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Failure to Rescue

A Literature Review

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Rapid response teams have been advocated as an intervention to reduce failure to rescue events. Such teams can improve nurse autonomy and control to rescue patients deteriorating in a medical surgical setting. The purpose of this review is to enhance nurse executives' understanding of failure to rescue as a nurse sensitive outcome, tested interventions, and implications for future research. The emergence of failure to rescue as an outcome measure will be initially discussed. Research regarding the relationship between failure to rescue and registered nurse staffing as well as research examining the potential to reduce failure-to-rescue events will be explored.

Patient safety is a high priority for chief nursing officers. Growing regulatory requirements and an increase in awareness of preventable adverse events have focused attention on this important area. Failure to rescue is one of several nurse-sensitive outcomes that are gaining importance in evaluating the quality of care provided. Recognition of the existence of unexpected, but preventable, events that influence mortality led to the conceptualization of the "failure-to-rescue" phenomenon. Failure to rescue refers to the inability to save a patient's life after the development of a complication.[1,2] The skills needed to appropriately intervene before the onset of life-threatening health problems require complex assessment, highly intensive therapies, targeted interventions, critical evaluation, and immediate adjustment dependent on patient response.[3] Although failure to rescue is commonly discussed within the context of preventable adverse events and hospital deaths, failure to rescue does not necessarily imply wrong doing.[1,4] Instead the reference is to not recognizing deterioration in patient status and taking steps designed to reverse these changes. The purpose of this review is to enhance nurse executives' understanding of failure to rescue as a concept and a factor that influences the frequency of these events.

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Methods

To identify eligible published English language original research articles, the search was conducted through OVID and MEDLINE from 1965 to April 2005 using the following terms: adverse events, failure to rescue, preventable deaths, medical emergency teams, and rapid response teams (RRT). All articles examined were research studies that explored the influence of hospital characteristics and registered nurse staffing on failure-to-rescue events and effectiveness of RRT. Only English language studies were reviewed, so the literature review may have missed some studies that merited inclusion. In addition, published bibliographies from the National Patient Safety Foundation and the Institute for Healthcare Improvement were reviewed. If there was uncertainty as to the appropriateness of an article, the

abstract was reviewed. The research revealed 3 major groupings. The first grouping was the emergence and use of failure to rescue as a quality outcome indicator. The second grouping was an evaluation of the relationship of failure-to-rescue and nurse staffing variables. The third grouping was an evaluation of the impact of RRT in reducing unexpected in-hospital cardiac arrest and unexpected transfers to the intensive care unit.

Emergence of Failure to Rescue as a Concept

In 1992, Silber and colleagues[1] conducted seminal research to determine if the factors that decrease mortality and prevent complications during a hospitalization are the same as those that promote rescue after a complication has occurred. This research was the first attempt to measure and evaluate failure to rescue as a discrete outcome that was separate from mortality (Table 1). Based on these data, Silber and colleagues argued that using death rate as a valid comparison of quality across hospitals ignored important precursors, including complications and response to patient condition once a complication occurred.[1] They argued further that the management of complications or preventing death after a complication, an outcome referred to as "rescue," was an important outcome measurement of hospital performance. Failure to rescue was defined as a death that occurs after a patient develops a complication in the hospital that was not present on admission.[1,2]

To support their argument, Silber and colleagues[1] examined the influence of hospital and patient characteristics on 3 variables: death rate, adverse occurrence rate, and failure-to-rescue rate. The study enrolled more than 5,900 patients who underwent 1 of 2 surgical procedures (cholecystectomy, prostatectomy) in 7 states and 531 hospitals. Two rationales were given for choice of these procedures: their commonality and association with adverse occurrences.

