Photo courtesy of Col. Peter G. Napolitano, M.D., Madigan Army Medical Center.

"[Getting] the wounded to a facility with the appropriate capabilities for providing definitive care . . . often involves rapid and frequent transitions of care for critically injured patients, which requires high degrees of communication and coordination among team members within as well as between levels of care. As in civilian health care, effective teamwork is crucial for success."

—Deering et al. (p. 350)

Joint Commission Resources

Implementing and Evaluating Team Training

Features

Teamwork and Communication

Team Training

Operations Management

Table of Contents

The blog of *The Joint Commission Journal on Quality and Patient Safety* features news and comments:
http://www.jcrinc.com/Blogs-All-By-Category/Journal-Blog/

The Joint Commission Journal on Quality and Patient Safety

2011 Editorial Advisory Board

Teamwork and Communication

Team Training Can Enhance Patient Safety—the Data, the Challenge Ahead

Eduardo Salas, Ph.D.; Megan E. Gregory, B.S.; Heidi B. King, M.S.

Teamwork has become a recurrent theme in health care—rightfully so, since patients' lives depend on it. As health care delivery systems strive to be high-reliability organizations,[1] team training and other quality improvement interventions (for example, coaching, checklists) are fundamental to achieving a culture that is mindful of safety.[2]

Team training strategies are now being considered more and more in hospitals and learning institutions—a giant step forward. But, do they work? What are the team training evaluations telling us? Are the evaluations robust, credible? Does team training result in the behaviors, cognitions, and attitudes needed? Do they last? These are the questions that CEOs, chief financial officers, and deans, among others, are asking, and the good news is that some answers are emerging.

The Data

In this issue of *The Joint Commission Journal on Quality and Patient Safety,* three articles directly address the question of whether team training works. In each article, training took the form of the TeamSTEPPS® implementation system, which focuses on training health care professionals on team competencies such as leadership, situation monitoring, mutual support, and communication.[3] Deering et al. found, for example, that TeamSTEPPS® in U.S. military combat support hospitals significantly decreased rates of medication and transfusion errors, as well as needlestick injuries and exposures.[4] However, this study was a pre-post design, with no control group, making it difficult to fully attribute results to the training intervention.

Both of the remaining two articles—Riley et al.[5] and Mayer et al.[6]—used their own customized versions of the TeamSTEPPS program (as it was designed). Mayer et al. found that observations of team performance were significantly higher at 1 and 12 months postimplementation.[5] Observations at 6 months postimplementation, however, trended back toward baseline observations—and served as an impetus for reinforcement of the training principles. In addition, clinical outcome data showed significant improvements on two dimensions (nosocomial infec-

tions and time for placing patients on extracorporeal membrane oxygenation). Improvements were also seen through surveys and interviews. Riley et al., who conducted a small-cluster randomized clinical trial with three hospitals to evaluate the effects of TeamSTEPPS training on perinatal harm and a culture of safety, found that only the didactic and simulation group showed a significant decrease in perinatal morbidity at hospitals receiving the didactic training program. It also found that a series of simulation training exercises showed a significant decrease in perinatal morbidity.[6] The article provides the first evidence that adding simulation to a TeamSTEPPS intervention (albeit customized) improves outcomes.

These three team training evaluations are consistent with other recent evaluations[7,8] and, furthermore, support findings from a recent meta-analysis of team training conducted by Salas et al.[9] The meta-analysis indicated that, in general, across several domains, team training accounted for 20% of the variance in team performance, which was judged to be a decent effect size.

Moreover, we are seeing more evaluations in health care—a good sign.[10] We acknowledge, of course, that no evaluation is perfect. They all have their strengths and weaknesses. However, the (credible) evaluations give us a glimpse of what works and why. Also in this issue of the *Journal,* Weaver, Salas, and King describe 12 best practices to improve the implementation and evaluation of team training efforts in health care.[11] Following these practices may help health care providers to design and deliver effective team training strategies. For example, the best practices refer to including frontline staff in the training design phase (Best Practice 3), gaining support from socially powerful individuals, such as physician leaders (Best Practice 8), and giving feedback to and coaching trainees (Best Practice 11). The three team training articles in this issue of the *Journal* each followed some of the best practices. For example, Deering et al. followed Best Practice 3 by including the patient safety officer on their development team. Mayer et al. aligned with Best Practice 4—do not reinvent the wheel; leverage existing data relevant to training objectives—by using hospitalwide surveys, independent of the

training, as part of their evaluation. Riley et al. followed Best Practice 11 by conducting debriefings after training simulations—but, by failing to evaluate for the effects of turnover, fell short on Best Practice 9.

Although the three team training evaluations, like many others, suggest that team training "works," more—and better—evaluations are needed. These will be reported (we hope) as more team training—adjusted to the conditions and culture of the particular setting (for example, ICU or operating room)—is implemented. The concern remains that relevant and credible metrics for Kirkpatrick's four levels of training evaluation—not just Level 1 (trainee reactions) and Level 2 (trainee learning) but also Level 3 (behavior on the job) and Level 4 (results)[12]—need to be deployed. A related concern is that progress is made in developing reliable, valid, relevant, and quantifiable measures of teamwork in the field—knowledge, skills, and attitudes (often termed *KSAs*), such as team leadership, shared mental models, and backup behavior.[13] In addition, directly correlating team training to clinical outcomes remains challenging.

In summary, data from the three articles provide some encouragement that a well-designed, scientifically rooted team training intervention can positively affect clinical outcomes and patient safety. In general, we know that health care providers like the team training—they have positive reactions and attitudes to it. They learn the concepts. They exhibit behaviors, cognitions, and attitudes back on the job. And it has some impact on patient safety.[7,8] As noted in the previously cited meta-analysis, team training alone cannot do it. The organization must be ready and able to facilitate the infusion of teamwork. Therein lies the challenge.

The Challenge Ahead

If team training accounts for about 20% of the team performance variance, as stated,[9] then we also know that 80% must be addressed through other organizational interventions. Perhaps the key challenge now is organizational sustainment; that is, how can health care organizations sustain the desired effects of team training over time? The greatest contributor to the long-term success of team training (or for any human resource intervention) is what the organization does. The organizational system matters. What the top leadership does, matters. What policies and procedures are in place to support teamwork, matters. The formal and informal signs and symbols of what is important in the organization—as conveyed through the norms, conditions, policies, procedures, metrics in place, and the messages that top leadership sends—make or break transformational culture

change. One cannot forget that organizations tend to obtain the behaviors, cognitions, and attitudes that they measure and reinforce. We need to shift from thinking about a "team training intervention" to creating and sustaining an organizational system that supports teamwork. The best team training in the world will not yield the desired outcomes unless the organization is aligned to support it. The next frontier lies in making effective teamwork, as seen in high-performance teams, an essential element in high-reliability organizations.[2,14] **J**

Eduardo Salas, Ph.D., is Pegasus Professor and Trustee Chair and **Megan E. Gregory, B.S.,** is Research Assistant, Department of Psychology and Institute for Simulation & Training, University of Central Florida, Orlando, Florida. **Heidi B. King, M.S.,** is Deputy Director, U.S. Department of Defense (DoD) Patient Safety Program, and Director, Patient Safety Solutions Center, Office of the Assistant Secretary of Defense (Health Affairs) TRICARE Management Activity, Falls Church, Virginia. Please address correspondence to Eduardo Salas, esalas@ist.ucf.edu.

References

1. Chassin M.R., Loeb J.M.: The ongoing quality improvement journey: Next stop, high reliability. *Health Aff (Millwood)* 4:559–568, Apr. 2011.
2. Baker D.P., Day R., Salas E.: Teamwork as an essential component of high-reliability organizations. *Health Serv Res* 41(4 pt. 2):1576–1598, Aug. 2006.
3. Alonso A., et al.: Reducing medical error in the Military Health System: How can team training help? *Human Resource Management Review* 16:396–415, 2006.
4. Deering S., et al.: On the front lines of patient safety: Implementation and evaluation of team training in Iraq. *Jt Comm J Qual Patient Saf* 37:350–356, Aug. 2011.
5. Riley W., et al.: Didactic and simulation nontechnical skills team training to improve perinatal patient outcomes in a community hospital. *Jt Comm J Qual Patient Saf* 37:357–364, Aug. 2011.
6. Mayer C.M., et al.: Evaluating efforts to optimize TeamSTEPPS implementation in surgical and pediatric intensive care units. *Jt Comm J Qual Patient Saf* 37:365–374, Aug. 2011.
7. Weaver S.J., et al.: Does teamwork improve performance in the operating room? A multilevel evaluation. *Jt Comm J Qual Patient Saf* 36:133–142, Mar. 2010.
8. Neily J., et al.: Association between implementation of a medical team training program and surgical mortality. *JAMA* 304:1693–1700, Oct. 20, 2010.
9. Salas E., et al.: Does team training improve team performance? A meta-analysis. *Hum Factors* 50:903–933, Dec. 2008.
10. Weaver S.J., et al.: The anatomy of health care team training and the state of practice: A critical review. *Acad Med* 85:1746–1760, Nov. 2010.
11. Weaver S.J., Salas E., King H.B.: Twelve best practices for team training evaluation in health care. *Jt Comm J Qual Patient Saf* 37:341–349, Aug. 2011.
12. Kirkpatrick D.L.: *Evaluating Training Programs: The Four Levels.* San Francisco: Berrett-Koehler, 1994.
13. Baker D.P., et al.: The role of teamwork in the professional education of physicians: Current status and assessment recommendations. *Jt Comm J Qual Patient Saf* 31:185–202, Apr. 2005.
14. Wilson K.A., et al.: Promoting health care safety through training high reliability teams. *Quality Saf Health Care* 14:303–309, Aug. 2005.

Teamwork and Communication

Twelve Best Practices for Team Training Evaluation in Health Care

Sallie J. Weaver, M.S.; Eduardo Salas, Ph.D.; Heidi B. King, M.S.

I mproving communication, a critical component of effective teamwork among caregivers, is the only dimension of teamwork explicitly targeted in the current Joint Commission National Patient Safety Goals (Goal 2, Improve the effectiveness of communication among caregivers).[1] Yet dimensions of teamwork underlie nearly every other National Patient Safety Goal in some form. For example, improving the safe use of medications (Goal 3), reducing the risk of hospital infections (Goal 7), and accurately reconciling medication (Goal 8) all require much more than communication. To achieve these goals, providers across the continuum of care must engage in mutual performance monitoring and backup behaviors to maintain vigilant situational awareness. They must speak up with proper assertiveness if they notice inconsistencies or potentially undesirable interactions, and they must engage the patient and his or her family to do the same. They must share complementary mental models about how procedures will be accomplished, the roles and competencies of their teammates, and the environment in which they are functioning. There must be leadership to guide and align strategic processes both within and across teams in order for care to be streamlined, efficient, and effective. In addition, providers, administrators, and patients and their families must want to work with a collective orientation, recognizing that they are all ultimately playing for the same "team"—that of the patient.

