# Implementing a Pediatric Rapid Response System to Improve Quality and Patient Safety

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**KEYWORDS**

• Rapid response team • Medical emergency team • Pediatrics
• Cardiac arrest • Emergency • Patient safety

Hospitals today are complex environments serving sicker patients than ever before. Patients who are not acutely ill are often managed as outpatients, leaving inpatient units to care for those with more severe conditions. According to the World Health Organization, the proportion of emergency admissions continues to rise in most countries,[1] while pressures to contain health care costs have resulted in shorter inpatient length of stay.[2] At the same time, recruiting and retaining trained nurses is increasingly difficult,[3] and physician work hours are trending downward.[4] The result is a more intricate inpatient milieu with proportionally fewer staff equipped to care for sicker patients who are more likely to experience life-threatening events, including cardiopulmonary arrest and unplanned admission to the intensive care unit (ICU).

Life-threatening events frequently arise in the hospital setting. Recent estimates suggest that 370,000 to 750,000 in-hospital resuscitation attempts are made every year in the United States.[5] The incidence of adult in-hospital cardiac arrest ranges from 1 to 5 events per 1000 hospital admissions,[5] while the incidence in children's hospitals is significantly lower at 0.19 to 2.45 events per 1000 admissions.[6] These events often result from preventable medical errors. Given the dismal survival rate of in-hospital cardiac arrest, it is critical to develop systems that recognize predictable clinical warning signs and intervene before patients reach the point of arrest.

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## MEDICAL ERROR AND ADVERSE EVENTS

A problem closely linked to the rising complexity of hospitals, and a factor in a significant proportion of life-threatening events, is medical error. In its 2000 report, *To Err is Human*, The Institute of Medicine concluded that between 44,000 and 98,000 patients die each year in US hospitals as a result of preventable clinical errors.[7] There are many terms used to describe inappropriate care and adverse outcomes experienced by patients. A list compiled by Andrews and colleagues[8] includes "adverse or untoward events, maloccurrences, complications, medical injuries, therapeutic misadventures, substandard care, unexpected outcomes, preventable deaths, iatrogenic injuries, mishaps, errors, negligence, and malpractice." Resar and colleagues[9] have defined medical error as "the failure of a planned action to be completed as intended or the use of a wrong plan to achieve an aim."

Estimates of the incidence of harm caused by medical error vary widely, depending on the research methodology and population studied. The Harvard Medical Practice Study, a retrospective chart review published in 1990, showed that 3.7% of more than 30,000 patient records from New York hospitals revealed an incident that two physicians agreed was adverse and caused serious harm.[10] Investigators in this study defined adverse events according to a legal-policy model, as their goal in measuring the event rate was to determine the feasibility of a no-fault system of compensation for medical malpractice.[8] Given the nature of the study, the authors only included errors that were clearly documented in the medical record. However, evidence from other studies suggests that fewer than 10% of adverse events are revealed in the medical record because documentation by hospital staff is often voluntary, time intensive, and perceived as potentially punitive.[11]

Other studies have demonstrated much higher rates of harm from medical error. For example, Steel and colleagues[12] found that an alarming 36% of 815 consecutive patients admitted to a general medical service at a university hospital had an iatrogenic illness, and 9% had an iatrogenic event that was life threatening or resulted in subsequent disability. This 1981 study reached the following conclusion: "Given the increasing number and complexity of diagnostic procedures and therapeutic agents, monitoring of untoward events is essential, and attention should be paid to educational efforts to reduce the risks of iatrogenic illness."

Rather than relying on medical records alone, Andrews and colleagues[8] searched for medical errors associated with 1047 adult surgical patients during inpatient rounds and case conferences. They reported that adverse events as a result of medical error occurred in 480 (46%) of the patients. Eighteen percent of patients experienced serious injury caused by medical error, with outcomes ranging from temporary physical disability to death. Patients who experienced adverse events stayed longer in the hospital (24 days versus 9 days for those without medical errors), and longer stays were associated with more medical errors. Adverse events were more likely to occur in patients with severe illness. Fifty-five percent of patients who required ICU care during their hospital stay experienced harm from medical error, compared with 38% of patients who did not spend time in the ICU.[8]

