentially Preventable Repeat Call (T2-PRC): those having a repeat call within 24 hours of an initial call and for the same recorded reason as the initial call
- Other Repeat Call (ORC): those whose repeat call was neither T1-PRC or T2-PRC (that is, unlikely to be reasonably foreseeable or preventable by the RRS)

Patients with more than one repeat call during their admission or whose repeat call was both T1-PRC and T2-PRC were excluded from the analyses to ensure that all groups were mutually exclusive.

Outcome Measure

The primary outcome was in-hospital mortality. Its relationship with each category of repeat calling was assessed initially in a univariate model, and then in an adjusted (multivariable) model that included patient demographics, comorbidities,[11] and hospital admission characteristics, as well as initial call characteristics, physiological parameters, and interventions.

Statistical Analysis

Descriptive data are presented as frequencies and percentages for categorical variables and medians with interquartile range for quantitative variables. Univariate (with SC as the reference group) or multivariable logistic regression models were fit, and covariate effects reported as odds ratios (ORs) with 95% confidence intervals (CIs). All variables were included in the initial multivariable model and were retained in the final model if their associated p value was less than 0.05. SPSS Statistics for Windows, version 24 (IBM Corp., Armonk, New York), was used for all analyses.

Ethics

This investigation forms part of a larger project, the Impact of a Communication and Teamworking Intervention on Performance and Effectiveness of a Medical Emergency Team (ClinicalTrials.gov: NCT01551160), which has been approved by the Central Adelaide Local Health Network Human Research Ethics Committee. The present study was granted waiver from individual patient consent due to use of retrospective de-identified data.

RESULTS

Descriptive Data

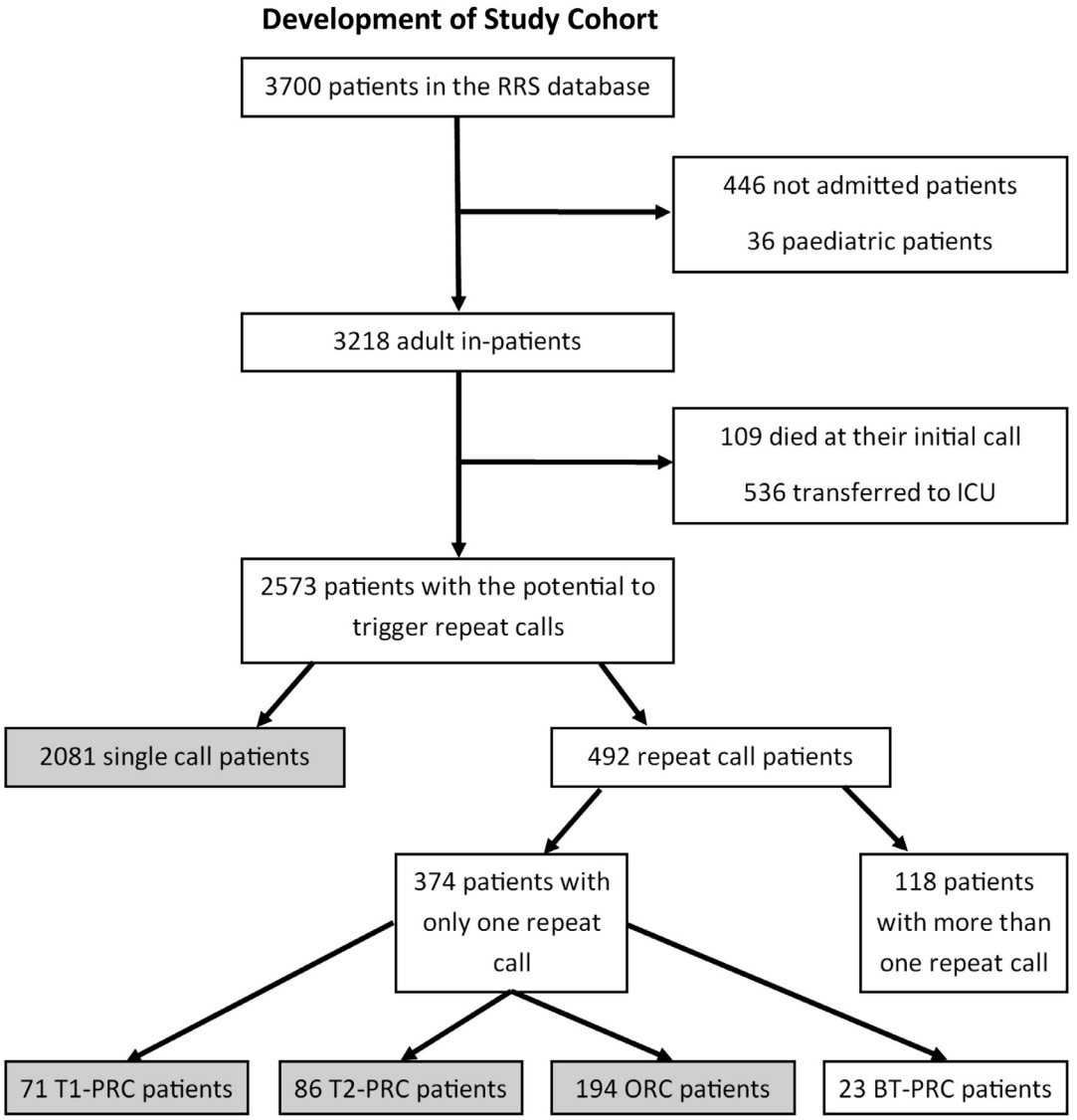
RRT calls were triggered to 3,700 patients over the study period, of whom 446 were not admitted to the hospital (outpatients, visitors, or staff members), and 36 were pediatric.

Of the 3,218 adult inpatients subject to RRT calls, 109 died at their initial call, and 536 were transferred to the ICU from an initial call. A total of 492 patients went on to have repeat calls, of whom 118 (24.0%) were excluded due to having more than one repeat call, and 23 were excluded due to having a repeat call that could be classified into both the T1-PRC and T2-PRC groups. The remaining 2,432 patients became the study cohort, composed of 2,081 (85.6%) SC patients, 71 (2.9%) T1-PRC patients, 86 (3.5%) T2-PRC patients, and 194 (8.0%) ORC patients, who were included in subsequent analyses. The flow of patients is represented in Figure 1.

Univariate Mortality Analyses

Repeat Calling. In-hospital mortality occurred in 31 (43.7%) T1-PRC, 13 (15.1%) T2-PRC, and 56 (28.9%) ORC patients. When compared to SC patients, of whom 13.9% died, the mortality ORs were 4.81 (95% CI: 2.96–7.81; $p < 0.001$), 1.10 (95% CI: 0.60–2.02; $p = 0.75$), and 2.52 (95% CI: 1.80–3.52; $p < 0.001$), respectively, for T1-PRC, T2-PRC, and ORC patients (Table 1).

Patient Demographics. Patients not surviving were more likely to be male and older. Compared to elective surgical cases, patients admitted for nonelective surgery or under the cardiology, medical specialities, or internal medicine



Patients in grey shaded boxes were included in analyses

Legend: RRS = rapid response system, T1-PRC = type 1 potentially preventable repeat call, T2-PRC = type 2 potentially preventable repeat call, ORC = repeat calls that were neither T1-PRC or T2-PRC, BT-PRC = repeat calls that were classified both as T1-PRC and as T2-PRC

Figure 1: The flow of patients in the development of the study cohort is shown.