Thanks to the expanding wealth of evidence dedicated to developing our understanding of the role teamwork plays in patient care quality[2–6] and provider well-being,[7] strategies to develop these skills, such as team training, have been integrated into the vocabulary of health care in the 21st century. Considerable effort and resources have been dedicated to developing and implementing team training programs across a broad spectrum of clinical arenas and expertise levels. For example, anesthesia Crew Resource Management[8–10] and TeamSTEPPS®[11,12] represent the culmination of more than 10 years of direct research and development built on nearly 30 years of science dedicated to the study of team performance and training.[13]

Article-at-a-Glance

Background: Evaluation and measurement are the building blocks of effective skill development, transfer of training, maintenance and sustainment of effective team performance, and continuous improvement. Evaluation efforts have varied in their methods, time frame, measures, and design. On the basis of the existing body of work, 12 best practice principles were extrapolated from the science of evaluation and measurement into the practice of team training evaluation. Team training evaluation refers to efforts dedicated to enumerating the impact of training (1) across multiple dimensions, (2) across multiple settings, and (3) over time. Evaluations of efforts to optimize teamwork are often afterthoughts in an industry that is grounded in evidence-based practice. The best practices regarding team training evaluation are provided as practical reminders and guidance for continuing to build a balanced and robust body of evidence regarding the impact of team training in health care.

The 12 Best Practices: The best practices are organized around three phases of training: planning, implementation, and follow-up. Rooted in the science of team training evaluation and performance measurement, they range from Best Practice 1: Before designing training, start backwards: think about traditional frameworks for evaluation in reverse to Best Practice 7: Consider organizational, team, or other factors that may help (or hinder) the effects of training and then to Best Practice 12: Report evaluation results in a meaningful way, both internally and externally.

Conclusions: Although the 12 best practices may be perceived as intuitive, they are intended to serve as reminders that the notion of evidence-based practice applies to quality improvement initiatives such as team training and team development as equally as it does to clinical intervention and improvement efforts.

Overall, evaluation studies in health care suggest that team training can have a positive impact on provider behavior and attitudes, the use of evidence-based clinical practices, patient outcomes, and organizational outcomes.[9,14–21] Such evaluations have begun to build the critical base of evidence necessary to answer questions regarding the overall effectiveness of team training in health care, as well as questions of intra-organizational validity (that is, would the strategy achieve similar, better, or worse outcomes in other units in the same organization?), and inter-organizational validity (that is, would similar, better, or worse outcomes be achieved using the strategy in other organizations?).

Evaluation and measurement are the building blocks of effective skill development, transfer of training, maintenance and sustainment of effective team performance, and continuous improvement.[22] Evaluation efforts have varied greatly in their methods, time frame, measures, and design.[23,24] The evidence-to-date surrounding team training evaluation underscores the need to approach the development and maintenance of expert team performance from a holistic systems perspective that explicitly addresses training development, implementation, and sustainment through the lens of continuous evaluation.[25] This in turn requires early consideration of the factors from the individual team member level to the organizational system level that will help (or hinder) the transfer, generalization, and sustainment of the targeted competencies addressed in training. Human factors models of error underscore that significant events are rarely the cause of a single individual acting alone.[26,27] This same systems perspective must be applied to evaluating the interventions dedicated to developing the knowledge, skills, and attitudes (KSAs) that are the hallmarks of effective teams.[28]

This article builds on the existing body of work dedicated to team training evaluation in health care by extrapolating principles from the science of evaluation and measurement into the practice of team training evaluation. Our goal is not to present a new methodology for evaluation but to distill principles from the science and temper them with the practical considerations faced on the front lines, where evaluation efforts compete with limited human, financial, and time resources. We provide guidance for expanding our definition of evidence-based practice to team-based training interventions that have been designed to support and maintain patient safety.

What is Team Training Evaluation?

At the simplest level, *team training evaluation* refers to assessment and measurement activities designed to provide information that answers the question, Does team training work?[29] The purpose of evaluation is to determine the impact of a given training experience on both learning and retention, as well as how well learners can (and actually do) generalize the KSAs developed in training to novel environments and situations over time.[28] Transfer of training is the critical mechanism through which training can affect patient, provider, and/or organizational outcomes.

The Science of Team Performance Measurement

There is a science of evaluation and measurement available to guide evaluation both in terms of *what* to evaluate and *how* to carry out evaluation efforts. Although a comprehensive review of team performance measurement is outside the scope of this article (*see,* for example, Salas, Rosen, and Weaver[30] and Jeffcott and Mackenzie[31]), we briefly summarize several of the critical theoretical considerations found to underlie effective measurement and evaluation to provide a background for the 12 best practices presented in this article. For example, conceptual models of team performance measurement differentiate between two broad dimensions: levels of analysis (individual task work versus teamwork) and type of measure (process versus outcome).[32]

In terms of levels of analysis, *task work* refers to the individual level technical requirements and processes of a given task that are usually specific to a given position, such as how to read and interpret an EKG (electrocardiogram) readout. *Teamwork* refers to the specific knowledge, behaviors, and attitudes—for example, communication, backup behavior, and cross-monitoring[33]—that individuals use to coordinate their efforts toward a shared goal. In terms of evaluation, measuring teamwork and task work can support instructional processes by allowing for a more fine-grained distinction regarding opportunities for improvement and can support a just culture of safety.[27,34] Within health care, recent studies of near misses and recovered errors also highlight the role that communication, backup behavior, and cross-checking—core components of teamwork—play in mitigating and managing unintentional technical errors.[35]

In terms of types of measures, *process* measures capture the specific behaviors, steps, and procedures that a team uses to complete a particular task. For example, evaluations of health care team training have examined behavioral measures of information sharing, information seeking, assertion, backup behavior, and other behavioral aspects of teamwork.[5,9,19,20] Such metrics capture the "human factor" involved in complex care systems.[34] Conversely, *outcome* measures capture the results of these behaviors, often in the form of an evaluative judgment regarding the

effectiveness or quality of a given outcome. Thus, outcome measures are additionally influenced by the context in which a team is performing. Whereas process measures are highly controllable by team members, outcomes are often the product of a constellation of factors, rendering them much less under the team's direct control.[36] In health care, patient outcomes or indicators of care quality are undoubtedly the gold standard for measurement in quality improvement (QI) evaluations. Although patient outcomes have been considered the ultimate criteria for evaluation of team training in health care, empirical evidence on the scale necessary to draw statistical conclusions regarding the impact of team training on patient outcomes is only beginning to emerge.[4,15,17,18] Although it is critical to measure such outcomes to ascertain the validity of team training effectiveness, they are deficient indicators for diagnosing team training needs or for providing developmental feedback to care team members. Thus, if the purpose of evaluation efforts is to support continuous improvement, it is important for outcome measures to be paired with process measures.

Within health care, the science of measurement and evaluation is also integrated into the disciplines of implementation science and improvement science. These disciplines underscore a need for the science of teamwork and training evaluation to take a systems view of teams and team training.

A Systems View of Team Training Evaluation

As understanding of complex systems has evolved, the definition of teams has also evolved, as reflected in the following definition:

> Complex and dynamic systems that affect, and are affected by, a host of individual, task, situational, environmental, and organizational factors that exist both internal and external to the team.[37(p.604)]

As such, the systems perspective advocates that training is but a single component in a broader constellation of organizational, task, and individual factors that affect team performance.[38] Therefore, to provide valid and reliable indicators of the effectiveness of team training, evaluation must also strive to account for factors that can moderate the effects of team training before, during, and after the actual training event(s). This notion of a systems-approach to evaluation is depicted in Figure 1 (right).

The Practice of Team Training Evaluation

A systems perspective on developing expert teams assumes that effective training does not exist without effective evaluation. The complexities of practice, however, can present hurdles to gather-

A Systems-Oriented Approach to Evaluation
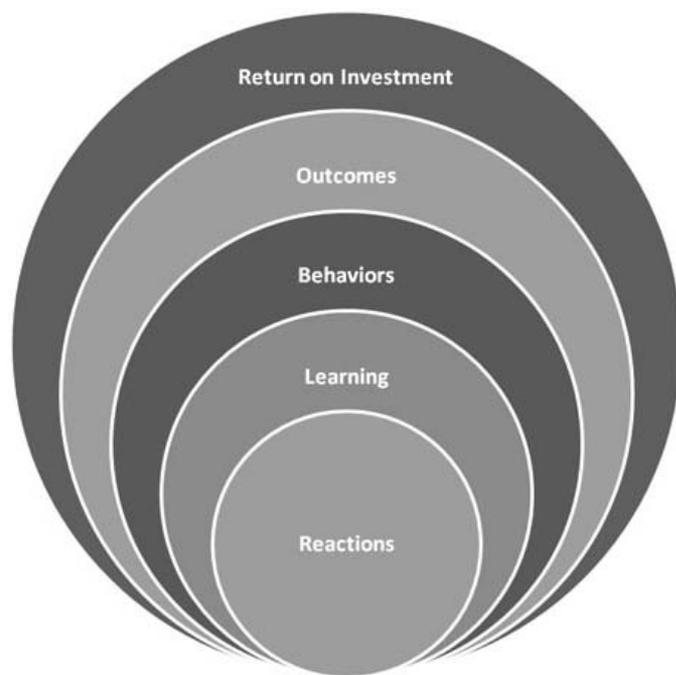
Figure 1. *Effective evaluation demands a systems-oriented approach, with evaluation objectives and specific training objectives aligned across multiple levels of analysis.*

ing the data, support, and buy-in necessary for effective evaluation. Table 1 (page 344) summarizes some of the pitfalls and warning signs related to team training evaluation, although there are undoubtedly many more.

In an attempt to provide some mechanisms for mitigating and managing these pitfalls, we present 12 best practices (Table 2, page 345), organized under the categories of *planning, implementation,* and *follow-up,* regarding the evaluation of team training in health care. Although we recognize that many other best practices could be added to this list, we have attempted to specifically target issues vital for consideration before, during, and after training that facilitate transfer and sustainment. Many of these best practices are generalizable across a multitude of training strategies and may be intuitive to experts in training and adult learning. However, we specifically offer the best practices as reminders oriented toward *team* training. The insights reflected in the best practices are built on the nearly 30 years of science dedicated to understanding the measurement and assessment of team performance and adult learning,[39,40] as well as the work during the last decade or so specifically dedicated to evaluating the impact of team training in health care.

Table 1. Some Team Training Evaluation Pitfalls and Warning Signs*	
Pitfalls	**Warning Signs**
Evaluation efforts do not account for or are not aligned with other events or QI initiatives.	The training program is well-received, but indicators of training outcomes are not meaningfully changing.
If surveys are used, protected time is not provided for training participants to complete evaluation measures.	Evaluation data collected from providers is coming back incomplete or has been rushed through.
Evaluation planning occurs after training has been designed and/or implemented.	Administrators, training team members, and providers assume evaluation requires a great amount of time and monetary resources to be useful.
Learning measures only measure declarative knowledge or attitudes toward teamwork.	Measures collected after training suggests that training content has been learned; however, behavior on the job remains the same.
Transfer of training is not supported beyond the initial learning experience—that is, beyond the classroom.	Evaluation data show an increase in performance immediately after training but decline relatively quickly back to baseline levels.
Evaluation results are not reported back to the front line in a meaningful way.	Providers express a sense that nothing is done with the evaluation data once collected—that they do not know the results of the evaluation they participated in or what actions were implemented as a result.

* QI, quality improvement.

