ORIGINAL RESEARCH

Four Years' Experience With a Hospitalist-Led Medical Emergency Team: An Interrupted Time Series

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BACKGROUND: The effect of Medical Emergency Teams (METs) on cardiopulmonary arrests (codes) and fatal codes remains unclear and widely debated.

OBJECTIVE: To describe the implementation of a hospitalist-led MET and compare the number of code calls and code deaths before and after implementation.

DESIGN: Interrupted time series.

SETTING: Tertiary care academic medical center.

PATIENTS: All hospitalized patients.

INTERVENTION: Implementation of an MET, consisting of a critical care nurse, respiratory therapist, intravenous therapist, and the patient's physician.

MEASUREMENTS: Number of MET calls, code calls, cardiac arrests and other medical crises, and code deaths per 1000 admissions, stratified by location (inside vs outside critical care).

RESULTS: From implementation in March 2006 through December 2009, the MET logged 2717 calls, most commonly for respiratory distress (33%), cardiovascular instability (25%), and neurological abnormality (20%). Overall code calls declined significantly between pre-implementation and post-implementation of the MET from 7.30 (95% confidence interval [CI] 5.81, 9.16) to 4.21 (95% CI 3.42, 5.18) code calls per 1000 admissions. Outside of critical care, code calls declined from 4.70 (95% CI 3.92, 5.63) before the MET was implemented to 3.11 (95% CI 2.44, 3.97) afterwards, primarily due to a decrease in medical crises, which averaged 3.29 events per 1000 admissions (95% CI 2.70, 4.02) before implementation and decreased to 1.72 (95% CI 1.28, 2.31) afterwards. Code calls within critical care also declined. The rate of fatal codes was not affected.

CONCLUSIONS: A hospitalist-led MET decreased code call rates but did not affect mortality rates. *Journal of Hospital Medicine* 2012;7:98–103. © 2011 Society of Hospital Medicine

In-hospital cardiopulmonary arrests are often preceded by signs of clinical instability, such as changes in vital signs or mental status.[1] Nearly 85% of patients who suffer from cardiopulmonary arrests have documented observations of deterioration in the 8 hours before arrest.[2] A Medical Emergency Team (MET), sometimes known as Rapid Response Team (RRT), can rapidly assess and manage unstable patients, with the goal that early intervention will prevent adverse outcomes. In 2004, the Institute for Healthcare Improvement (IHI), as part of its 100,000 Lives Campaign, called for hospitals to implement rapid response systems as 1 of 6 strategies to reduce

deaths in hospital.[3] Since this recommendation, hundreds of hospitals in the United States have invested substantial financial and personnel resources to implement some form of a rapid response system, which is comprised of a varying array of healthcare providers who bring critical care expertise to the patient's bedside.[4,5]

Despite the intuitive appeal of the approach, and early observational data which suggested that METs could reduce both "codes" and unexpected in-hospital mortality,[2,6] the largest randomized controlled trial found that METs failed to reduce unplanned intensive care unit (ICU) admissions, cardiac arrests, or unexpected deaths.[7] More recently, in a prospective observational cohort study at 1 US hospital, Chan et al. found that a nurse-led RRT did not impact hospital-wide code rates or mortality.[4]

The study of rapid response systems is further complicated by a lack of standard definition, and the many types of hospitals in which they may be implemented. In 2006, a consensus conference suggested that MET be used to refer to teams led by physicians (usually intensivists), and RRT be used for teams led by nurses.[8] Many studies have been conducted at non-

US institutions, and follow-up periods have generally been 1 year or less. We report on almost 4 years of experience with a hospitalist-led MET implemented in a major US academic medical center, and examine the subsequent changes in code calls, cardiac arrests, deaths following cardiopulmonary resuscitation, and overall hospital mortality. Because the MET did not operate in the critical care units, and because cardiac arrest may occur without prior signs of deterioration, we hypothesized that implementation of the MET would correspond to a small drop in total code calls, no change in codes called inside of critical care units, no change in cardiac arrest outside of critical care, and a marked drop in other medical crises (mostly respiratory distress) outside critical care. We also hypothesized that there would be no change in the rate of fatal codes, because most deaths occur in patients who were found to be pulseless on arrival of the code team.