One or more causes of error were identified for just over half of the adverse events. Errors by an individual, such as poor technical performance, poor judgment, or failure to obtain or act on information contributed to 38% of the adverse events. Flawed interactions between individuals, such as failure of a consultant team to communicate adequately with the requesting team, were found to be responsible for 16% of the errors. About 10% of the errors were related generally to administrative decisions or protocols, such as inadequate staffing or defective equipment.[8]

Compared with adults, published estimates of adverse events in pediatric patients are few. Three studies using the “first-generation” methodology of the Harvard Medical Practice Study (nontargeted retrospective chart review) revealed similar low rates of adverse events in pediatric inpatients (2.3%, 2.9%, and 3.7%).[11] Studies using trigger tools, methods for increasing the efficiency of detection, have revealed higher rates of error. For example, in a 12-site children’s hospital quality and safety collaborative study, Takata and Currier[13] reported a rate of 11.1 adverse drug events per 100 pediatric inpatients. Twenty-two percent of these errors were deemed preventable.

While post hoc analysis often links adverse events in the medical setting to “human error,” many can be traced to a systems problem, defined by Bright and colleagues[2] as a sequence of events in the macro- and micro-environment that involve deficiencies in the structure and organization of health care. Cook and colleagues[14] point out that gaps in the continuity of care, such as the loss of information that occur at change of shift and transfer to a different facility, makes it more difficult to appreciate trends in a deteriorating patient’s condition. Resolving systems problems and eliminating preventable medical errors is an important means of reducing adverse events, including cardiac arrest.

## OUTCOMES FOR CARDIAC ARREST

Research over the past several decades has led to improved understanding of the epidemiology and pathophysiology of cardiac arrest in both adults and children. Corresponding advances in resuscitation, particularly coordinated strategies to strengthen the community chain of survival, have resulted in a marked improvement in outcomes for arrests that occur outside of the hospital setting.[15] Efforts by the American Heart Association and other groups have brought these advances to the public in effective ways. As a result, an increasing segment of the general public is equipped to react quickly to an unresponsive person outside the hospital setting. Peberdy and colleagues[15] point out that today one can find automated external defibrillators in schools, theaters, grocery stores, restaurants, shopping malls, airports, and many other public places. In addition to police and firefighters, many security officers, airline flight attendants, and trained laypersons are trained to use them while waiting for paramedics to arrive. In an effort to make the technical aspects of resuscitation easier to remember, elements of popular culture have been incorporated into education. The 1970s song “Staying Alive” by the Bee Gees is now immortalized as the proper tempo for chest compressions (100/minute). “Another One Bites the Dust” by Queen is a less hopeful but acceptable alternative. As a result of these developments, resuscitation in the prehospital setting is gradually moving closer to that in the hospital setting.

In contrast, procedures and outcomes for in-hospital resuscitation have remained relatively unchanged over the past 30 years.[5,16] In most hospitals, a “code team” responds to cardiac arrest in a general ward area. However, this approach has not been associated with a significant improvement in the mortality rate.[17] According to prospective data from 14,720 in-hospital cardiac arrests recorded by National Registry of Cardiopulmonary Resuscitation (NRCPR), fewer than half (44%) of adult in-hospital arrest victims had return of spontaneous circulation, and only 17% survived to hospital discharge. Pediatric patients (<18 years of age) in the study had a higher survival rate of 27%. Thirty-four percent of pediatric survivors had a poor neurologic function postarrest.[15,18] A 1999 meta-analysis of 554 in-hospital pediatric cardiac arrests demonstrated a similar survival rate of 24%. Twenty-two percent of survivors had poor neurologic function postarrest.[19]

For both children and adults in the NRCPR study, survival rates were higher when arrests occurred in monitored units and when the resuscitation team arrived quickly. Ninety-five percent of the pediatric arrests in the NRCPR study were either monitored or directly witnessed by a member of the health care team at the time of the event. In 86% of the 207 hospitals submitting data for the study, an organized emergency team responds 24 hours per day.[15]

Berg and colleagues[20] carefully analyzed the 880 pediatric arrests reported in the NRCPR study. Pediatric cardiac arrests occurred in the intensive care unit (ICU; 65%), emergency department (ED; 13%), general pediatric ward (14%), operating room (OR) or postanesthesia care unit (3%), diagnostic area (2%), and other/unknown location (2%). Immediate causes of pediatric cardiac arrests included acute respiratory insufficiency (57%), hypotension (61%), arrhythmia (49%), metabolic/electrolyte disturbance (12%), airway obstruction (5%), and acute pulmonary edema (4%). Many patients had more than one immediate cause.