PLANNING

To design a training program that meets the organizational definition of effectiveness means first defining what "effectiveness" means to you—in your organization and for your providers and patients. That means beginning to think about evaluation long before the first slide or simulation scenario is designed. Traditional models of training evaluation such as Kirkpatrick's[41] multilevel evaluation framework have been framed from a bottom-up perspective that begins with participant reactions and moves upward through the various levels of learning, behavior, and outcomes. However, clearly linking training objectives to desired outcomes requires a "reverse" approach that begins by first defining the desired outcomes and the *specific behaviors* that would enable these outcomes to occur. That means first operationally defining return on investment (ROI). Would a team training program be considered viable if patient falls decreased by 10%; if central lines were replaced every 48 hours reliably; or if providers began to reliably engage in discussions regarding near misses that were observably open, honest, and framed as learning experiences? In this sense, ROI must be approached from a perspective that extends traditional financial indicators to consider both human and patient safety capital. The defining aspect of the human capital perspective is the view of the people and teams who comprise the organization as the ultimate organizational asset. This underscores the principle that investing resources into their development can positively affect quality of care and organizational outcomes. Therefore, when considering team training evaluation, ROI should be conceptualized in a manner consistent with this perspective.

For evidence regarding the effectiveness of a training program to be meaningfully related to outcomes, it is also critical that all core stakeholders, from frontline providers to managers to patients, have ownership in both training design and evaluation. These stakeholders should be asked to complete the following sentence during the earliest stages of training development: "I would consider this training program a success if . . ." This process will help to not only map out specific evaluation metrics and processes for data collection but also to define and refine the ultimate objectives of the training program itself.

This also means "evaluating along the way" during the training design process; that is, applying the principles of measurement and assessment to the actual training development and planning process. For example, several critical questions should be addressed throughout planning and development, including: Are desired outcomes really a training problem? Is content mapped directly to training objectives? and Do training strategies and methods teach learners how to mimic behavior or actively apply new KSAs in novel situations?

Best Practice 1. Before Designing Training, Start Backwards: Think About Traditional Frameworks for Evaluation in Reverse. Imagine trying to describe an evaluation of a new, experimental drug to the U.S. Food and Drug Administration (FDA) on the basis of a small field study with no control group and none of the other hallmarks of basic experimental design. We would not dare to use anything less than the most robust experimental designs and scientific protocols when evaluating pharmaceutical or sur-

Table 2. 12 Best Practices for Team Training Evaluation*

Planning
■ **Best Practice 1.** Before designing training, start backwards: Think about traditional frameworks for evaluation in reverse.
■ **Best Practice 2.** Strive for robust, experimental design in your evaluation: It is worth the headache.
■ **Best Practice 3.** When designing evaluation plans and metrics, ask the experts—your frontline staff.
■ **Best Practice 4.** Do not reinvent the wheel; leverage existing data relevant to training objectives.
■ **Best Practice 5.** When developing measures, consider multiple aspects of performance.
■ **Best Practice 6.** When developing measures, design for variance.
■ **Best Practice 7.** Evaluation is affected by more than just training itself. Consider organizational, team, or other factors that may help (or hinder) the effects of training (and thus evaluation outcomes).

Implementation
■ **Best Practice 8.** Engage socially powerful players early. Physician, nursing, and executive engagement is crucial to evaluation success.
■ **Best Practice 9.** Ensure evaluation continuity: Have a plan for employee turnover at both the participant and evaluation administration team levels.
■ **Best Practice 10.** Environmental signals before, during, and after training must indicate that the trained KSAs and the evaluation itself are valued by the organization.

Follow-up
■ **Best Practice 11.** Get in the game, coach! Feed evaluation results back to frontline providers and facilitate continual improvement through constructive coaching.
■ **Best Practice 12.** Report evaluation results in a meaningful way, both internally and externally.

* KSAs, knowledge, skills, and attitudes.

gical treatments for patients. So why would we accept less when evaluating a training program that directly affects how providers and administrators interact with and care for patients?

Poor evaluation designs can either make it harder to detect the true effects of training on important outcomes or can skew evaluation results, suggesting that training had an impact on important outcomes, when in reality it did not. However, the most common issues associated with training evaluation in the field relate to small samples, inconsistencies, and poorly mapped outcomes——all of which make it more difficult to detect the true effect of training. Integrating as many elements of robust experimental design as possible (when tempered with practical constraints) strengthens the inferences that can be drawn from evaluation results. Although the evidence to date generally demonstrates that team training strategies are effective, such con-

clusions are muddled by extreme variation across studies, a lack of comparative approaches, uncontrolled sampling variation, and confounding, as pinpointed in reviews of team training[22,23] and simulation-based training.[42,43]

The need for robust evaluation efforts must be undoubtedly tempered with realistic constraints of both monetary and human resources. Thus, while calling for robust evaluation, our goal is to not oversimplify the "how" of implementing such efforts. For example, one of the most robust evaluations of team training in the surgical service line to date found that the reduction in risk-adjusted surgical mortality was nearly 50% greater in U.S. Department of Veterans Affairs (VA) facilities that participated in team training (18% reduction) compared to a nontrained control group (7% reduction, risk ratio [R.R.], 1.49, p = .01).[17] However, this study included a sample of more than 182,000 surgical procedures, 108 facilities (74 treatment, 34 control), and a comprehensive training program that included quarterly coaching support and checklists to support transfer of trained teamwork skills to the operational environment. As noted by Pronovost and Freischlang,[44] the study was possible only because of substantial investment by the VA system, both monetarily and in terms of leadership and the human resources to conduct training and analyze the data.

Undoubtedly, more studies of this caliber are needed. Given calls for quality and safety improvement at the federal level, there is support available for facilities to engage in robust evaluation efforts. For example, the Agency for Healthcare Research and Quality has funding programs for both research and demonstration projects dedicated to improving team functioning and interdisciplinary care. Similarly, many organizations and some private foundations offer mechanisms to support evaluation efforts. Partnering with local academic institutions can also provide a mechanism for finding manpower resources to collect, analyze, and report evaluation data. Nonetheless, although we encourage comprehensive approaches to evaluation, we are not so naïve as to believe or advocate that all efforts to optimize team performance can or should be the target of large-scale evaluation efforts. What we do argue is that all evaluation efforts—no matter their size or scope—can be and should be based in the tenants of good experimental inquiry. At a local level, QI leaders can invoke the Plan-Do-Study-Act (PDSA) Model for Improvement,[45] which, at its core, is a model of evaluation. It provides questions that consider both program implementation and evaluation simultaneously, as follows:

1. What are we trying to accomplish? For example, what behaviors, attitudes, knowledge, patient outcomes, or provider outcomes are we hoping to change?

2. How will we know that a change is an improvement? What indicators will tell us that team training is having the desired effect?

3. What change can we make that will result in an improvement? What training strategies, methods, and tools to support transfer will affect the indicators identified in Question 2?

4. How will we know that improvement is related to the implemented changes? Do the improvements we see occur after training is implemented? If we were to vary our training would we likely see variation in our outcomes? Do the processes or outcomes of trained providers differ from those of untrained providers? What factors outside of training could have caused the improvement or lack of improvement?

Training programs and evaluation efforts in any capacity in health care are an investment—in patient care quality and in the quality of the working environment for providers. Considering that resources are finite, organizational initiatives must be evaluated to make data-based decisions. Why expend these resources—on either the training itself and/or on the evaluation—unless the results of these efforts are a valid and reliable indication of true effects? To garner valid, defensible data regarding the impact of team training, we must strive to apply the principles of experimental design that underlie our most basic clinical studies, within the constraints inherent in the field context. As Berwick noted, "measurement helps to know whether innovations should be kept, changed, or rejected; to understand causes; and to clarify aims."[46(p. 312)] The cost of not having this information arguably outweighs the effort and cost invested to obtain good data on the effects of quality and process improvement efforts such as team training.

Best Practice 2. Strive for Robust, Experimental Design in Evaluation Efforts: It Is Worth the Headache. To create valid and reliable indicators of effectiveness, it is important to build evaluation procedures and measures based on the science of training evaluation; however, the procedures and measures must be integrated with relevant contextual expertise. Frontline staff know the intricacies of daily work on the floor, they know what will be used and what will not be used, when certain measures can or should be collected and when they should not, as well as what will motivate participation in the evaluation efforts and what will hinder it. So ask them and do it early in the training development phase. The evaluation design team should represent a mix of administrators at multiple levels—frontline providers of multiple levels (who work multiple shifts), and system-level (or external) individuals well versed in measurement and QI.

Best Practice 3. When Designing Evaluation Plans and Metrics, Ask the Experts—Your Frontline Staff. Robust training eval-

uation, however, does not mean starting from scratch. Hospitals and other health care environments are virtual data gold mines, considering the breadth and depth of metrics already calculated and reported for accreditation, external monitoring, and QI. If existing data points align directly with targeted training objectives, leverage them as indicators in the battery of relevant evaluation metrics. If a relevant measure has been tracked for a preceding period of time, retrospective analyses allows for longitudinal analyses that quantify the degree of change attributable to training.

Best Practice 4. Do Not Reinvent the Wheel; Leverage Existing Data Relevant to Training Objectives. Best Practice 3 must be tempered with the fact that perhaps the most extensive mistake in training evaluation relates to efforts that measure only those indicators for which the data are the easiest to collect and track. Team training is not a single-dose drug whose effect can be immediately identified through one or two patient outcome indicators. Although teamwork has been related to patient outcomes,[17] as stated, teamwork also affects patient safety through indirect pathways, such as creating the psychological safety that is necessary for providers to speak up when they notice an inconsistency. Evaluation protocols must be designed to assess the impact of training by using multiple indicators across multiple levels of analysis. For example, assessments of trainee reactions should capture satisfaction (for example, with trainer and materials/exercises), perceived utility, and perceived viability of both the strategies and methods used in training. Measures of learning should go beyond declarative knowledge to evaluate changes in knowledge structure (that is, mental models) and procedural knowledge. Measures of behavior should assess both analogue transfer (transferring learned KSAs into situations highly similar to those encountered in training) and adaptive transfer (degree to which KSAs are generalized to novel situations). This includes analyses of the barriers and challenges that providers encounter on the job which inhibit transfer of desirable skills. Finally, outcomes of training should be represented by indicators at the level of the patient (for example, safety, care quality, satisfaction), provider (satisfaction, turnover intentions), and organization (quality and safety, turnover, financial).

Best Practice 5. When Developing Measures, Consider Multiple Aspects of Performance. It has undoubtedly been difficult to quantify the relationship between teamwork, team training, and critical outcomes.[24] The base rate for outcomes such as adverse events is low. Many outcome measures collected as indicators in team training evaluation may show little to no variance, which limits the power of traditional statistical tests used to assess change. The very nature of statistical testing requires variance in

both predictors and outcomes. Therefore, evaluation metrics must be designed with variance in mind.

An innovative approach that helps in creating this much needed variance is the Adverse Outcome Index (AOI).[47,48] The index combines several key outcomes, assigns a weight to each outcome, and then combines them into scores (usually out of 1,000) to track performance over time. It simultaneously captures multiple, important outcomes and helps create the variance necessary for statistical testing.

