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Use of Rapid Response Systems in Adult Academic Medical Centers

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Introduction

Prevention of patient death from clinical errors is an important priority for our health care system.¹ One strategy to reduce preventable hospital deaths are rapid response systems (RRS) which were initially described in 1995.² Since that time, there has been an alphabet soup of designations used to refer to RRS, (e.g. rapid response team [RRT], medical emergency team [MET], rapid assessment team, critical care outreach team [CCO], and the medical emergency rapid intervention team [MERIT]).^{3–21} Despite the varied designations, the consistent purpose of RRS is early, decisive intervention *before* a patient's condition deteriorates into cardiopulmonary arrest. The recent RRS consensus conference clarified the nomenclature used to describe the structure and function of RRS.²² These consensus guidelines define the functions of RRS as including four limbs—early patient identification, response triggering, crisis response, and administration/process improvement responsible for providing the resources to run the system.²²

Despite the obvious benefit of bringing quick, multidisciplinary care to the bedside of a patient in distress, the literature has not shown consistently strong evidence of a benefit in use of RRS. Guidelines specifying appropriate, meaningful endpoints have recently attempted to standardize the disparate outcomes measured in earlier studies²³; study designs have consistently included quasi-experimental approaches with one randomized clinical trial and one meta-analysis; team structures have varied immensely; settings have varied from multiple single-center studies in community hospitals to multicenter studies in countries with vastly

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different health care systems.^{3–21} The one meta-analysis of RRS studies noted weak evidence that use of RRS offers a benefit in decreasing mortality or arrest rates.²⁰ Effectiveness of the RRS in pediatric populations has also yielded mixed results in single-center, academic medical center (AMC) studies.^{14–17} The Australian multicenter, randomized trial, the Medical Emergency Response Intervention Trial (MERIT), found no significant decrease in overall mortality associated with use of RRS.¹⁹ A recent secondary analysis of data from the MERIT trial has shed light on potential confounding issues surrounding design, outcome endpoints, and implementation of RRS in light of the negative randomized trial findings.²¹ Questions regarding implementation and measurement of benefits of RRS continue to be debated in the literature.^{20,24}

Despite a lack of definitive data to document its benefits related to clinical outcomes, implementation of RRS has become widely accepted and popularized by the Institute for Healthcare Improvement's (Cambridge, MA) "Saving 100,000 Lives" campaign.²⁵ The Joint Commission on Accreditation of Healthcare Organizations has also included requirements for the establishment of RRS as one of their national patient safety goals.²⁶ Administrators are often in a quandary whether it is wiser to put scarce resources into implementation of RRS (with little or no scientific data to support decreased mortality) or into other aspects of patient safety that have been linked statistically to decreasing patient mortality such as increasing nursing staffing.²⁷

Questions remain as to the necessity and effectiveness of RRS in AMCs compared to community hospitals. Academic medical centers have different missions and responsibilities than community hospitals, and generalization of findings from community hospitals cannot routinely be applied to the AMCs. Patient safety goals may be more difficult and time consuming for AMCs to achieve as they deliver complex care to higher acuity patients, have responsibilities for medical, nursing, and allied health care education, as well as conducting cutting edge clinical research. The multiple layers of physician hierarchy (interns, residents, fellows, and attendings) at AMCs may provide an argument for implementing RRS,⁷ but also complicates the implementation process and demands clarification of the role of the RRS in regard to other processes already in place.

The purpose of this paper is to describe a survey conducted to determine current practice related to RRS in adult AMCs in the U.S. and the characteristics and structure of those RRS.

Materials and Methods

Study Design

This cross-sectional study utilized an exploratory design in a telephone survey of a convenience sample of Directors of ICUs, Emergency Departments, or Patient Safety at AMCs in the U.S. Informed consent was obtained for this project from the UCSF Committee on Human Research. A list of urban, tertiary care AMCs was identified from the American College of Graduate Medical Education's website of critical care medicine or combined pulmonary/critical care fellowship training programs in the U.S.; from conversations with knowledgeable experts in the field of critical care and emergency medicine; and from conversations with the RRS faculty expert at the Institute for Healthcare Improvement, Cambridge, MA (personal communication, Kathy Duncan, May 23, 2006). Purposive sampling was used to choose 20 AMCs representing different geographic regions of the United States (3–4 AMCs in each of 5 geographical areas of country). Centers handling a variety of specialties in adult patients (16 centers), pediatrics (2), and oncology (2) were included. Two attempts were made to contact directors of the RRS at each of the 20 AMCs.