## WARNING SIGNS AND SYMPTOMS

Observations over the past two decades have changed the belief that most incidents of cardiopulmonary arrest are sudden and unpredictable. In fact, cardiopulmonary arrest is often preceded by up to several hours of warning signs and symptoms that predict subsequent deterioration. This pattern has been demonstrated repeatedly and reliably in a series of prospective studies of adult patients who experience cardiac arrest on a general inpatient ward. In each of the studies listed in **Table 1**, patients who arrested in other locations (ED, OR, ICU) and those who had "do not resuscitate"

**Table 1**
**Landmark adult studies demonstrating clinical antecedents to cardiac arrest**

| Publication | Major Findings |
|---|---|
| Sax 1987 | 95% (19 of 20) had acute clinical instability and/or high burden of baseline comorbidities |
| Schein 1990 | 84% (54 of 64) had new complaints or clinical deterioration within 8 hours of arrest<br>70% had abnormal respiratory or neurologic function; 25% had both<br>No consistent laboratory findings were found before arrest<br>77% had underlying diseases not expected to cause death during hospitalization |
| Franklin 1994 | 66% (99 of 150) had documented clinical deterioration within 6 hours of arrest<br>Former ICU patients had significantly higher risk of arrest compared with patients never in the ICU (14.7 versus 6.8 per 1000 admissions)<br>Failures: notifying physician, obtaining/interpreting labs, ICU triage, stabilization on floor |
| Hodgetts 2002 | 68% (80 of 118) had documented clinical deterioration before arrest<br>100% of patients with potentially avoidable arrests received inadequate pre-arrest treatment<br>Avoidable arrests five times more likely for patients on general wards than in ICU |
| Hillman 2002 | 70% (386 of 551) had serious antecedents within 8 hours of urgent transfer to ICU<br>Most commonly: tachycardia, hypotension, tachypnea, sudden change in mental status |

(DNR) orders were excluded. Each study builds on the findings of its predecessors, resulting in a clear pattern of events that typically precede in-hospital cardiac arrest.

Franklin and Mathew[21] investigated nurse and physician responses to the pre-arrest decline of 150 adult inpatients. In 99 (66%) of 150 patients, a nurse or physician documented deterioration in the patient's condition within 6 hours of arrest. Of the 51 arrests that could not be anticipated, 2 were in-hospital suicides and 4 occurred in association with medical procedures. Several pitfalls were appreciated in the 99 potentially predictable arrests. In 25 cases, a nurse documented deterioration but failed to notify a physician. In 42 cases, the ward physician was notified but failed to alert the ICU physician. With another group of patients, the ward physician failed to obtain (30 cases) or respond to an abnormal arterial blood gas (8 cases) in the setting of respiratory distress and/or altered mental status. ICU triage error was noted in 32 cases, most of which involved failure of the ICU physician to stabilize the patient before transfer to the ICU. The authors concluded that strategies to prevent cardiac arrest should include training for nurses and physicians that concentrates on cardiopulmonary stabilization and how to respond to neurologic and respiratory deterioration.[21]

Hodgetts and colleagues[22] reviewed records from 32,348 consecutive adult admissions over a 1-year period and found 118 in-hospital cardiac arrests that prompted code team involvement. An expert panel reviewed each case and unanimously agreed that 68% of in-hospital arrests were potentially avoidable. Cardiac arrests were more likely to occur on weekends than weekdays. The odds of potentially avoidable cardiac arrest were five times greater for patients on general wards than critical care areas, and patients who arrested in critical care areas were more likely to survive. The odds of a potentially avoidable cardiac arrest was 12.6 times greater for patients in a clinical area judged "inappropriate" for their main complaint, compared with those in "appropriate" areas. The panel agreed that 100% of potentially avoidable arrests were judged to have received inadequate treatment before arrest. The authors noted several common errors including delays and errors in diagnosis, inadequate interpretation of test results, incomplete treatment, inexperienced physicians, and management in inappropriate clinical areas.

Hillman and colleagues[23] studied the characteristics and incidence of serious abnormalities in 551 adult patients before unplanned ICU admission. They found that patients transferred urgently to ICU from the general ward were more severely ill, had longer ICU stays, and higher mortality (47.6% mortality) than those admitted from the ED (31.5%) and OR (19%). Seventy percent of ward patients had serious documented antecedents during the 8 hours before transfer, most commonly including hypotension, tachycardia, tachypnea, and/or sudden change in level of consciousness.