Best Practice 6. When Developing Measures, Design for Variance. Because training does not occur in a vacuum, consider how learning climate, leadership and staff support, opportunities to practice, reinforcement, feedback systems, sustainment plans, and resources will affect the degree to which trained KSAs are actually used on the job. Consider how these factors are reflected in your evaluation measures. If such confounding factors are measured, they can be accounted for statistically, improving the power of your statistical tests and heightening the validity of conclusions.

Best Practice 7. Evaluation Is Affected by More Than Just Training Itself: Consider Organizational, Team, or Other Factors That May Help (or Hinder) the Effects of Training (and thus Evaluation Outcomes).

IMPLEMENTATION

A structured approach to training design built on early consideration of evaluation lays a foundation for successful training implementation. However, even the most well-planned team training programs using the most advanced training methods will fail if a systems-oriented approach is lacking during implementation. Organizational, leader, and peer support for training significantly affects trainee motivation, the degree to which training is transferred into daily practice, and participation in evaluation efforts. Socially powerful individuals—respected official and unofficial leaders viewed as positive role models—are vital mechanisms for creating trainee investment and ownership in both the training itself and related evaluation processes. Even if staff have and want to use targeted teamwork skills, they will hesitate to use these skills if their doing so is not supported by their immediate physician leaders and peers. Similarly, they will hesitate to participate in evaluation efforts if a climate of support and learning is not adopted. Staff must be able to trust that data collected for training evaluation efforts will be used for that purpose alone—not to judge them personally, judge their competence, or for reporting purposes. Training evaluation is about just that—training—not for evaluating individuals or teams.

Best Practice 8. Engage Socially Powerful Players Early;

Physician, Nursing, and Executive Engagement Is Crucial to Evaluation Success. Turnover can be high for frontline providers and members of the evaluation planning team, especially as administrative members get pulled onto other projects. This lack of continuity creates inherent problems for training evaluation efforts. It is important to consider contingency plans early that explicitly deal with turnover at both the trainee and planning team level. In the planning stages, it is vital to decide how new, untrained individuals' needs will be addressed and how refresher training for staff and physicians will play out. Furthermore, it is important to consider how turnover will be accounted for in statistical evaluation analyses. Although a traditional intent to treat approach can be used,[49] metrics such as team training load—an index of the proportion of trained team members[20,50]—can also be used to account for turnover of trained team members.

To preserve continuity at the evaluation planning team level, create an evaluation briefing book that details the purpose, aims, and value of the evaluation; the explicit data collection protocol; measures collected; and time line to bring new members up to speed. This also creates a historical record of final evaluation efforts, which can help in developing future briefings and publications, as well as offering a template for future training projects.

Best Practice 9. Ensure Evaluation Continuity: Have a Plan for Employee Turnover at Both the Participant and Evaluation Administration Team Levels. Given the ultimately precious resource of time, evaluation efforts, including filling out measures, observation, and providing feedback, can easily be seen as low priorities and hassles. This can lead to overly quick filling out of measures without much thought (or not completed at all), thus limiting the integrity of evaluation data. Measures filled out carelessly can be more detrimental to generalization and sustainment then conducting no training evaluation at all.

To optimize the integrity of the evaluation data collected, dedicated time and resources must be provided for participating in evaluation efforts. In addition, evaluation should be explicitly considered to be part of the training program itself. The systems approach means that participation in training is really only just beginning when trainees walk out of the training environment and into their daily practices. The experiential learning necessary for generalizing and sustaining trained KSAs in the actual care environment is arguably more influential on training success than what actually happens in the classroom or simulation laboratory.

Best Practice 10. Environmental Signals Before, During, and After Training Must Indicate That the Trained KSAs and the Evaluation Itself Are Valued by the Organization.

FOLLOW-UP

Spreading and sustaining QI initiatives (such as team training) have been identified as two of the greatest challenges faced by health care leadership.[51,52] The science of training and adult learning underscores the principle that team training is not simply a "place" where clinicians go or necessarily a single program or intervention.[13] Therefore, what happens after training in the actual practice environment is more important than what happens in the classroom. Developing and implementing a strategic sustainment plan is critical for both valid evaluation and spread.

Inherent in the definition of *evaluation* is the importance of using what was learned from evaluation data in a meaningful way.[24] Feeding data back to frontline providers and mapping actionable changes that results from evaluation findings can be importance catalysts for sustainment and maintenance of teamwork skills developed in training. In addition, coaching is one mechanism for implementing direct support for trainees as they attempt to generalize and sustain trained KSAs in their daily practice environment. Constructive on-the-floor coaching demonstrates supervisory and peer support for appropriate use of the trained KSAs and can also cue providers as to when/where it is appropriate to use trained KSAs in their actual daily work. Furthermore, simple recognition and reinforcement for using effective teamwork skills on the job can be a powerful motivator for integrating training concepts into daily practice.

Best Practice 11. Get in the Game, Coach! Feed Evaluation Results Back to Frontline Providers and Facilitate Continual Improvement Through Constructive Coaching. As evaluation data are collected, it is important to recognize that statistical significance may not capture practical significance; therefore, it is important to report the results of evaluation efforts in multiple ways that are practically meaningful in terms of the training objectives. This may mean including traditional statistical analysis of targeted indicators, a more qualitative approach, or a method that mixes both quantitative and qualitative analyses. For example, statistical results can be combined with explicit stories about the effects of training compiled directly from trainees.

Most importantly, evaluation efforts must be reported with thoroughness and rigor. This means adhering to the Standards for Quality Improvement Reporting Excellence guidelines for QI reporting.[53] These guidelines are also helpful to consider during early planning and development phases to ensure that critically important elements of evaluation design and analysis are addressed and planned for.

Best Practice 12. Report Evaluation Results in a Meaningful Way, Both Internally and Externally.

Conclusions

Although the 12 best practices may be perceived as intuitive to those working in quality development and improvement on a daily basis, they are intended to serve as reminders that the notion of evidence-based practice applies to QI initiatives such as team training and team development as equally as it does to clinical intervention and treatment. Robust evaluation designs and assessment metrics are the critical foundation for valid, effective QI efforts and are necessary components for continuing to build the body of evidence regarding what works (and what does not) to optimize patient safety within complex care delivery systems. **J**

Sallie J. Weaver, M.S., is Doctoral Candidate and **Eduardo Salas, Ph.D.,** is Pegasus Professor and Trustee Chair, Department of Psychology and Institute for Simulation & Training, University of Central Florida, Orlando, Florida. **Heidi B. King, M.S.,** is Deputy Director, U.S. Department of Defense (DoD) Patient Safety Program, and Director, Patient Safety Solutions Center, Office of the Assistant Secretary of Defense (Health Affairs) TRICARE Management Activity, Falls Church, Virginia. Please address correspondence to Sallie J. Weaver, sweaver@ist.ucf.edu.

References

1. The Joint Commission: *2011 Comprehensive Accreditation Manual for Hospitals: The Official Handbook.* Oak Brook, IL: Joint Commission Resources, 2010.
2. Klein K.J., et al.: Dynamic delegation: Shared, hierarchical, and deindividualized leadership in extreme action teams. *Administrative Science Quarterly* 51:590–621, Dec. 2006.
3. Manser T.: Teamwork and patient safety in dynamic domains of healthcare: A review of the literature. *Acta Anaesthesiol Scand* 53:143–151, Feb. 2009.
4. Sorbero M.E., et al.: *Outcome Measures for Effective Teamwork in Inpatient Care.* RAND technical report TR-462-AHRQ. Arlington, VA: RAND Corporation, 2008.
5. Thomas E.J., et al.: Teamwork and quality during neonatal care in the delivery room. *J Perinatol* 26:163–169, Mar. 2006.
6. Williams A.L., et al.: Teamwork behaviours and errors during neonatal resuscitation. *Qual Saf Health Care* 19:60–64, Feb. 2010.
7. Fassier T., Azoulay E.: Conflicts and communication gaps in the intensive care unit. *Curr Opin Crit Care* 16:654–665, Oct. 2010.
8. Gaba D.M.: Crisis resource management and teamwork training in anesthesia. *Br J Anaesth* 105:3–6, Jul. 2010.
9. Howard S.K., et al.: Anesthesia crisis resource management training: Teaching anesthesiologists to handle critical incidents. *Aviat Space Environ Med* 63:763–770, Sep. 1992.
10. Holzman R.S., et al.: Anesthesia crisis resource management: Real-life simulation training in operating room crises. *J Clin Anesth* 7:675–687, Dec. 1995.

11. U.S. Agency for Healthcare Research and Quality (AHRQ): *TeamSTEPPS® Guide to Action.* AHRQ publication no. 06-0020-4. Rockville, MD: AHRQ, Sep. 2006.

12. Morey J.C., et al.: Error reduction and performance improvement in the emergency department through formal teamwork training: Evaluation results of the MedTeams project. *Health Serv Res* 37:1553–1581, Dec. 2002.

13. Salas E., Cannon-Bowers J.A.: The science of training: A decade of progress. *Annu Rev Psychol* 52:471–499, Feb. 2001.

14. DeVita M.A., et al.: Improving medical emergency team (MET) performance using a novel curriculum and a computerized human patient simulator. *Qual Saf Health Care* 14:326–331, Oct. 2005.

15. Farley D.O., et al.: *Achieving Strong Teamwork Practices in Hospital Labor and Delivery Units.* RAND Technical Report 842-OSD. Santa Monica, CA: RAND Corporation, 2010.

16. Flin R., et al.: Teaching surgeons about non-technical skills. *Surgeon* 5:86–89, Apr. 2007.

17. Neily J., et al.: Association between implementation of medical team training and surgical mortality. *JAMA* 304:1693–1700, Oct. 20, 2010.

18. Pratt S.D., et al.: John M. Eisenberg Patient Safety and Quality Awards: Impact of CRM-based training on obstetric outcomes and clinicians' patient safety attitudes. *Jt Comm J Qual Patient Saf* 33:720–725, Dec. 2007.

19. Thomas E.J., et al.: Team training in the neonatal resuscitation program for interns: Teamwork and quality of resuscitations. *Pediatrics* 125:539–546, Mar. 2010.

20. Weaver S.J., et al.: Does teamwork improve performance in the operating room? A multilevel evaluation. *Jt Comm J Qual Patient Saf* 36:133–142, Mar. 2010.

21. Wolf F.A., Way L.W., Stewart L.: The efficacy of medical team training: Improved team performance and decreased operating room delays: A detailed analysis of 4,863 cases. *Ann Surg* 252:477–483, Sep. 2010.

22. Russ-Eft D., Preskill H.: *Evaluation in Organizations,* 2nd ed. Philadelphia: Basic Books, 2009.

23. Weaver S.J., et al.: The anatomy of health care team training and the state of practice: A critical review. *Acad Med* 85:1746–1760, Nov. 2010.

24. McCulloch P., Rathbone J., Catchpole K.: Interventions to improve teamwork and communications among healthcare staff. *Br J Surg* 98:469–479, Feb. 2011.

25. Nolan K., et al.: Using a framework for spread: The case of patient access in the Veterans Health Administration. *Jt Comm J Qual Patient Saf* 31:339–347, Jun. 2005.

