The Use of Rapid Response Teams to Reduce Failure to Rescue Events: A Systematic Review

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Failure to rescue (FTR) is the failure to recognize and respond to a hospitalized patient experiencing complications from a disease process or medical intervention. As an indicator of patient safety, FTR is often measured as mortality after a treatable, in-hospital complication and/or in-hospital cardiac arrest (CA) rates, although there is no universally agreed upon definition and variations exist between institutions.

Rapid response systems (RRS) have emerged as an intuitive approach to address the 2 core contributors to FTR: failure in adequately monitoring and identifying, and failure in responding to hospitalized patients who are at high risk of rapid clinical deterioration. A conceptual model for RRS, adapted from DeVita et al., describes the relationship between the afferent limb, in which the event is detected and a trigger is activated, and the efferent limb, in which a systematic response is carried out and the crisis resolved (Fig. 1). There are different models for the response teams such as rapid response teams (RRTs), medical emergency teams (METs), and critical care outreach. For the purposes of this review, we use the RRT as an umbrella term, as all models are conceptually united by the goal of early intervention on patients who are at high risk of clinical deterioration.

Brought to widespread attention by the 2005 Institute for Healthcare Improvement’s 100,000 Lives Campaign, the development of the RRT was in reaction to a growing body of evidence that revealed deficiencies in the response to rapid clinical decline in the inpatient setting. A key principle underlying RRT is that early intervention can prevent avoidable morbidity and mortality in the non-intensive care hospital setting.

Rapid response teams act as the efferent limb of the RRS and include the critical care team that responds to the patient as a result of activation by the afferent limb. Although there is no universal standard, most triggering criteria include abnormalities in physiologic measures such as respiratory rate, heart rate, systolic blood pressure, oxygen saturation, and urine output. Additional criteria may include staff member or family member concern about the patient’s condition, mental status changes, or uncontrolled pain.

The RRT team is typically multidisciplinary and can consist of a nurse, physician, and respiratory therapist, although team composition may vary depending on institutional policy and guidelines. They are able to assess the patient, diagnose, provide initial treatment, and rapidly triage the patient. Patients can then transfer to a higher level of care (i.e., intensive care unit [ICU]), have their care returned back to the primary medical team, or have their treatment plan revised.

A significant number of hospitals implement RRS as a means to reduce failure-to-rescue events, but questions remain as to their effectiveness. The aim of this systematic review was to synthesize the evidence on the impact of RRTs on FTR events, including in-hospital mortality and in-hospital CAs.

**METHODS**

We conducted a search of 4 databases (CINAHL, MEDLINE, PsychINFO, and Cochrane) for articles published from 2008 to 2018 to identify those that described the use of RRTs to reduce incidence of FTR. Search terms included “patient deterioration,” “patient decompensation,” “failure to rescue,” “death after treatable complication,” “rapid response system,” “rapid response teams,” “medical emergency teams,” and related synonyms. English-language, peer-reviewed articles that reported the impact of RRT on FTR were included.

The lead author reviewed the titles and abstracts for the articles identified by the search to determine relevance to the study objectives. If deemed relevant or additional information was needed to...
make that determination, the full text was obtained for further screening. Data were abstracted into an evidence table and checked by a second reviewer. Through a consensus process, the authors selected the articles for inclusion. If a study was referenced within a selected systematic review, it was not included as a separate study. The study was designed to be compliant with Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines.11

RESULTS

The 4 searches yielded 121 results. Once duplicates were removed and additional relevant referenced articles were added, a total of 97 articles were screened and 41 full-text articles were retrieved. Of those, 10 were selected for inclusion in this review, including 3 meta-analyses, 3 systematic reviews, and 4 single studies.

Because the purpose of RRSs is to identify patients who are at risk of deterioration and who may need higher levels of care (i.e., the ICU), the primary setting for the studies is non-ICU general and/or surgical units of acute care hospitals. All studies reported a range of patient outcomes including overall hospital mortality (8 studies), in-hospital CA rates (9 studies), and ICU admission or transfer rates (5 studies; Table 1). One systematic review had the primary aim of evaluating the impact of the RRT composition on outcomes and will be discussed separately.20

Hospital Mortality

Of the 3 meta-analyses that reported the impact of RRS implementation on overall hospital mortality, 2 found significant decreases in mortality rates.13,14 Maharaj et al.13 using 20 adult and 7 pediatric studies in their analysis, determined a significant decrease hospital mortality in both the adult (relative risk [RR], 0.87; 95% confidence interval [CI], 0.81–0.95) and pediatric (RR, 0.82; 95% CI, 0.76–0.89) in-patient populations, with both showing substantial heterogeneity across the studies. Solomon et al.14 using 20 studies, also found a significant decrease in hospital mortality with substantial heterogeneity (RR, 0.88; 95% CI, 0.83–0.93; \( I^2 = 86\% \)). The other meta-analysis, Chan et al.12 using 15 adult and pediatric studies, found no difference in overall hospital mortality (RR, 0.92; 95% CI, 0.82–1.04), with substantial heterogeneity of these studies (\( I^2 = 90.3\%, \ P < 0.001 \)). A sub-group analysis of the 4 pediatric studies did show a significant decrease in hospital mortality (RR, 0.79; 95% CI, 0.63–0.98), although this finding was not robust to sensitivity analyses. In addition, significant heterogeneity was observed (\( I^2 = 66.0\% \), \( P = 0.03 \)).