Both hospital and patient characteristics were shown to be associated with the death rate. However, the only hospital characteristic that had a significant association ($P < .05$) was the percentage of full-time board-certified surgical staff. Failure to rescue revealed a different pattern. A reduced risk of failure to rescue was associated with a higher proportion of board-certified anesthesia staff ($P < .01$) and an increased risk with the presence of surgical house staff ($P < .05$). There were no differences across hospital groups and the distribution of adverse occurrences, which disputed the argument that some hospitals cared for sicker patients. These findings were noteworthy because they directed attention to hospital characteristics as a potential cause of failure to rescue. Silber and colleagues[1] posed that failure to rescue provided a powerful tool to detect true differences in patient outcomes across hospitals.

Building on their initial study, Silber and colleagues[2] conducted a second study to compare the relative importance of patient and hospital characteristics in explaining variations in the death rate, adverse occurrence rate, and failure-to-rescue rate. Notably, this was the first study to introduce the variable of registered nurse staffing as a possible explanation of variation in failure-to-rescue events across hospitals. The study included surgical patient admissions in 1990 and 1991 at 137 hospitals. Each hospital was described by 12 variables, including the number of beds, percentages of surgical and anesthesia staff who were board-certified, ratio of registered nurses to hospital beds, and indicators reflecting activities and facilities such as cardiac catheterization services, open heart surgery, organ transplant, magnetic resonance imaging, trauma, and teaching programs. Using logit models, they concluded that both patient and hospital characteristics contribute to the variation in death rate.

This study had several findings of particular interest to nursing. First, there was a negative correlation for failure to rescue with the ratio of registered nurses ($r = -0.45$; $P = .01$). High values of registered nurse staffing were associated with hospitals in the model that had a low risk of failure to rescue. Second, the study identified the ratio of registered nurses as an important characteristic that explained the outcomes of death rate, adverse occurrence rate, and failure-to-rescue rate. These and other studies conducted by this research team extended prior thinking about mortality as an indicator of hospital quality, introduced the failure-to-rescue event as an important phenomenon when assessing mortality, and provided objective evidence documenting the importance of registered nurse staffing when evaluating hospital quality and patient outcomes.[1,2,5-7]

The works of Silber and colleagues led to a more critical evaluation of the use of mortality as an outcome measurement for quality. In addition, introduction of the concept of failure to rescue provided insight into the influence of hospital characteristics and included registered nurse staffing as an important contributor to patient outcomes. Their findings introduced an analytic approach not previously used in studying these variables. There

Table 1. *Relationship Between Nurse Staffing and Failure-to-Rescue Rates Conducted by Silber and Colleagues*

	Purpose	Sample	Statistical Analysis	Hospital Characteristics	Definition	Findings
Silber et al[1]	To determine whether hospital and patient characteristics that prevent mortality are the same as those that prevent complications, or allow for rescue, should a complication occur	Surgical patients younger than 65 years admitted for cholecystectomy (n = 2,831) or transurethral prostatectomy (n = 3,141) in 1985 in 7 states and 531 hospitals Data obtained from HCFA MEDPAR files and Hospital Association Annual Survey	Student and χ^2 tests Multiple logistic regression models OR	Number of beds % of board certified anesthesiologists and surgeons Presence of anesthesia and surgical house staff	Failure rate = number of deaths in those patients that develop an adverse occurrence	Failure rate showed different pattern than death or adverse event. Anesthesia board certification significantly reduced risk of failure; odds ratio (OR), 0.63 (0.5, 0.9); $P < .01$. Failure rate not influenced by severity or procedure
Silber et al[2]	To determine why and when adjusted for recorded patient characteristics, mortality, adverse occurrence, and failure rates rank hospitals differently	73,174 patients admitted in 1990 and 1991 at 137 hospitals who underwent surgical procedures Merged data from HCFA MEDPAR files and Hospital Association Annual Survey	Logit model fitting Spearman correlation	12 hospital variables—ratio of registered nurses to hospital beds was included	Failure was defined as death after adverse occurrence.	Failure rates negatively correlated with ratio of registered nurses to beds ($r = -0.45$; $P < .01$).
Silber et al[5]	To determine whether hospital rankings based on complication rates provide the same information as hospital rankings based on mortality rates	All patients undergoing CABG at hospitals in 1992 and 1992 MedisGroups National Comparative Data Bases linked American Hospital Association Annual Survey data (1991). 16,673 total patients	Correlations-pairwise interactions Logistic regression models OR	Number of beds % of board certified anesthesiologists and surgeons; presence of anesthesia and surgical house staff; MRI, transplant, trauma programs; nurse-to-bed ratio	Failure rate = number of deaths in patients who developed an adverse occurrence	After adjusting for patient admission, severity correlations between hospital rankings based on death or failure to rescue (FTR) and complications (CP) were not significant. Death vs CP ($r = 0.07$; $P = .58$) FTR vs CP ($r = -0.22$; $P = .11$) 717 of 7,173 FTR developed CP = 10% FTR rate
Silber et al[6]	To compare outcomes of surgical patients whose anesthesia care was or was not personally performed or medically directed by anesthesiologist	Medicare claims records for patients older than 65 years in Pennsylvania who underwent general or orthopedic surgical procedures among 245 hospitals procedures between 1991 and 1994. 194,430 directed and 23,010 undirected	Logistic regression models OR	11 hospital variables—ratio of registered nurses to hospital beds was included.	Failure was defined as death after adverse occurrence.	Ratio of registered nurses' significant relationship to FTR Nurse-to-patient ratio; OR, 0.95 (0.93,0.98); $P < .0001$