26. Reason R.: Human error: Models and management. *West J Med* 172:393–396, Jun. 2000.

27. Woods D.D., et al.: *Behind Human Error,* 2nd ed. Burlington, VT: Ashgate, 2010.

28. Baldwin T.T., Ford J.K.: Transfer of training: A review and directions for future research. *Personnel Psychology* 41:63–105, Dec. 1988.

29. Goldstein I., Ford J.K.: *Training in Organizations,* 4th ed. Belmont, CA: Wadsworth, 2002.

30. Salas E., Rosen M.A., Weaver S.J.: Evaluating teamwork in healthcare: Best practices for team performance measurement. In McGaghie W.C. (ed.): *International Best Practices for Evaluation in the Health Professions.* Abingdon, UK: Radcliffe Publishing Ltd., forthcoming.

31. Jeffcott S.A, Mackenzie C.F.: Measuring team performance in healthcare: review of research and implications for patient safety. *J Crit Care* 23:188–196, Jun. 2008.

32. Cannon-Bowers J.A., Salas E.: A framework for developing team performance measures in training. In Brannick M.T., Salas E., Prince C. (eds.): *Team Performance Assessment and Measurement: Theory, Methods, and Applications.* Hillsdale, NJ: Erlbaum, 1997, pp. 56–62.

33. Salas E., et al.: The wisdom of collectives in organizations: An update of the teamwork competencies. In Salas E., Goodwin G.F., Burke C.S. (eds.): *Team Effectiveness in Complex Organizations.* New York City: Routledge, 2009, pp. 39–79.

34. Smith-Jentsch K.A., Johnston J., Payne S.C.: Measuring team-related expertise in complex environments. In Cannon-Bowers J.A., Salas E. (eds.): *Making Decisions Under Stress: Implications for Individual and Team Training.* Washington, DC: American Psychological Association, 1998, pp. 61–87.

35. Dykes P.C., Rothschild J.M., Hurley A.C.: Medical errors recovered by critical care nurses. *J Nurs Adm* 40:241–246, May 2010.

36. Wright N., et al.: Maximizing Controllability in Performance Measures. Poster presented at the 25th Annual Conference of the Society for Industrial and Organizational Psychology, Atlanta, Apr. 8–10, 2010.

37. Cannon-Bowers J.A., Bowers C.: Team development and functioning. In Zedeck S. (ed.): *APA Handbook of Industrial and Organizational Psychology. Vol 1: Building and Developing the Organization.* Washington, DC: American Psychological Association, 2010, pp. 597–650.

38. Salas E., et al.: Team training for patient safety. In Carayon P. (ed.): *Handbook of Human Factors and Ergonomics in Healthcare and Patient Safety.* New York City: Francis & Taylor, 2006, forthcoming.

39. Ilgen D.R., et al.: Teams in organizations: From input-process-output models to IMOI models. *Annu Rev Psychol* 56:517–543, Feb. 2005.

40. Aguinis H., Kraiger K.: Benefits of training and development for individuals and teams, organizations, and society. *Annu Rev Psychol* 60:451–474, Jan. 2009.

41. Kirkpatrick D.L.: *Evaluating Training Programs: The Four Levels.* San Francisco: Berrett-Koehler, 2004.

42. Cook D.A.: One drop at a time: Research to advance the science of simulation. *Simul Healthc* 5:1–4, Feb. 2010.

43. Gaba D.: The pharmaceutical analogy for simulation: A policy perspective. *Simul Healthc* 5:5–7, Feb. 2010.

44. Pronovost P.J., Freischlag J.A.: Improving teamwork to reduce surgical mortality. *JAMA* 304:1721–1722, Oct. 20, 2010.

45. Langley G.J., Nolan K.M., Nolan T.W.: *The Foundation of Improvement.* Silver Spring, MD: API Publishing, 1992.

46. Berwick D.M.: A primer on leading the improvement of systems. *BMJ* 312(7031):619–622, Mar. 9, 1996.

47. Nielsen P.E., et al.: Effects of teamwork training on adverse outcomes and process of care in labor and delivery: A randomized controlled trial. *Obstet Gynecol* 109:48–55, Jan. 2007.

48. Pratt S.D., et al.: John M. Eisenberg Patient Safety and Quality Awards: Impact of CRM-based training on obstetric outcomes and clinicians' patient safety attitudes. *Jt Comm J Qual Patient Saf* 33:720–725, Dec. 2007.

49. Hillman K., et al.: Introduction of the medical emergency team (MET) system: A cluster-randomized controlled trial. *Lancet* 365(9477):2091–2097, Jun. 18–24, 2005. Erratum in *Lancet* 366(9492):1164, Oct. 1, 2005.

50. Morgan B.B. Jr., et al.: The team-training load as a parameter of effectiveness for collective training in units (Lab Report No.: A561360). Norfolk, VA: Old Dominion University Performance Assessment. Sponsored by the Department of Defense, 1978.

51. Schall M., Nolan K. (eds.): *Spreading Improvement Across Your Health Care Organization.* Oak Brook, IL: Joint Commission Resources, 2008.

52. Berwick D.M.: The science of improvement. *JAMA* 299:1182–1184, Mar. 12, 2008.

53. SQUIRE: Standards for Quality Improvement Reporting Excellence: *SQUIRE Guidelines.* http://www.squire-statement.org/ (accessed Jun. 20, 2011).

Teamwork and Communication

On the Front Lines of Patient Safety: Implementation and Evaluation of Team Training in Iraq

Shad Deering, M.D.; Michael A. Rosen, Ph.D.; Vivian Ludi, R.N.; Michelle Munroe, C.N.M.; Amber Pocrnich, R.N.C.; Christine Laky, M.D.; Peter G. Napolitano, M.D.

Changes to the processes of delivering care to wounded soldiers in the modern military health care system have drastically improved patient outcomes in the wars in Iraq and Afghanistan when compared to other major conflicts.[1] A fundamental change contributing to this improvement has been a focus on moving patients quickly through levels (or echelons) of care to get the wounded to a facility with the appropriate capabilities for definitive care. This often involves rapid and frequent transitions of care for critically injured patients and consequently requires high degrees of communication and coordination among team members within as well as between levels of care. As in civilian health care, effective teamwork is crucial for success.

In the decade since the Institute of Medicine's (IOM) groundbreaking report *To Err Is Human,*[2] a wide variety of teamwork-based interventions have been implemented.[3] This article documents the implementation of the TeamSTEPPS® program throughout medical facilities in Iraq between November 2007 and December 2008—one of the most intense phases of the conflict. It also reports on the intervention's impact on the rate of different types of patient safety events at the initial location of implementation—a combat support hospital (CSH) in Baghdad.

TeamSTEPPS, the Military Healthcare System, and the TeamSTEPPS Implementation

In the following sections, background information on the TeamSTEPPS program, the organization of the deployed Military Healthcare System (MHS), and the TeamSTEPPS implementation initiative in Iraq is provided.

TEAMSTEPPS

The TeamSTEPPS program is an evidence-based teamwork system aimed at optimizing patient outcomes by improving communication and other teamwork skills among health care professionals.[4] An intervention designed to develop a culture of safety through training teamwork skills, TeamSTEPPS was developed by the U.S. Department of Defense Patient Safety Pro-

Article-at-a-Glance

Background: Team training has been identified as a key strategy for reducing medical errors and building a culture of safety in health care. Communication and coordination skills can serve as barriers to potential errors, as in the modern deployed U.S. Military Healthcare System (MHS), which emphasizes rapid movement of critically injured patients to facilities capable of providing definitive care. A team training intervention—TeamSTEPPS®—was implemented on a large scale during one of the most intense phases of the conflict in Iraq. This evaluation of the program constituted the first undertaken in a combat theater of operations.

Implementing TeamSTEPPS in Iraq: The Baghdad combat support hospital (CSH) conducted continuous operations from a fixed facility for a 13-month deployment—between November 2007 and December 2008. The TeamSTEPPS implementation in Iraq began at this facility and spread throughout the combat theater of operations. Teamwork training was implemented in two primary training sessions, followed up with reinforcement of team behaviors on the unit by hospital leadership.

Results: A total of 153 patient safety reports were submitted during the 13 months reviewed, 94 before TeamSTEPPS implementation and 59 afterwards. After training, there were significant decreases in the rates of communication-related errors, medication and transfusion errors, and needlestick incidents. There was a significant decrease in the rate of incidents coded communication as the primary teamwork skill that could have potentially prevented the event.

Conclusions: Process improvement programs such as TeamSTEPPS implementation can be conducted under the extremely austere conditions of a CSH in a combat zone. Teamwork training decreased medical errors in the CSH while deployed in the combat theater in Iraq.

Table 1. Overview of Echelons of Care and the Units included in the TeamSTEPPS Implementation	
Level of Care	**General Description**
Level I: Battalion Aide Stations (BASs)	Battalion aide stations are embedded within the troops and serve as the first line of care for wounded soldiers. BASs consist of the unit medics and usually a general medical officer.
Level II: Forward Surgical Teams (FSTs)	FSTs are small, 20-member teams consisting of 3 general surgeons, 1 orthopedic surgeon, 2 nurse anesthetists, 3 nurses, medics, and other support staff. FSTs are designed to be rapidly deployable (setup time of 1 hour) and to move close to the front lines. The goal of the FST is to stabilize and evacuate patients to higher levels of care.
Level III: Combat Support Hospitals (CSHs)	CSHs are 200-plus-bed hospitals with operating rooms and radiology and laboratory services. The goal is to have patient stays no longer than 3 days before the patient is either released or transferred to the next level of care if further treatment is needed.
Level IV: Definitive Care*	Level IV facilities, located outside the theater of operations, are where definitive treatment is provided for patients needing more than 30 days of care.

* Not a part of this TeamSTEPPS implementation.

gram, in collaboration with the Agency for Healthcare Research and Quality. Although local applications of this program have been evaluated in the United States,[5,6] its potential to affect patient safety has not previously been investigated in a combat theater of operations.

THE MILITARY HEALTHCARE SYSTEM IN A COMBAT THEATER OF OPERATIONS

In the Iraq theater of operations during 2007–2009 there were four echelons (or levels) of care, as summarized in Table 1 (above). This organization and process is intended to move wounded soldiers as quickly as possible to facilities that have the capabilities to provide definitive care.

When the Baghdad CSH began the TeamSTEPPS implementation, there were three CSHs in the combat theater. Each CSH is a flexible collection of people, equipment, and other resources that can be divided into multiple task force (TF) sites as the needs demand and conditions permit in the combat theater. These TF sites were the workhorses of surgical support in combat zones, with wounded flowing to them directly from the point of injury on the battlefield. This often resulted in rapid escalation of patient census, followed by rapid de-escalation within a matter of hours. Each CSH typically had around 500 individuals assigned before being split into separate TF sites that would function at different locations. Local Iraqi patients who were admitted to the CSH were discharged or transferred to civilian Iraqi care, which was very limited, within 1 to 30 days when stable. U.S. soldiers were transferred to Level IV echelon care within 6 to 48 hours unless delayed by operational or environmental conditions.

IMPLEMENTING TEAMSTEPPS IN IRAQ

The Baghdad CSH conducted continuous operations from a fixed facility for a 13-month deployment—between November 2007 and December 2008. The TeamSTEPPS implementation in Iraq began at this facility and spread throughout the combat theater of operations. We now describe the implementation, which began at the Baghdad CSH and proceeded to other locations within the combat theater of operations.