Efforts to ascertain the leadership of the RRS at the AMCs consisted of contact with the Director of Patient Safety, or the Medical or Nursing Director of either the Intensive Care Unit or the Emergency Department at that center to identify the Director of the RRS or a similar position. Internet searches of the medical centers yielded names, phone numbers and/or email addresses of the initial contact personnel at each center. Once key directors with the RRS were identified, contact was made with those individuals by telephone or email. The interviews with the directors of the RRS at each center took place via telephone using a structured questionnaire (Appendix 1). The answers were recorded through field notes; no conversations were tape recorded. Written field notes were completed without identifying institutional information. Confidentiality and anonymity of information were maintained.

Survey Development

A specific survey questionnaire was developed for this study containing 26 items pertaining to RRS functioning within AMCs. The list of questions was initially developed after discussion and review by a group of RRS experts including ED physicians, hospitalists, quality improvement personnel, and ICU clinical nurse specialists at our facility and at the Institute for Healthcare Improvement. The questionnaire was pilot tested with two Directors of ICU at AMCs not included in the sample and revisions were made.

Data Analysis

Data were analyzed using both qualitative and quantitative methods. Content analysis was carried out on field notes from conversations with the directors at each site, and quantitative data analyses included means and standard deviations.

Results

Directors of RRS at fifteen AMCs responded to our inquiries (14 adult focused centers, 1 oncology center). The mean size of the medical centers included was 710 beds (range 398 to 1228 beds). Four centers had a strictly critical care fellowship program and the remaining (11) had a combined pulmonary/critical care fellowship program. The centers included showed broad geographic differences, had RRS in place for a mean of 18 months, and used a variety of team structures used as shown in Table 1. The “Trigger” structure of RRS used at two centers does include all four arms defined as mandatory components of a RRS (event detection, response triggering, crisis response, and process improvement); however, once the trigger system is activated, it utilizes a physician-led response team comprised of physicians who already have responsibility for the patient.²⁸ Endpoints that centers used to gauge success were varied and are also presented in Table 1.

How Calls are Initiated

The criteria differed slightly between centers but generally included all criteria listed in Table 2. The most frequent reasons reported for RRS calls fell into two main categories: respiratory (70%) or nurse concern (30%). Once criteria were met to activate the RRS, calls were initiated in a variety of ways. Most (75%) centers used a system where the bedside nurse (or unit secretary) notified either the medical center switchboard or a unique number which in turn activated pagers/cell phones of team members. Overhead pages were used by all centers initially, but these led in many centers to crowds and confusion at the bedside. Bedside crowds were found to be intimidating and served as a disincentive to call the RRS again.

After assessment of the unstable patient, the RRS team leader had the responsibility to notify the on-call resident for the primary team. In the two centers using the Trigger system, the on-call physician for the primary team carried out the initial assessment. Four centers not using the Trigger system required the bedside nurse (or unit secretary) to simultaneously notify the

RRS as well as the primary team physician on call. Notification of the primary physician by the bedside nurse gave the physician the option to participate if he or she so chose or to temporarily transfer patient care to the RRS response team. All centers expressed difficulties with this process initially as multiple primary physicians were reluctant to cede control to the RRS, and often chastised bedside nurses for activation of the RRS. One center shared their script that provided confidence to the bedside nurse when notifying the primary physician and increased acceptance of the RRS intervention by physicians in the medical center: "I needed another pair of hands to help the patient in this situation, so I activated the RRS." Four centers found it more efficient and successful to contact the primary physician only after the RRS team's assessment was complete, similar to the process following a cardiopulmonary arrest.

Over time however, centers with longer running RRS noted the primary physicians came to trust members of the response team and expressed not only relief and appreciation, but also a desire for intervention by the RRS. Centers with mature RRS discussed the success of marketing the RRS as a strategy to protect the primary physicians' time and improve care of their patients.