A prospective study of 6300 hospitalized adults by Buist et al.[17] further clarified a set of abnormal antecedent clinical parameters with a high predictive value for subsequent cardiac arrest. These included a decrease in Glasgow Coma Score by two points, onset of coma, hypotension (<90 mm Hg), respiratory rate less than 6/minute, hypoxia (oxygen saturation <90%, on or off oxygen therapy), and bradycardia higher than 30/minute. The presence of any of these six factors was associated with a 6.8-fold increase in the risk of in-hospital mortality. Risk of mortality was higher for patients with multiple abnormalities (88% risk with four) compared with a single factor (16% risk). The authors recommended that these criteria be used for activating a rescue response before further deterioration.

These and other studies[24,25] clearly demonstrate that most adult patients who suffer cardiac arrest on the general inpatient floor exhibit antecedent abnormal signs and symptoms. Prospective studies documenting the reliable presence of similar patterns in children are lacking. While some hospitalized children may suffer sudden and unexpected cardiac arrests from acute arrhythmia, airway obstruction, seizure, or other events, the more common pattern is thought to be a gradual progression of hypoxemia and hemodynamic instability.[6] "Vital signs" have earned that distinction for good reason.

The limitation of these studies, and resulting challenge for hospital personnel, is the absence of a reliable denominator (ie, how many patients exhibiting abnormal signs and symptoms did *not* suffer cardiac arrest). No doubt, the denominator is very large. For example, Buist and colleagues[17] found that serious clinical abnormalities resolved spontaneously in 67% of patients. However, given universally poor outcomes for in-hospital cardiac arrest, the need to respond urgently to patients with serious abnormalities is compelling, prompting the Institute for Healthcare Improvement and others to call for the implementation of rapid response systems to recognize and respond to deteriorating hospitalized patients of all ages to prevent cardiac arrest.

There are multiple single institution studies in adult populations showing statistically significant decreases in cardiac arrest and mortality rates after the development of a rapid response system.[26] However, the only multicenter cluster randomized control study examining the effects of a rapid response system on cardiac arrests and mortality in adult populations showed no significant differences between groups, although both control and intervention institutions experienced significant improvements in cardiac arrest rates at the end of the study period.[27] There are few published studies examining rapid response systems in single pediatric institutions and no multicenter studies in a pediatric population. Despite the paucity of published studies, several pediatric studies report significant decreases in cardiac and/or respiratory arrest rates[28–32] and one study reports a significant decrease in hospital-wide mortality rates.[31]

## OUTCOME MEASURES OF PEDIATRIC RAPID RESPONSE SYSTEMS

As rapid response systems are implemented and sustained with specific outcomes in mind, process and outcome measures must be followed to detect changes at the institution level as well as provide a framework for benchmarking. In 2007, the International Liaison Committee on Resuscitation (ILCOR) published "recommended guidelines for monitoring, reporting, and conducting research on medical emergency team, outreach, and rapid response systems: an Utstein-style scientific statement."[33] In addition to patient and hospital demographics, peri-event data, and universal nomenclature, there are specific recommendations for patient and hospital outcomes data reporting. According to their recommendations, hospital outcomes should include total acute care discharges whether alive or dead, hospital deaths, DNR deaths, number of emergency team activations, total number of in-hospital cardiac arrests, and cardiac arrests occurring in non-ICU, operating room, or emergency departments.

Although most of the adult literature has used similar outcomes in published studies, there remain many differences in the definitions of reported outcomes in published studies of pediatric rapid response systems (**Table 2**). These differences make it difficult to assess and compare the small number of pediatric rapid response system studies in the literature. For example, Tibballs and colleagues[28] and Hanson and colleagues,[32] like in adult studies, report cardiac arrests as one of their main outcome variables. Brilli and colleagues[29] and Sharek and colleagues[31] use the term "code" to include respiratory and cardiac arrests and Hunt and colleagues[30] report both "cardiopulmonary" and "respiratory" arrests. In addition, these outcomes are indexed differently in pediatric

