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Statement paper

Quality metrics for the evaluation of Rapid Response Systems: Proceedings from the third international consensus conference on 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 predictability, timeliness of escalation, critical care interventions and presence of written treatment goals 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.

Keywords: Rapid response, Cardiac arrest, Critical care, Cost, Predictable, Medical emergency team, Critical care outreach

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 differing healthcare environments as well as changing needs of patients admitted to hospital 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 metrics 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

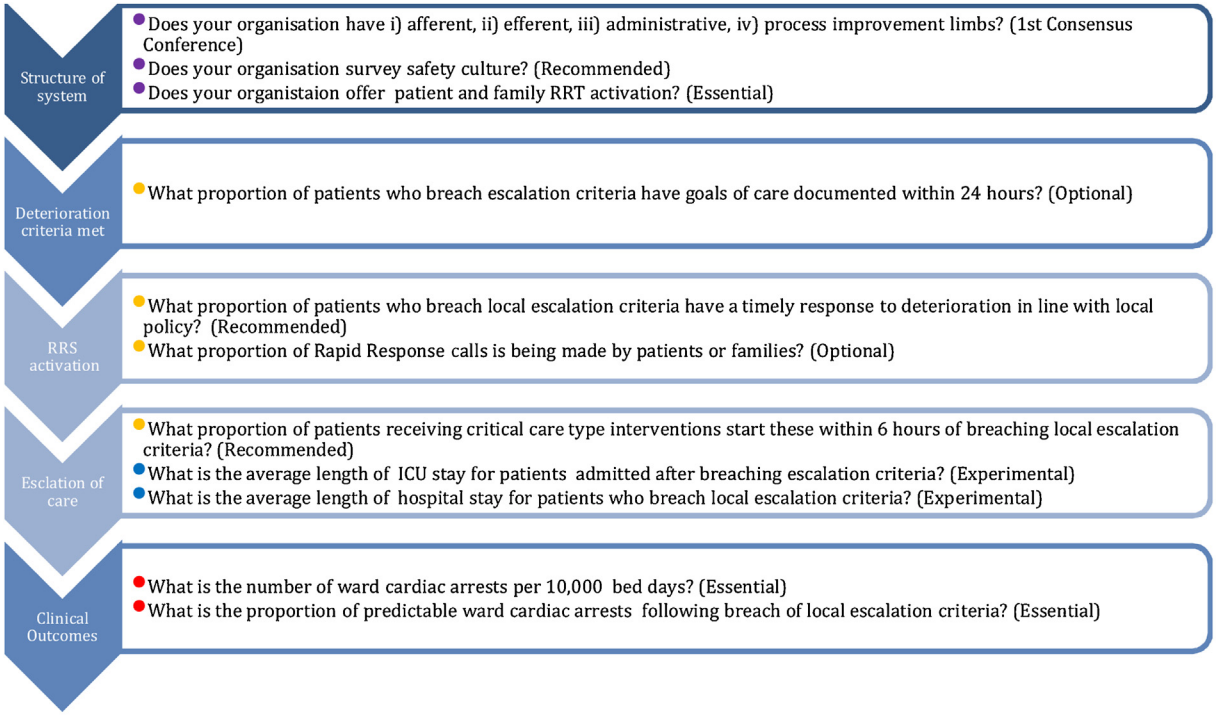
A full description of committee selection, sponsorship, and consensus processes is contained in the Appendix in Supplementary material. The consensus had four phases: a series of pre-conference conference calls to agree agenda items, a two-day consensus meeting in July 2018, a public session with over 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 in regular ward patients

Type of metric: clinical outcome, essential.



Classification of metrics modified from Donabedian

- Structure of services
- Process of care
- Outcome (clinical)
- Outcome (financial)

Fig. 1 – Location of metrics in the hospital system.
(IHCA: in-hospital cardiac arrest; RRT: rapid response team; ICU: intensive care unit).

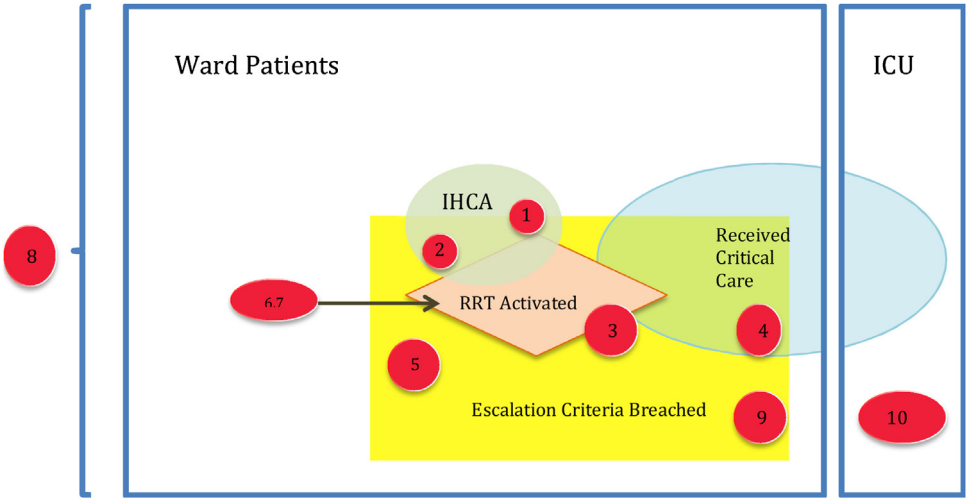


Fig. 2 – Metrics in the context of a patient journey. (RRT: rapid response team; ICU: intensive care unit).