METHODS

Setting

Beginning in March 2006, Baystate Medical Center implemented an MET in accordance with the recommendations of the IHI. Baystate is a 670-bed tertiary care referral center in Springfield, Massachusetts, and a major teaching hospital for Tufts University. Throughout the study period, the hospital had full-time intensivists and >90% of medical patients were cared for by hospitalists with 24-hour coverage. As a result, a medical patient's attending physician or corresponding coverage was usually on site. In order to promote acceptance of the team as well as to maximize continuity of care, we constructed our MET to include a critical care nurse, a respiratory therapist, intravenous therapist, and the patient's physician (either attending or resident). Baystate staff members carry alpha-numeric pagers, so attendings could be alerted to the fact that the MET had been activated by means of a text page. In the event that the patient's physician could not respond, an ICU physician served as a backup team member. The MET was implemented initially in March of 2006 on 2 medical floors, and over a period of 3 months was gradually expanded to cover the entire hospital. For surgical patients, the MET was led by the attending surgeon or appropriate resident. Educational efforts, including meetings, e-mails, and posters, targeted nurses in particular, but anyone could summon the MET by calling the activation number posted on all ward telephones. Nurses were encouraged to activate the system for any of the following: heart rate (<40 and >130 beats per minute), systolic blood pressure (<90 mmHg), respiratory rate (<8 or >24 per minute), oxygen saturation (<90% despite supplemental oxygen), altered mental status, or simply "concern that something is wrong." The MET implementation oversight committee met biweekly and made adjustments to the team composition and protocols using rapid Plan Do Study Act (PDSA) cycles. A full description of the implementation process has been published elsewhere.[9]

In addition to the MET, Baystate has a separate "code" team which can be activated for cardiovascular arrests via a call to a designated phone extension, which activates a page to the code team members and an overhead announcement. Code team members include the ICU medical resident and intern, a critical care nurse, an anesthesiologist, a respiratory therapist, a staff nurse, and the house supervisor. In response to the overhead announcement, doctors, nurses and students in the vicinity often respond as well. Prior to implementation of the MET, a code blue was the only level of immediate response available.

Data and Outcomes

The nurse attending a "code blue" or "code" completes a report form which becomes part of the permanent medical record. A copy of the report is reviewed by the Division of Healthcare Quality and housed in the Critical Care administrative offices. For this study, we reviewed all "code" reports from January 2004 through December 2009. For each report, we extracted the following information: the date, location (inside or outside of a critical care unit), whether the patient had a pulse on arrival of the team, and whether the patient survived to discharge. All activations of the code system were included, regardless of the patient's code status (ie, even if the code was called in error) or the reason for the code call. Patients were then aggregated to calculate the rate of codes called per calendar quarter, as well as the rates of codes called in and out of critical care and the rates of two subsets of code calls, namely cardiac arrests and other medical crises (eg, respiratory arrest or seizures).

MET members were also required to collect data on the reason for the MET call, as well as the response time, time of day and unit, duration of the call, whether the physician was present, whether the patient was transferred to critical care, and whether the patient survived to discharge. In addition, we surveyed the nursing staff directly after the call, asking the following questions: 1) Did the team arrive promptly? 2) Were the critical care nurse and respiratory therapist efficient and respectful? 3) Did you feel the patient's needs were addressed appropriately? 4) Did you feel supported by the MET? and 5) Would you call the MET again?