**Table 2**
**Clinical outcomes for pediatric rapid response systems**

| Publication | Institution | Statistically Significant Outcomes |
|---|---|---|
| Tibballs 2005 | Royal Children's Hosp. Melbourne, Australia | No significant decrease in total cardiac arrest or mortality rates except in those deaths and cardiac arrests the transgressed MET criteria:<br>Decrease in mortality 0.11 → 0 per 1000 admissions<br>Decrease in Cardiac Arrests 0.16 → 0 per 1000 admissions |
| Brilli 2007 | Cincinnati Children's Hospital; Cincinnati | Decrease in Non-ICU codes 1.54 → 0.62 per 1000 admissions<br>0.27 → 0.11 per 1000 patient days |
| Sharek 2007 | Lucile Packard Children's Hospital; Stanford University | Decrease in non-ICU codes: 2.45 → 0.69 per 1000 discharges<br>0.52 → 0.15 per 1000 patient days |
| Hunt 2008 | Johns Hopkins Hospital Baltimore, Maryland | No significant change in cardiopulmonary arrests<br>Decrease in respiratory arrest: 1.46 → 0.40 per 1000 discharges<br>0.23 → 0.06 per 1000 patient days |
| Hanson 2008 (*In press*) | North Carolina Children's Hospital, Chapel Hill | Increase in mean time interval between non-ICU cardiac arrests: 2512 → 9418 patient days between cardiac arrests<br>Decrease in median duration of clinical instability before ICU assessment: 9 h 55 m → 4 h 15 m |

studies with many reporting arrest events per 1000 patient days instead of or in addition to 1000 admissions/discharges. Although patient days likely offer a more accurate measure of effect on the patient population, it is not standardized for reporting in the literature. Effects on wards mortality before and after rapid response system development were reported by Brilli and colleagues,[29] Hunt and colleagues,[30] and Tibballs and colleagues,[28] whereas Sharek and colleagues[31] and Hanson and colleagues[32] focused on hospital-wide mortality rates. It is clear that pediatric institutions need further recommendations for standardized measures of rapid response systems. One immediate solution would be to follow the ILCOR recommendations for data reporting for all rapid response systems including those in pediatric populations.

## IMPLEMENTATION OF A SUCCESSFUL RAPID RESPONSE SYSTEM

According to the Medical Emergency Team Consensus Conference, successful rapid response systems include four necessary components: (1) an afferent limb, (2) an efferent limb, (3) an evaluative/process improvement limb, and (4) an administrative limb.[34] The afferent limb is defined as the component of the emergency response system that is able to detect an event and trigger a response. The efferent limb provides a crisis response including resources such as a medical emergency team (MET) or rapid response team (RRT) and equipment. The evaluative/process improvement component exists to improve patient care and safety. Finally, the administrative limb exists to implement and sustain the service. To highlight the process of developing a pediatric rapid response system and measuring its effects on patient safety, we share case examples that describe our experiences at the North Carolina Children's Hospital at the University of North Carolina-Chapel Hill and Levine Children's Hospital in Charlotte, North Carolina.

## CASE EXAMPLE: UNIVERSITY OF NORTH CAROLINA-CHAPEL HILL

An institution-wide pediatric rapid response system (PRRS) has been active at North Carolina Children's Hospital since August 2005. Antecedents described in the adult literature along with pattern antecedents identified in detailed institution-specific chart reviews were used to establish the criteria for activation of the RRT. Calling criteria were designed without numeric vital sign parameters to be highly sensitive for pre–cardiac arrest states. The criteria for activation are displayed in poster format throughout the hospital. The PRRS includes all four consensus conference components.

The afferent limb relies on human assessment and interpretation of monitoring to detect an event and activate the RRT. The primary system change is the empowerment of any member of the hospital staff or family member to activate the RRT. The RRT is activated though both a pager call to team members and a public announcement. A public announcement is used not only to notify the RRT members but also the primary team to assist in the decision-making process and foster acceptance of the team to other hospital staff.

The efferent limb, or RRT, includes a pediatric critical care fellow or attending, a senior resident, a critical care charge nurse, and a pediatric respiratory therapist. The primary team for the patient is also expected to be present and participate as members of the RRT. The RRT has all of the following competencies: (1) ability to prescribe therapy; (2) advanced airway management; (3) capability to establish central venous access; and (4) ability to begin ICU level of care at the bedside.[34] The team responds to all areas excluding the neonatal and pediatric intensive care units. This includes clinics within the hospital building, adult patient areas where pediatric visitors may be present, inpatient wards, burn unit, bone marrow transplant unit, radiology, or any other physical space within the institution walls.

