Quality Metrics for the Evaluation of Rapid Response Systems: Proceedings from the third international consensus conference on Rapid Response Systems

On behalf of the international Society for Rapid Response Systems

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Abstract

Background

Clinically significant deterioration of patients admitted to general wards is a recognized complication of hospital care. Rapid Response Systems (RRS) aim to reduce the number of avoidable adverse events. The authors aimed to develop a core quality metric for the evaluation of RRS.

Methods

We conducted an international consensus process. Participants included patients, carers, clinicians, research scientists, and members of the International Society for Rapid Response Systems with representatives from Europe, Australia, Africa, Asia and the US.

Scoping reviews of the literature identified potential metrics. We used a modified Delphi methodology to arrive at a list of candidate indicators that were reviewed for feasibility and applicability across a broad range of healthcare systems including low and middle-income countries. The writing group refined recommendations and further characterized measurement tools.

Results

Consensus emerged that core outcomes for reporting for quality improvement should include ten metrics related to structure, process and outcome for RRS with outcomes following the domains of the quadruple aim. The conference recommended that hospitals should collect data on cardiac arrests and their potential preventability, timeliness of escalation, critical care interventions and presence of written treatment plans for patients remaining on general wards. Unit level reporting should include the presence of patient activated rapid response and metrics of organizational culture. We suggest two exploratory cost metrics to underpin urgently needed research in this area.

Conclusion

A consensus process was used to develop ten metrics for better understanding the course and care of deteriorating ward patients. Others are proposed for further development.

Introduction

Patients admitted to acute care hospitals are at risk of clinical deterioration. Deterioration is associated with an increased risk of potentially preventable in-hospital mortality and morbidity.

A Rapid Response System (RRS) is defined as "a whole system … for providing a safety net for patients who suddenly become critically ill and have a mismatch of needs and resources". There are four components of an RRS: an afferent limb (to identify the deteriorating patient and escalate care), an efferent limb (the responding team), a process improvement arm, and a governance/administrative structure [1].

Safety bodies in several jurisdictions have developed metrics to evaluate the function of an RRS [2,3]. However, variability in the calling criteria for the response team, number of tiers of response, and composition of the responding team, as well as differing healthcare environments, have made development of universally applicable metrics challenging. Such variability has also confounded the comparisons of published studies and benchmarking of hospitals with peers.

The International Society for Rapid Response Systems (iSRRS) was founded in 2012 with the aim of making hospitals safer by improving the detection and response to deteriorating patients, raising awareness of RRS and improve quality of the RRS internationally. [4] In July 2018, the iSRRS held the third consensus conference on RRS to develop metrics that measure the function of the RRS to guide quality improvements. The intent was to produce metrics that permit hospitals to measure the function of their own RRS to allow identification of areas of sub-optimal performance for subsequent quality improvement processes, which were also broad enough in scope to be applicable to a wide range of health care settings, independent of the income status, patient case mix or RRS structure and composition.

Methods

Target and aims

The Consensus Conference assumed that hospitals have processes for identifying deteriorating patients and methods for activating specialized responders. In the absence of such a policy, the recommendations of this conference are applicable to facilities that wish to develop these capabilities.

The primary aim was 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. The metric are across the escalation journey from deterioration to admission to critical care (Fig 1) and cover all clinical areas (Fig 2). The consensus conference considered all three dimensions of metrics: structural, process, and outcomes indicators. [5,6] Levels of recommendations were graded as essential, recommended, optional and exploratory. The latter recommendations are to underpin future research.

Committee membership and processes

A full description of committee selection, sponsorship, and consensus processes is contained in the **Appendix.** The consensus had four phases: a series of pre-conference conference calls to agree agenda items, a two-day consensus meeting in July 2018, a public session with over 200 stakeholders, and post-consensus conference consultation on wording of the document.

Results

Consensus was achieved for ten RRS quality metrics, of which four were related to improving population health, three to enhancing the patient experience of care, two to cost and one to enhancing provider well-being. Level of recommendations were graded as "essential," "recommended", "optional" and “experimental”. Terms used in the formulation of recommendations are described in **Table 1.** **Table 2** provides a summary of specific numerators, denominators and inclusion and exclusion criteria to be used when tracking each entity. We are aware that many hospitals use a multi level activation system; for these institutions, we provide guidance in Table 2 as to which warning level should be used for a given metric.

Recommendation 1: Hospitals should measure and track cardiac arrests of regular ward patients

Type of metric: Clinical outcome, essential

Description of metric: A cardiac arrest is defined as an event in which a patient receives chest compression and/or defibrillation for a non-perfusing rhythm. The definitions of terms used in this and other metrics are presented in **Table 1.**

Rationale: Retrospective reviews of in-hospital cardiac arrests (IHCA) consistently show that signs of deterioration are present for several hours before the event in more than two-thirds of patients.[7-9] This deterioration can take the form of physiological instability, alterations in consciousness or uncontrolled pain that is either not recognised, recognised but not acted upon, or subject to an inadequate level of intervention.[10] Rates of cardiac arrest on general wards can therefore be seen as an indicator of an organization’s ability to appropriately identify, triage, and respond to patients whose course changes for the worse. The proposed recommendation is that hospitals with a RRS or similar notification/ response system measure all cardiac arrests occurring on their non-ICU wards.

Importantly, the definition also includes patients found dead in bed with “full code” status. The latter situation, if clustered around a particular time frame, may suggest a lack of uniform standards for monitoring and event detection throughout the day.[11,12]

We have excluded cardiac arrests occurring amongst non-admitted patients, and also those in the Emergency Department, ICUs and procedural areas such as the operating room, as these settings tend to function under high suspicion for deterioration, use advanced physiologic monitors, and are generally not the subject of hospital-wide RRS. While the metric focuses on a subset of

hospitalized patients, it does not obviate the need to track, analyse and report arrests in other hospital locations [13,14].

The denominator is ward bed days. This approach better reflects the amount of time that patients are exposed to the risk of a cardiac arrest when compared to using admissions or discharges as denominators;[15] the latter underestimate risks contributed by patients with long lengths of stay. The metric allows for multiple cardiac arrests in single patients to be included.