Implementation at the Baghdad CSH. The patient safety officer [V.L.], along with several TeamSTEPPS Master Trainers* assigned to the Baghdad CSH developed a two-phase approach to implementing TeamSTEPPS. The basic content of the training was not altered from what is delivered in civilian facilities, but examples where used from the CSH context. In the first phase, as many staff as possible were exposed to the Team-STEPPS concepts and tools. The second phase focused on providing more comprehensive training as scheduling allowed.

The first phase of implementation began with two Team-STEPPS fundamentals courses attended by one to three individuals from every unit and section of the hospital for a total of 50 people. This initial cadre of trained staff served as leaders in their sections and were each responsible for implementing one Team-STEPPS concept in their area twice a week. Staff members were trained on these tools in several ways, including morning reports, posting on a community whiteboard, daily announcements by the deputy in charge of physicians, a shared intranet-based calendar, and direct e-mails to all CSH staff.

In addition, the TeamSTEPPS modules were accessible to all staff via the intranet. Although simulation is the preferred method of delivery for team training, the needed resources were not available. However, delivering the teamwork content to individuals through Web-based methods does not differ signifi-

---

* The TeamSTEPPS Master Trainer course includes content on both teamwork and implementation and improvement.

cantly from typical delivery of TeamSTEPPS through didactic methods, which have proven effective.[6] Section leaders also trained, modeled, and coached these behaviors in their area of the hospital. All staff—including patient administrators, laboratory personnel, for example, and not just the providers—received TeamSTEPPS training.

In the second phase of implementation, a four-hour TeamSTEPPS fundamentals course was given one to three times a week. In a three-month period, all 330 individuals (providers and general staff) at the Baghdad component of the CSH, including the Iraqi translators, received the fundamentals course. Typical deployment length for the CSH was 12–15 months. There was some turnover of physicians and nurses, depending on their specialty—for example, surgeons typically deployed for 6 months, emergency department physicians for 12 months—but in general, turnover was minimal.

Expansion Throughout the Combat Theater of Operations. The TeamSTEPPS implementation efforts at the Baghdad CSH were recognized early by leadership at the medical brigade level (the command for all medical services in the combat theater of operations), and a plan for spreading this initiative to all medical facilities in Iraq (Levels I through III) was requested soon after the implementation began. TeamSTEPPS was viewed as a potential solution to problems that led to a sentinel event* that the CSH experienced before implementation, and early successes and "good catches" helped to solidify support for the broader implementation.

The implementation strategy included two general methods:

1. Level I and Level II facilities used Web-based training; these were small units, and travel within a combat zone was difficult and dangerous.

2. Level III facilities sent a champion or change team, which typically consisted of a physician, a nurse, and a non-commissioned officer, to the CSH in Baghdad for a 2.5-day session covering TeamSTEPPS fundamentals, trainer, and culture change training. These teams then returned to their facilities and repeated the two-phase implementation method, as described previously. In some instances, instructors from the Baghdad CSH traveled to other CSH sites to assist the change team with training sessions. In total, more than 3,000 personnel were trained in TeamSTEPPS concepts across the three levels of care in Iraq.

---

* A sentinel event is an unexpected occurrence involving death or serious physical or psychological injury, or the risk thereof. Serious injury specifically includes loss of limb or function. The phrase "or the risk thereof" includes any process variation for which a recurrence would carry a significant chance of a serious adverse outcome. The Joint Commission: *Sentinel Event Policy and Procedures.* http://www.jointcommission.org/Sentinel_Event_Policy_and_Procedures/ (accessed Jun. 17, 2011).

Methods

PRE- AND POSTIMPLEMENTATION PERIODS

For the purposes of evaluation, the 13-month deployment period for the CSH in Baghdad was divided into a 7-month preimplementation period and a 6-month postimplementation period (after TeamSTEPPS training was implemented and the majority of providers/staff were trained).

DATA COLLECTION: PATIENT SAFETY INCIDENT REPORTS

During the period of this process improvement project, patient safety/incident reports were filled out for any unusual occurrence or near miss/good catch. Examples of such events included but were not limited to missed or incorrect medication doses, delay in care episodes, and missed physician orders. This standard patient safety report—the patient safety event (PSE) form—was modified by adding items that were appropriate to the environment of a deployed CSH. In addition, the form was changed to include the steps that the staff were expected to go through to debrief after a patient safety event to guide the debrief process after each event. Specifically, items were added to report communication and handoff clarity, role and responsibility clarity, maintenance of situation awareness, distribution of workload, task assistance requests and provision, as well as an assessment of errors and lessons learned (Appendix 1, available in online article; *see* SUPERVISOR/Team leader section for specific items). We now discuss the use of these data in the process improvement initiative and data coding for analysis.

INCIDENT REPORT CODING

The patient safety reports were analyzed in two steps. In the first step, the event was analyzed as it happened for the purpose of immediate process improvement. In the second step, all reports for the 13-month period were retrospectively reviewed.

Step 1. The CSH patient safety committee, which consisted of the patient safety officer, CSH leadership, and representatives from each clinical area, held monthly meetings to review PSE reports. This committee addressed precipitating factors leading to PSEs. After TeamSTEPPS training, the PSE form included TeamSTEPPS tools, such as a Brief or Huddle (Table 2, page 354), in the analysis process for each incident. Breakdowns in specific teamwork behaviors were considered as factors contributing to the event. In addition, other features of the event, including general type of event (for example, medication and transfusion errors, needlestick exposures) were tracked.

Step 2. At the end of the CHS deployment, a group of three providers (two nurses and one physician) retrospectively ana-

lyzed all of the reports for the entire 13-month period. This group (including the CHS patient safety officer) had extensive experience with TeamSTEPPS training. The patient safety officer had firsthand knowledge of the incidents and was able to provide clarification of documentation, such as background information incompletely explained in reports, when needed. The group evaluated each incident report and determined whether there were deficiencies in any of the TeamSTEPPS competencies, grouped in four broad categories in Table 2, that contributed to the event. The group determined whether any of the specific TeamSTEPPS tools (Table 2) could have been useful in preventing the incident.

The group also evaluated incidents to determine if any of the following were factors in the occurrence: knowledge deficit, systems/facilities issues, and individual errors (that is, something that could not have been avoided by application of Team-STEPPS tools). Distinguishing between individual and team errors was important for the coding process. For example, one needlestick injury, which occurred when a provider was performing a routine procedure on a stable patient and tried to recap a needle, could not have been avoided by applying TeamSTEPPS principles. On the other hand, a scalpel injury that occurred in the middle of a busy trauma case because the surgeon placed the blade on the scrub table without notifying the scrub technician might have been avoided by better communication or situation monitoring.

INCIDENT REPORTS PER INPATIENT DAYS

To ensure that the number of patient safety reports was properly represented between the pre- and postimplementation periods, they were analyzed relative to the number of inpatient days as rate of incidents per inpatient day.

Results

For the 7-month pre-implementation period, there were a total of 4,230 inpatient days, and for the 6-month postimplementation period there were 3,260.

PATIENT SAFETY EVENT RATES

As summarized in Table 3 (page 355), PSE data were analyzed in terms of changes in the frequencies of events relative to the inpatient census (that is, the number of events per inpatient days for each of the two periods). To determine if there was a significant change in event rates, chi-square tests were conducted on the pre- and postimplementation data. Rates are presented as the number of patient safety events per 1,000 inpatient days; however, the actual event rates per actual inpatient days were

used in the analyses. An alpha level of 0.05 was adopted for all significance testing.

A total of 153 patient safety reports were submitted during the 13 months reviewed, 94 before TeamSTEPPS implementation and 59 afterwards. When adjusted for inpatient census, the decrease from 22.2 events pre-implementation to 18.2 per 1,000 inpatient days postimplementation was nonsignificant (Pearson's chi-square test [1 degree of freedom] = 1.5, p = .22).

However, as also shown in Table 3, the decreases in rates of medication and transfusion errors and needlestick injuries and exposures were significant. These two event types were chosen because they were judged to be specifically sensitive to improved communication, mutual support, and situation monitoring. The inpatient census-adjusted rate of medication and transfusion errors decreased from 7.1 events per 1,000 inpatient days pre-implementation to 1.2 events post-implementation (Pearson's chi-square test [1 degree of freedom] = 13.9, p < .001), an 83% decrease. Similarly, the inpatient census adjusted rates of needlestick injuries and exposures decreased from 4.0 events per 1,000 inpatient days pre-implementation to 1.2 events per 1,000 days postimplementation (Pearson's chi-square test [1 degree of freedom] = 4.14, p < .05), a 70% decrease.

THE ROLE OF TEAMSTEPPS COMPETENCIES AND TOOLS IN PATIENT SAFETY EVENTS

To investigate the potential underlying causes of the events, each incident was analyzed in relation to the four broad Team-STEPPS competencies (Table 2). Only three incidents were coded as having two relevant competencies (all involved Communication as the primary issue and Leadership as a secondary issue). For these cases, the primary competency was the only one included in the analysis.

As detailed in Table 4 (page 355), there were no statistically significant changes in the inpatient census-adjusted rates of incidents coded as having Leadership, Situation Monitoring, or Mutual Support competencies as the primary teamwork skill that could have potentially prevented the event. However, there was a large and significant decrease—from 5.2 events per 1,000 inpatient days pre-implementation to 1.8 events postimplementation (Pearson's chi-square test [1 degree of freedom] = 5.54, p < .05), a 65% decrease—in the rate of incidents coded as having Communication as a likely mitigating factor.