Table 1. Univariate Regressions for Mortality Associated with Repeat Call Type Patient Groups (Compared to the SC Group)

Patient Group	Number of Patients	Mortality (%)	Odds Ratio (95% CI)	*P* Value
SC	2,081	289 (13.9)	Reference	
T1-PRC	71	31 (43.7)	4.81 (2.96–7.81)	< 0.001
T2-PRC	86	13 (15.1)	1.10 (0.60–2.02)	0.75
ORC	194	56 (28.9)	2.52 (1.80–3.52)	< 0.001

SC, single call; T1-PRC, type 1 potentially preventable repeat call; T2-PRC, type 2 potentially preventable repeat call; ORC, other repeat call; CI, confidence interval.

team had higher hospital mortality. There was no statistically significant association between Charlson Comorbidity Index and mortality (OR: 0.99 [95% CI: 0.94–1.05]; $p = 0.82$).

Initial Call Characteristics. In-hospital mortality occurred more often when the recorded reason for the initial call was low conscious state, tachycardia, hypotension, hypoxia, tachypnea, or cardiac arrest (when the patient survived the call itself), in comparison to patients whose initial call was for "worried." Mortality was also associated with calls occurring on monitored or general hospital wards (compared to nonclinical areas), outside standard consulting hours (8:00 AM to 6:00 PM Monday to Friday), longer interval between admission and call, and longer call duration.

The need for an airway intervention, such as insertion of a nasopharyngeal tube, was associated with higher in-hospital mortality, even when not delivered as part of cardiopulmonary resuscitation (OR: 2.40 [95% CI: 1.23–4.66]; $p = 0.02$). However, administration of oxygen, an intravenous fluid bolus, or noninvasive ventilation had no significant relationship with vital status at hospital discharge (see Table 2).

Initial Call Physiological Parameters. Patients who later died in-hospital had higher pulse and respiratory rates and lower oxygen saturation, systolic blood pressure, and consciousness level, both at RRT arrival and at the end of RRT calls. Mortality was also associated with ongoing breach of one and two or more of any of the standard calling criteria at the end of a call (OR: 2.20 [95% CI: 1.67–2.89]; $p < 0.001$; and OR: 6.63 [95% CI: 3.38–13.02]; $p < 0.001$, respectively).

Multivariable Regression Analysis

When adjusted for all covariates as detailed above, the mortality ORs were slightly attenuated for T1-PRC patients and ORC patients (4.07 [95% CI: 2.36–7.01]; $p < 0.001$; and 2.29 [95% CI: 1.57–3.34]; $p < 0.001$, respectively), and slightly increased for T2-PRC patients (1.29 [95% CI: 0.67–2.50]; $p = 0.45$). Other variables retained in the final model included age; male gender; admission under a cardiology, medical specialities, or internal medicine team (compared to admission for elective surgery); and initial call characteristics (including number of days since admission; recorded call reason being tachypnea, hypotension, hypoxia or cardiac arrest; oxygen saturation < 90% on team arrival; and requirement for an airway intervention) (Table 3).

DISCUSSION

Key Findings

This study explored different reasons for repeat calls and shows that these should not be viewed as a homogenous entity. Mortality was associated with type 1 potentially preventable and other type repeat calls, but not type 2 potentially preventable calls, even when adjusted for a wide range of patient and other factors.

Potentially Preventable Repeat Calls

Type 1. Increased in-hospital mortality was observed when repeat calls followed an initial call that ended despite ongoing breach of one or more RRT calling criteria. It is possible that some of these calls reflected chronic tolerated abnormalities, such as mild hypoxemia in airways disease.[12] However, the fact that the effect on mortality persisted in a multivariable model indicates an association between this type of potentially preventable repeat call and mortality that cannot be explained by physiological or other risk factors.

In keeping with the original ethos for the RRS, this finding reinforces the established risks from leaving acute physiological deterioration untreated.[13–16] Abnormal physiology that is refractory to corrective efforts at the RRT call should prompt reassessment of the patient and evaluation of management options.[17,18] Some instances of repeat calling in this study may have arisen due to inexperience of clinicians attending calls. It is notable that mortality was associated with calls occurring outside office hours, when junior staff are typically rostered. Although consultants were always available for advice, hospital protocols did not mandate their involvement for all calls. Unfortunately, data were not available to ascertain how often they were called.

Another potential explanation for these repeat calls could be patients with recognized irreversible deterioration, such as the terminal phase of a terminal illness. This may have been acknowledged at their initial call, resulting in physiological abnormalities being reasonably left unresolved. In this scenario, it may be worth reconsidering further RRT involvement at the initial call, as subsequent repeat calls do not seem to benefit patients in such circumstances.[10] Furthermore, these additional repeat calls impose an organizational resource burden that may affect RRS responsiveness and distract RRT staff from other duties.[19]

Type 2. The other postulated surrogate marker of RRS efferent limb performance was not significantly related to in-hospital mortality in univariate or adjusted analyses. It is possible that these repeat calls arose from underappreciation by the RRS of the pathology that manifested as the initial call trigger. Incomplete resolution of this disease process, either at the call or subsequently by ward teams, could result in recurrence of that call trigger.

Given that repeat calling has been previously associated with mortality, it is of interest that this group had no increased risk. This suggests that the additional patient reviews by experienced RRT staff at the repeat calls likely conferred an improvement in care delivery. They may also have mitigated any potential harm from recurrence or persistence of the clinical issue that triggered an initial

Table 2. Univariate Initial Call Characteristics Associated with Hospital Mortality