Recommendation 2: Hospitals should measure predictable ward cardiac arrests

Type of metric: Clinical outcome, essential

Description of metric: Cardiac arrests occurring in hospitalized ward patients where there is an escalation criteria breach within 24 hours prior to the arrest, excluding the thirty minutes immediately preceding the event. This metric can be expressed as an absolute number (count), or a proportion of all ward cardiac arrests. In hospitals with multiple response levels the threshold for this metric should be agreed upon locally.

Rationale: IHCA is associated with a mortality risk of approximately 80% [16,17]. Historic studies show that such events are preceded by derangements in patient vital signs for up to 8hrs prior to the event in up to 80% of instances. [7,18,19] Such derangements form the basis of escalation criteria for the RRSs, either in the form of single parameter track and trigger criteria [20], aggregated early warning scores [21], or computer-generated risk scores. [22,23]

The introduction of a RRS has been shown to be associated with a reduction in the risk of IHCA in three meta-analyses. [24-26] Even in mature RRS a portion of IHCAs are still preceded by escalation criteria breaches. [27-29]

Activation of the RRS in the presence of objective escalation criteria in a period of greater than 30 min prior to an IHCA may allow the RRS to prevent the event from occurring. [30,31] Periods of less than 30 min may not be sufficient to allow the RRT to effectively intervene. For any arrest - but especially in situations where there is a criteria breach - hospitals might want to conduct an in-depth review to assess the quality of care provided prior to the arrest.

Recommendation 3: Hospitals should measure timeliness of their response to ward patient deterioration

Type of metric: Process measure, recommended

Description of metric: Proportion of hospitalized ward patients in whom there was an escalation criteria breach who received an evaluation by staff with critical care skills within the pre-specified time period for evaluation. In some settings lacking a formal ICU or outreach team, calls to a transfer center, remote ICU, or appropriate consultant fulfil this goal. The expected time for critical care responders to review the patient is defined at the hospital or health system level. In hospitals with multiple response levels, it is recommended that the highest or most stringent level of response be used in this measure.

Rationale: Escalation criteria for the RRS were developed in response to observations that arrests, unplanned ICU admissions and unexpected deaths were frequently preceded by derangements in vital signs.[7,16,18] Many hospitals throughout the world now have escalation policies that stipulate the conditions under which the care of patients should be escalated.[32] Such protocols include 1) the criteria that should trigger the escalation; 2) how the escalation should be initiated; 3) which clinicians are expected to respond to the escalation; 4) a time frame defining an appropriate response.

At the core of this recommendation is the need to assess whether the local RRS functions as designed, and specifically the component that brings a deteriorating patient to the attention of critical care personnel. Delayed activation of the RRS is associated with a variety of adverse outcomes as described in the section below, yet even in hospitals with a mature RRS, some IHCAs are associated with escalation criteria breaches that were not acted upon.[27-29] Thus, ongoing assessment of the reliability of detection and evaluation of deteriorating patients is warranted.

Recommendation 4: Hospitals should evaluate timeliness of critical care interventions

Type of metric: Process measure, recommended

Description of metric: The proportion of hospitalized ward patients who received critical care within six hours of an escalation criteria breach.

Rationale: Intrinsic to the mission of rapid response is the facilitation or provision of critical care services in a timely manner. We recommend that hospitals measure the time between the breaching of warning criteria and the initiation of critical interventions, and specifically, track the fraction that receive a critical intervention within six hours. If multiple levels of warning are

used, this metric should be associated with the criteria that would summon critical care consultation.

We take a broad definition of critical care that includes initiation of treatment at the ward of origin by a rapid response team, treatment in a separate intensive care unit, or critical care interventions following transfer to a different hospital. Critical interventions include those that are not typically delivered on the ward of origin and should include forms of respiratory support (both invasive and non-invasive), renal replacement therapies, rapid infusion of blood products, vasopressor and inotrope infusions, institution of continuous invasive monitoring or staffing to patient ratios that cannot be achieved on the ward of origin. Which patients require such interventions is left to discretion of the individuals participating in patient care.

Intensive care unit admission has in multiple studies been used to indicate clinical deterioration [33,34], yet in others avoidance of ICU admission is considered desirable [35]. With these considerations in mind, we propose the use of critical intervention as a functional end point to indicate delivery of stabilizing care. It is a patient-centered metric that removes any assumptions of what therapies are being delivered in the ICU and also controls for the vast international and inter-regional heterogeneity in ICU bed availability and in admission practices [36]. Measurement of time to intervention rather than ICU admission preserves clinician judgment as to where to best deliver care and obviates any 'gaming' of this care delivery metric by ICU transfer alone.

The six-hour metric is the most conservative integration of several retrospective studies showing increases in morbidity and mortality associated with delays in RRT evaluation and ICU transfer. A decrease in survival was associated with intervals as low as 15 and 30 minutes between development of documented abnormalities and calling an RRT [37,38], arrival of the RRT [30]. Other studies found an association between documented instability and RRT calls greater than one hour later and odds for mortality and ICU admission [39,40], and similar findings with delays greater than four hours [41], and twelve hours [42].

Recommendation 5: Patients that exhibit warning signs should receive a timely documentation of goals of care

Type of metric: Patient-centered, optional

Description of metric: The proportion of hospitalized ward patients who developed an escalation criteria breach who had goals of care discussions either in place, or newly documented by a clinical provider within 24 hours of first breaching the clinical escalation criteria (Table 2).

Rationale: Multiple studies of RRS have shown that the time when escalation criteria are present in ward patients defines an important juncture: While over half of patients remaining on wards following RRS improved [36] one in eight might die within a week, half without admission to critical care[48] and between a quarter[36] and a third[49] of encounters will involve end-of-life or limitations of care decisions.

Delays of care at either end of the palliation-invasive spectrum are thus associated with avoidable morbidity. [38,50] The deteriorating patient's best interest can only be served if a treatment plan communicating the goal/s of care is developed and implemented at this time.