Statistical Analysis

Quarterly event rates per 1000 admissions were calculated for each outcome. Event rates were compared using piecewise Poisson regression[10] with robust standard errors.[11] We excluded the 2 quarterly periods (2006 Q1 and Q2) during which the MET was implemented. A piecewise Poisson regression model
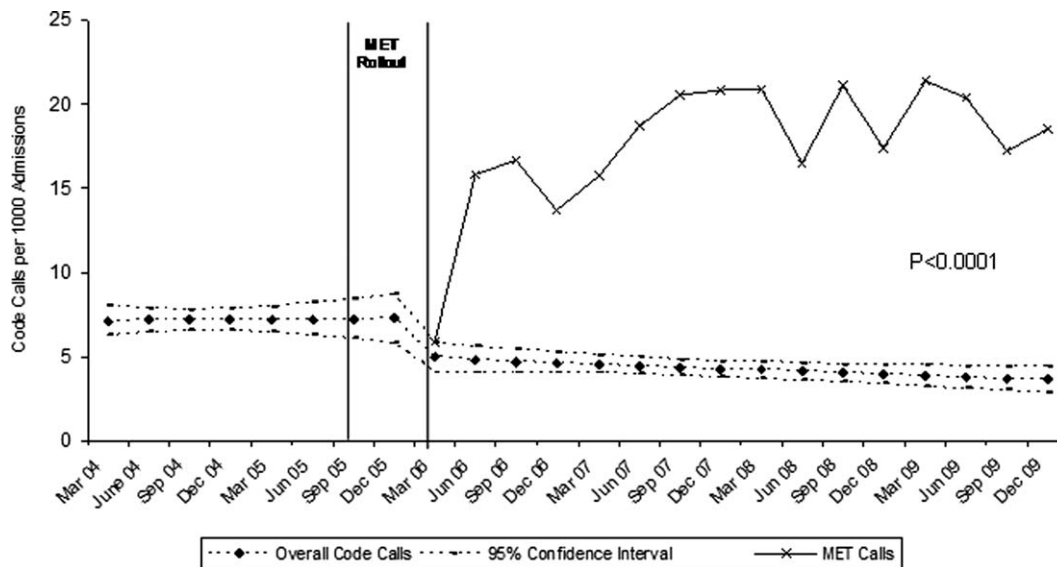
FIG. 1. Overall code and Medical Emergency Team (MET) calls. Confidence intervals are for individual data points.

was chosen to facilitate estimation of: 1) change in code calls from immediately before implementation to immediately after; and 2) temporal trends in code calls before and after implementation. Each model was built with 1 pre-implementation intercept (December 2005), and 1 post-implementation intercept (July 2006), as well as 2 slopes, with time coded negatively before the intervention (ie, −2, −1, 0), and positively after (ie, 0, 1, 2). Linear contrasts tested for differences in each parameter. A significant difference in intercepts suggests a post-intervention decrease in code call rates; a significant, negative post-intervention slope suggests continuing decline in code call rates. Statistical inferences were aided with visual plots of predicted incidence rates for each quarter in the observation period, with 95% confidence intervals (CI) for each quarterly rate estimated by the delta method.[12] Alpha was specified at ≤0.05 and all significance tests were 2-sided. Analyses were conducted in Stata 11.1 for Windows (© 2010, StataCorp LP, College Station, TX).

RESULTS

Implementation of the MET

The MET was introduced in the first and second quarters of 2006, with 2717 calls logged through the end of 2009 (out of 154,382 admissions). The rate of MET calls increased during the first 6 months of implementation from 5.95 per 1000 admissions in the first quarter of the intervention, to 15.8 calls per 1000 admissions in the second quarter. Call rates peaked in the first half of 2009, at 20.9 calls per 1000 admissions, leveling off to 17.9 calls per 1000 admissions in the last half of 2009 (Figure 1). Of calls with time recorded, 40% occurred on the day shift, 35% on the evening shift, and 25% on the night shift. The most common reason to call the MET was respiratory distress (33%), followed by cardiovascular instability