	Non-Survivors (%)	Survivors (%)	Odds Ratio (95% CI)	*P* Value
Location				
Non-ward area	4 (3.1)	125 (96.9)	reference	
Monitored ward	55 (13.2)	363 (86.8)	4.74 (1.68–13.33)	0.003
General ward	325 (17.5)	1,537 (82.5)	6.61 (2.42–18.01)	< 0.001
Reason for call				
Worried	36 (8.2)	401 (91.8)	reference	
Systolic blood pressure ≥ 200	1 (7.7)	12 (92.3)	0.93 (0.12–7.34)	0.94
Prolonged seizure	9 (8.6)	96 (91.4)	1.04 (0.49–2.24)	0.91
Heart rate < 40	5 (9.4)	48 (90.6)	1.16 (0.44–3.10)	0.77
Airway compromise	4 (10.5)	34 (89.5)	1.31 (0.44–3.90)	0.63
Low conscious state	83 (13.2)	547 (86.8)	1.69 (1.12–2.55)	0.01
Heart rate ≥ 140	22 (14.2)	133 (85.8)	1.84 (1.05–3.24)	0.03
Systolic blood pressure < 90	65 (15.2)	364 (84.8)	1.99 (1.29–3.06)	0.002
Respiratory rate < 8	4 (20.0)	16 (80.0)	2.79 (0.88–8.77)	0.08
Respiratory rate > 30	53 (25.2)	157 (74.8)	3.76 (2.37–5.97)	0.001
Cardiac arrest	10 (27.0)	27 (73.0)	4.13 (1.85–9.20)	< 0.001
Pulse oximetry < 90%	97 (31.8)	208 (68.2)	5.20 (3.42–7.89)	< 0.001
Call outside standard hours	193 (18.6)	844 (81.4)	1.40 (1.13–1.74)	0.003
Airway intervention	13 (31.0)	29 (69.0)	2.40 (1.23–4.66)	0.02
Noninvasive ventilation	11 (22.9)	37 (77.1)	1.58 (0.80–3.12)	0.23
Oxygen therapy	256 (16.5)	1,300 (83.5)	1.10 (0.88–1.38)	0.42
Intravenous fluid bolus	91 (14.1)	553 (85.9)	0.82 (0.64–1.06)	0.15
Arrival calling criteria breach				
Heart rate	36 (18.7)	157 (81.3)	1.23 (0.84–1.79)	0.31
Respiratory rate	71 (25.2)	211 (74.8)	1.94 (1.45–2.60)	< 0.001
Systolic blood pressure	75 (18.8)	325 (81.3)	1.26 (0.96–1.67)	0.10
Pulse oximetry	94 (33.1)	190 (66.9)	3.11 (2.36–4.10)	< 0.001
Number of call arrival criteria breaches				
0	466 (20.7)	1,786 (79.3)	reference	
1	315 (23.8)	1,009 (76.2)	1.20 (1.02–1.41)	0.03
2	129 (37.2)	218 (62.8)	2.27 (1.78–2.88)	< 0.001
3 or more	32 (43.8)	41 (56.2)	2.99 (1.86–4.80)	< 0.001
End calling criteria breach				
Heart rate	13 (18.1)	59 (81.9)	1.16 (0.63–2.14)	0.62
Respiratory rate	41 (27.9)	106 (72.1)	2.15 (1.48–3.14)	< 0.001
Systolic blood pressure	37 (29.8)	87 (70.2)	2.36 (1.58–3.53)	< 0.001
Pulse oximetry	33 (44.0)	42 (56.0)	4.42 (2.76–7.06)	< 0.001
Number of end-of-call criteria breaches				
0	283 (13.8)	1,772 (86.2)	reference	
1	88 (26.0)	251 (74.0)	2.20 (1.67–2.89)	< 0.001
2 or more	18 (47.4)	20 (52.6)	6.63 (3.38–13.02)	< 0.001
Interval to initial call in days*	3.0 (1.3– 7.9)	1.9 (1.0– 4.4)	1.02 (1.01–1.03)	0.002
Call duration in minutes*	30 (19– 40)	25 (16– 35)	1.01 (1.00–1.02)	0.002

* Numerical data shown as median (interquartile range).
CI, confidence interval.

call. However, this is an inefficient substitute for careful scrutiny for underlying conditions by the RRS and devising of thorough care plans in liaison with ward teams at the time of the initial RRT call.

Other Repeat Calls

This group aggregated the repeat calls that the RRS could not be reasonably expected to prevent. As such, it represents a diverse range of patients who experienced repeated clinical deterioration during their admission. Not surprisingly, this group had higher mortality than single call patients congruent with the findings of previous studies on repeat calling.[3,4]

Strengths and Limitations

This study represents a comprehensive examination of a large cohort of patients, with findings in keeping with previous studies, reinforcing an association between in-hospital mortality and repeat calling. Patient and call characteristics associated with mortality have been examined and reported previously.[3,4] However, to date the involvement of the RRS in repeat calling and the potential for resultant mortality have only been raised as a concept. This study is the first to develop repeat call indicators for RRS performance and assess their association with mortality.

The study cohort was constrained to exclude patients who had no possibility of triggering repeat calls, and any

Table 3. Variables Retained in the Final Multivariable Logistic Regression Model for In-Hospital Mortality

Variables	Variable Reference Category	Odds Ratio (95% CI)	*P* Value
Repeat call patient types	Single call patients		
T1-PRC patients		4.07 (2.36–7.01)	< 0.001
T2-PRC patients		1.29 (0.67–2.50)	0.45
ORC patients		2.29 (1.57–3.34)	< 0.001
Age	n/a	1.04 (1.03–1.05)	< 0.001
Male gender	Female gender	1.29 (1.01–1.65)	0.05
Attending team	Elective surgery patients		
Psychiatry		1.49 (0.33–6.65)	0.60
Emergency surgery		2.60 (0.97–7.02)	0.06
Cardiology		4.63 (1.61–13.34)	0.004
Medical specialities		7.94 (2.90–21.72)	< 0.001
Internal medicine		7.14 (2.83–17.97)	< 0.001
Initial call location	Low acuity or nonclinical area		
Monitoring ward		2.43 (0.81–7.31)	0.11
General ward		3.40 (1.21–9.55)	0.02
Initial call reason	"Worried" criterion		
Systolic blood pressure ≥ 200		0.85 (0.10–7.17)	0.88
Prolonged seizure		1.19 (0.52–2.72)	0.69
Heart rate < 40		0.93 (0.32–2.69)	0.89
Airway compromise		0.96 (0.26–3.59)	0.95
Low conscious state		1.29 (0.82–2.04)	0.27
Heart rate ≥ 140		1.67 (0.90–3.10)	0.10
Systolic blood pressure < 90		1.78 (1.10–2.88)	0.02
Respiratory rate < 8		2.60 (0.72–9.38)	0.15
Respiratory rate > 30		2.43 (1.45–4.07)	0.001
Cardiac arrest		4.97 (2.00–12.38)	0.001
Pulse oximetry < 90%		2.59 (1.60–4.21)	< 0.001
Number of days between admission and initial call	n/a	1.02 (1.01–1.04)	0.001
Pulse oximetry < 90% on team arrival to initial call	Pulse oximetry ≥ 90% on team arrival	1.86 (1.32–2.61)	< 0.001
Airway intervention performed at initial call	Airway intervention not performed at initial call	3.57 (1.65–7.73)	0.001

CI, confidence interval; T1-PRC, type 1 potentially preventable repeat call; T2-PRC, type 2 potentially preventable repeat call; ORC, other repeat call (that is, repeat call that was not T1-PRC or T2-PRC); n/a, not applicable.

effects on mortality from care delivered in the ICU. This permitted robust analyses to provide insights into the effects of RRS performance on mortality. Patients who had more than one repeat call were also excluded, and it is possible that doing so reduced the study power. However, this exclusion was necessary, as most of these patients had repeat calls that were of different types. To maintain mutually exclusive groups and ensure robust mortality risk assessment would have required creating six additional study groups with different combinations of repeat call types. This would make interpretation of results more difficult, particularly for RRS managers looking to apply them to clinical practice.

The nature of the analyses permit association to be inferred only; the establishment of true cause and effect would require a prospective investigation. In-hospital mortality can be affected by many variables, and while useful inferences can be drawn from this database, the possibility that some unavailable or unmeasured factors have also influenced outcomes cannot be discounted. For example, due to the regression analysis methodology, it was not possible to include repeat call characteristics in the multivariable models (the single call patients would lack data for these variables, leading to their automatic censoring by the statistical package). So, any effect on mortality from repeat call afferent limb factors (including delayed detection of deterioration) in the repeat call groups cannot be reasonably determined within the scope of this study.

Unfortunately, data on treatment limitation or not-for-resuscitation orders were not available in the database, nor were data captured regarding patients who were managed under an end-of-life care plan either at or after RRT calls. However, protocols at the investigating hospital preclude further RRT calling in patients under an end-of-life plan. Therefore, it is reasonable to presume that patients receiving repeat calls were assessed as having a reversible deterioration at their initial call.