Table 1 – Terms and definitions 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 staff with critical care knowledge and skills 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 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.

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 cardiac arrests in general ward patients

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 h 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 8 h 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

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), in-hospital cardiac arrest (IHCA), do-not-attempt-resuscitation (DNAR), high dependency unit (HDU), respiratory rate (RR).

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 (e.g. 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 predictable 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 escalation threshold at least 30 min prior to and within 24 h 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 min of the cardiac arrest; 2. Arrests in patients found to be DNAR or a comfort only care plan 3. Erroneous measurements
3	Hospitals should measure timeliness of their response to ward patient deterioration	Recommended	Process measure (1); proportion	Hospitalized ward patients evaluated by critical care personnel within the time frame specified by the hospital for such evaluation	All ward patients meeting deterioration criteria that would lead to the summons or consultation by ICU personnel	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.
4	Hospitals should evaluate timeliness of critical care interventions	Recommended	Process measure (1); proportion	Patients receiving critical care application within 6 h following first threshold breach	Patients receiving critical care services who breached threshold in prior 24 h	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 h 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 Rapid Response Team	Essential	Structural metric (2); binary (yes/ no)	Hospitals offering means for self or caregiver activation of RRT	N/A	N/A	N/A
7		Optional					

(continued on next page)

Table 2 (continued)

Metric	Description	Level	Type	Numerator	Denominator	Inclusions	Exclusions
	Hospitals should consider evaluating the frequency of RRT activations generated by patients and family members		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 on general wards of all patients with a breach of escalation criteria (including ICU cost)	Exploratory	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 lacking such care plans.	N/A	Patients breaching escalation criteria on general wards.	As metric 1
10	Hospitals should measure ICU length of stay of patients transferred to ICU following breach of local escalation criteria	Exploratory	Cost measure (3)	Duration of ICU stay in days for all hospitalized ward patients meeting escalation criteria in the 24 h prior to ICU transfer with delay 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.

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 [43–47]. 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 (Table 1) 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 min 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]

The proportion of patients with a given severity of illness who receive critical care type of treatments might be a target for future development of this quality metric.

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 h 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 as well as the important provision of high quality palliative care.

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 outcome.[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 h. 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.[59] 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.[57,60,58,56] 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.[55,56,85]

Recommendation 7: hospitals should consider measuring 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 triggered by 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 organization-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 affect 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 organizational 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 Safety 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 (see metric 10) 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 health-care 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 h 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 amongst 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 utilization and costs.

Discussion

We have developed ten metrics for the function of an individual hospital's RRS under the domains of the quadruple aim of the IHI.[85] 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 for 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 organizations' 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.

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 cost for patients, families and staff and the financial cost to organizations and healthcare systems of avoidable and often catastrophic deterioration.

Conflicts of interest

Name, country	Workstream	Conflict of Interest
Bannard-Smith J, UK	Clinical outcomes, local host	None declared
Bunch J, USA	Health economic outcomes	None declared
Champunot R, Thailand	Clinical outcomes	None declared
DeVita M, USA	Clinical outcomes	EarlySense: Chief Medical Officer; stock options for EarlySense
Durham L, UK	Clinical outcomes	None declared
Edelson D, USA	Clinical outcomes	Founder & CEO Quant HC
Gonzales I, UK & Spain	health economic outcomes	None declared
Hancock C, UK	clinical outcomes	None declared
Haniffa R, UK & Sri Lanka	Clinical outcomes	None declared
Hartin J, UK	Patient and staff outcomes	None declared
Haskell H, USA	Patient and staff outcomes	BETA Healthcare: Speaker's honorarium & travel expenses
Hogan H, UK	Clinical outcomes	None declared
Jones D, AUS	Clinical outcomes	None declared
Kalkman CJ, Netherlands	Health economic outcomes	Holder of EU Horizon 2020 grant for procurement of monitoring systems
Lighthall G, USA	Clinical outcomes, group lead	Consulting for Welch-Allyn
Malycha J, AUS & UK	Clinical outcomes	None declared
Ni, MZ, UJ	Health economics	None declared
Phillips AV, UK	Patient and staff outcomes	None declared
Rubulotta F, UK & Italy	Health economics, group lead	None declared
So RKL, Netherlands	Patient and staff outcomes, group lead	None declared
Subbe CP, UK & Germany	Patient and staff outcomes, overall chair	Philips Healthcare: Principal Investigator of studies & travel expenses
Welch J, UK	Clinical outcomes, president iSRRS	Holder of EU Horizon 2020 grant for procurement of monitoring systems

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Francesca Rubulotta made the case for the need of the consensus conference and Dana Edelson wrote a first draft outline. Without these initial steps the meeting would not have taken place.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resuscitation.2019.05.012.

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