Winters et al.16 in their systematic review, which included the studies from Chan et al.12 in addition to newer publications, found that 18 of 23 studies showed favorable point estimates, 7 of which were significant for adult total hospital mortality. For pediatric total hospital mortality, 5 of 6 studies had point estimates favoring RRSs, with 2 studies having significant results. The systematic review by McNeill and Bryden15 found similar results across studies, with RRT reducing mortality.

Two single studies found no significant change in the overall mortality rate after the implementation of the RRT.3,18 Chen et al.18 in a 2016 study assessing the impact of RRS implementation across New South Wales, Australia, found that overall hospital mortality rates and CA rates had been progressively decreasing in the 2 years before RRS implementation. There were no changes in these trends once an RRS was implemented. However, in the post-RRS period, there was a significant decrease in mortality among low-mortality diagnostic-related group patients (defined by combining all patients admitted under a diagnostic related group with a mortality <0.5% in any of the previous 3 years). The decreased mortality rate in this group of patients was attributed entirely to RRS prevention of CAs, suggesting that this population is where future RRS implementation may have the most impact. Moriarty et al.3 using a retrospective pre/post study design, found no difference in overall hospital mortality between the preimplementation and postimplementation periods: 1.5% and 1.6%, respectively (\( P = 0.299 \)). The authors did find a significant decrease (\( P = 0.016 \)) in the original AHRQ Patient Safety Indicator 04, Failure to Rescue. This measure has since been renamed
| Study                  | Methods                                                                 | Afferent Limb                      | Efferent Limb                      | Overall Hospital Mortality | CA Rate               | ICU Transfer Rate |
|------------------------|-------------------------------------------------------------------------|-----------------------------------|-----------------------------------|---------------------------|----------------------|------------------|
| Meta-analyses          |                                                                         |                                   |                                   |                           |                      |                  |
| Chan et al\(^{12}\)    | Meta-analysis (18 studies)                                              | Not specified                     | RRTs (13/16 studies reporting team composition included physicians) | No significant difference | Decreased (non-ICU) | Not reported     |
| Maharaj et al\(^{13}\) | Meta-analysis (29 studies)                                              | Not specified                     | RRTs (19 studies reported physicians as part of team) | Decreased                | Decreased (non-ICU) | No significant difference |
| Solomon et al\(^{14}\) | Meta-analysis (30 studies)                                              | Not specified                     | RRTs (14 studies with physicians and 4 studies without) | Decreased                | Decreased (non-ICU) | Not reported     |
| Systematic reviews     |                                                                         |                                   |                                   |                           |                      |                  |
| McNeill and Bryden\(^{15}\) | Systematic review (42 studies)                                            | Activation by early warning systems | Physician-led METs (20 studies) or nurse-led multidisciplinary outreach services (22 studies) | Decreased                | Decreased (not specified) | Decreased        |
| Winters et al\(^{16}\) | Systematic review (43 studies: 18 studies from Chan et al\(^{12}\) and 26 studies published after) | Not specified                     | RRTs (varied across individual studies) | Decreased                | Decreased (non-ICU) | Not reported     |
| Single studies         |                                                                         |                                   |                                   |                           |                      |                  |
| Blotsky et al\(^{17}\) | Prospective pre/post study evaluating the effect of a medical CTU-based RRS in a single hospital | CTU nurse-activated based on specific criteria or serious concern | Responder is CTU senior medical resident | Not reported | Decreased (CTU) No significant difference (hospital-wide) | Decreased |
| Chen et al\(^{18}\)    | Interrupted time series to evaluate the effect of a standardized RRS (BTF) in 232 hospitals | Activation using standard criteria | CERS, specific to each facility | No significant difference | No significant difference | Not reported     |
| Moriarty et al\(^{1}\) | Retrospective pre/post study evaluating the effect of an RRT             | Activation by any care provider based on concern or physiologically based criteria | RRT (critical care fellow, critical care nurse, respiratory therapist, supervised by in-house intensivist) | No significant difference | Not reported | Increased |
| Pain et al\(^{19}\)    | Prospective longitudinal study evaluating the implementation of an RRS (BTF) in 225 hospitals | Activation using standard criteria | CERS, specific to each facility | Not reported | Decreased (hospital-wide) | Not reported     |

*Findings are statistically significant except where noted.