Finally, although data were not available on ICU capacity at the time of calls, hospital protocol mandated that patients accepted for admission would be taken there regardless of bed availability. In such instances, the RRT would continue care of the patient in the ICU while staffing resources were sought. Therefore, it can be reasonably assumed that no T1-PRC patients occurred due to ICU logistical limitations.

Potential Lessons

Repeat RRT calling appears commonplace and associated with in-hospital mortality. The findings of this study suggest that such mortality is, at least in part, a reflection of RRS efferent limb performance. From a clinical effectiveness perspective, reversible clinical deterioration should not be left unresolved, as these patients had the highest mortality risk of all groups subject to repeat calls. Because these are vulnerable patients, routine involvement of a critical care specialist would seem to be indicated to guide decision making and ensure appropriate oversight.[20] Furthermore, a safe, albeit resource-demanding, practice would be to err toward admitting such patients to an area of higher acuity, such as an ICU.

There may be circumstances in which it is appropriate to leave patients on wards despite incomplete resolution of clinical deterioration. However, this decision should not be made lightly, as it requires development of a comprehensive management plan in liaison with senior members of ward teams to ensure continuity of care after departure of the RRT. It is reasonable to consider this consensus management plan as an extension of the RRS efferent limb. The onus is on both the RRT and the ward staff to ensure effective handover of required clinical tasks and goals. This should include a review of the frequency of physiological monitoring to prevent delays to detection of any subsequent deterioration.[17,18]

If the resource exists, ongoing care and subsequent follow-up can be supported by outreach or liaison services based out of an ICU.[21] These provide an important role in bringing experience and expertise to wards to potentially avoid the need for up-transfer while maintaining high levels of patient care and safety.

From an organizational efficiency perspective, the potentially preventable repeat calls represent an avoidable operational and logistic burden, particularly as most RRSs are not directly funded and have non-supernumerary staffing.[22] Clinical incidents due to RRT members being diverted from their routine duties to attend calls have not been demonstrated.[19] However, such interruptions and distractions to work flow are undesirable and may still present a potential risk to other patients.

Finally, repeat calls may be a symptom of staff frustration, particularly when there may be a perception that the concerns of those activating an RRT have not been acknowledged or addressed.[6,7] Thus, to some extent, addressing RRT–related factors such as nontechnical skills to improve communication and cooperation may reduce the occurrence of avoidable repeat calls.[23,24]

CONCLUSION

This study has shown that repeat calls following an initial call that ends with the patient still triggering physiological calling criteria are associated with in-hospital mortality. This presents an opportunity for the RRT to make efforts to reduce repeat calling by ensuring that reversible clinical deterioration is resolved at the end of calls. Doing so would be of benefit to patients by recognizing the associated mortality risk, and to the organization through improved RRS responsiveness.

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RESEARCH ARTICLE

Effect of a multi-faceted rapid response system re-design on repeat calling of the rapid response team

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Abstract

Background

Repeat Rapid Response Team (RRT) calls are associated with increased in-hospital mortality risk and pose an organisation-level resource burden. Use of Non-Technical Skills (NTS) at calls has the potential to reduce potentially preventable repeat calling. NTS are usually improved through training, although this consumes time and financial resources. Re-designing the Rapid Response System (RRS) to promote use of NTS may provide a feasible alternative.

Methods

A pre-post observational study was undertaken to assess the effect of an RRS re-design that aimed to promote use of NTS during RRT calls. The primary outcome was the proportion of admissions each month subject to repeat RRT calling, and the average number of repeat calls per admission each month was the secondary outcome of interest. Univariate and multivariable interrupted time series analyses compared outcomes between the two study phases.

Results

The proportion of admissions with repeat calls each month increased across both phases of the study period, but the increase was lower in the post re-design phase (change in regression slope -0.12 (standard error 0.07) post versus pre re-design). The multivariable model predicted a 6% reduction (95% confidence interval -15.1–3.1; P = 0.19) in the proportion of admissions having repeat calls at the end of the post redesign phase study compared to the predicted proportion in the absence of the re-design. The average number of calls per admission was also predicted to decrease in the post re-design phase, with an estimated difference of -0.07 calls per admission (equivalent to one fewer repeat call per 14 patients who had RRT calls) at the end of the post re-design phase (95% confidence interval -0.23–0.08, P = 0.35).

Competing interests: The authors have declared that no competing interests exist.

Conclusion

This study of an RRS re-design showed modest, but not statistically significant, reductions in the proportion of admissions with repeat calls and the mean number of repeat calls per admission. Given the economic and workforce capacity issues that all health care systems now face, even small improvements in the RRS may have lasting impact across the organisation. For the potential interest of RRS managers, this paper presents a pragmatic, low-cost initiative intended to enhance communication and cooperation at RRT calls.

Introduction

Over the past quarter century, the Rapid Response Team (RRT) has evolved from a conceptual advancement of the response to in-hospital cardiac arrest to become a ubiquitous patient safety mechanism [1, 2]. Throughout this time, studies, and reviews of Rapid Response System (RRS) activity have consistently demonstrated increasing rates of RRT calling, as RRS mature and the hospitals they are based within become busier [2–5].

In some respects, this suggests desirable awareness and utilisation of a patient safety mechanism. Indeed, the increase in RRS usage within an organisation has been associated with improved patient survival statistics [3, 6, 7]. However, increasing RRS activity poses a logistical and resourcing burden for hospitals, as most RRTs tend to not be supernumerary, with staff rostered from other substantive roles [4, 8, 9]. Although adverse effects have not yet been attributed to team members leaving other duties to attend RRT calls [10], the potential exists for these to occur. This risk could be magnified during concurrent RRT calls as resources are typically not available to provide a full response to more than one call simultaneously [9].

Against this background of increasing activity, the RRS should seek efficiencies to facilitate RRT capacity to promptly attend all unexpected clinical deteriorations. One avenue could be through reduction of potentially preventable repeat calling, that is the RRT attending a patient more than once due to inadequate resolution of an initial call, especially when the repeat call closely follows the first. In a previous study, we found increased mortality risk in patients re-attended by the RRT within 24 hours of a previous completed call in which clinical issues remained unresolved [11].

Deficits in non-technical skills (NTS), such as communication and cooperation, at RRT calls have been identified as a risk factor for potentially preventable repeat calling [11–13]. Effective employment of NTS are crucial due to the inherent time and clinical pressures imposed by the deteriorating patient [14, 15]. Ideally, NTS would be augmented by delivery of specialised, simulated scenario training for RRTs [14, 16]. However, such training requires taking staff away from clinical duties, which is often not feasible in resource-limited hospitals.

Therefore, a comprehensive, multi-faceted RRS re-design aimed to enhance use of NTS at RRT calls, without the need for dedicated training or additional funding, was implemented. The re-design drew on themes from the TeamSTEPPS® program [17, 18], and previous research which described RRS improvement initiatives [14, 19–21]. The present study uses Interrupted Time Series analysis to investigate the effects of the re-design of an existing RRS.

Methods

This was a pre-post intervention study assessing the proportion of patients who had repeat RRT calls before and after implementation of a RRS re-design. Data were collected over a five-

year period prior to the re-design and another five years after its implementation. The present study was part of the *Impact of Non-Technical Skills on Performance and Effectiveness of a Medical Emergency Team (IMPACT)* research program (ClinicalTrials.gov: NCT01551160), components of which have already been reported [11–13].