Quality of documentation is associated with effective interventions, and better patient outcomes.[51] Patients and their families must be equal partners in the development of these goals, thus ensuring patient-centeredness. Patients deserve a clear communication in relation to their care and expected course. It might be reasonable to evaluate response to ward-based treatment prior to making a definite decision on escalation and care targets. Expert group consensus indicated that this should take no longer than 24 hours. Primary treating teams might consult with specialists to address goals of care. Frameworks to support this process include scoring systems [50,52], frailty assessment [53], and the question 'Would you be surprised if this patient were to die in the next few months, weeks, days'?' [54] Goals might include timely transfer to the operating theatre or a higher level of care, rapid resuscitation on the ward (e.g., to achieve adequate oxygenation or circulating blood volume); or – in some cases – comfort care and peaceful death.

Recommendation 6: Hospitals should provide means by which patients and family members can activate the Rapid Response Team

Type of metric: Structural metric, essential

Description of metric: It is recommended that hospitals have means by which patients, family members, visitors, or others not directly responsible for a patient's care can activate the RRT when they are concerned about the clinical status of a ward patient.

Rationale: The acceptance of RRS was accelerated by moving accounts of patient deterioration that family members, but not health care workers were able to recognize. {Haskel, 2017 #133} This may be especially true in vulnerable populations such as children and the elderly who may not possess the facility to seek help on their own. In Australia, USA and UK, patients and families have been more actively involved in co-designing RRSs. A number of studies have been published on patient activated RRS, indicating that this intervention has positive effects on patient and family satisfaction and no adverse response by health care workers to such services. {Albutt, 2017 #134;Gerdik, 2010 #170;Gill, 2016 #135;Vorwerk, 2016 #132} This recommendation is made to protect patients from avoidable harm and resulting life-long complications, but also to protect the family and ward staff that are often secondary victims when there is a failure to act in time. [61] Such a metric provides another layer of protection for the patient and the opportunity to detect deterioration as soon as possible.

The availability of a patient activated RRT is therefore a recommended structural metric to describe patient centeredness of a RRS in line with the Triple and Quadruple aim[55,56] [Sikka R. PMID: 26038586].

Recommendation 7: Hospitals should consider evaluating the frequency of RRT activations generated by patients and family members.

Type of metric: Process measure, optional

Description of metric: In relation to recommendation 6, the authors felt that hospitals may benefit from tracking the proportion of RRT activations that are due to patients and family members as outlined above.

Rationale: This is a process measure that would indicate that the system is working as designed and if it is being over used.. [56] While experience suggests that family activations are generally uncommon, [62] complete lack of activations may question whether the provision of non-staff activations are somehow discouraged or otherwise impaired.

Recommendation 8: Hospitals should evaluate safety culture in relation to deteriorating patients and their care.

Type of metric: Structural metric, recommended

Description of metric: The hospital uses a survey tool regularly to evaluate hospital staff perceptions of safety culture in relation to the RRS.

Rationale: RRSs are one of the first organisation-wide, patient-focused systems to be developed to prevent potentially avoidable deaths and serious adverse events such as cardiac arrests [63]. However, we know that hierarchy and socio-cultural factors continue to inhibit speaking up about concerns and acquiring additional help. Organizational culture is a system of shared assumptions, values, and beliefs, which governs how people behave in organizations. Various national safety programs have shown that the culture and attitudes of an organization effect patient outcomes[64] There are a number of published tools to measure safety culture in hospitals.[65,66]

Staff satisfaction is a key determinant of quality and safety of care. We found strong evidence that catastrophic deterioration of patients has adverse psychological impacts on ward staff, and that this type of experience is common. [61] We were unable to identify specific tools that capture experience of staff in relation to deteriorating patients or RRS. In a broader context we found evidence that organisational culture influences staff experience and the ability to speak up. [67,68] and importantly can be influenced by Rapid Response Systems.[69]

Despite the awareness of cultural differences in countries deploying RRSs we do wish to emphasize organizational culture and attitudes as an important component to the function of a reliable RRS, and the need to examine these by objective means. [70] Based on our review, it is not possible to recommend a single tool but the Safety Attitude Questionnaire[71] and the AHRQ Hospital Survey on Patient Culture[72] have been used in international settings.

We therefore suggest using or adapting existing tools and including items that allow assessment of institutional attitudes and practices regarding acquisition of help and escalation of care for deteriorating ward patients. Evaluations need to capture confidence of staff to speak up and escalate concerns across hierarchies.

Recommendation 9: Hospital should measure the length of stay on general wards of all patients with a breach of escalation criteria

Type of metric: Cost measure, exploratory

Description of metric: The total length of stay for ward patients who breach escalation criteria. Patients with timely documented goals of care (metric 5) should be differentiated from those lacking such care plans. Length of stay (LOS) measurement should begin at the time of the first breach of escalation criteria and extend to the time of discharge to home, nursing facility, hospice unit or death. LOS should include ICU LOS if applicable.

Rationale: The rapid response team operates under the premise that early identification of patients experiencing clinical deterioration leads to early intervention and better clinical outcomes.

Patients who did not receive a timely or appropriate RRT review or written goals of care with metric 5 may require escalation of care, which can result in prolonged hospitalization and increased healthcare costs including ICU days [73,74] (see metric 10).

Measuring the cost of achieving these and subsequent assessment of the financial value of a RRS is challenging: The deteriorating ward patient often has a myriad of medical conditions with which they negotiate a complex pathway of care. Ideally attributable costs are allocated to each existing condition, diagnostic test, specialist review, treatment delivered and total days of care provided. A simplified way to express costs is in 'unit costs' (chargeable costs) expressed as unified cost per patient per day.

The influence of clinical deterioration of patients on total healthcare costs is largely unknown. Therefore, we propose hospitals gather data related to hospital length of stay and associated costs for these patients. This financial data will allow hospitals to observe trends in financial performance for patients breaching escalation criteria over time and design appropriate interventions.