On arrival to the patient's bedside, the RRT provides immediate medical evaluation and treatment as required. The team then communicates further treatment plans to the patient's primary medical team and family. The team is trained to perform a debriefing with immediate feedback to the resident physicians and nurses regarding recognition of clinical deterioration and strategies for improvement. The RRT members are instructed to adopt a supportive attitude and not to make negative comments. An RRT activation form is completed by the pediatric critical care physician and then collected for performance improvement.

The administrative and process improvement limbs are necessary for implementing and sustaining the system. Before implementation, a 4-month period of educational sessions for all medical staff including physicians, nurses, respiratory therapists, chaplains, security, and communications staff was completed. During these sessions, criteria for activation of the RRT were reviewed, illustrative cases discussed, and concerns and questions addressed.

Once education was complete, the system changes were initiated without a run-in period. From that time onward the rapid response system has been evaluated by prospectively collected data recorded on RRT activation forms and existing performance improvement database information. The administrative committee meets monthly to review the data collected and discuss individual cases that prompted additional safety concerns. Further root cause analyses are performed as needed to address these safety concerns. As a result, several changes to the system have been made to further decrease variation in response and improve safety. For example, a new policy preventing the cancellation of a "code blue" or RRT call was implemented to reinforce the concept that there are no false alarms. In addition, the pediatric ICU staff began activating the RRT for urgent consults when it was identified that the team was not being used fully. Individual cases are discussed formally at a monthly resident conference to reinforce management and resuscitation of the critically ill pediatric patient.

As a result of the PRRS, the mean time interval between cardiac arrests increased significantly from a baseline of 2512 to 9418 days, indicating a significant decrease in non-ICU cardiac arrests. In addition, median duration of predefined clinical instability before assessment by ICU personnel decreased from 9 hours 55 minutes to 4 hours 15 minutes postintervention ($P = .028$).[32] The duration of clinical instability significantly decreased for unplanned ICU admissions whether assessed by the RRT or not, indicating that implementation of a PRRS resulted in a hospital-wide culture change favoring early assessment by critical care personnel. This culture change is likely the most important aspect of rapid response systems leading to early recognition and treatment of clinical deterioration. One recent study similarly found that DNR orders and delayed MET activation are the strongest independent predictors of mortality in patients receiving a Medical Emergency Team review. The investigators stressed that avoidance of delayed MET activation should be a priority for hospitals operating rapid response systems.[35]

## CASE EXAMPLE: LEVINE CHILDREN'S HOSPITAL

An institution-wide Pediatric Early Response Team (PERT) was initiated at Levine Children's Hospital (LCH) in 2004, and has evolved considerably since then. The initial afferent system for identifying a deteriorating patient used evidence-based criteria for airway, breathing, circulatory, and neurologic concerns, but activating the efferent response was inefficient and cumbersome. The nurse typically paged the inpatient physician and charge nurse and waited for recommendations or "permission" to have the ICU team evaluate the patient. In spring 2007, a multidisciplinary task force including representatives from critical care, inpatient general pediatrics, nursing, respiratory care, and risk management began a collaboration to enhance the system by adopting the latest evidence-based strategies. LCH adopted the simple age-neutral activation criteria listed in **Box 1**.

The revised system empowers concerned staff members to activate PERT by calling the hospital paging operator. A group text page immediately informs PERT members, including a pediatric hospitalist, supervising resident physician, critical care charge nurse, and pediatric respiratory therapist. Each PERT member has authority to implement a wide range of standing orders shown in **Box 2**, including transfer to a higher level of care. After the patient has been stabilized, a brief record is completed to document which staff member initiated the call, reason for the call, assessment and intervention measures, and outcomes. In addition, the patient's bedside nurse completes a feedback tool to record response time; quality of communication between the PERT members, primary inpatient team, nursing staff, and patient/family; and suggestions for improvement. Staff members initiate PERT are acknowledged for their commitment to patient safety by a personalized letter from the chief nursing officer and chief medical officer. There are no "false alarms."