Participants

Patients attended by the RRT at a tertiary, outer metropolitan hospital between 1st July 2009 and 30th June 2019 were identified from RRS records. Those who were not admitted to the hospital (e.g. day procedures, outpatients, or visitors) and patients under 18 years of age were ineligible for inclusion.

The cohort of in-patient admissions who were attended by the RRT were divided into two groups: those attended by the RRT more than once during an admission (the 'Repeat Call' group) and those with only one RRT call.

Clinical staff were classified into two groups: those rostered to attend calls as part of the RRT ('members'), and those who recognise clinical deterioration and call the RRT ('users').

Intervention

The RRS re-design incorporated three components, described in detail previously [13]. These components targeted the key NTS domains of leadership, communication, and co-operation both within the RRT and between RRT members and users.

1. Regular RRT meetings. Short meetings for RRT members, designed to address **Leadership** and **Cooperation** within the team, were scheduled to occur at the beginning of each shift. The primary purpose of these meetings was to pre-emptively establish each team member's role and initial task at RRT calls. This approach was designed to avoid spending valuable time doing this at a deteriorating patient's bedside.

2. Team role badges. Each member of the RRT was required to wear a badge indicating their role while attending calls. This was designed to reinforce the team **Leadership** role as well as facilitate non-verbal **Communication** of all role designations to RRT members and users present at calls.

3. RRT members-to-users"hand-off" procedure. A structured verbal and written process, aiming to improve **Communication** and **Cooperation** between RRT members and users, was introduced for RRT calls ending with the patient remaining on their ward. This formalised the transfer of primary clinical responsibility from the RRT back to the ward team. In particular, the hand-off process encouraged RRT users to voice any ongoing clinical concerns and have them addressed before the RRT departed.

Study phases

There were two phases of data collection, punctuated by the implementation of the RRS re-design as detailed above. Phase 1 comprised five years (July 2009 –June 2014) and Phase 2 a further five-year period (July 2014 –June 2019). The data presented in this paper were collected retrospectively, extracted at the end of the study from the hospital's RRS and in-patient electronic databases.

Aside from the re-design described above, the configuration and operations of the RRS did not change over the entire study period (i.e. Phase 1 and 2). In particular, the RRT activation criteria, composition of the RRT and provision of Critical Care services at the investigating hospital remained the same throughout.

Outcome measures

RRT call data, obtained from the hospital RRS database, were aggregated at the per-patient-admission level. Variables were then created to indicate if each admission contained repeat calls, or not, and the count of those repeat calls.

The admission-level data were then collapsed by study month, derived from the date of hospital entry, with month 1 representing July 2009, through to month 120 in June 2019. A variable was created to indicate study phase (Phase 1: months 1–60, Phase 2: months 61–120).

The primary outcome in this study was the proportion of admissions with repeat RRT calls from all admissions with at least one RRT call (per month). This was chosen as an indicator of potentially preventable RRS activity that could be measured throughout both study phases.

The secondary outcome was the mean number of RRT calls per admission (from all admissions with at least one RRT call) to investigate aggregate RRT call load on the hospital.

Other variables

Demographic data, captured at time of admission, included age, gender, Indigenous identification and socioeconomic status (expressed as a binary variable for Socio-Economic Indexes for Australia (SEIFA) decile of three or less versus greater than three, derived from the 2016 Postal Area Index of Relative Socio-economic Advantage and Disadvantage) [22]. Hospital admission data included elective vs non-elective admission, Charlson Co-Morbidity Index (CCI) and in-patient length of stay (LOS). Counts of hospital admissions during each month of the study were derived from the hospital activity database.

These variables were similarly aggregated by month to account for variations in hospital activity and casemix over the study period. For each study month, the number of admissions, and the percentage of admissions corresponding to male gender, Indigenous identification, SEIFA ≤ 3, and non-elective admissions were derived. The mean age, CCI, and hospital LOS were also calculated for each study month.

Data analysis

Monthly hospital activity and aggregated patient demographics were compared between study phases using Mann-Whitney U-tests.

The effect of the re-design was assessed by Interrupted Time Series (ITS) methodology as described by Bernal et al [23]. In general terms, ITS analyses use segmented regression to compare the observed effect of an intervention, introduced at a defined time point, on an outcome to the effect predicted in the absence of the intervention [24, 25]. ITS quantified the impact of the RRS re-design on the outcomes of interest through the change in coefficients of the fitted regression line at the point of introducing the re-design.

Non-seasonal Auto Regressive Integrated Moving Average (ARIMA) models with a first-order auto-correlation were fit for each outcome variable [26]. Study month was used as the time metric in all models. Initially, simple models were fit that considered only time (study month), phase and the interaction of time and phase (i.e. a different intercept and slope corresponding to the post-intervention phase compared to the pre-intervention phase were allowed for in the regression model–see Fig 2 in Bernal et al [23]). Subsequently, multivariable models that included hospital admission rates, patient demographics and admission characteristics were fit to adjust for any variations between months in hospital activity and casemix over the study phases. The final multivariable model retained variables with a corresponding P-value < 0.1. Sensitivity analyses were also undertaken to examine the impact of potential outliers [27].

Predicted changes in the percentage of repeat call admissions and mean number of calls per admission were derived for each year using the approach outlined in Wagner et al [28]. In this way, the cumulative annual changes in the outcome measures that were attributable to the RRS design were estimated.

Model fit was assessed by the stationary R^2 value, where values closer to 1 are indicative of better fit, and the Ljung-Box Q statistic, which indicates if there is a marked lack of fit of the corresponding ARIMA model [29]. Durbin's alternative statistic was used to assess the extent of auto-correlation in the statistical models [30].

Statistical analyses were conducted with SPSS (IBM Corp. Released 2019. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp), with the exception of Durbin's alternative statistic, which was calculated using Stata (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC).

Ethics

This study was approved by the Central Adelaide Health Network Human Research Committee (approval number: 2012069).

The need for patient signed consent was waived on the grounds that data used in this study were already collected electronically for hospital quality assurance purposes, no unique patient identifiers were included in the study database, and all individual patient level variables were aggregated by study month prior to analysis and reporting.

Results

The RRS database provided records for 9754 patients who were attended by the RRT during the study period. From these, 93 paediatric patients and 122 visitors, staff or outpatients were excluded as being ineligible. A further 12 in-patients for whom the database had incomplete records were also excluded. Of the remaining 9527 patient admissions, 3073 occurred in Phase 1 and 6454 in Phase 2. The hospital in-patient database recorded 188016 admissions during Phase 1 and 240910 in Phase 2.

In Phase 2, by comparison to Phase 1, there were more mean hospital admissions per month (4015 [SD 419.7] vs 3134 [SD 222.0], $P<0.01$) and a greater percentage of those hospital admissions were attended by the RRT (2.6% [standard deviation (SD) 0.5] versus 1.6% [SD 0.4], $P<0.01$).

Compared to Phase 1, in Phase 2 there were shorter mean in-patient LOS (10.9 days [SD 1.6] vs 12.9 [SD 3.0], $P<0.01$), lower mean patient age (67.4 [SD 2.0] vs 68.6 [SD 2.8], $P<0.01$), lower percentage of patients with low socioeconomic status (68.2% [SD 7.0%] vs 79.7% [SD 6.4%], $P<0.01$) and lower mean CCI (4.5 [SD 0.3] vs 4.8 [SD 0.46], $P<0.01$). Hospital activity and patient demographic data are summarised by year of the study in Table 1.