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Table 1. Continued

	Purpose	Sample	Statistical Analysis	Hospital Characteristics	Definition	Findings
Silber et al[7]	To compare outcomes of patients who underwent surgical procedures under the care of an anesthesiologist with or without board certification	Medicare claims records for 144,883 patients in Pennsylvania who underwent general surgical and orthopedic procedures between 1991 and 1994. Outcomes of 8,894 cases involving midcareer anesthesiologist who lacked certification were compared with all others.	Logistic regression models OR	10 hospital variables—ratio of registered nurses to hospital beds was included.	Failure is defined as death after adverse occurrence.	Ratio of registered nurses' significant relationship to FTR OR, 0.84 (0.79,0.89); $P < .0001$

CABG indicates coronary-artery bypass graft; MRI, magnetic resonance imaging; HCFA MEDPAR, health care finance and administration medicare provider analysis records.

were also several important limitations. Only surgical patients were studied, so study findings cannot be generalized to other patient populations. Also, the method used to determine registered nurse staffing was not clearly described, and therefore, it was not possible to determine if their analysis included all nurses employed in the institution or only those providing direct patient care.

Failure to Rescue and Registered Nurse Staffing

Ten years after Silber and colleagues published their original work, 2 pivotal studies appeared.[8,9] These studies were the first to identify the relationship of failure to rescue to nursing-related structures, processes, and hospital characteristics. They also extended pervious findings by examining the role of nursing in failure-to-rescue events in more detail using large sample populations.

Using the same type of surgical patient population as Silber and colleagues,[1,2] Aiken and colleagues[8] conducted a cross-sectional analyses of linked data from staff nurse surveys and surgery patients discharged from 168 hospitals in Pennsylvania. Failure to rescue was included as a main outcome variable, along with risk-adjusted mortality, nurse-reported job dissatisfaction, and job burnout. Failure to rescue was defined as death in a surgical patient who developed serious complications. The study offered a unique contribution in methodology by linking de-identified nurse and patient data. It also addressed another limitation of prior research when looking at registered nurse staffing by using a direct measurement rather than a retrospective administrative database.

Data were collected on structural characteristics from 2 administrative databases (American Hospital Association Annual Survey, Pennsylvania Department of Health Hospital Questionnaire) for hospitals with at least 10 nurses responding to the questionnaire. Three hospital characteristics were used as control variables: size, teaching status, and technology. Nurse staffing was measured as the mean patient load across all staff registered nurses who reported having responsibility for at least 1, but fewer than 20, patients on the last shift they worked. Nurses were asked to use a list to identify the hospital where they worked and were asked about demographics, work history, workload, job satisfaction, and feelings of job burnout.