(25%), and neurological abnormality (20%). In 15% of cases, concern about a patient's condition prompted the nurse to call. Calls came primarily from medical floors (75%) and surgical units (20%). The median response time was 4 minutes (interquartile range [IQR], 2.8 to 5.2 minutes) with no meaningful trend during the study period. The median call duration was 50 minutes (IQR, 38 to 72 minutes). Again, there was no trend over time. The most common interventions were arterial blood gas, fluid resuscitation, and electrocardiogram (see Supporting Web Appendix Table 1 in the online version of this article). A physician was present at 52% of the calls in the first year, which rose to 93% of calls in the final year. Approximately 25% of calls resulted in the patient being transferred to a critical care unit. Staff evaluations were overwhelmingly positive. Nurses rated the teams on the following points: whether the critical care nurse and respiratory therapist were efficient and respectful (mean rating 98%, SD 5.6%); promptness (98%, SD 5.6%); whether the patient's needs were addressed appropriately (mean 98%, SD 4.2%); whether the nurse felt supported by the MET (99.5%, SD 1.7%); and whether they would call the MET again (99.7%, SD 1.4%).

Effect of MET on Code Calls and Mortality

Between January 2004 and December of 2009, the hospital case mix index remained constant, and there were a total of 1202 codes called. The majority (62%) took place outside of critical care units. Linear contrasts of pre-piecewise and post-piecewise intercepts revealed that overall code calls declined significantly between pre-implementation and post-implementation of the MET from 7.30 (95% CI 5.81, 9.16) codes called per 1000 admissions to 4.21 (95% CI 3.42, 5.18) calls per 1000 admissions (Figure 1; also see Supporting Web Appendix Table 2 in the online version of this article). Outside of critical care, code
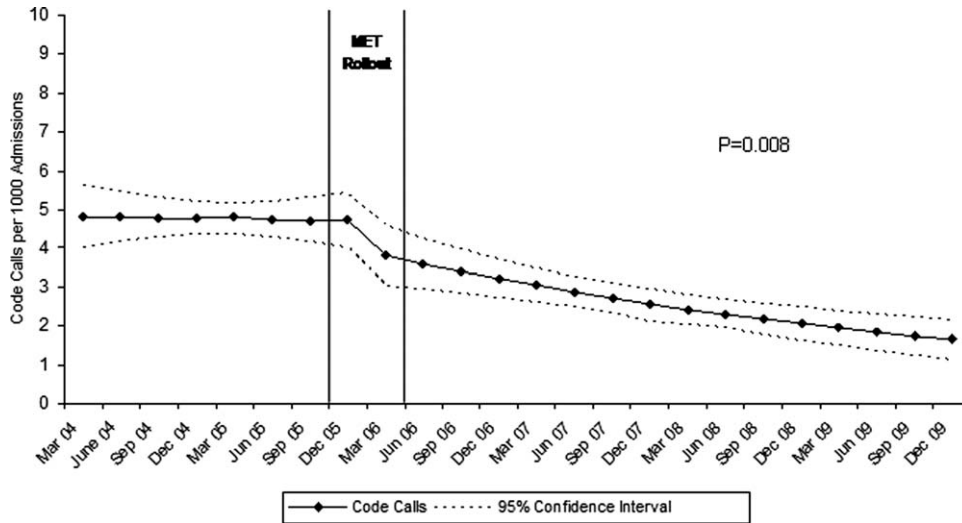
FIG. 2. Codes called outside of critical care. Confidence intervals are for individual data points. **Abbreviations:** MET, Medical Emergency Team.
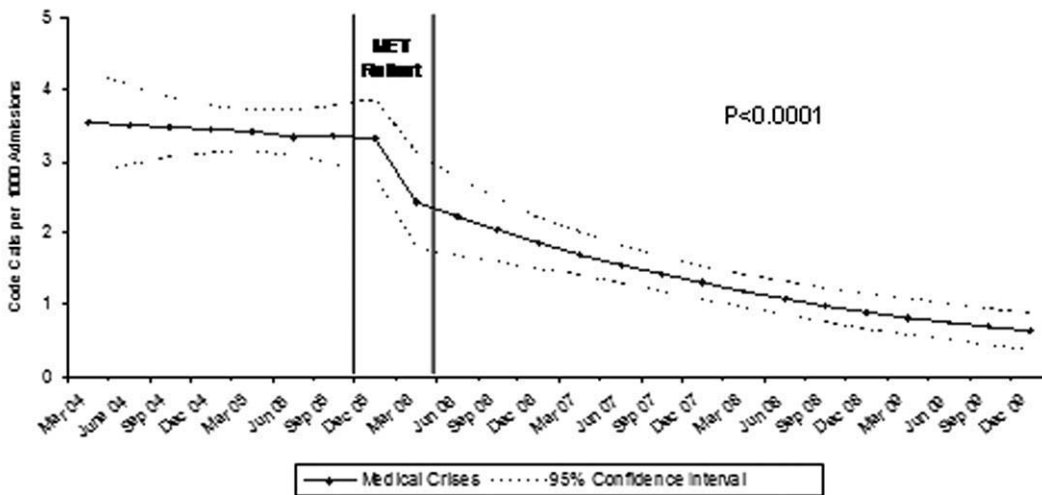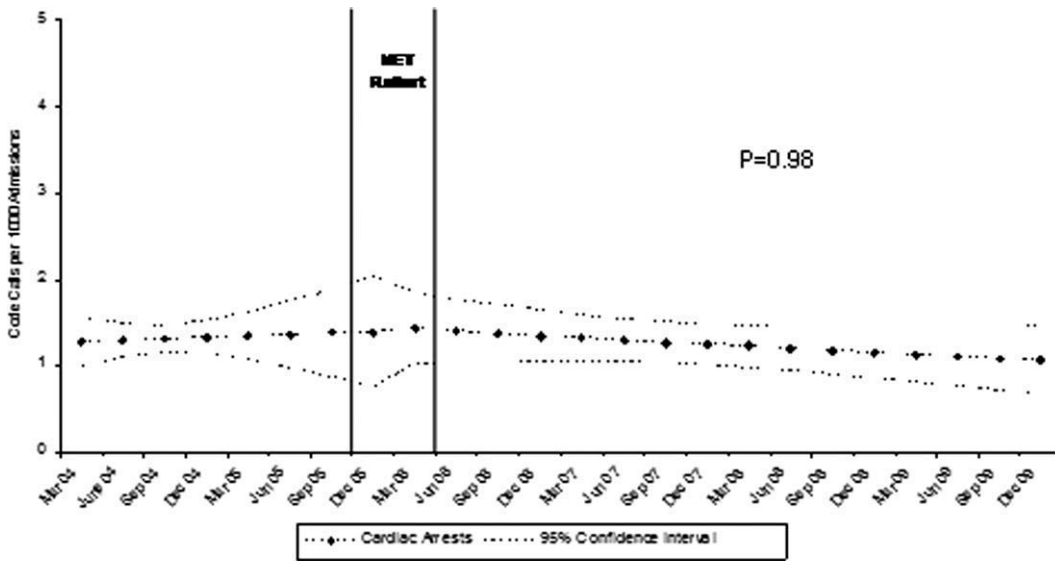

FIG. 3. Codes called outside of critical care, cardiac arrests (top) versus medical crises (bottom). Confidence intervals are for individual data points. **Abbreviations:** MET, Medical Emergency Team.