Primary outcome

The ARIMA univariate model estimated the slope as 0.115 (standard error (SE) 0.047) in Phase 1, and 0.029 (SE 0.047) in Phase 2, indicating an observed change in slope between phases of -0.087 (SE 0.067), as shown in Fig 1.

Similar results were found for the final multivariable model, in which proportion of non-elective admissions and average hospital LOS were also retained as covariates. In this model, the change in slope due to the re-design was estimated to be -0.118 (SE 0.067).

The final multivariable model estimated a 6% decrease (95% confidence interval (CI)-15.1–3.1, $P = 0.19$) in the proportion of RRT attended patients triggering repeat calls (per month) by the fifth-year post-implementation of RRS re-design. The estimated cumulative change in the

Table 1. Hospital activity and demographic data (for patients having RRT calls) by study year.

Study Year	Count of All Admissions	Count of RRT Call Admissions	LOS Mean (SD)	Age Mean (SD)	Male Mean % (SD)	Indigenous Mean % (SD)	Low SEIFA Mean % (SD)	CCI Mean (SD)	Non-Elective Mean % (SD)
1	34238	507	14.4 (4.2)	67.8 (3.3)	48.7 (6.2)	0.9 (1.3)	81.7 (6.7)	4.7 (0.4)	90.8 (3.1)
2	36087	506	14.0 (3.0)	69.1 (2.8)	52.3 (9.4)	1.8 (2.0)	79.0 (6.7)	4.9 (0.5)	94.4 (2.7)
3	37785	578	11.7 (2.1)	68.9 (2.6)	51.4 (7.4)	3.0 (1.8)	82.3 (4.5)	4.8 (0.5)	93.4 (3.0)
4	39441	666	12.1 (2.2)	68.0 (3.1)	50.8 (8.7)	2.6 (1.7)	78.4 (8.2)	4.6 (0.5)	94.9 (3.2)
5	40465	816	12.6 (2.5)	69.3 (2.4)	47.9 (5.2)	1.7 (1.4)	77.0 (5.0)	4.9 (0.4)	92.9 (2.9)
Phase 1 overall	188016	3073	12.9 (3.0)	68.6 (2.8)	50.2 (7.5)	2.0 (1.8)	79.7 (6.4)	4.8 (0.5)	93.3 (3.2)
6	41098	887	11.0 (0.6)	67.2 (2.5)	52.1 (6.6)	2.4 (2.1)	74.5 (5.5)	4.7 (0.4)	92.4 (2.7)
7	45307	1174	9.9 (1.5)	65.8 (2.1)	45.7 (5.0)	1.9 (1.2)	72.4 (6.4)	4.3 (0.3)	92.0 (2.8)
8	49009	1223	11.6 (2.0)	67.8 (1.6)	49.5 (5.2)	2.0 (1.6)	65.5 (5.6)	4.4 (0.2)	94.6 (2.6)
9	52123	1541	11.5 (1.8)	68.2 (1.6)	49.7 (4.8)	3.1 (1.7)	66.6 (4.9)	4.6 (0.2)	93.2 (3.3)
10	53373	1629	10.7 (1.3)	67.9 (1.5)	49.3 (5.3)	3.6 (1.8)	61.8 (4.5)	4.6 (0.3)	93.4 (1.9)
Phase 2 overall	240910	6454	10.9 (1.6)	67.4 (2.0)	49.3 (5.6)	2.6 (1.7)	68.2 (7.0)	4.5 (0.3)	93.1 (2.7)

RRT = Rapid Response Team, SD = standard deviation, LOS = length of stay, SEIFA = socio-economic indexes for Australia, CCI = Charlson co-morbidity index.

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observed percentage of repeat call admissions in Phase 2, compared to the percentage predicted if the re-design had not been implemented, is shown in Fig 2.

Durbin's alternative test statistics were 2.35 on 1 df (P = 0.12) and 2.13 on 1 df (P = 0.14) for the univariate and multivariable models, respectively, and the stationary R^2 values were 0.26 for the univariate and 0.30 for the multivariable models, respectively. The Ljung-Box Q statistic indicated there was no significant lack of fit observed for the univariate (15.77 on 17

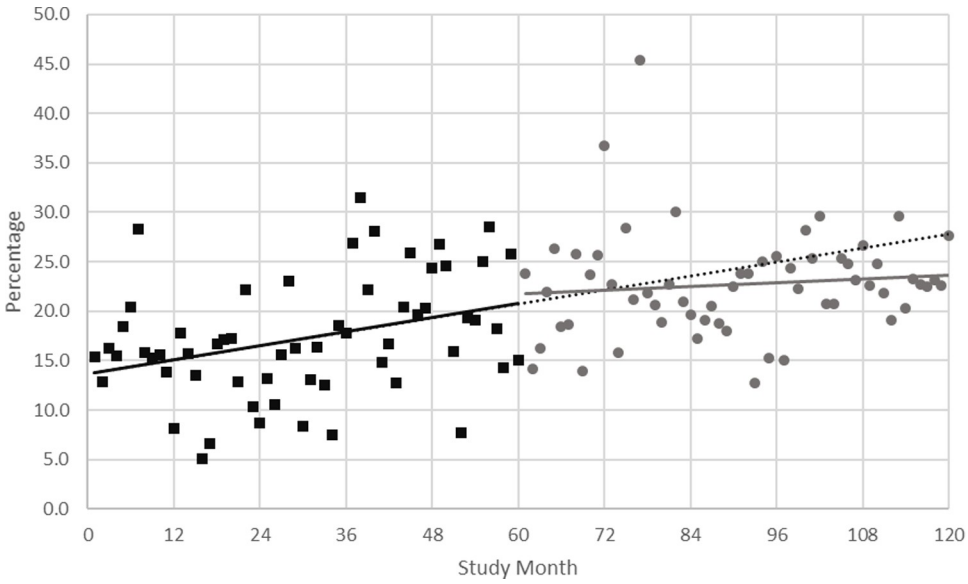

Fig 1. Percentage of repeat call admissions per month representing the ARIMA univariate model. Phase 1 monthly observed data in black squares, with slope illustrated by the solid black line. Phase 2 monthly observed data in grey circles, with slope illustrated by the solid grey line. The slope in Phase 1 is extended into Phase 2 and represented by the dotted black line for comparison with Phase 2 observed data.

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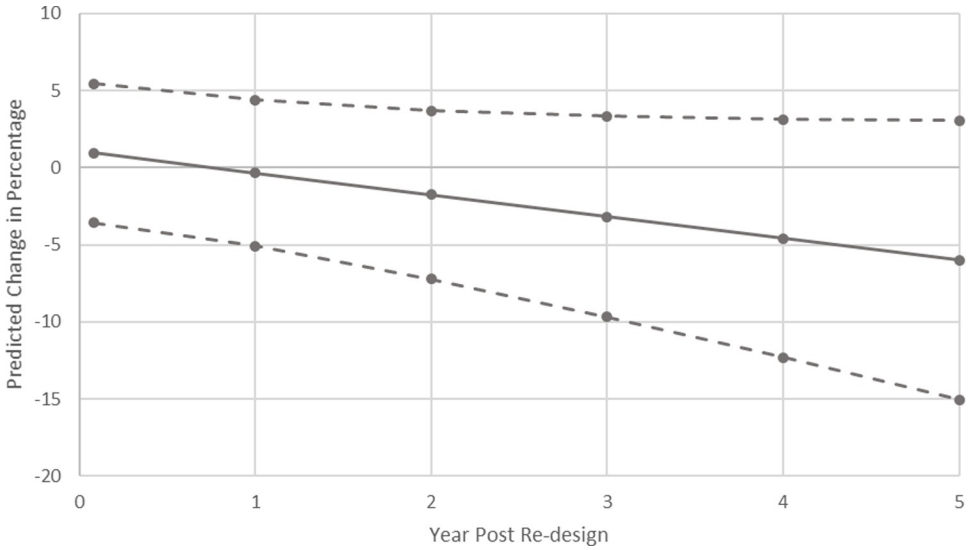

Fig 2. Final multivariable model. Cumulative predicted change in percentage of repeat call admissions (per month) associated with the RRS re-design, with 95% confidence intervals.