After adjusting for patient and hospital characteristics (size, teaching status, technology), having been assigned 1 additional patient per nurse was

associated with a 7% (odds ratio, 1.07; 95% confidence interval, 1.03-1.12) increase in the likelihood of dying within 30 days of admission and a 7% (odds ratio, 1.07; 95% confidence interval, 1.02-1.11) increase in the odds of failure to rescue. There were a number of limitations to the ability to reach this conclusion. There was considerable variation in mean patient-to-nurse ratio, which ranged from 4:1 to 8:1. Also, the sample of surgical patients represented only approximately 50% of the total surgery patients admitted to these hospitals. The response rate to the survey was 52%, which, although high, creates the potential for response bias. Despite these limitations, the study suggested important implications for registered nurse staffing and patient safety.

The researchers posited that the nursing surveillance system explained the link between higher nursing skill mix and lower rates of failure to rescue and the ability to intervene before the patient's condition deteriorates so severely that it cannot be reversed or a cardiac arrest event occurs. This research supports the assertion that nurses are in the best position to initiate action that could minimize negative outcomes and prevent failure-to-rescue events. There are ongoing efforts to introduce technology that supplements nursing surveillance by alerting clinicians to changes that signal a change in patient status.[10,11] Such technology can automatically notify the RRT or other clinicians to intervene and avoid the need to solely rely on nursing observation, which is limited by the need to care for multiple patients.

Needleman and colleagues[9] added to these findings by conducting research designed to define the relationship between patient outcomes potentially sensitive to nursing and nurse staffing in acute care hospitals. They used hospital discharge data from 799 hospitals across 11 states (covering more than 6 million discharges) to identify outcomes potentially sensitive to nursing in medical and surgical patients. State hospital financial reports or hospital staffing surveys were used to construct measures of nurse staffing at the level of registered nurses, licensed nurses, and nursing aides. The level of staffing was estimated in hours. To allow for comparison of staffing levels across hospitals, they estimated the relative level of nursing care needed by patients and constructed a nursing case mix index for each hospital. They defined failure to rescue as the death of a patient with 1 of 5 life-threatening complications (pneumonia, shock or cardiac arrest, upper gastrointestinal bleeding, sepsis, or deep vein thrombosis). These complications were selected because they could be identified by nurses and influenced by nursing intervention.

Their findings were consistent with those of Silber and colleagues:[2] among surgical patients, a greater number of registered nurse hours per day was associated with a lower failure-to-rescue rate ($P = .008$). The evidence for a relationship between failure to rescue and a higher proportion of care provided by registered nurses was not as strong as that by medical patients ($P = .05$). Among both medical and surgical patients, they found no evidence of an association between in-hospital mortality and the proportion of registered nurse hours. The authors acknowledge the limitations encountered when using large data sets involving hospitals in multiple states, including the inability to standardize and interpret different methods of reporting allocation of nursing staff to direct patient care. This is one of the major weaknesses of this type of analysis. Conversely, strength of this approach is the size of the sample and its geographic distribution.

Failure to Rescue and Registered Nurse Education

Our literature search found limited research investigating the effect of educational level of the registered nurse and effect on nurse performance and patient safety outcomes. Aiken and colleagues[4] conducted a follow-up study using the same database of 168 Pennsylvania hospitals to determine if hospitals with a higher proportion of direct care registered nurses educated at the baccalaureate level or above had a lower risk-adjusted mortality and lower failure-to-rescue rates. A secondary aim of the study was to determine if educational background was a predictor of patient mortality beyond factors of nurse staffing and experience. Aiken and colleagues constructed a risk-adjustment model similar to that used by Silber and colleagues.[2] Significance testing was used to compare groups of hospitals that varied in educational composition and hospital characteristics including nurse staffing, nurse experience, and patient characteristics. Logistic regression models were used to estimate the effect of a 10% increase in the proportion of nurses who held a bachelors or masters degree on mortality and failure to rescue. After adjusting for patient and hospital characteristics, they estimated that a 10% increase in the proportion of nurses holding a bachelors degree was associated with a decrease in failure to rescue by a factor of 0.95 or by 5%.