Recommendation 10: Hospitals should measure ICU length of stay of patients transferred to ICU following breach of local escalation criteria

Type of metric: Cost measure, exploratory

Description of metric: Length of stay is a surrogate for cost. The length of stay for patients admitted to ICU from the ward within 24 hours of triggering deterioration criteria should be collected. Patients admitted after delayed initiation of critical care type of treatments (metric 4) should be differentiated from those with prompt escalation of care.

Rationale: Value in healthcare is defined as the health outcomes achieved relative to their financial cost. [75]

ICU length of stay is a well-recognized outcome measure that is routinely collected by many national data registries. The cost of providing ICU services varies, but is significant across all healthcare economies. The ICU costs associated with emergency admissions from general wards are largely unknown.[76] Delayed admissions might result in increased or decreased critical care utilization [74,77-80] and utilization depends in part on availability of ICU beds. [81]

Faced with a scarcity of literature on the economic cost of RRSs we believe that it is reasonable to recognize the role of Rapid Response in the larger critical care enterprise. This metric is exploratory and based on the clinical metric 4. It will provide vital data concerning the ICU costs of acute illness among ward patients, whilst allowing exploratory economic assessment of the impact of RRSs. Cost-efficiency will require future evaluation and will depend on institutional context. Developing such cost measurement may help hospitals to develop means of understanding how the RRS impacts ICU utilisation and costs.

Discussion

We have developed ten metrics for evaluating the function of an individual hospital's RRS under the domains of the quadruple aim of the IHI [Sikka R PMID: 26038586]. These are intended to apply to all acute hospitals regardless of setting and RRS composition or structure. We intend these metrics to be used by hospitals to evaluate the function and performance of their own RRS in order to guide subsequent quality improvement activities. In the future, we aim to assess how feasible it is for organizations to measure and track these metrics as well as assess the internal and external validity of these metrics in evaluating RRS function.

Due to variations in case-mix, alerting criteria, RRT composition and ICU utilization practices amongst different hospitals, and the lack of validated risk-adjustment scoring systems for unstable ward patients, we wish to emphasize that these metrics are not intended to judge or compare the quality of health care systems with each other.

National guidelines on provision of RRS have been published in a number of jurisdictions focusing on clinical outcomes. [82] Cardiopulmonary resuscitation guidelines have included recommendations on RRS, but not the metrics to assure quality. [83] Guidelines for diagnosis and treatment of sepsis continue to emphasize timeliness of recognition and treatment and thus imply a role for RRS in fulfilling such goals. [84]

We brought together a group of experts in the field and patient representatives from a broad range of practice and experience backgrounds including Asia, Australia, Africa, Europe, and the United States. All research groups with a large number of publications on RRSs were invited and all bar the Scandinavian researchers were represented. The inclusion of Health-service researchers aimed to limit the impact of groupthink.

The recommended metrics were chosen from a long list of possible candidate-variables. Patient reported outcome measures (PROMs) and patient reported experience measures (PREMs) should be an essential part of monitoring quality of care. Patients suffering deterioration on general wards are subject to similar medical conditions as those admitted to Intensive Care: While in the latter group patient reported outcomes measures have been described, none have been published on patients experiencing catastrophic deterioration.

Measures of long-term outcomes for patients following deterioration on general wards are required but scoping reviews of the literature did not yield enough evidence to achieve consensus

for a recommendation. While there is literature on outcomes following admission to critical care (including prevalence of post-traumatic stress syndrome) we were unable to identify patient related outcome measures and patient related experience measures in relation to clinical instability and its evaluation/ treatment. The same holds true for measures that capture the experience of those close to patients. In the interest of transparency we believe that ways of sharing reports about critical incidents and encounters with RRTs with patients and families should be explored.

Staff training and assurance of competencies is a key part of a functioning RRS and we debated the value of staff turnover as a proxy measure for staff satisfaction but we did not reach consensus on specific recommendations. Looking after patients who suffer catastrophic deterioration is stressful for families and for clinical teams with an increasing recognition of the health (and financial) consequences for 'second victims'. [61] While the latter problem has been quantified in a number of recent studies, the best way to capture it or how to offer support (including peer support) is not clear yet.

Costs linked to RRS could include many other parameters such as monetary value of lives saved, staff retention, cost of litigation and broader allocation of value to patient and staff satisfaction.

We have taken great care to avoid the inclusion of metrics that rely on specific configurations of systems or that apply only to a limited number of jurisdictions. Some of our metrics are already collected by a number of healthcare systems. We hope that this publication can support hospital teams from areas where these metrics are not already collected to establish them as an essential part of their organisations' strategy to improve patients' safety and reduce avoidable harm. We hope to report on tools for and experience with implementation of the metrics as part of the next international meeting of the iSRRS in Singapore in 2019.

Conclusions

We present a simple set of ten quality metrics to supplement previously published consensus statements for Rapid Response Systems. The authors hope that this work encourages researchers, grant funding agencies and health policy experts to further develop our set of metrics and establish reporting mechanisms.

Urgent research is needed to find better ways to quantify the emotional cost for patients, families and staff and the financial cost to organisations and healthcare systems of avoidable and often catastrophic deterioration.

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References

1. Devita MA, Bellomo R, Hillman K, et al. Findings of the first consensus conference on medical emergency teams. Crit Care Med 2006;34:2463-78.

2. Care. ACoSaQiH. Hospital Acquired Complications--Cardiac Complications. Sydney: ACSQHC; 2018.

3. Australasian Clinical Indicator Report 2009–2016, 18th Edition. 2016. at https://www.achs.org.au/media/130859/intensive_care_long_report_2009-2016.pdf.)

4. . December 12, 2018, at https://rapidresponsesystems.org/.)

5. Donabedian A. The quality of care. How can it be assessed? Jama 1988;260:1743-8.

6. Mainz J. Defining and classifying clinical indicators for quality improvement. International journal for quality in health care : journal of the International Society for Quality in Health Care 2003;15:523-30.