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df; P = 0.54), nor for the multivariable model (Q = 20.83 on 17 df; P = 0.23). Taken together, these statistics suggest reasonable fit of the ITS models.

Given the unusual observation in November 2015 (study month 77), a sensitivity analysis was conducted excluding this value. This analysis resulted in slightly attenuated regression coefficients for the univariate (-0.068 [SE 0.064] vs -0.087 [SE 0.067]) and multivariable models (-0.094 [SE 0.065] vs -0.118 [SE 0.067]), and a modest alteration of the estimated change in percentage of patients having repeat calls versus predicted to -4.9% (95% CI -13.7–3.8, P = 0.27) as shown in S1 Fig.

Secondary outcome

The change in regression coefficient for the mean number of calls per admission in Phase 2 compared to Phase 1 associated with implementation of the re-design was -0.001 (SE 0.001) in the ARIMA univariate model. Fig 3 shows the observed data for Phase 1 and Phase 2.

At the end of the Phase 2, the final multivariable model, retaining hospital LOS, showed a predicted difference of -0.07 (95%CI -0.23–0.08) calls per admission (P = 0.35) as shown in Fig 4.

The fit statistics from the ITS models for the calls per admission were similar to those observed in the analysis of the primary outcome, again suggesting reasonable fit. Durbin's alternative test statistics were 0.68 on 1 df (P = 0.41) and 0.58 on 1 df (P = 0.45) for the univariate and multivariable models, respectively. The stationary R^2 values were 0.26 for the univariate and 0.30 for the multivariable models. The Ljung-Box Q statistic indicated there was no significant lack of fit for the univariate (12.83 on 17 df; P = 0.75), nor for the multivariable model (Q = 15.82 on 17 df; P = 0.54).

A sensitivity analysis excluding the unusual November 2015 observation led to results that were essentially unchanged, with the pre-post regression coefficient change in slope of -0.001 [SE 0.001] and 0.07 fewer predicted calls per admission (95%CI -0.21–0.07, P = 0.34), as presented in the final multivariable model in S2 Fig.

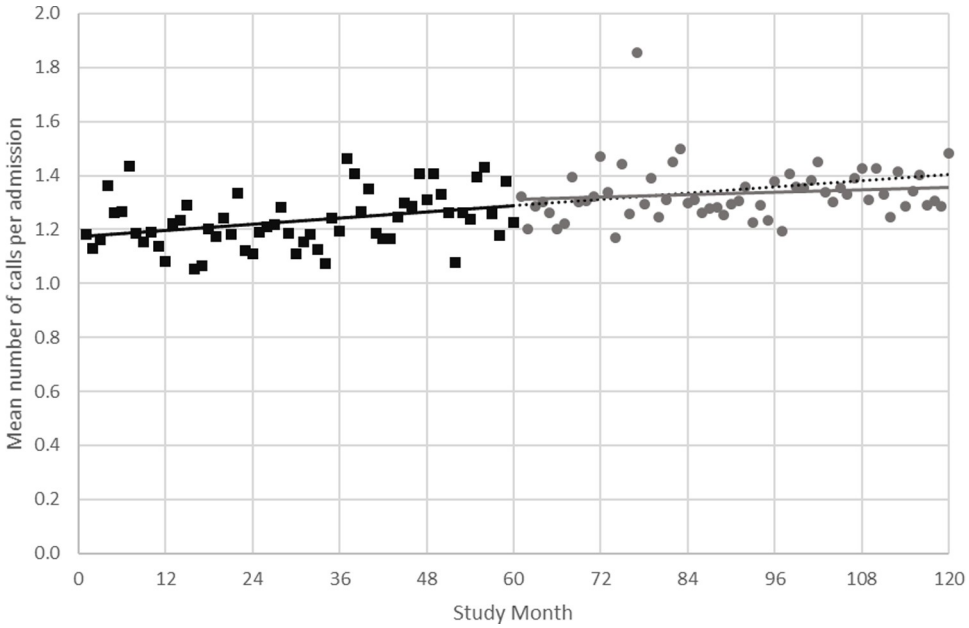

Fig 3. Mean number of calls per admission by study month for the ARIMA univariate model. Phase 1 observed data in black squares, with slope illustrated by the solid black line. Phase 2 observed data in grey circles, with slope illustrated by the solid grey line. The Phase 1 slope is extended into Phase 2 and represented by the dotted black line for comparison with Phase 2 observed data.

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Discussion

Key findings

Following a multi-faceted RRS re-design, modest, but not statistically significant, reductions were estimated in the percentage of RRT-attended patients having repeat calls and the average number of repeat RRT calls per patient, with changes in hospital activity and patient demographics accounted for in the statistical analyses. The observed reduction saw six percent fewer

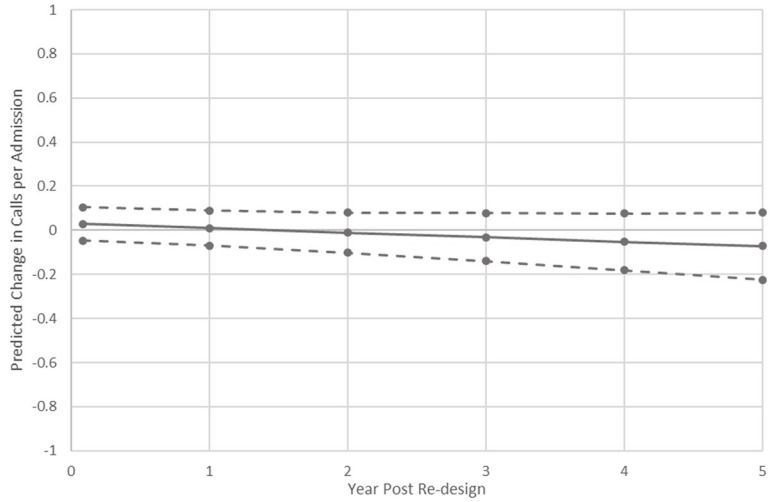

Fig 4. Final multivariable model. Cumulative predicted change in calls per admission associated with the RRS re-design, with 95% confidence intervals.

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RRT attended patients going on to have repeat calls (per month). In the context of a median 30-minute call duration [12], this would be equivalent to a reduction in RRS activity of three hours per 100 patients attended by the RRT.

Interpretation of results

Notably, the investigating hospital saw markedly increased activity throughout the study period. This partly explains the disparity in the number of subjects between the two study Phases. However, there was also a statistically significant increase in the percentage of admissions subject to RRT calls in Phase 2 versus Phase 1. Reviews of RRS operational activity observations have reported that increases in RRT calling over time following introduction of an RRS are commonplace [1–7]. A likely cause is familiarity and acceptability that reduce barriers to calling as the RRS matures.