All centers reported RRS calls were initiated mainly by nurses, although one center reported that as the RRS had matured, 20% of their calls came from interns and residents. One AMC allowed families to activate the RRS. Usually initiated by a parent or family member of the patient, these calls were not as frequent as initially predicted. Allowing families to call the RRS was a feature that the center initiated after painstaking discussions between AMC providers and administration. Successful outcomes of these family-initiated RRS events encouraged the AMC to use this feature in the public marketing of their center as an added safety feature.

Barriers to RRS Success

The most common barrier to success with implementation of a RRS was the lack of funding for full-time staff positions. Most centers reported difficulty achieving success when forced to operate the RRS with staff who had other full-time responsibilities. Funding sources varied, yet became less problematic as call volume increased and successful data outcomes could be reported. Financial benefits of the RRS program consistently were reported as nebulous and difficult to quantify, yet as programs became more active, this evidence became obvious. Another common barrier reported was perceived lack of support from administration. If hospital administration was weakly supportive or a physician champion was not initially involved, then success was more difficult to attain and functioning of the RRS was greatly compromised.

Changes in RRS over Time

Directors at 86% of the seven nurse-led RRSs reported that their center had started with a different team structure than what was currently in practice and that these changes were made due to perceived underutilization of the prior team. Centers whose teams changed their structure changed in one of two ways: (1) they started with a full cardiopulmonary arrest physician-led team and evolved to a nurse-led team with much more frequent, proactive functions; or (2) they started with a RRS nurse and/or respiratory therapist who worked on the RRS team in addition to their regular jobs then changed to a fulltime RN position or RN plus respiratory therapist on the response team. Due to the high prevalence of RRS calls related to respiratory events, having a respiratory therapist on the team as an initial responder was reported to be more efficient than having to page them separately.

The number of RRS calls were reported to increase the longer the RRS was in existence; however the rate of increase varied widely. There was a mean of 45 RRS calls per month (range from 5–166 calls/month) reported. While only 20% of centers noted a decrease in hospital

mortality as RRS call volume increased, 60% of centers did report a corresponding decrease in codes outside the ICU. All centers using proactive rounding spoke of seeing the call volume increase with more frequent, proactive functions such as regular patient rounds and noted that this was more feasible once the full-time RRS positions were established. Proactive rounds were expanded in many of the centers who had successful RRS to include any patient who was: transferred out of an ICU whose ICU stay was ≥ 3 days; admitted with a primary or secondary diagnosis of sepsis; and receiving high flow oxygen and/or nebulizer treatments. Identification of the most seriously ill patients on each unit also became part of expanded rounds over time. This ability to identify potential patients early in anticipation of their deterioration also served to improve patient outcomes.

Funding positions for data management personnel who would maintain the RRS call database was a challenge at all organizations. In 31% of centers RRS nurse coordinators were responsible for managing the RRS call data, especially while call volume was low. This responsibility in other AMCs fell to staff managing cardiopulmonary arrest data for the AMC, or to the ICU director's administrative staff. Other responsibilities for nurse and physician response team members included development of and teaching the RRS content for educational classes, as well as frequent lectures at hospital employee orientation and nursing unit inservices.

The patient areas covered by the RRSs expanded over time. All inpatient medical and surgical patient care units, as well as procedural units holding admitted patients awaiting inpatient beds were covered at all AMCs. Most centers (75%) had the team cover the emergency department; however four centers did not. Ten medical centers (67%) provided RRS coverage to inpatients and outpatients in the areas of endoscopy, cardiac catheterization, stress testing, dialysis, bronchoscopy, and interventional radiation. Four (27%) of these centers reported that their RRS also covered the general population of outpatients and visitors in the outpatient clinics, parking garages, outpatient pharmacy, cafeteria, and physician offices.

Six centers (38%) were considering expanding the functions of the RRS to include proactive management of acute myocardial infarction and sepsis patients in the emergency room awaiting treatment or a critical care bed. Standing medical order protocols for similar types of urgent patient situations were developed at these AMCs to enable faster patient intervention.