7. Schein RM, Hazday N, Pena M, Ruben BH, Sprung CL. Clinical antecedents to in-hospital cardiopulmonary arrest. Chest 1990;98:1388-92.

8. Smith AF, Wood J. Can some in-hospital cardio-respiratory arrests be prevented? A prospective survey. Resuscitation 1998;37:133-7.

9. Kause J, Smith G, Prytherch D, et al. A comparison of antecedents to cardiac arrests, deaths and emergency intensive care admissions in Australia and New Zealand, and the United Kingdom--the ACADEMIA study. Resuscitation 2004;62:275-82.

10. Hodgetts TJ, Kenward G, Vlackonikolis I, et al. Incidence, location and reasons for avoidable in-hospital cardiac arrest in a district general hospital. Resuscitation 2002;54:115-23.

11. Peberdy MA, Ornato JP, Larkin GL, et al. Survival from in-hospital cardiac arrest during nights and weekends. Jama 2008;299:785-92.

12. Robinson EJ, Smith GB, Power GS, et al. Risk-adjusted survival for adults following in-hospital cardiac arrest by day of week and time of day: observational cohort study. BMJ quality & safety 2016;25:832-41.

13. Cummins RO, Chamberlain D, Hazinski MF, et al. Recommended guidelines for reviewing, reporting, and conducting research on in-hospital resuscitation: the in-hospital 'Utstein style'. American Heart Association. Circulation 1997;95:2213-39.

14. Nolan JP, Soar J, Smith GB, et al. Incidence and outcome of in-hospital cardiac arrest in the United Kingdom National Cardiac Arrest Audit. Resuscitation 2014;85:987-92.

15. Merchant RM, Yang L, Becker LB, et al. Incidence of treated cardiac arrest in hospitalized patients in the United States. Crit Care Med 2011;39:2401-6.

16. Fennessy G, Hilton A, Radford S, Bellomo R, Jones D. The epidemiology of in-hospital cardiac arrests in Australia and New Zealand. Internal medicine journal 2016;46:1172-81.

17. McGrath RB. In-house cardiopulmonary resuscitation--after a quarter of a century. Annals of emergency medicine 1987;16:1365-8.

18. Franklin C, Mathew J. Developing strategies to prevent inhospital cardiac arrest: analyzing responses of physicians and nurses in the hours before the event. Crit Care Med 1994;22:244-7.

19. Kause J, Smith G, Prytherch D, Parr M, Flabouris A, Hillman K. A comparison of antecedents to cardiac arrests, deaths and emergency intensive care admissions in Australia and New Zealand, and the United Kingdom--the ACADEMIA study. Resuscitation 2004;62:275-82.

20. Investigators A-CMd, Jones D, Drennan K, Hart GK, Bellomo R, Web SA. Rapid Response Team composition, resourcing and calling criteria in Australia. Resuscitation 2012;83:563-7.

21. Subbe CP, Davies RG, Williams E, Rutherford P, Gemmell L. Effect of introducing the Modified Early Warning score on clinical outcomes, cardio-pulmonary arrests and intensive care utilisation in acute medical admissions. Anaesthesia 2003;58:797-802.

22. Escobar GJ, LaGuardia JC, Turk BJ, Ragins A, Kipnis P, Draper D. Early detection of impending physiologic deterioration among patients who are not in intensive care: development of predictive models using data from an automated electronic medical record. Journal of hospital medicine 2012;7:388-95.

23. Green M, Lander H, Snyder A, Hudson P, Churpek M, Edelson D. Comparison of the Between the Flags calling criteria to the MEWS, NEWS and the electronic Cardiac Arrest Risk Triage (eCART) score for the identification of deteriorating ward patients. Resuscitation 2018;123:86-91.

24. Chan PS, Jain R, Nallmothu BK, Berg RA, Sasson C. Rapid Response Teams: A Systematic Review and Meta-analysis. Archives of internal medicine 2010;170:18-26.

25. Maharaj R, Raffaele I, Wendon J. Rapid response systems: a systematic review and meta-analysis. Critical care 2015;19:254.

26. Winters BD, Weaver SJ, Pfoh ER, Yang T, Pham JC, Dy SM. Rapid-response systems as a patient safety strategy: a systematic review. Annals of internal medicine 2013;158:417-25.

27. Jones D, Mercer I, Heland M, et al. In-hospital cardiac arrest epidemiology in a mature rapid response system. British journal of hospital medicine 2017;78:137-42.

28. Trinkle RM, Flabouris A. Documenting Rapid Response System afferent limb failure and associated patient outcomes. Resuscitation 2011;82:810-4.

29. Vetro J, Natarajan DK, Mercer I, et al. Antecedents to cardiac arrests in a hospital equipped with a medical emergency team. Critical care and resuscitation : journal of the Australasian Academy of Critical Care Medicine 2011;13:162-6.

30. Downey AW, Quach JL, Haase M, Haase-Fielitz A, Jones D, Bellomo R. Characteristics and outcomes of patients receiving a medical emergency team review for acute change in conscious state or arrhythmias. Crit Care Med 2008;36:477-81.

31. Quach JL, Downey AW, Haase M, Haase-Fielitz A, Jones D, Bellomo R. Characteristics and outcomes of patients receiving a medical emergency team review for respiratory distress or hypotension. Journal of critical care 2008;23:325-31.

32. Care. ACoSaQiH. National consensus statement: essential elements for recognising and responding to clinical deterioration. Sydney: ACSQHC; 2010.

33. Bonafide CP, Localio AR, Roberts KE, Nadkarni VM, Weirich CM, Keren R. Impact of rapid response system implementation on critical deterioration events in children. JAMA Pediatr 2014;168:25-33.

34. Hillman K, Chen J, Cretikos M, et al. Introduction of the medical emergency team (MET) system: a cluster-randomised controlled trial. Lancet 2005;365:2091-7.

35. Taenzer AH, Pyke JB, McGrath SP, Blike GT. Impact of pulse oximetry surveillance on rescue events and intensive care unit transfers: a before-and-after concurrence study. Anesthesiology 2010;112:282-7.