In this study, the changes in hospital activity and patient demographics were accounted for in the multivariable Interrupted Time Series analyses. The estimated reduction in proportion of patients experiencing a repeat call following the RRS re-design has potential implications for patient mortality. A previous publication from this research program and two other studies corroborated the association between repeat calling and mortality [12, 31, 32].

Implications of results

For organisations, there are two important potential benefits to operational efficiency from exploring potentially avoidable repeat calling. First, RRTs tend to draw resources from other acute clinical unit rosters, such as ICU and Internal Medicine, rather than have their own supernumerary staffing [8, 9]. Therefore, even modest reductions in potentially avoidable re-calling of the RRT allow staff more time to attend to their primary rostered clinical duties.

Second, as RRS activity increases, there is a proportionate potential for concurrent RRT calls. Most RRS only roster a single RRT [8, 9], which presents a risk to simultaneously deteriorating patients from delayed or incomplete attendance by an RRT. Thus, attempts to reduce the likelihood of avoidable repeat calls may help to ensure constant RRS capability to attend clinical deterioration promptly and effectively.

Contribution to evidence base

The literature on re-designing the RRS to improve use of NTS during RRT calls is scant. Most published articles reinforce simulation training as the gold standard mechanism to achieve this [14, 15]. Staff training is labour and cost intensive, so alternative strategies need to be explored.

Kansal et al. evaluated streamlining information sharing by ward staff to the RRT on their arrival to calls, alongside other restructuring of their respective RRS [19]. Although they did report reductions in rates of unexpected deaths and other adverse patient outcomes after re-designing the RRS, these authors could not ascribe the role of the enhanced handover as the sole reason for these improvements due to changes to a tiered RRS response taking place at the same time.

Prince et al. and Mardegan et al. described changes to operations of the RRT during calls [20, 21]. Prince et al. focused on visual identification of team member roles during cardiac arrest calls which was incorporated into simulation training for the RRT. These authors noted perceived improvements in communication during RRT calls, although no pre-training data were collected. This reflects improvements in perceptions and experiences of interactions during RRT calls we found in a previous publication from this research program [13]. Mardegan et al. only described staff satisfaction after introduction of a RRT call checklist that facilitated

handover from ward staff to the RRT on their arrival to calls. While staff were positive in general about each of these interventions, no effects on patient outcomes were presented in either study [20, 21].

The present study reports implementation of a multi-faceted RRS re-design that aimed to promote use of NTS during RRT calls. While not statistically significant, the results may still be worthy of consideration at an organisational level, especially given the negligible barriers or overheads to implementing the three components of this RRS re-design.

Strengths and limitations

To the best of our knowledge, this is the first description of objective RRS performance outcomes measured around implementation of a Non-Technical Skills focused system re-design.

The Interrupted Time Series approach is particularly helpful for studying organisation-level interventions where randomised controlled trials are infeasible [23–25]. Its use in this study allowed us to investigate the effect of the re-design on the outcomes and accounted for temporal trends and variations [28]. The analysis also demonstrated that the effect of the re-design in reducing rates of repeat calling was sustained throughout Phase 2, with no evidence of attrition of benefit.

As with any pragmatic study, there are limitations. First, we acknowledge the absence of results regarding RRS compliance with the components of the re-design, or usage of NTS during RRT calls. Due to limited financial resources for the study, it was not possible to employ observers to objectively record attendance at RRT meetings, wearing of badges or usage of NTS during RRT calls, and adherence to the required hand-off process at RRT call completions.

Second, although a range of demographic and hospital activity co-variates were included in the analyses and the configuration of RRS did not otherwise alter during the entire study period, it is still possible that some other unmeasured factors, such as seniority of RRT clinicians, could have influenced the findings.

Finally, some repeat calls may indicate a correctly functioning RRS responding to clinically discrete deteriorations. However, this study focused on the wider resourcing implication for organisations, and so did not separate these from the preventable calls. All repeat calls present a potential logistical and staffing burden on hospitals, so that even modest improvements, such as observed here, may confer benefits to the organisation.

Future scope for re-designing the RRS

The RRS re-design used in this study was developed with the understanding that further iteration and re-evaluation would be worthwhile. Some potential revisions to the re-design, such as role stickers, rather than badges, and electronic availability of RRT rosters, have already been proposed in a previous publication from this research program [13].

Further to those, a natural addition to the RRS would be debriefs for the RRT and other hospital staff involved in calls [33, 34]. This could take one of two forms: "hot debrief" conducted immediately after completion of each RRT call or "cold debrief" in which cases are reviewed later at scheduled meetings [34]. There are challenges in implementing either of these debrief methods. Hot debrief depends on RRT members, and possibly also ward staff, involved in that call remaining available to attend. For ad-hoc RRTs rostered from other clinical roles, this may be infeasible [8, 9]. The scheduled, delayed nature of cold debrief provides more opportunity for RRT members to plan their attendance and avoid conflicts with other clinical duties, so may be easier to implement, but all RRT members are unlikely to be rostered to work at the scheduled time of the cold debrief [34].

Context within the IMPACT research project

As outlined earlier, this study was conducted as part of a larger research project. In a parallel survey study of perceptions and experiences of NTS use during RRT calls of RRT members and those calling the RRT (users), this RRS re-design was associated with significant reductions in reported experience of conflict [13]. Furthermore, both in quantitative data and free-text comments, improvements in leadership, communication and cooperation between RRT members and users during RRT calls were reported following introduction of the re-design.

Thus, the apparent lack of effect of the RRS re-design on the proportion of admissions with repeat RRT calls and the mean number of RRT calls per admission raises the question of whether organisational change did not occur, or whether a potential improvement (as suggested by the survey findings) was not captured by the outcomes used here. Therefore, as part of future research, identification and use of other outcome measures that are more sensitive to NTS performance during RRT calls should be explored.

Conclusions

This study reports a multi-faceted RRS re-design which was associated with a modest, but not statistically significant, reduction in the percentage of patients per month having repeat calls and the average number of repeat calls per admission.

In an era of economic and health workforce constraints, even small potential improvements may still have relevance to organisations. This RRS re-design (and assessment thereof) has scope for further refinement, and may be of interest to RRS clinicians and managers seeking to implement their own pragmatic, low-cost quality improvement initiatives.

Supporting information

S1 Fig. Percentage of repeat call admissions per month representing the ARIMA univariate model with outlier detection enabled. Phase 1 observed data shown as black squares, with trend shown as the solid black line. Phase 2 observed data shown as grey circles, with trend shown as the solid grey line. The Phase 1 trend is extended into Phase 2 as the dotted black line for comparison with Phase 2 observed data. Observation for study month 77 (November 2015) was identified as an outlier and excluded for this sensitivity analysis.
(TIF)

S2 Fig. Mean number of calls per admission by study month for the ARIMA univariate model with outlier detection enabled. Phase 1 observed data shown as black squares, with trend shown as the solid black line. Phase 2 observed data shown as in grey circles, with trend shown as the solid grey line. The Phase 1 trend is extended into Phase 2 as the dotted black line for comparison with Phase 2 observed data. Observation for study month 77 (November 2015) was identified as outlier and excluded for this sensitivity analysis.
(TIF)

S1 Data. De-identified, by-month aggregated data used in statistical analyses.
(CSV)

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