**Box 1**
**Pediatric Early ResponseTeam activation criteria at Levine Children's Hospital**

Acute change in HR, BP, RR, O2 Sat

Acute change in mental status

Pain or agitation that is difficult to control

New or prolonged seizure

Staff member is worried about a patient

PERT calls at LCH increased significantly since implementation of the direct activation mechanism in May 2007. The average number of PERT events per 1000 discharges was 1.37 during the 12 months before implementation, compared with 8.42 during the 18 months after implementation. There were 80 PERT events between July 1, 2006, and December 31, 2008. PERT was predominantly activated by the patient's bedside nurse (84%), and occasionally by the physician (9%), charge nurse (5%), or respiratory therapist (2.5%). Activation triggers included acute changes in heart rate (22%), blood pressure (7.5%), respiratory rate (41%), hypoxia (35%), mental status (25%), and other/staff concern (68%). More than one reason for calling PERT was frequently documented. PERT arrival occurred within 5 minutes of the call in 95% of cases, and within 10 minutes in all remaining cases. Assessments and interventions provided by PERT are documented in **Table 3**.

PERT intervention was typically brief, lasting less than 30 minutes in 86% (69/80) of cases. Nine cases lasted 30 to 60 minutes, and two cases lasted 60 to 90 minutes.

**Box 2**
**Standing orders for Pediatric Early ResponseTeam at Levine Children's Hospital**

Patient weight: —— kg

Obtain HR, BP, RR, O2 saturation and continue to monitor

Assess Airway Breathing status

Assess Circulatory status

Obtain situation and background information from bedside nurse

—— Oxygen to keep saturations above 92% or for respiratory distress

—— Albuterol 2.5 mg neb (or 2 puffs MDI), repeat × 3 doses PRN wheezing/respiratory distress

—— Epinephrine 2.25% (Racemic Epi) 0.5 mL dilutes to 3 mL nebulized × 1 dose PRN stridor

—— Obtain blood glucose. If below 40, give D25% 2 mL/kg IV × 1 dose.

—— Initiate IV access based on patient condition

—— Normal Saline 20 mL/kg IV × 1 dose based on patient condition

—— Narcan 0.1 mg/kg IV for known narcotic administration with altered mental status/resp depression. May repeat × 1 dose (max dose 2 mg)

—— Transfer to PICU based on patient condition; PICU attending notified: Dr. ____________________

—— Notify primary attending/service of patient's condition: Dr. ____________________

**Table 3**
**Assessment and intervention by Pediatric Emergency ResponseTeam at Levine Children's Hospital (n = 80)**

| Intervention | Number of Cases (%) |
|---|---|
| Airway suctioning | 23 (29%) |
| Supplemental oxygen | 47 (59%) |
| Bag-valve mask ventilation | 15 (19%) |
| Oral/nasal airway | 5 (6%) |
| Beta-agonist inhalation | 2 (2.5%) |
| Racemic epinephrine inhalation | 5 (6%) |
| Chest x-ray | 8 (10%) |
| IV placement | 11 (14%) |
| IV fluid bolus | 17 (21%) |
| Naloxone (Narcan) | 2 (2.5%) |
| Blood glucose measurement | 16 (20%) |
| Dextrose administration (D25 IV) | 3 (4%) |
| Other medications given | 17 (21%) |
| No intervention necessary | 6 (7.5%) |

Education to initiate ICU transfer for interventions lasting more than 30 minutes was subsequently provided. Following PERT intervention, 56% (45/80) of patients remained on the general or progressive floor, whereas 39% (31/80) were transferred to the ICU, including three cases where the patient required resuscitation for cardiac arrest on the general ward. Four patients requiring PERT intervention were admitted to the hospital from an outpatient area such as radiology or dialysis following the event.

Levine Children's Hospital opened in December 2007, 6 months after implementation of the revised PERT system. Despite a 10% increase in inpatient volume in 2008 compared with 2007, the mean rate of non-ICU codes (defined at LCH as either cardiac or respiratory arrest) decreased to 1.5 per 1000 discharges. The rate of codes outside the ICU had previously been approximately four cases per 1000 discharges. Interestingly, there were zero non-ICU codes during the period of intense education about upcoming changes to PERT. Since the PERT revision, the rate of non-ICU codes has remained below 2.25 per 1000 discharges, even during periods when total pediatric codes (ICU + non-ICU) exceeded 10 per 1000 discharges.