36. Bannard-Smith J, Lighthall GK, Subbe CP, et al. Clinical outcomes of patients seen by Rapid Response Teams: A template for benchmarking international teams. Resuscitation 2016;107:7-12.

37. Boniatti MM, Azzolini N, Viana MV, et al. Delayed medical emergency team calls and associated outcomes. Crit Care Med 2014;42:26-30.

38. Chen J, Bellomo R, Flabouris A, Hillman K, Assareh H, Ou L. Delayed Emergency Team Calls and Associated Hospital Mortality: A Multicenter Study. Crit Care Med 2015;43:2059-65.

39. Calzavacca P, Licari E, Tee A, et al. The impact of Rapid Response System on delayed emergency team activation patient characteristics and outcomes--a follow-up study. Resuscitation 2010;81:31-5.

40. Barwise A, Thongprayoon C, Gajic O, Jensen J, Herasevich V, Pickering BW. Delayed Rapid Response Team Activation Is Associated With Increased Hospital Mortality, Morbidity, and Length of Stay in a Tertiary Care Institution. Crit Care Med 2016;44:54-63.

41. Young MP, Gooder VJ, McBride K, James B, Fisher ES. Inpatient transfers to the intensive care unit: delays are associated with increased mortality and morbidity. J Gen Intern Med 2003;18:77-83.

42. Sankey CB, McAvay G, Siner JM, Barsky CL, Chaudhry SI. "Deterioration to Door Time": An Exploratory Analysis of Delays in Escalation of Care for Hospitalized Patients. J Gen Intern Med 2016;31:895-900.

43. Dellinger RP, Levy MM, Rhodes A, et al. Surviving sepsis campaign: international guidelines for management of severe sepsis and septic shock: 2012. Crit Care Med 2013;41:580-637.

44. Harker M, Carville S, Henderson R, Gray H, Guideline Development G. Key recommendations and evidence from the NICE guideline for the acute management of ST-segment-elevation myocardial infarction. Heart 2014;100:536-43.

45. Jaff MR, McMurtry MS, Archer SL, et al. Management of massive and submassive pulmonary embolism, iliofemoral deep vein thrombosis, and chronic thromboembolic pulmonary hypertension: a scientific statement from the American Heart Association. Circulation 2011;123:1788-830.

46. Kushner FG, Hand M, Smith SC, Jr., et al. 2009 focused updates: ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction (updating the 2004 guideline and 2007 focused update) and ACC/AHA/SCAI guidelines on percutaneous coronary intervention (updating the 2005 guideline and 2007 focused update) a report of the American College of Cardiology

Foundation/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol 2009;54:2205-41.

47. Powers WJ, Derdeyn CP, Biller J, et al. 2015 American Heart Association/American Stroke Association Focused Update of the 2013 Guidelines for the Early Management of Patients With Acute Ischemic Stroke Regarding Endovascular Treatment: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association. Stroke 2015;46:3020-35.

48. Harris S, Singer M, Sanderson C, Grieve R, Harrison D, Rowan K. Impact on mortality of prompt admission to critical care for deteriorating ward patients: an instrumental variable analysis using critical care bed strain. Intensive care medicine 2018.

49. Sulistio M, Franco M, Vo A, Poon P, William L. Hospital rapid response team and patients with life-limiting illness: a multicentre retrospective cohort study. Palliative medicine 2015;29:302-9.

50. Cardona-Morrell M, Kim J, Turner RM, Anstey M, Mitchell IA, Hillman K. Non-beneficial treatments in hospital at the end of life: a systematic review on extent of the problem. International journal for quality in health care : journal of the International Society for Quality in Health Care 2016;28:456-69.

51. Muller-Staub M. Evaluation of the implementation of nursing diagnoses, interventions, and outcomes. International journal of nursing terminologies and classifications : the official journal of NANDA International 2009;20:9-15.

52. Cardona-Morrell M, Hillman K. Development of a tool for defining and identifying the dying patient in hospital: Criteria for Screening and Triaging to Appropriate aLternative care (CriSTAL). BMJ supportive & palliative care 2015;5:78-90.

53. So RKL, Bannard-Smith J, Subbe CP, et al. The association of clinical frailty with outcomes of patients reviewed by rapid response teams: an international prospective observational cohort study. Critical care 2018;22:227.

54. Pattison M, Romer AL. Improving Care Through the End of Life: launching a primary care clinic-based program. Journal of palliative medicine 2001;4:249-54.

55. Berwick DM, Nolan TW, Whittington J. The triple aim: care, health, and cost. Health affairs 2008;27:759-69.

56. Vorwerk J, King L. Consumer participation in early detection of the deteriorating patient and call activation to rapid response systems: a literature review. Journal of clinical nursing 2016;25:38-52.

57. Albutt AK, O'Hara JK, Conner MT, Fletcher SJ, Lawton RJ. Is there a role for patients and their relatives in escalating clinical deterioration in hospital? A systematic review. Health expectations : an international journal of public participation in health care and health policy 2017;20:818-25.

58. Gill FJ, Leslie GD, Marshall AP. The Impact of Implementation of Family-Initiated Escalation of Care for the Deteriorating Patient in Hospital: A Systematic Review. Worldviews on evidence-based nursing 2016;13:303-13.

59. Haskel H. Why have a rapid response system ? Cold with fear: the patient and family experience of failure to rescue. In: DeVita MA HKaBRe, ed. Textbook of rapid response systems: concept and implementation: Springer; 2017:3-15.

60. Gerdik C, Vallish RO, Miles K, Godwin SA, Wludyka PS, Panni MK. Successful implementation of a family and patient activated rapid response team in an adult level 1 trauma center. Resuscitation 2010;81:1676-81.

61. Mira JJ, Lorenzo S, Carrillo I, et al. Interventions in health organisations to reduce the impact of adverse events in second and third victims. BMC health services research 2015;15:341.