Strategies for Success

Discussion of the role, criteria, and success stories of the RRS during initial hospital personnel orientation served as a crucial factor in success for 67% of centers. Presentation of this content during orientation of new employees and medical trainees served to develop awareness of the RRS, as well as widespread understanding of the criteria for impending patient deterioration. The educational piece of building RRS awareness in all hospital staff was linked by these centers to increased call volume and improved patient outcomes. All centers agreed that the importance of RRS members being approachable and developing a good rapport with staff on the nursing unit cannot be underestimated if the RRS is to succeed. Any negative feedback directed to the bedside nurse that the call was inappropriate, or questions regarding the nurse's judgment were found to severely hamper the success of the RRS.

Also of note as a strategy for success was establishment and growth of the process improvement arm of the RRS. Follow-up surveys, completed within 24–48 hours of the event by the initiating staff member, were crucial to identifying and correcting antecedents to the event. Eighty percent of centers used this method of evaluation, leading to novel ideas for improvements within the RRS and served to increase levels of satisfaction among the nursing staff. Additionally, directors at all 15 centers reported weekly, biweekly, or monthly meetings of the multidisciplinary RRS committee for detailed evaluation of each RRS call. Information about the clinical situation and interventions were reviewed for appropriateness and success. These

debriefing sessions served as an educational opportunity for team members, maintained the motivation of the team, and provided data for improvement of other systems throughout the medical center.

Nine centers (60%) reported that as the RRS matured and achieved success, other system issues within the organization came to light. For example, one center reported a majority of RRS calls from a certain nursing unit were repeatedly due to undetected hypoglycemia. After identifying of a lack of glucometers on the unit as the problem, additional equipment dramatically decreased the number of RRS calls due to hypoglycemia. Another center reported repeated respiratory RRS calls on two units. Those particular units were found to be ill-equipped with respiratory supplies and have several new graduate nurses with little expertise in managing respiratory equipment. Additional content on respiratory equipment was added to nursing orientation classes, along with clarification of respiratory job responsibilities of daily checks on respiratory equipment in each room, and repeated pulmonary inservices for all nursing units. These steps significantly decreased RRS call volume for that specific reason on those units. Another center reported RRS calls related to issues of miscommunication between primary physicians and nurses on certain floors. Those units adopted the SBAR (situation, background, assessment, recommendations) communication system through educational sessions for staff, use of tip cards, and posters in the nursing lounge. The result was a decrease in RRS calls related to communication issues and an increase in nurse and physician satisfaction. These process changes are examples of how the quality improvement limb of the RRS can assist in preventing future events by creating a culture of safety at the organization.

Impact on Patient Safety

Two centers successful MET centers reported eliminating cardiac arrest teams due to the success of the RRS. The MET answered all RRS and cardiopulmonary arrest calls with higher efficiency and less duplication of services. A decrease in the percent of patients moving to a higher level of care was reported as an important marker of success. Since the initiation of the RRS, a mean of 50% (range of 40%–70%) of patients were now cared for at the bedside instead of needing an ICU bed across all centers.

Discussion

To our knowledge, this study was the first attempt to survey AMCs throughout the U.S. as to the functioning of RRS in their environment. Although limited by a small sample, this survey provides initial insight into how AMCs in the U.S. utilize RRS in clinical practice. The teams varied in name, composition, purpose, and patient care areas covered, and no one optimal team composition was identified. Most centers reported at least moderate success in many endpoints with nurse-led teams, although there were several team models reported. The use of proactive rounds was reported to significantly increase RRS call volume, nurse satisfaction, and improve patient outcomes; although no center reported data on lowered costs through the use of an RRS. Additionally, the AMC teams surveyed possessed all four limbs of the RRS.

Many of the centers had struggled with similar issues and identified key factors in the success of the RRS. The key factors were: (1) despite differing models of response team composition, the initial responders should be at least an experienced, ACLS-certified, critical care nurse and respiratory therapist who have no other full time responsibilities; (2) expert physician availability or backup should be easily accessible and provided 24 hours a day/7 days a week; (3) proactive rounds and frequent visibility of RRS team members on units increase call volume and effective intervention; (4) an extensive educational and marketing plan for all hospital staff about key patient identification criteria, and feedback to staff about RRS success on an ongoing basis; (5) at least monthly RRS evaluation sessions for ongoing quality improvement; and (6) ongoing administrative and physician support for implementation of the RRS must be provided.