calls declined from 4.70 (95% CI 3.92, 5.63) before the MET was implemented to 3.11 (95% CI 2.44, 3.97) afterwards (Figure 2); this was due primarily to a decrease in medical crises, which averaged 3.29 events per 1000 admissions (95% CI 2.70, 4.02) before implementation and decreased to 1.72 (95%
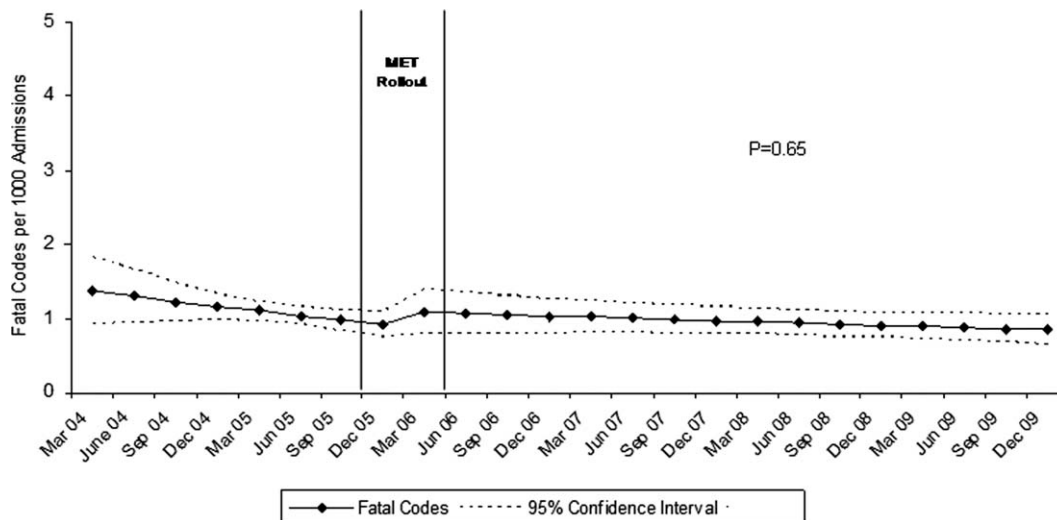
FIG. 4. Deaths among patients undergoing cardiopulmonary resuscitation. Confidence intervals are for individual data points. **Abbreviations:** MET, Medical Emergency Team.

CI 1.28, 2.31) afterwards, whereas cardiac arrests did not change significantly (Figure 3). Following implementation, code calls within critical care also declined significantly, from 2.59 events per 1000 admissions (95% CI 1.82, 3.69) before to 1.24 events per 1000 admissions (95% CI 0.94, 1.63) afterwards. The change in codes called within critical care was smaller, however, and included reductions in both cardiac arrests (Δ -0.84 events, $P = 0.01$) and medical crises (Δ -0.55, $P = 0.08$). There was no significant change in the rate of fatal codes per 1000 admissions (Δ $+0.06$, $P = 0.65$) (Figure 4). Overall hospital mortality remained steady at 22.0 deaths per 1000 admissions throughout the study period.

DISCUSSION

In this report, we detail the implementation of a novel hospitalist-led medical emergency team at a large academic medical center over a period of 4 years. The team, which consisted of the patient's physician, a critical care nurse, a respiratory therapist, and an intravenous therapist, achieved full implementation within 6 months, was well received by the nursing staff, and was associated with a 42% decrease in code calls hospital-wide. Most of the overall reduction was due to a reduction in codes called for medical crises outside of critical care, accompanied by a lesser reduction in codes called for cardiac arrests and medical crises within critical care units. There was no significant effect on the rate of cardiac arrest outside critical care. More importantly, there was no change in the rate of fatal codes or overall hospital mortality.

The idea of early intervention to prevent deterioration among hospitalized patients appeals to the concept that "an ounce of prevention is worth a pound of cure." Like many other preventive interventions, rapid response systems have not always delivered on this promise. Since several early reports from Australia[2]

suggested that medical emergency teams could reduce not only cardiopulmonary arrests, but overall hospital mortality, there has been a rapid proliferation in their implementation, spurred on by the IHI's 100,000 Lives Campaign, which incorporated rapid response systems as one of 6 hospital-wide interventions aimed at reducing harm and mortality.[13] Subsequent randomized trials have both reproduced and refuted the early observational results. A ward-randomized trial within 1 British hospital found a 50% reduction in hospital mortality for wards assigned to have an RRT,[14] while a cluster randomized trial conducted at 23 Australian hospitals found no difference in rates of cardiac arrest or mortality between hospitals implementing METs and those continuing with usual care.[7] Interestingly, in the Australian trial, the rates of cardiac arrest and mortality declined for both groups compared to historical controls, an important limitation to observational trials. Reports from single-institution observational trials are also divided between those that found a reduction in mortality following implementation and those that did not. A recent meta-analysis reported that there was too much heterogeneity among these trials to reach a conclusion about the benefits of rapid response systems.[15]