This is the first study to provide empirical evidence that the employment of nurses with bachelor and higher degrees in hospitals improves patient outcomes. An important criticism of this study is the methodology used to combine education categories, particularly the baccalaureate degree and higher. In rebuttal, the authors provide support to their methodology by explaining the number of checks they instituted to insure the validity of the findings. This testing included allowing the nurse education variable to have a nonlinear effect and testing whether the effect of education varied across levels using quadratic and dummy variables. This analysis did not improve the fit of the model. Consequently, the authors argue that they can provide strong evidence to validate their methodology and the findings. As in prior studies, the use of surgical patient populations prohibits generalization to other patient populations.[1,2,4,8] In addition, the sample used by Aiken and colleagues[4,8] was drawn from a single state.

Failure to Rescue and Professional Work Environment

We identified one additional study that used failure to rescue as an outcome measurement. Boyle[12] conducted an exploratory cross-sectional study that examined the association between nursing unit organizational characteristics, nurse-sensitive adverse events, and failure to rescue. The sample was drawn from a 944-bed teaching facility that included 21 medical surgical units. The Nursing Work Index was used to measure unit characteristics, and bivariate correlation and Pearson r were used to detect relationships between variables. The results showed a significant relationship between organizational characteristics and adverse events at the unit level. In addition, nurse autonomy and collaboration showed a statistically significant inverse relationship ($r = -0.53$) with failure to rescue. The authors concluded that unit-level study provided the best understanding of the effect of unit work environment on nursing practice and outcomes.

Failure to Rescue as a Quality Indicator

Failure-to-rescue event has been identified by the Agency for Health Care Quality as 1 of 16 patient safety indicators to be used to assess and improve patient safety in US hospitals.[13] Four patient safety indicators are recognized by the Agency for Health Care Quality as staffing/nurse-sensitive quality indicators: decubitus ulcer, postoperative respiratory failure, postoperative deep vein thrombosis, and failure to rescue.[13]

The Health Grades Second Annual Quality Study, which used the Agency for Health Care Quality patient safety indicators to study the safety and associated cost of inpatient care among Medicare patients, reported approximately 1.18 million patient safety incidents among nearly 39 million hospitalizations.[14] Failure to rescue was one of the patient safety indicators with the highest incidence rate (along with decubitus ulcer and postoperative sepsis), accounting for 62% of all patient safety incidents among Medicare patients hospitalized in 2001 through 2003. There were 198,793 failure-to-rescue incidents, which accounted for 16.9% of the total number of incidents. Of concern, failure to rescue was 1 of 6 indicators that did not demonstrate substantial improvement in frequency. This finding speaks to the struggle the healthcare industry has in achieving improved approaches to healthcare delivery, even when areas for patient safety improvement are evident. It also speaks to the need for ongoing investigation into the causes of failure-to-rescue events to develop empirically sound interventions.

RRT to Prevent Failure-to-Rescue Events

The empirical evidence that identified consequences of a failure to rescue led to the institution of measures to improve surveillance, recognition, and response-to-rescue events. One approach involves the formation of a team that can be rapidly summoned when clinicians experience concern for their patients or when patients meet predefined clinical criteria.[15-22] The Institute for Healthcare Improvement has identified the deployment of such teams, termed RRT or medical emergency teams, as 1 of 6 changes to prevent death in patients who are progressively failing outside the intensive care unit.[23] Commonly, such teams include a critical care physician, intensive care unit nurse, and respiratory therapist.