The last three key factors refer to the importance of the process improvement arm of the RRS. This fourth arm of a RRS should include administrative input into designing the type of response team structure and professional membership of that team, allocating appropriate funding for staff positions and equipment, participation in tracking the outcome data and cost savings, and a willingness to modify hospital processes when necessary.

The case for rapid response systems may be similar to the introduction of coronary care units in the 1960's that had little, if any, initial physician or administrative support due to sparse data from clinical trials demonstrating decreased patient mortality. Yet over time, evidence demonstrated the effectiveness of these highly specialized units and early nurse-led interventions at improving a variety of outcomes related to acute care of the cardiac patient.^{29–32} Others have suggested that use of RRS is similar to use of pulse oximetry which, despite no evidence from randomized trials, has been widely accepted as a valuable method of monitoring patients' oxygenation status due to analysis of patient events, suggesting a decrease in the risks of anesthesia.³² At this point it would be unethical to go back and randomize patients to a control group that did not receive either access to a coronary intensive care unit or pulse oximetry.

The centers with successful RRS programs defined each RRS call as a chance to save a life, as well as an educational opportunity to increase the knowledge base of nurses, interns, and residents throughout the institution, leading to a culture of improved patient care. Frequent evaluation of each RRS call to better understand how to predict which patients will need a higher level of care serves to illuminate other problematic processes within the medical center such as medication errors and patient safety issues.³³ The most important goal of these types of teams should be creating systems whereby all hospital staff are attuned to the early warning signs of imminent patient deterioration and delivery of more effective, higher quality, and safer patient care.

Additionally, the RRS system was reported to: empower nursing staff with education increasing their knowledge of early signs of patient deterioration, giving them a sense of control over the patient situation, and providing expert clinical support when needed; serve as a method of identifying other processes negatively affecting patient safety in the medical center; improve issues of bed allocation by allowing a higher percentage of critically ill patients to be cared for outside of the ICU; improve communication and respect between disciplines leading to increased job satisfaction; and served to reduce hospital expenditures because care is delivered more efficiently.

We recognize that although these data represent experiences from a small number of AMCs using RRS, we attempted to select centers from a broad variety of geographical areas and specialties to increase the generalizability of the findings. Our findings are supported by those of King and colleagues in the introduction of an RRS in their AMC over one year's time.³³ However, the use of RRS in other AMCs and non-AMC hospitals in the U.S. may be very different. We sought to minimize the issues surrounding content validity of the newly developed survey by drawing the questions from clinical experience and a literature review, having experts in the field review the questions, and pilot testing of the survey prior to the current study.

Conclusions

Nationally, many models of RRS exist. Although improvements in patient outcomes were identified, no one optimal structure for RRS was found to be successful for all AMCs. The findings in this survey suggest that RRS can be effective in an AMC to improve patient safety.

However, operational steps for implementation are challenging and obtaining benefits from the RRS takes time.

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Appendix A. Survey on Use of Rapid Response Teams in Academic Medical Centers

1. Number of beds_____, Number of Intensive Care Unit beds_____
2. Does your hospital have a Rapid Response System (RRS)? What kind of response team structure and function exists?
3. How long have you had your system in place and has it changed over time?
4. What types of professionals comprise the response team?
5. Do you have a separate cardiac arrest team?