Our study adds to this literature in several ways. First, our MET design, which included the patient's physician (as opposed to an intensive care physician), was different from those previously studied. Including the patient's physician increases the team's knowledge of the patient and disease, and may improve physician acceptance of METs. In addition, our study provides 4 full years of follow-up. Second, our rate of MET activation (18 calls/1000 admissions) was 2 to 3 times higher than that seen in most other studies,[16] thus, the lack of mortality benefit was not likely the result of underuse. Third, our hospital employs a large number of hospitalists whose continuous presence might be

expected to attenuate the benefits of an MET. Indeed, our initial rate of codes (7.5/1000 admissions) was similar to the post-intervention rate in other studies.[4] Nevertheless, the decrease in the overall rate of code calls following implementation of our MET was similar to that observed by others.[17] Finally, our stratification of code calls inside critical care (where the MET was not deployed) and outside critical care, as well as the division of codes into cardiac arrest (where intervention is often unsuccessful) and other medical crises (primarily respiratory distress), gives further insight into how METs might work. As expected, we found that outside critical care only, codes called for medical crises declined, implying that the main effect of the MET was to provide early interventions for patients who were not likely to die anyway (eg, respiratory care for patients with respiratory distress or intravenous fluids for hypotensive patients). Instead of intervening to prevent death, MET may avoid emergent intubation by providing respiratory therapy and/or urgent intubation. In addition, it represents a less-intense option for responding to non–life-threatening emergencies, such as seizures or syncope. As codes were no longer called for these types of crises, the rate of code calls necessarily fell. The reason that code calls declined inside critical care is less clear. It could be that patients transferred to critical care by the MET were less likely to code than those transferred before implementation, or the decline might be due to other factors that were not evaluated. Regardless, it is clear that the MET did not simply relocate codes to critical care units.

Our study has a number of limitations. First, it is an observational study and cannot account for other confounders relating to temporal trends in the hospital. However, our long time window allowed us to examine trends over several years. For 2 years prior to implementation of the MET, there was no decline at all in the rate of code calls, followed by an immediate and sustained drop after implementation. Other interventions, including ventilator-associated pneumonia bundles, sepsis bundles, and advanced cardiac life support simulation training were also implemented at different times during the study period. However, the stark demarcation in code call rates coinciding with MET implementation makes it less likely that these other interventions were responsible for the observed decline. Second, our study was limited to a single institution and a single type of MET. Our findings may not apply to other types of institutions with different staffing arrangements or a different hospital culture, nor would they necessarily apply to different types of MET. Third, our nurse surveys were not collected anonymously, and this may have affected the nurses' responses. Finally, we did not collect physiological parameters on our patients, so we cannot state with certainty what the MET intervention accomplished.

Since initial studies suggested that METs could reduce hospital mortality rates, the Joint Commission has effectively mandated implementation of rapid response systems in all hospitals. Newer evidence, however, has been less convincing of mortality or other benefit. Our study adds to the literature in that we also did not find a mortality benefit. However, there were 2 clear benefits that we did identify. Our MET did appear to substantially reduce total numbers of code calls, particularly codes called for medical crises. Also, our nurses had a very positive response to the MET, which empowered them to get help for a patient when the patient's physician was unavailable or did not take their concerns seriously. Clearly, additional study is needed to better understand the effects of METs on mortality, codes, and other indicators of patient outcomes. However, in the current regulatory environment, such studies will be difficult to perform. Instead, additional studies can clarify which models deliver best outcomes and optimal use of our limited resources.

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