The first study describing outcomes of the use of RRT was reported in 1995 by clinicians in Australia who implemented this intervention in a 375-bed teaching institution.[15] During the 12-month observation period, there were 522 medical emergency team calls, including 62% in the emergency department and 26% on hospital wards. Nurses summoned the team in the majority (69%) of the calls. Most patients were medical (76%) and acute respiratory failure, and seizures were the most frequent conditions prompting the

call. In almost half (42%) of the events, a decreased level of consciousness was one of the main alerting physiological abnormalities. In this study, concern that the patient would deteriorate if urgent help was not available occurred only in 3 (<1%) calls. Conversely, others[21] have reported that this concern was the most frequent reason for calling the team (58% of calls).

Table 2 includes a review of research testing ability of RRT to improve patient outcomes. In particular, the establishment of an RRT seems to impact the incidence of cardiac arrest. Buist and colleagues[18] reported a 50% reduction in the incidence of unexpected cardiac arrest before and after use of an RRT. DeVita and colleagues[20] retrospectively analyzed outcomes after the introduction of an RRT and reported a 17% decrease in incidence of unexpected cardiopulmonary arrest during a 5-year period (1996-2000; n = 1,973) before objective criteria were developed for team response and 1.8-year period after the development of clinical criteria (January 2001-September 2002; n = 1,296).

Although these findings provide consistent support for the ability of an RRT to reduce the number of unexpected cardiac arrest events, all were conducted at a single institution and none were randomized or blinded. Consequently, it is not possible to eliminate the influence of potential confounding variables, such as changes in the delivery of care or staffing.

One study evaluated the benefits of RRT using a randomized design.[22] In this study, 23 hospitals in Australia were randomly assigned to function with (n = 12) or without (n = 11) an RRT. During the study period, the rate of calls for the RRT or cardiac arrest team was significantly higher ($P < .0001$) than that in control hospitals. When an RRT was present, 80% of calls were not associated with a cardiac arrest or unexpected death compared with 50% in the control group. Compared to baseline, the incidence of cardiac arrest ($P = .003$) and unexpected deaths ($P = .010$) decreased in both groups. The authors concluded that institution of an RRT increased calls but did not affect the incidence of cardiac arrest, unplanned intensive care unit admissions, or unexpected death.

Although conceding their study failed to show a benefit, the authors noted that the power of the study was unexpectedly low due to a large variance in the baseline event rate. Consequently, more than 100 hospitals would have been required in each arm to detect a significant difference. They also noted that both groups of hospitals showed a statistically significant benefit compared with their own baseline, which may represent a Hawthorne effect. Another limitation was the study design, which used a relatively short observation interval (4 months). Most studies suggest that at least 6 months is required to achieve reasonable compliance with the new system of care. Despite these limitations, the potential of RRT to alter the outcome of adverse events is promising and worthy of additional inquiry.

Future Research

Failure to rescue as a nurse-sensitive outcome measurement has important implications for nurse executives. The posited relationship with nurse staffing provides an opportunity to serve as the base for further testing of staffing models. Studies that support benefits of registered nurse staffing and educational preparation on outcomes such as failure to rescue can be used to justify financial support that will enrich the number of baccalaureate-prepared nurses at the bedside.

Nurse executives with their physician colleagues across the country have joined the Institute for Healthcare Improvement campaign to save 100,000 lives. This initiative requires executives leading nursing practice to understand scientific rationale for interventions that support the work of the registered professional nurse at the bedside in improving patient outcomes. Notably, this literature review revealed a lack of studies examining factors that precede development of failure-to-rescue events.

The relationships between failure to rescue and critical thinking, the education of newly graduated nurses, specialty training, influence of control and autonomy in the professional work environment, and nurse/physician relationships are yet to be understood. It may be possible to implement workplace changes that reduce need for an RRT. Because nurse surveillance is limited by the need to care for multiple patients, it may be appropriate to test systems of care that permit health team members and the family to activate an RRT and automatic notification systems.