## IMPLEMENTATION OF FAMILY ACTIVATION

At Levine Children's Hospital, family members are encouraged to immediately notify a staff member when they are concerned about their child. The NC Children's Hospital used a similar approach initially. During the first year after implementation of the PRRS at NC Children's Hospital, "family concern" was one of the reasons for activation in 8% of the calls. More than half of those patients required transfer to the ICU, demonstrating that the calls were appropriate and necessary. In the spring of 2007, after piloting the system in two units, family activation was introduced throughout the institution, allowing families to directly activate the RRT using the same system as the hospital staff without a triage step.[36] Researchers at the University of Pittsburgh Medical Center recently described their patient and family activation system. At their institution, a call by a family member results in the activation of a special Condition HELP team (a physician, a nursing supervisor, and a patient advocate) who evaluates whether to elevate the situation and activate a rapid response emergency team, called Condition A (cardiopulmonary arrest) or Condition C (a crisis that might result in imminent arrest).[37]

The 2009 National Patient Safety Goals have identified partnership with patients and families as “an important characteristic of a culture of safety” and according to the Institute for Family-Centered Care, the core concepts of patient- and family-centered care are dignity and respect, information sharing, participation, and collaboration.[38,39] These goals are even more important in pediatrics, where patients are reliant on parents and caregivers for most of their needs.

At NC Children’s Hospital, members of the medical staff feared that family activation would result in numerous calls for nonemergent situations as well as calls that would be better routed to patient relations representatives. Focus groups, open communication, and finally a pilot of family activation on two units of the institution reassured the medical staff and families that the introduction of family activation would not disrupt or overwhelm the existing rapid response system. The rule of “no false alarms” helps all staff understand that any serious concern of a family member or a member of the child’s medical team is valid cause for activating the system.

At the time of admission, all patients and families are educated about the RRT by their nurse. If families are not educated at the time of admission, several educational tools are available to ensure that families are fully equipped to activate the RRT. The key elements of the family activation and education include staff education and mock scripts, bilingual flyers in visitor areas and waiting rooms, electronic chart education reminders for nurses, and large colorful bilingual posters in each patient room. The posters serve as a both a reminder of the number to call and a prompt for nurses to provide education at the time of admission. A tear-off card mechanism for activation by non–English-speaking families is available next to the poster in every room.

Audits and interviews with families to assess their understanding of the RRT in their own words are conducted routinely, with feedback provided to the unit staff. Through audits, it has been discovered that the poster alone is not sufficient education for families. In fact, many families have never read the information unless their nurse mentioned it at the time of admission. Without the poster, however, it may be difficult to remember the phone number to call to activate the team. In addition to the other tools, information about the RRT is included in the hospital guide that is provided to families at the time of admission.

Since the introduction of family activation, the mean number of RRT calls has increased significantly from 16 to 24 calls per 1000 discharges (Willis, unpublished data, 2009). The number of rapid response calls made directly by a family member is very low—only two calls during the first year of implementation. Many staff members have indicated that families prefer to have a medical professional call on their behalf. Despite this fact, family concern continues to be recorded as a reason for activation in 6% of all calls. Efforts to provide education to patients and families about rapid response systems serve not only to help them summon care in a time of need, but also to move toward a hospital-wide culture of recognizing families as critical members of the medical team.

## USE OF RAPID RESPONSE SYSTEM FOR QUALITY IMPROVEMENT

There are many reported benefits of rapid response systems beyond a reduction in cardiac arrest and mortality rates. These include improved staff satisfaction and safety culture, improved nursing documentation, earlier palliative care, and improved education for physician trainees.[26,40–43] In addition, rapid response and medical emergency team activations can be used for detection of medical errors and system safety issues. In fact, at one institution, more than 30% of RRT activation reviews detected a medical error, and a focus on standardization of hospital processes was completed to improve hospital-wide safety.[44] These processes included standardized protocols for hypoglycemia and transfer of patients. Standardized protocols can also be used by RRTs to improve care of sepsis patients.[45] RRT activations can easily be incorporated into existing morbidity and mortality reviews and used as a trigger tool for system reviews and further improvement in hospital processes.

## SUMMARY

Life-threatening events are common in today's complex hospital environment, where an increasing proportion of patients with urgent admission for severe illness are cared for by understaffed, often inexperienced personnel. Medical errors play a key role in causing adverse events and failure to rescue deteriorating patients. Outcomes for in-hospital cardiac arrest in both adults and children are generally poor, but these events are often preceded by a pattern of deterioration with abnormal vital signs and mental status. Fortunately, when hospital staff or a family member observes warning signs and triggers timely intervention by a rapid response team, rates of cardiac arrest and mortality can be reduced. Moreover, rapid response team involvement can be used to trigger careful review of preceding events to help uncover important systems issues and allow for further improvements in patient safety.

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