BTF, Between-the-Flags; CERS, Clinical Emergency Response System; CTU, clinical teaching unit.
and redefined as Death Rate among Surgical Inpatients with Serious Treatable Complications.\textsuperscript{21}

**Cardiac Arrest Rate**

In their meta-analysis in 2010, Chan et al\textsuperscript{12} determined the pooled RR using 16 studies and found an overall decrease in non-ICU CAs after RRT implementation, although with substantial heterogeneity among the included studies (RR, 0.65; 95% CI, 0.55–0.77; \( F = 73.99\%, P < 0.001\)). In subgroup analyses, RRT was associated with a 33.8% reduction (RR, 0.66; 95% CI, 0.54–0.80) in the adult population and a 37.7% reduction (RR, 0.62; 95% CI, 0.46–0.84) in the pediatric population. Similar results were described in the meta-analysis by Maharaj et al,\textsuperscript{13} who found a significant reduction in CA in the adult (RR, 0.65; 95% CI, 0.61–0.70) and pediatric (RR, 0.64; 95% CI, 0.55–0.74) populations. In the 2016 meta-analysis by Solomon et al,\textsuperscript{14} implementation of an RRT was found to be associated with significantly decreased rates of non-ICU CA (RR, 0.62; 95% CI, 0.55–0.69), with substantial heterogeneity among the included studies. The systematic reviews conducted by Winters et al\textsuperscript{16} and McNeill and Bryden\textsuperscript{15} are in alignment with these findings, concluding that RRT significantly reduces in-hospital CA rates.

Two of the single studies reached similar conclusions,\textsuperscript{17,19} and one study\textsuperscript{18} showed a continuing significant trend of decreasing CA that was present before the implementation of the RRT, but unchanged by its introduction.

**ICU Transfers**

Four studies reported the impact of RRT on ICU transfer/admission rates, with varying results. Maharaj et al,\textsuperscript{13} based on their meta-analysis of 10 studies, found no association between RRT and ICU admissions for the adult population (RR, 0.90; 95% CI, 0.70–1.16; \( P = 0.43\)). None of the pediatric studies reported results on the effect of RRT on ICU admissions. McNeill and Bryden\textsuperscript{15} in their systematic review found that RRT (both METs and multidisciplinary outreach services) reduced unplanned ICU admissions.

Among single studies, Blotsky et al\textsuperscript{17} found a decrease in ICU admissions from 4.8 to 3.3 per 1000 patient days ( \( P = 0.04\) ), suggesting that their intervention of a senior-resident-led RRT decreased ICU transfers by intervening before patient deterioration, although for patients transferred to the ICU, they did not demonstrate a decrease in overall mortality or 30-day mortality. Conversely, Moriarty et al\textsuperscript{3} found an increase in ICU transfers from 13.7 to 15.2 per 1000 floor days ( \( P < 0.001\) ) and hypothesized that this could be due to a larger number deteriorating patients being seen and transferred to the ICU appropriately by the RRT.

**Impact of RRT Composition on Outcomes**

Daniele et al\textsuperscript{20} conducted a systematic review of 26 articles to assess the impact of team composition on patient outcomes. Ten RRTs were physician led, 13 were critical care registered nurse led, and 3 were nurse practitioner led. Team composition was not associated with the patient outcomes of non-ICU cardiopulmonary arrest, unexpected mortality, or unplanned ICU transfers.

Two meta-analyses described similar results.\textsuperscript{13,14} A meta-regression conducted by Maharaj et al\textsuperscript{13} found the presence of a physician on the RRT was not significantly associated with a reduction in mortality. Solomon et al\textsuperscript{14} compared RRTs with physicians (14 studies) to RRTs without (4 studies) and found that team composition had no impact on hospital mortality or in-hospital CA.

In their systematic review, McNeill and Bryden\textsuperscript{15} concluded that physician-led METs might improve survival and reduce CA rates and unplanned ICU admissions, whereas the evidence to support nurse-led teams is equivocal.

**DISCUSSION**

This systematic review, which focused on the efferent limb (i.e., response) of the RRS, found the implementation of RRTs to be associated with decreases in the 2 most frequently studied patient outcomes: hospital mortality and in-hospital CA. The strength of evidence for the reduction in in-hospital CAs remains moderate to high, with results from the higher-quality studies, including the meta-analyses, supporting their use. For overall hospital mortality, the evidence supports an association between RRT and declining mortality, although a more recent, prospective study of 232 hospitals,\textsuperscript{18} found no change in the already declining mortality trend after implementation. In a subgroup analysis, however, the authors did find a significant decrease in mortality among low-mortality diagnostic-related group patients, which may be a more sensitive indicator of failure to rescue.