Conclusion

Failure to rescue as an outcome measure provides a base from which to move away from the broadly used and often criticized choice of mortality as a nurse sensitive outcome. The adoption of failure to rescue as a nurse sensitive outcome has promise, for further research to add to the body of knowledge of the contribution of professional nursing practice on patient outcomes.

Table 2. *Medical Emergency Team (MET) Intervention and Outcomes*

Author	Design	MET Team Composition	MET Team Criteria	Outcome Evaluation	Findings
Lee et al[15]	Description of utilization of MET and outcomes of patients requiring MET in Australia	Medical and nursing staffs skilled in resuscitation	Temperature <35.5 or >39.5; systolic blood pressure, <100 or >200; respirations <10 or >30; pulse rate <40 or >120; urine output <500/24 h; decreased or altered level of mental status	1. Reason and time of MET call 2. Physiological observation and treatment 3. Patient outcome 24 h post-MET and discharge	522 MET calls: 29% to medical surgical areas; 75% to medical patients; 13% to surgical patients; cardiac arrest for 148/522 calls (28%); physiological abnormality in 121/522 (23%); decrease level of consciousness most frequent physiological abnormality (n = 51; 42%); blood pressure 35/121 (29%). Resuscitation occurred in 371/522 (71%); mortality from cardiac arrest, 29%; mortality from other response, 76%.
Hourihan et al[16]	Prospective study of all MET calls over 6 months in a 460-bed teaching hospital in Australia	Unspecified—consisting of medical and nursing staff skilled in resuscitation	Respiratory arrest; respiratory rate <5 or >36; cardiac arrest; pulse rate <40 or >140; systolic blood pressure <90; sudden fall in LOC; fall in GCS >2 points; seriously worried about patient	1. Unplanned readmission to ICU 2. Mortality	294 MET calls. MET response for medical (71%) greater than surgery patients (21%). 70/294 (24%) cardiac arrest; 35/294 (12%) airway; 166/278 (60%) abnormal physiologic variables—decreased level of consciousness (70/294); hypotension (42/294)
Parr et al[17]	Retrospective analysis of MET calls for 12 months; 580-bed tertiary care hospital in Australia	ICU physician, medical physician, ICU nurse	Respiratory arrest; cardiac arrest; respiratory rate <5 or >36; pulse rate <40 or >140; systolic blood pressure <90; sudden fall in LOC; fall in GCS >2 points; seriously worried about patient	1. Reason for MET call 2. Immediate outcome 3. Impact on not-for-resuscitation orders	713 MET calls evaluated. Four most common reasons were decrease in GCS (n = 155), systolic blood pressure <90 (n = 142), respiratory rate >35 (n = 109), and worry (n = 83). Early identification of 252 patients who required ICU transfer
Buist et al[18]	Nonrandomized; retrospective review before and after introduction of MET; 300-bed tertiary hospital in Australia	2 MDs, 1 ICU nurse	Respiratory rate <6 or >30; Sa_{O_2} <90% on oxygen; difficulty speaking; systolic blood pressure <90 despite treatment; pulse rate >130; any unexplained decrease in consciousness; agitation or delirium; concerned	Incidence and outcome of unexpected cardiac arrest	Unexpected cardiac arrest calls decreased ($P < .001$). Mortality after intervention decreased ($P < .001$). Odds ratio after adjustment for risk of cardiac arrest, 0.50 (0.35-0.73)