6. Do you have a separate Intensive Care Unit team that evaluates patients prior to ICU admission?
7. What are the certification or experience pre-requisite criteria for team members?
8. What are the roles of members?
9. Is the RRS staffed with full time RRS personnel?
10. How are RRS calls initiated?
11. Do you limit crowds during RRS/cardiopulmonary arrest calls? Is this an issue?
12. Does RRS complete a written report? Who completes form? Who reads the forms?
13. How often does the team meet to go over the forms &/or events?
14. How do you keep track of calls? Whose responsibility is it to maintain call log or manage database?
15. Does the RRS cover the Emergency Department? Is there a separate Pediatric RRS? Does RRS cover the outpatient clinics, Endoscopy, Cardiac catheterization lab, dialysis? Does the RRS cover other areas of hospital campus including cafeteria, lobby of hospital, or parking garage?
16. At your center, is the RRS response team called only for inpatients or anyone in hospital who feels weak or injured?
17. Why did your center start an RRS?
18. Number of RRS calls/month _____; number of cardiopulmonary arrests/month _____. Do you also count informal calls from floor nurse to ICU nurse in this number?
19. Has your RRS call volume been increasing over time, maintaining same volume, or decreasing over time?
20. Who initiates the majority of the calls? (nurse, respiratory therapy, physician, family, other)?
21. Does your center allow family members to call the RRS?
22. How is notification of primary physician handled?
23. Does your RRS participate in proactive rounds on patients within hours of leaving Emergency Department, Post Anesthesia Care Unit, Intensive Care Unit? If so, within how many hours?
24. What are the main indications for calls (Vital Sign changes, clinical concern, etc.)? If Vital Sign changes are used, which are the most commonly seen?
 - ☐ Respiratory Rate changes ≤ 8 or ≥ 28
 - ☐ Heart Rate changes ≤ 40 or ≥ 120
 - ☐ Blood Pressure changes ≤ 90 mm Hg ≥ 40 mm change
 - ☐ Drop in O₂ Saturation $\leq 90\%$ on O₂
 - ☐ Change in Level of Consciousness
 - ☐ Caregiver concerned
 - ☐ Temperature changes $< 35.0^{\circ}$ C orally
 - ☐ Oliguria

☐ New Onset of: bleeding or chest pain

☐ Other _____

25. What are the outcome measures you most commonly use to gauge success and effect on patient safety? How often are they measured?

☐ ↓ cardiopulmonary arrests	☐ ↑ nurse retention
☐ ↓ cardiac arrests outside of unit	☐ ↓ unplanned transfers to ICU
☐ ↓ mortality	☐ ↓ Length of Stay after RRS
☐ ↓ ventilator days after RRS	☐ ↑ staff satisfaction
☐ ↓ respiratory emergencies	☐ appropriateness of Call
☐ ↑ number of RRS calls	☐ ↑ survival after non-ICU cardiac arrest
☐ ↓ nurse turnover	☐ ↑ physician satisfaction
☐ ↓ costs or ↑ financial savings	

26. What were the main barriers to success of RRS at your center?

☐ ↓ physician support	☐ No funding for full time positions
☐ ↓ administration support	☐ No marketing/education push
☐ Other: _____	

Table 1

Demographics of Academic Medical Centers in Sample (N=15)

Center ID	Location by State	Duration of RRS	RRS Team Composition	Proactive Rounds?	Most Common Endpoints Measured
1	MA	8 mths	RN-led	No	↓ transfers into ICU, ↓ cardiopulmonary arrests, ↑ RN retention, ↓ mortality, ↑ RRS calls, ↓ arrests inside/outside ICU, ↑ patient safety culture as measured by staff responses on safety questionnaire
2	WV	2 yrs	MD-led	Yes	↓ arrests outside of ICU, ↑ MET calls, ↓ mortality, ↓ cardiopulmonary arrests, ↓ transfers into ICU, ↑ appropriateness of RRS calls
3	PA	3 mths	RN-led	No	↓ mortality, ↓ arrests outside of ICU, ↓ transfers into ICU, ↓ cardiopulmonary arrests, ↑ RRS calls
4	PA	4 yrs	MD-led	No	↓ mortality, ↓ cardiopulmonary arrests, ↑ RRS calls, ↓ arrests inside/outside ICU, ↓ transfers into ICU, ↑ appropriateness of RRS calls, ↑ survival from arrests outside ICU, ↓ arrests after transfers from ICU, ED, PACU
5	OH	7 mths	RN-led	No	↓ cardiopulmonary arrests, ↑ RRS calls, ↓ mortality, ↓ arrests inside/outside ICU
6	MI	2 yrs	RN-led	Yes	↓ mortality, ↓ respiratory arrests, ↓ LOS, ↑ RN retention, ↓ transfers to ICU, ↑ RRS calls, ↑ appropriateness of RRS calls, ↑ survival from arrests outside ICU
7	IL	1 yr	RN-led	No	↓ cardiopulmonary arrests, ↓ mortality, ↑ RRS calls, ↓ arrests inside/outside ICU
8	MO	3 mths	MD-led	No	↓ mortality, ↓ transfers to ICU, ↑ MET calls, ↓ cardiopulmonary arrests, ↓ arrests inside/outside ICU
9	IA	2 yrs	MD-led	No	↓ arrests outside of ICU, ↑ survival from arrests outside ICU, ↓ mortality, ↓ cardiopulmonary arrests, ↑ MET calls, ↓ transfers into ICU, ↑ appropriateness of RRS calls, ↓ ICU days after arrest
10	NE	2 yrs	MD-led	Yes	↓ unplanned admissions to ICU, ↓ total arrests, ↓ mortality, ↓ arrests after transfers from ICU, ED, PACU, eliminated separate cardiac arrest team, ↑ MET calls, ↑ appropriateness of RRS calls, ↑ survival from arrests outside ICU, ↑ RN satisfaction
11	TX	1.5 yrs	RN-led	Yes	↓ arrests outside of ICU, ↓ unplanned ICU admissions, ↓ pts needing higher level care, ↑ RRS calls, ↓ mortality, ↓ cardiopulmonary arrests
12	WA	5 mths	RN-led	Yes	↓ cardiopulmonary arrests, ↓ ICU transfers, ↓ mortality, ↑ RRS calls
13	CA	1 yr	MD-led	No	↓ cardiopulmonary arrests, ↓ arrests outside of ICU, ↓ mortality, ↓ LOS, ↑ RN satisfaction & retention, ↑ RRS calls