The specific TeamSTEPPS tools judged to have been of potential value for mitigating the patient safety event are reported in Table 2. For example, cross-monitoring, rated as being applicable in 35 (23%) of the 153 reports, was the TeamSTEPPS tool most frequently judged to be of use. This was followed by

Table 2. Overview of TeamSTEPPS Tools and Number of Cases in Which Each Tool Was Retrospectively Judged to Have Potential Value in Mitigating a Patient Safety Event*

TeamSTEPPS Competency Areas	TeamSTEPPS Tools	Description	Number of Instances the Tools Could Have Helped (*N* = 153)
Leadership Coordination of the activities of team members by ensuring team actions are understood, changes in information are shared, and that team members have the necessary resources	Brief	Pre-performance planning involving forming the team, designating team roles and responsibilities, establishing a climate and goals, and engaging the team in short- and long-term planning	1 (< 1%)
	Huddle	In-process or ad hoc problem solving; brief meetings held to regain situational awareness, discuss critical issues and emerging events, anticipate outcomes and likely contingencies, assign resources, and express concerns	1 (< 1%)
	Debrief	Postperformance process improvement; information exchange and feedback sessions aimed at developing an accurate reconstruction of key events, analysis of why the event occurred, and what should be done differently next time	0
Situation Monitoring Actively scanning and assessing situational elements to gain information, understanding, or maintain awareness to support functioning of the team	Cross Monitoring	Process of monitoring the actions of other team members for the purpose of sharing the workload and reducing or avoiding errors	35 (23%)
	IM Safe	Structured tool to help assess the status of team members: Illness, Medication, Stress, Alcohol and drugs, Fatigue, Eating, and Elimination	1 (< 1%)
Mutual Support Anticipation and support of other team members' needs through accurate knowledge about their responsibilities and workload	Task Assistance	Team members actively seeking and offering support to avoid failures resulting from overload situations	5 (3%)
	2-Challenge Rule	Rule for managing information conflict and invoked when an initial assertion is ignored; you must assertively voice your concern at least twice to ensure it is acknowledged; the member being challenged must acknowledge; if the outcome is still unacceptable either (1) take a stronger course of action, or (2) use supervisor or chain of command.	5 (3%)
	Collaboration	Process of developing a solution that meets all stakeholder goals, including the patient's	0
	CUS	Key words to raise attention around a specific issue: I am concerned. I am uncomfortable. This is a safety issue.	3 (2%)
	DESC Script	Script for managing interpersonal conflict: Describe the specific situation. Express your concerns about the action. Suggest other alternatives. Consequences should be stated.	0
Communication Clearly and accurately exchanging information among team members	SBAR	Structured communication tool: Situation, Background, Assessment, and Recommendation	4 (3%)
	Call-Out	Strategy used to communicate important or critical information; it informs all team members simultaneously during emergency situations	4 (3%)
	Check Back	Pattern of closed-loop communication: sender initiates message→receiver accepts message, provides feedback confirmation→sender verifies message was received	3 (2%)
	Handoff	Transfer of information and authority/responsibility during transitions of care	16 (10%)
	I PASS the BATON	Structured handoff tool: Introduction, Patient, Assessment, Situation, Safety, Background, Actions, Timing, Ownership, Next	0

* For more information on these tools, see U.S. Agency for Healthcare Research and Quality: *Team STEPPS®: National Implementation.* http://teamstepps.ahrq.gov/ (last accessed Jun. 21, 2011).

Table 3. Summary of Pre- and Posttraining Implementation Rates of Patient Safety Event Reports						
	Pre-training		Posttraining			
Measure	Actual Rates of Events per Inpatient Days	Events per 1,000 Inpatient Days	Actual Rates of Events per Inpatient Days	Events per 1,000 Inpatient Days	Pearson's $\chi^2(1)$	% Change
No. of Patient Safety Reports	94:4,230	22.2:1,000	59:3,260	18.2:1,000	1.5	n/a
Medication/Transfusion Errors	30:4,230	7.1:1,000	4:3,260	1.2:1,000	13.9†	–83%
Needlestick injuries/exposures	17:4,230	4.0:1,000	4:3,260	1.2:1,000	4.14*	–70%

* $p < .05$

† $p < .001$

Table 4. Summary of Rates of Patient Safety Events Linked to TeamSTEPPS Competencies						
	Pre-training		Posttraining			
TeamSTEPPS Competency	Actual Rates of Events per Inpatient Days	Events per 1,000 Inpatient Days	Actual Rates of Events per Inpatient Days	Events per 1,000 Inpatient Days	Pearson's $\chi^2(1)$	% Change
Leadership	27:4,230	6.4:1,000	20:3,260	6.1:1,000	.02	n/a
Communication	22:4,230	5.2:1,000	6:3,260	1.8:1,000	5.54*	–65%
Situation Monitoring	22:4,230	5.2:1,000	22:3,260	6.8:1,000	.75	n/a
Mutual Support	None		1:3,260	0.3:1,000	1.3	n/a

* $p < .05$

handoffs (10% of cases), task assistance, two-challenge rule, Situation-Background-Assessment-Recommendation (SBAR) and call-out (approximately 3% of cases each), and check-back and CUS (2% of cases each).

Discussion

This study indicates that TeamSTEPPS was successful in improving patient safety in this deployed medical treatment environment. Although the rate of patient safety event reports did not decrease significantly, the types of errors attributable to communication issues decreased significantly—by 65%. In addition, the marked decrease in the rate of medication and transfusion errors (83%) supports the finding that TeamSTEPPS training improved communication. This is consistent with reviews of sentinel event data that suggest that communication is a leading root cause of sentinel events.[7]

The TeamSTEPPS tools that appeared to be the most likely to help in this environment included handoffs and cross-monitoring. This is not surprising, given that in this context patients move quickly between different care facilities, a situation that can potentially magnify the risks of missing or incorrect information exchange during these transitions. Unfortunately, it was not feasible to collect information on actual changes in the quality or quantity of handoff information. Staff members in the deployed

environment are in a stressful situation in which they might be especially likely to benefit from other staff members' monitoring and catching errors.

As is often the case, it is assumed that patient safety events were underreported, but it is likely that underreporting would have been comparable before and after training. If there was more awareness of PSEs after the training, then we would expect to have seen an increase in the rate of incidents reported after training. However, contrary to this expectation, there was a (nonsignificant) decrease in the rate. It is also important to note that TeamSTEPPS training was provided to all staff and not just clinical providers. This broad-based approach may have contributed to the decreases in rates of events such as medication and transfusion errors.

Many good catches were attributed to the TeamSTEPPS tools, which were of potential value to staff and leadership alike, as illustrated in the case study in Sidebar 1 (page 356).

A possible limitation of the current study involves the incident-coding process, although consensus was reached among three providers with access to firsthand knowledge of all cases. In addition, although reported events are potentially unreliable measures, we used the rate of reporting within a specific facility and did not combine or compare across facilities, so that many of the factors possibly influencing error variance, such as orga-

Sidebar 1. A Sample Good Catch

Case Study

Two critically wounded soldiers arrived at the staging area for transport from the Baghdad CSH to Balad Joint Base (50 miles from Baghdad; the central hub for airlift and U.S. Air Force operations in Iraq and a major transshipment point for U.S. Army supply convoys). Two ICU nurses were accompanying the soldiers on the flight to respond to any emergencies. After completing the flight-line checklist, the patients and nurses were ready to board the helicopter. However, the attending ICU physician unexpectedly arrived at the flight line and explained that she had missed her usual TeamSTEPPS handoff before the patients left the ICU.

Consequently, she wanted to call a huddle to review any last-minute issues with the nurses. During the huddle, she reminded the flight nurses that one of the patients had particularly severe respiratory injuries and that a special piece of equipment—a positive end-expiratory pressure (PEEP) valve—would be needed should he need to be resuscitated in flight. Because this valve was rarely used, it was not included in a standard flight resuscitation set. After the huddle, the crew obtained the valve before the flight left. Fifteen minutes into the 30-minute flight, the soldier suffered a respiratory arrest. Using the equipment identified in the huddle, the ICU nurses successfully resuscitated the patient. The huddle likely saved this soldier's life, and the inclusion of PEEP valves in flight resuscitation sets became standard practice.

Comments

Although briefs, debriefs, and huddles were not frequently coded as a potential mechanism for avoiding a patient safety event, this case study illustrates their value. As preparatory and reflective processes, briefs and debriefs are often more distal to an event than other teamwork behaviors, such as communication and leadership. Consequently, in a retrospective review, it may be more difficult to judge whether a brief or debrief would have helped in a given situation as compared with other team behaviors with clear and immediate connections to the event.

training with deploying CSH units before they leave for theater. In addition, TeamSTEPPS has been integrated with specific trauma training scenarios and the mandatory provider training course (the Joint Forces Combat Trauma Management Course) that all units receive before being deployed to Iraq or Afghanistan. An ongoing evaluating plan for this training is under development. ◼

Online-Only Content

See the online version of this article for

Appendix 1. Sample Patient Safety Incident Report

Shad Deering, M.D., is Medical Director, Andersen Simulation Center, Madigan Army Medical Center, Tacoma, Washington, and Assistant Clinical Professor, Uniformed Services University of the Health Sciences, Bethesda, Maryland. **Michael A. Rosen, Ph.D.,** formerly Consulting Human Factors Psychologist, U.S. Department of Defense Patient Safety Program, Washington, D.C., is Assistant Professor, Department of Anesthesiology and Critical Care Medicine and Staff Member, Quality and Safety Research Group, Johns Hopkins School of Medicine, Baltimore. **Vivian Ludi, M.S.N.,** is Nursing Section Supervisor, Department of Emergency Medicine, William Beaumont Army Medical Center, Fort Bliss, Texas. **Michelle L. Munroe, C.N.M.,** is Deputy Commander for Nursing, Kenner Army Health Clinic, Fort Lee, Virginia. **Amber Pocrnich, R.N.C.,** is Clinical Nurse Officer-In-Charge, Labor & Delivery, Tripler Army Medical Center, Hawaii. **Christine Laky, M.D.,** is Staff OB/GYN Physician, Darnall Army Community Hospital, Fort Hood, Texas. **Peter G. Napolitano, M.D.,** is Director, Maternal-Fetal Medicine Fellowship, Department of Obstetrics and Gynecology, Madigan Army Medical Center. Please address correspondence to Shad Deering, Shad.deering@us.army.mil.

nizational policies and reporting culture, were held constant. A final possible limitation involves accounting for differences in the severity or frequency of large boluses of patients or mass casualty events. Patient census was accounted for in the analysis with the number of inpatient days (census averaged 604 inpatient days per month in the pre-implementation period and 543 inpatient days after postimplementation), but it is difficult to adjust for differences in the intensity of the conflict.

CONCLUSIONS

The provision of care in an active combat theater of operations is a challenging and even unique endeavor. This study indicates that process improvement programs such as Team-STEPPS implementation can be conducted under the extremely austere conditions of a CSH. In response to this initial implementation, master trainers are now conducting TeamSTEPPS

References

1. Gawande A.: Casualties of war: Military care for the wounded from Iraq and Afghanistan. *N Engl J Med* 251:2471–2475, Dec. 9, 2004.
2. Institute of Medicine: *To Err Is Human: Building a Safer Health System.* Washington, D.C.: National Academy Press, 1999.
3. Baker D.P., et al.: Medical team training programs in health care. In Henriksen K., et al. (eds.): *Advances in Patient Safety: From Research to Implementation (Vol 4: Programs, Tools, and Products).* Rockville, MD: Agency for Healthcare Research and Quality, Feb. 2005. http://www.ncbi.nlm.nih.gov/books/NBK20580/ (last accessed Jun. 21, 2011).
4. Alonso A., et al.: Reducing medical error in the Military Health System: How can team training help? *Human Resource Management Review* 16:396–415, Sep. 2006.
5. Nielsen P., et al.: Effects of teamwork training on adverse outcomes and process of care in labor and delivery: A randomized controlled trial. *Obstet Gynecol* 109:48–55, Jan. 2007.
6. Weaver S.L.: Does teamwork improve performance in the operating room? A multi-level evaluation. *Jt Comm J Qual Saf* 36:133–142, Mar. 2010.
7. The Joint Commission: *Sentinel Event Data Root Causes by Event Type 2004-Fourth Quarter 2010.* http://www.jointcommission.org/assets/1/18/SE_RootCausesEventType2004_4Q2010.pdf (last accessed Jun. 21, 2011).

Online-Only Content

Appendix 1. Sample Patient Safety Incident Report

PATIENT SAFETY REPORT

☐ GOOD CATCH: Any process variation, error, or circumstance that could have resulted in harm, but thru chance or timely intervention did not reach the Patient.

☐ ADVERSE EVENT: An occurrence due to commission or omission that actually reached the patient, even if it did NOT result in harm.