			about patient; uncontrolled pain; failure to respond to treatment; unable to obtain prompt assistance		
Foraida et al[19]	Retrospective review of utilization of MET at 567-licensed bed tertiary care facility. Comparison of outcomes before and after increase of MET team use between January and June 2000	ICU physician, 2 ICU nurses, respiratory therapist	Respiratory rate <8 or >36; new onset difficulty breathing; new onset of Sao_2 of <85% for 5 min; heart rate <40 or >140; blood pressure systolic <80 or >200, diastolic >110 with symptoms; acute neurological change (acute loss of consciousness, new onset lethargy or difficulty waking, sudden collapse, seizure, sudden loss of extremity movement); other (multiple stat pages); patient c/o of chest pain, color change, unexplained agitation for >10 min, suicide attempt, uncontrollable bleeding, bleeding into airway, administration of naloxone	1. Incidence of crisis events 2. Incidence of cardiac arrest events 3. Crisis with fatal outcomes	After creation and dissemination of objective criteria, significant change in number of condition events and sequential stat pages. Number of condition events increased by 19.2% ($P < .0001$), and sequential stat pages decreased by 5.7% ($P < .0001$). Significant inverse correlation (−0.52) between number of condition events and sequential stat pages. Incidence of fatal cardiac arrest decreased from 4.3 to 2.2/1,000 admissions ($P < .0001$). Overall incidence of cardiac arrest declined from 6.0 to 5.2/1,000 admissions (did not reach statistical significance).
DeVita et al[20]	Retrospective review of incidence of cardiac arrest before and after initiation of objective MET criteria. Tertiary 622-licensed bed facility	ICU physician, 2 ICU nurses, respiratory therapist	Respiratory rate <8 or >36; new onset difficulty breathing; new onset of Sao_2 of <85% for 5 min; heart rate <40 or >140; blood pressure systolic <80 or >200, diastolic >110 with symptoms; acute neurological change (acute loss of consciousness, new onset lethargy or difficulty waking, sudden collapse, seizure, sudden loss of extremity movement); other (multiple stat pages); patient c/o of chest pain, color change, unexplained agitation for >10 min, suicide attempt, uncontrollable bleeding, bleeding into airway, administration of naloxone	Cardiac arrest event	MET usage significantly increased ($P < .001$). Incidence of cardiac arrest events decreased by 17% (from 6.5/1,000 admission to 5.4/1,000 admission; $P = .016$). No change in mortality of cardiac arrest events (33% of the patients with cardiac arrest event died)

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Table 2. Continued

Bellomo et al[21]	Prospective controlled before and after intervention enrolling consecutive patients admitted to hospital for major surgery; 2 hospital systems in Australia	Cardiology fellow, ICU fellow, coronary care nurse, receiving unit fellow	Acute change in: Heart rate <40 or >130; systolic blood pressure <90; respiratory rate <8 or >30; pulse ox saturation to <90 despite O_2; conscious state; urine output 50 mL/4 h; worried about patient	1. Percent of patients affected by adverse outcomes (respiratory failure, stroke, sepsis, ICU readmission) 2. Incidence of in-hospital deaths 3. Incidence of individual adverse outcomes 4. Mean duration of hospital stay	Decreased adverse outcomes in intervention period ($P < .0001$). Decrease in respiratory failure ($P < .0001$), stroke ($P = .0026$), sepsis ($P = .0044$). Emergent ICU admissions reduced ($P = .001$). Decrease in postoperative deaths ($P = .0178$); decrease in mean hospital stay from 23.8 to 19.8 ($P = .0092$)
Hillman et al[22]	23 hospitals randomized to control (n = 11) or intervention (n = 12). In Australia, United Kingdom, and New Zealand, during a 6-month period	At least 1 RN and 1 MD from ICU or ED	Respiratory arrest; cardiac arrest; respiratory rate <5 or >36; pulse rate <40 or > 140; systolic blood pressure <90; sudden fall in LOC; fall in GCS >2 points; seriously worried about patient	1. Rate of cardiac arrests without preexisting do-not-resuscitate order 2. Rate of unplanned ICU admissions 3. Rate of unexpected deaths	Rate of calls for cardiac arrest team or MET higher in intervention hospitals ($P < .0001$). Also, calls not associated with cardiac arrest or unexpected death higher in MET hospitals ($P = <.0001$). No significant differences between MET and control hospitals for any outcome

ICU indicates intensive care unit; MD, medical doctor; RN, registered nurse; ED, emergency department; LOC, level of conciousness; GCS, Glascow coma scale.

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