Many of the studies also used the rate of ICU transfer as an indicator for RRT success with mixed results. It is difficult to interpret changes in the ICU transfer-rates, as an increase can mean that there is effective uptake of the RRTs and patients are appropriately transferred to a higher level of care. A decrease in transfers may mean that the RRT is effective in intervening on patients at risk of deteriorating before the need for ICU care. The ICU transfer rate should be linked to other outcomes (e.g., ICU mortality) to provide context to the findings.

Several themes emerged from the review of the literature. First, there is a general lack of discussion across studies regarding the mechanisms of RRT activation and the potential impact on RRT response and patient outcomes. Studies that do acknowledge an activation process either analyze the impact of the event detection mechanism and the impact of the team response on patient outcomes separately\textsuperscript{15} or analyze the impact of the RRS as a whole.\textsuperscript{17–19}

The actual mechanism of the activation process is often left undefined, without clear descriptions of who participates, what the process involves (including use of electronic monitoring systems), or whether activation is mandatory versus voluntary. One study included in the systematic review by Daniele et al\textsuperscript{20} found that changing the activation mechanism from a voluntary to mandatory call based on physiologic criteria resulted in a statistically significant decrease in cardiopulmonary arrest rates.\textsuperscript{22} This suggests that voluntary activation may present a barrier to successful RRT use, whereas mandatory activation may act as a facilitator. Further research to address the link between the afferent and efferent limbs of the RRS is needed.

Cultural barriers and traditional hierarchical models of patient monitoring and rapid response may prevent successful implementation of RRTs. For example, Moriarty et al\textsuperscript{15} suggest that the monitoring team may hesitate to activate the response team in fear of the call being viewed “as an acknowledgment of inadequacy on their part.” Just as a culture of clear communication and teamwork can help to facilitate successful RRT implementation, one that discourages speaking up and instead supports a hierarchical structure can impede both perceptions and utilization of an RRT.

Several studies describe lapses between RRT implementation and seeing increases in RRT activations and improved in patient outcomes. Pain et al\textsuperscript{19} found a significant increase in RRT activation rates 3 years after implementation. Moriarty et al\textsuperscript{15} identified significant findings beginning in the second year after response team implementation. However, these changes coincided with the institution’s efforts to educate nursing staff as well as to increase positive perception of the RRT, suggesting that educational efforts, rather than time, drive lasting culture and process changes.
In the systematic review by Daniele et al.,²⁰ 8 of 9 studies that found significantly decreased rates of CAs had an RRT in place for at least 1 year. On the contrary, the meta-analysis by Mahraj et al.¹³ was unable to find any dose-response relationship between duration of RRT implementation and hospital mortality.

**Limitations**

There are several moderate-to-high quality systematic reviews and meta-analyses, but the methodological quality of each study included in these reviews is generally moderate to good. Studies have been mostly single center, before-after observational, and retrospective, without control groups or accounting for confounding factors. Conventional randomized controlled trials may no longer be possible because of widespread uptake, which eliminates the pool of control groups. Without the presence of a concurrent control group in most studies, it is difficult to make conclusions about causality. This is especially true for overall hospital mortality rate, which Solomon et al.,¹⁴ noted has been independently falling since 2000. Therefore, even those studies that observe a decrease in hospital mortality rate may be falsely attributing a secular trend to RRS implementation.

Even if control groups can be identified, it is difficult to control for the possibility of contamination of knowledge and cultural changes around RRT. Because RRT utilization is now so widespread, it has become difficult to produce high-quality, randomized controlled trials.

**CONCLUSIONS**

There has been rapid uptake in the implementation of RRT as a means to reduce failure-to-rescue events, defined by hospital mortality and in-hospital CA rates. Our systematic review of 3 meta-analyses, 3 systematic reviews, and 4 single studies demonstrates moderate evidence linking the implementation of RRTs with decreased mortality and non-ICU CA rates. Results linking RRT to ICU transfer rates are inconclusive and challenging to interpret, as increases or decreases in transfer rates may indicate overall improvement in patient care. There is some evidence to support the use of physician-led teams, although evaluation of team composition was variable. Lastly, the benefits of RRTs may take a significant period after implementation to be realized, owing to the need for a change in safety culture that supports voicing concern over patient care without the fear of reprimand.

Given the state of the literature as presented in this review and the challenges with conducting high-quality randomized controlled trials due to an ever-decreasing number of control groups, it may be time to shift the focus of FTR research. Studies are now needed to assess the optimal (and most efficient both in time and in cost) team composition, as well as the screening systems and types of criteria and alerts, including automated patient monitoring systems used in the afferent limb of the system to activate the RRT.

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