62. Bavare AC, Thomas JK, Elliott EP, Morgan AC, Graf JM. Family-Initiated Pediatric Rapid Response: Characteristics, Impetus, and Outcomes. Journal for healthcare quality : official publication of the National Association for Healthcare Quality 2018;40:103-9.

63. Hillman KM, Chen J, Jones D. Rapid response systems. The Medical journal of Australia 2014;201:519-21.

64. Shearer B, Marshall S, Buist MD, et al. What stops hospital clinical staff from following protocols? An analysis of the incidence and factors behind the failure of bedside clinical staff to activate the rapid response system in a multi-campus Australian metropolitan healthcare service. BMJ quality & safety 2012;21:569-75.

65. Gershon RR, Stone PW, Bakken S, Larson E. Measurement of organizational culture and climate in healthcare. The Journal of nursing administration 2004;34:33-40.

66. Mannion R, Konteh, Davies H, et al. Measuring and Assessing Organisational Culture in the NHS (OC1) v June, 2008.

67. Nacioglu A. As a critical behavior to improve quality and patient safety in health care: speaking up! Safety in Health 2016;2.

68. Alingh CW, van Wijngaarden JDH, van de Voorde K, Paauwe J, Huijsman R. Speaking up about patient safety concerns: the influence of safety management approaches and climate on nurses' willingness to speak up. BMJ quality & safety 2019;28:39-48.

69. Stevens J, Johansson A, Lennes I, Hsu D, Tess A, Howell M. Long-term culture change related to rapid response system implementation. Medical education 2014;48:1211-9.

70. Foundation. TECobotH. 2. Research scan: Measuring safety culture. "Does improving safety culture affect patient outcomes?". London: The Health Foundation; 2011:1-25.

71. Sexton JB, Helmreich RL, Neilands TB, et al. The Safety Attitudes Questionnaire: psychometric properties, benchmarking data, and emerging research. BMC health services research 2006;6:44.

72. Jones KJ, Skinner A, Xu L, Sun J, Mueller K. The AHRQ Hospital Survey on Patient Safety Culture: A Tool to Plan and Evaluate Patient Safety Programs. In:

Henriksen K, Battles JB, Keyes MA, Grady ML, eds. Advances in Patient Safety: New Directions and Alternative Approaches (Vol 2: Culture and Redesign). Rockville (MD)2008.

73. Bonafide CP, Localio AR, Song L, et al. Cost-benefit analysis of a medical emergency team in a children's hospital. Pediatrics 2014;134:235-41.

74. Simmes F, Schoonhoven L, Mintjes J, Adang E, van der Hoeven JG. Financial consequences of the implementation of a rapid response system on a surgical ward. Journal of evaluation in clinical practice 2014;20:342-7.

75. Porter ME. What is value in health care? The New England journal of medicine 2010;363:2477-81.

76. Vlayen A, Verelst S, Bekkering GE, Schrooten W, Hellings J, Claes N. Exploring unplanned ICU admissions: a systematic review. JBI library of systematic reviews 2011;9:925-59.

77. Bellomo R, Ackerman M, Bailey M, et al. A controlled trial of electronic automated advisory vital signs monitoring in general hospital wards. Crit Care Med 2012;40:2349-61.

78. Champunot R, Thawitsri T, Kamsawang N, Sirichote V, Nopmaneejumruslers C. Cost effectiveness analysis of an initial ICU admission as compared to a delayed ICU admission in patients with severe sepsis or in septic shock. Journal of the Medical Association of Thailand = Chotmaihet thangphaet 2014;97 Suppl 1:S102-7.

79. O'Callaghan DJ, Jayia P, Vaughan-Huxley E, et al. An observational study to determine the effect of delayed admission to the intensive care unit on patient outcome. Critical care 2012;16:R173.

80. Mardini L, Lipes J, Jayaraman D. Adverse outcomes associated with delayed intensive care consultation in medical and surgical inpatients. Journal of critical care 2012;27:688-93.

81. Stelfox HT, Hemmelgarn BR, Bagshaw SM, et al. Intensive care unit bed availability and outcomes for hospitalized patients with sudden clinical deterioration. Archives of internal medicine 2012;172:467-74.

82. Wachter RM, Pronovost PJ. The 100,000 Lives Campaign: A scientific and policy review. Joint Commission journal on quality and patient safety 2006;32:621-7.

83. Soar J, Donnino MW, Maconochie I, et al. 2018 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations Summary. Resuscitation 2018;133:194-206.

84. Rhodes A, Evans LE, Alhazzani W, et al. Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock: 2016. Intensive care medicine 2017;43:304-77.

Table 1: Terms used in the development and description of consensus recommendations

Escalation criteria breach: This has occurred when the hospital-specific calling criteria have been breached or exceeded by the patient. Such criteria are typically based on derangements of vital signs and may include abnormalities of single vital signs, or multiple vital signs as in early warning scores. If a hospital has multiple levels of escalation criteria, we recommend the most sensitive (lowest) threshold be used for assessing avoidability of cardiac arrests (metric 2), the level that recommends call out of a Rapid Response Team for goal setting (metric 5) and the more stringent for metrics (highest threshold) involving the activation of critical care personnel (metric 4) to be used to assess time to response and treatment.

In-hospital cardiac arrest (IHCA): The group acknowledged that there was no accepted or consensus definition for an IHCA. Consensus for a practical definition of cardiac arrest was achieved in which the patient received chest compression and/or defibrillation for a non-perfusing rhythm. In some jurisdictions pulselessness is required as part of the definition. The consensus definition also included patients found dead in bed who ***did not*** have a "do not attempt resuscitate [DNAR]" order. The definition did not include isolated cardioversion for conscious ventricular tachycardia or atrial fibrillation and did also not include isolated respiratory arrest where there was no loss of circulation.