Center ID	Location by State	Duration of RRS	RRS Team Composition	Proactive Rounds?	Most Common Endpoints Measured
14	MA	10 mths	Triggers	No	↓ mortality, ↓ cardiopulmonary arrests, ↓ unplanned ICU admits, ↑ survival after arrest, ↑ RRS calls, ↓ arrests inside/outside ICU
15	CO	4 yrs	Triggers	No	↓ cardiopulmonary arrests, ↓ arrests inside/outside ICU, ↓ ICU days after arrest, ↓ mortality, ↑ RN satisfaction, ↑ RRS calls, ↓ transfers into ICU, eliminated cardiopulmonary arrest team, ↓ LOS, ↑ patient safety culture as measured by staff responses on safety questionnaire

Note. Center ID = identification number of academic medical center; Location by State = Rapid Response System; Response Team Composition refers to the type of response team used by the academic medical center; RN-led = response team led by experienced, critical care registered nurse; MD-led = response team led by critical care experienced physician; Triggers = a “Trigger” system was used where the bedside nurse notified the patient’s on-call primary team physician along with a nursing supervisor simultaneously; mths = months ↑ = increased; ↓ = decreased; LOS = length of stay; RN = registered nurse; ICU = intensive care unit; ED = emergency department; PACU = post-anesthesia recovery unit.

Table 2**Criteria for Calling the Rapid Response Team**

If a patient meets any 1 criterion ^{*}, the RRS should be called:

- Temperature: ^{**} < 35.0° C OR >38.9° C orally
 - Respiratory Rate: < 8 breaths per minute OR >28 breaths per minute ⁺
 - Heart Rate: < 40 beats per minute OR >130 beats per minute ⁺⁺
 - Blood Pressure: < 90 mm Hg OR >40 mm Hg change from baseline OR drop > 20% of baseline OR SBP > 190 or DBP > 110mm Hg
 - O₂ Saturation: < 90% on ≥ 60% FiO₂
 - Urine Output: < 50 mL in 4 hours
 - Level of Consciousness: Acute change in mental status
 - Staff Member Worried or Concerned
 - New onset of chest pain ^{**}
 - New onset of seizure ^{**}
 - Significant bleeding or decrease in Hct ^{**}
 - Change in patient color (cyanosis) ^{**}
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^{*} Four centers required patients to exhibit two criteria to initiate a RRS call, all other centers required only one criterion to be met for an RRS call;

^{**} criterion found in only four centers;

⁺ Respiratory High limit varied from > 28 to > 36 breaths per minute;

⁺⁺ Pulse High limit varied from > 120 beats per minute to > 160 beats per minute.