Application of critical care: The consensus definition for application of critical care acknowledged the need to include models of care in low and medium income countries and rural/regional areas that may not have traditional intensive care units. It also acknowledged tertiary and quaternary centers that have intensive care-led Rapid Response Teams that are able to commence critical care level treatment outside of the intensive care unit. Thus, a patient is said to have received critical care when that patient has been attended to by critical care staff and there is commencement of

vasoactive medications, artificial ventilation (either invasive or non-invasive), continuous arterial pressure monitoring, other advanced monitoring, or infusion of large volumes of fluid or blood products regardless of hospital location. In instances where the hospital does not have a critical care unit, critical care may be applied on the hospital general wards (low income countries) or following transfer to a second hospital.

General wards. This term includes all patients residing in traditional medical/ surgical or specialty wards including short-stay and observation beds. Patients in the emergency department, ICU, palliative care (hospice), and 'nursing home' equivalent wards should not be included in counts of general ward patients.

Data analysis. The goals of these metrics are to understand and improve care of deteriorating ward patients. Due to local variability in practices and personnel, collection of data elements that allow for 'by unit' as well as 'whole hospital' analyses is recommended. Depending on number of patients involved, institutions may choose to compare averages from single or multiple months.

Use of data: Assuming use of monthly data, inspection of trends as part of a quality assurance dashboard or equivalent was considered valuable by consensus conference members. Comparisons between time periods, say after a quality improvement intervention has been implemented, are especially relevant.

Levels of recommendation of the expert consensus:

Essential:	These metrics should we used by all hospitals with RRS.
Recommended:	These metrics add significant value to understanding the function of a RRS.
Optional:	These metrics have strong face validity; hospitals may benefit from measurement.
Exploratory:	These metrics describe an area with lack of high-quality evidence. Collection might aid future understanding and research of RRS.

Table 2: Metrics, level of recommendation and description. Metrics are linked to the dimensions of the Institute for Healthcare Improvement's Quadruple Aim:
(1) improving population health,
(2) enhancing the patient experience of care,
(3) reducing the per capita cost of health care,
(4) enhancing provider well-being.
Operating room (OR), Emergency Room (ER) and Post-Anaesthesia Care Unit (PACU)

Metric	Description	Level	Type	Numerator	Denominator	Inclusions	Exclusions
1	Hospitals should measure and track cardiac arrests in general ward patients	Essential	Clinical outcome (1); rate	Non-ICU, non-procedural IHCA	10,000 adult ward bed-days, including DNAR patients	General wards (see definition) Step-down/HDU, observation patients/day cases, ward patients in diagnostic areas. Includes non DNAR patients (full code status) found dead in bed.	All ICU patients regardless of location (eg diagnostic area). All arrests occurring in an OR, ER, PACU, cath lab, or other procedural area, regardless of admission status. Outpatients/visitors/employees. Excludes DNAR cardiac arrests/ deaths.
2	Hospitals should measure potentially preventable cardiac arrests in general ward patients	Essential	Clinical outcome (1); count or proportion	Cardiac arrests occurring in hospitalized ward patients who met the hospital's lowest escalation threshold at least 30 minutes prior to and within 24 hours of the cardiac arrest	Total ward cardiac arrests (as defined in metric 1)	Same as above	1. Cardiac arrests occurring in hospitalized ward patients where the first instance of escalation criteria breach occurred within 30 minutes of the cardiac arrest; 2. Erroneous measurements
3	Hospitals should measure timeliness of their response	Recommended	Process measure (1); proportion	Hospitalized ward patients evaluated by critical care personnel within the time	All ward patients meeting deterioration criteria that would lead to the summons or	Moderate and high risk thresholds criteria if not binary.	1. Accidental or other calls for patients with a "no ICU" or "no escalation" status. 2. Erroneous measurement or recordings (eg RR=98). Non-ward patients.

	to ward patient deterioration			frame specified by the hospital for such evaluation	consultation by ICU personnel		
4	Hospitals should evaluate timeliness of critical care interventions	Recommended	Process measure (1); proportion	Patients receiving critical care application within 6 hours following first threshold breach	Patients receiving critical care services who breached threshold within 24 hours of the critical care services??	Critical care transfer, Critical care application at the bedside, transfer to a higher level hospital	Patients receiving critical care services without meeting deterioration criteria
5	Patients that exhibit warning signs should receive a timely documentation of goals of care	Optional	Process measure (2); proportion	The proportion of hospitalized ward patients in whom there was an escalation criteria breach who had goals of care discussions either in place, or newly documented by a clinical provider within 24 hours of first breaching the clinical escalation criteria	All hospitalized ward patients breaching escalation criteria.	All patients admitted to hospital	Patients with treatment plans limited to hospice or comfort care measures at the time of meeting the escalation criteria
6	Hospitals should provide means by which patients and family members can activate the	Essential	Structural metric (2); binary (yes/no)	Hospitals offering means for self or caregiver activation of RRT	N/A	N/A	N/A

	Rapid Response Team						
7	Hospitals should consider evaluating the frequency of RRT activations generated by patients and family members	Optional	Process measure (2); proportion	The number of patient or family activated RRT calls	Total number of RRT activations for inpatients	Calls for real or perceived medical deterioration	1. Instances where there has been activation for issues unrelated to clinical deterioration. 2 Activations for ill staff members or visitors 3. Care areas not served by the rapid response system
8	Hospitals should evaluate safety culture in relation to detection and response to deteriorating patients	Recommended	Structural metric (4); binary	Hospitals conducting evaluations of safety culture	N/A	N/A	N/A
9	Hospital should measure the length of stay of patients breaching escalation criteria including ICU stay where applicable	Exploratory	Surrogate cost measure (3)	The total length of stay for ward patients who breach escalation criteria. Patients with timely documented goals of care (metric 5) should be differentiated from those	N/A	Patients breaching escalation criteria on general wards.	As metric 1

				lacking such care plans.			
10	Hospitals should measure ICU length of stay of patients transferred to ICU following breach of local escalation criteria	Exploratory	Surrogate cost measure (3)	Duration of ICU stay in days for all hospitalized ward patients meeting escalation criteria in the 24 hours prior to ICU transfer with delayed and without delay	N/A	Patients transferred to critical care areas from medical or surgical wards.	Direct or planned admissions from Emergency Departments, Procedure areas or other hospitals.