☐ SENTINEL EVENT: An unexpected occurrence involving death or serious physical or psychological injury to a patient that is not related to the natural course of the patient's illnesses or underlying condition. Serious injury specifically includes loss of limb or function.

DATE OF EVENT:	HOUR OF EVENT:	LOCATION OF EVENT:

PERSON AFFECTED BY EVENT: ☐ INPATIENT ☐ OUTPATIENT ☐ VISITOR ☐ STAFF MEMBER

GENERAL TYPE OF EVENT	PERSONS INVOLVED	OUTCOME/SEVERITY
☐ Fall	☐ Registered Nurse	☐ No known injury
☐ Blood Transfusion Occurrence	☐ Licensed Practical Nurse	
☐ Radiology Related	☐ Medic / Nursing Assistant	☐ Insignificant / No or minimal treatment
☐ Surgical Case Review	☐ Advanced Practice RN	
☐ Blood Borne Pathogen Exposure	☐ Physician	☐ Minor / Some treatment / No residual effects
☐ Defective Materials	☐ Physician's Assistant (PA)	☐ Significant / Possible residual effects
☐ AMA / LWOBS	☐ Pharmacist	
☐ Assault	☐ Pharmacy Technician	☐ Major / extensive residual effects
☐ Equipment Failure	☐ Dietitian	
☐ Delay in Diagnosis, Transfer, Treatment	☐ Physical/Occupational Therapist	☐ Grave / Prognosis poor
☐ Needle Stick	☐ Interpreter	☐ Death related to occurrence
☐ Infection Control	☐ Laboratory Technician	
☐ Laboratory Related	☐ Radiology Technician	
☐ Other: _____	☐ Respiratory Therapist	

Medication/IV Error block:
☐ Medication/IV Error
☐ Wrong Drug
☐ Wrong Route
☐ Wrong Dose
☐ Wrong Time
☐ Wrong Patient
☐ Missed Dose
☐ Written incorrectly (abbreviations, illegible)
☐ Prepared incorrectly
☐ Look alike-sound alike
☐ Transcribed wrong
☐ Adverse Drug Reaction
☐ Practice/Procedure Variance
☐ Policy
☐ Procedure
☐ Personnel
☐ Plant/Facilities
☐ Supplies/Equipment

Persons Involved continued:
☐ Logistics Technician
☐ Housekeeping
☐ Medical Records Technician
☐ Patient
☐ Visitor
☐ Volunteer
☐ Contractor
☐ Other: _____

TREATMENT

a. WAS PROVIDER NOTIFIED? ☐ YES ☐ NO ☐ NA

b. DID HE/SHE SEE PATIENT? ☐ YES ☐ NO ☐ NA

c. PROVIDER'S NAME:: _____

d. Actions taken:

<<<<<<<<<<<<<<<<<<<<<<   DETAILED EVENT SCREEN (Select one if applicable)   >>>>>>>>>>>>>>>>>>>>>>>>

☐ **NO OCCURRENCE**

☐ Re-admission within 30 days
   ☐ Unplanned same/related condition due to complication of previous care

☐ Unplanned Transfer
Transfer to a higher level of care due to complication of treatment /procedure

☐ Unplanned Admission due to Complication of Outpatient Care
   ☐ Missed diagnosis
   ☐ Unexpected complication of outpatient treatment
   ☐ Complication of outpatient procedure
   ☐ Other:_____

☐ Organ Deterioration/Failure, Not Present on Admission
   ☐ MI/CVA ☐ Renal failure
   ☐ Liver failure ☐ Neurological deficit,
   ☐ Decubitus ulcer ☐ Cardiac/Respiratory Arrest
   ☐ Other:

☐ Suicide Attempts, Inpatient

☐ Equipment Failure or Disconnected Unintentionally

☐ Death, unexpected

☐ OTHER OCCURRENCE: _____

☐ Operative/Anesthesia Related
   ☐ Retained/removal of foreign body
   ☐ Repeat same procedure, initial was unsuccessful
   ☐ Injury to organ/body part, functional/neurosensory deficit
   ☐ Wrong procedure performed, wrong body part, wrong patient
   ☐ Failed regional anesthesia
   ☐ Postoperative complications
   ☐ Other _____

☐ Unplanned extubation

☐ Complication of Invasive Procedure, Inpatient

☐ Obstetrical/Nursery Related
   ☐ Delivery unattended by a provider
   ☐ Intrapartum maternal or fetal death (>500 grams)
   ☐ APGAR <6 at 5 minutes
   ☐ Injury to infant organ/body prior to/during delivery

☐ Hospital Acquired Infection
   ☐ Surgical Wound ☐ Central Line
   ☐ Pneumonia ☐ Peripheral Line
   ☐ Other:_____

☐ Blood Product Related
   ☐ Unexpected Transfusion of Blood Products
   ☐ Transfusion Reaction, (transfusion stopped)

☐ Emergency Visit Return within 72 hrs for same diagnosis prior to scheduled follow-up

If any box is checked, give summary on reverse side>>>>>>>>>>>>>>>

Patient information (HOSP ID OR ISN)	ATTENDING PHYSICIAN AND DEPARTMENT/SERVICE
	This block for Patient Safety only LOG NUMBER:_____
	SAC: _____ DATE RECEIVED: _____

Confidential QA Protected Document 10USC 1102(b)   Do not leave completed form in Closed Record   Form 400, June 2008

Teamwork and Communication

Didactic and Simulation Nontechnical Skills Team Training to Improve Perinatal Patient Outcomes in a Community Hospital

William Riley, Ph.D.; Stanley Davis, M.D.; Kristi Miller, R.N., M.S.; Helen Hansen, Ph.D., R.N.; Francois Sainfort, Ph.D.; Robert Sweet, M.D.

Birth trauma is a low-frequency, high-severity event that makes obstetrics a major challenge for patient safety in the hospital setting. At least 1.5% of hospitalized obstetric patients in the United States experience an adverse event,[1] and communication failure is associated with 72% of root cause analyses of sentinel events in perinatal units.[2] Despite tremendous individual commitment and the conscientious efforts of superbly trained professionals, high reliability is not a dominant feature of the health care delivery system.[3] The United States ranks 17th in the world in the perinatal mortality rate, largely because of obstetric causes,[4] and 29th worldwide in infant mortality—near the bottom of industrialized nations.[5]

Nontechnical skills (NTS) are the cognitive and interpersonal skills, supplementing clinical and technical skills, necessary to ensure safe patient care.[6,7] Two of the foremost NTS in health care are communication and teamwork,[8,9] both of which have been identified as major risks in perinatal units.[10] Poor communication increases the risk of error tenfold,[11] and poor teamwork accounts for approximately 55% of all active failures in a hospital setting.[12]

Interdisciplinary team training is highly effective at improving communication and teamwork,[13] while simulation is a learning strategy to amplify real clinical situations with guided experiences in an interactive fashion.[14] Simulation training is commonplace in high-reliability organizations (HROs)[15] and strongly recommended by the Institute of Medicine to improve patient safety.[16] However, there is little empirical evidence of the direct impact of simulation training on patient outcomes.[15] Simulation training programs affects knowledge, attitudes, and behavior about team skills[17] and have been applied extensively throughout health care to enhance both technical and nontechnical skills in many specialties and procedures,[18] such as anesthesia,[19] emergency medicine,[20] neonatal resuscitation,[21] perinatal emergencies,[22,23] critical care air support,[24] and surgery,[25] as well as to expose process failures in hospital systems.[26] However, proficiency during simulation does not ensure proficiency in clini-

Article-at-a-Glance

Background: Birth trauma is a low-frequency, high-severity event, making obstetrics a major challenge for patient safety. Yet, few strategies have been shown to eliminate preventable perinatal harm. Interdisciplinary team training was prospectively evaluated to assess the relative impact of two different learning modalities to improve nontechnical skills (NTS)—the cognitive and interpersonal skills, such as communication and teamwork, that supplement clinical and technical skills and are necessary to ensure safe patient care.

Methods: Between 2005 and 2008, perinatal morbidity and mortality data were prospectively collected using the Weighted Adverse Outcomes Score (WAOS) and a culture of safety survey (Safety Attitudes Questionnaire) at three small-sized community hospitals. In a small cluster randomized clinical trial conducted in the third quarter of 2007, one of the hospitals served as a control group and two served as the treatment intervention sites—one hospital received the TeamSTEPPS® didactic training program and one hospital received both the TeamSTEPPS program along with a series of in-situ simulation training exercises.

Results: A statistically significant and persistent improvement of 37% in perinatal morbidity was observed between the pre- and postintervention for the hospital exposed to the simulation program. There were no statistically significant differences in the didactic-only or the control hospitals. Baseline perceptions of culture of safety were high at all three hospitals, and there were no significant changes.

Conclusions: A comprehensive interdisciplinary team training program using in-situ simulation can improve perinatal safety in the hospital setting. This is the first evidence providing a clear association between simulation training and improved patient outcomes. Didactics alone were not effective in improving perinatal outcomes.

cal settings.[27] In-situ simulation is a high-fidelity team-based simulation strategy that occurs on a patient care unit rather than in a simulation laboratory and provides the unique opportunity for individual hospitals and hospital units to improve NTS and correct latent conditions that may contribute to patient safety hazards.[28]

In the prospective cohort study described in this article, we examine the relative impact of a didactic TeamSTEPPS® program[29] and a didactic TeamSTEPPS program supplemented by an in-situ simulation program in relation to a comparison hospital on patient outcomes and culture of safety in the context of perinatal emergencies in small-sized community hospitals.

Methods

Study Design

In a four-year period between 2005 and 2008, we conducted a prospective study of pre- and postintervention periods at three small-sized community hospitals (50 to 66 beds) serving comparable rural/suburban patient populations in the Midwest (Table 1, page 359). Together, the three hospitals represent approximately 1,800 deliveries per year. We randomly assigned the hospitals to three conditions, as follows:

■ One hospital had no intervention and served as a control.

■ One hospital received the TeamSTEPPS didactic training.

■ The third hospital received a full intervention, which consisted of TeamSTEPPS augmented by a series of in-situ training exercises, which were repeated until summative staff saturation and repetition targets were met.

The randomization was that of the clusters, not the individual women. All analyses were conducted at the cluster level because the intervention goal was to improve NTS and reduce perinatal harm. All labor and delivery staff at the three hospitals were eligible to participate. Comparisons were made between the three hospitals, each subjected to a different treatment in the first quarter of 2007. All women who were admitted to the hospitals between 2005 and 2008 were included in the study.

Interventions

We used two methods for interdisciplinary team training—didactic training and in-situ simulation. The didactic intervention is used to teach team members knowledge about key NTS. The second method used experiential learning based on in-situ simulation training to provide an opportunity for practice, application, and coaching. We hypothesized that this method would be more effective in creating behavioral change.

Didactic Training. Didactic training was based on the TeamSTEPPS training curriculum, an evidence-based teamwork curriculum developed by the U.S. Department of Defense and the Agency for Healthcare Research and Quality with a focus on four learnable, teachable skills to improve team performance: leadership, situation monitoring, mutual support, and communication.[29] The TeamSTEPPS program is an extensive curriculum that involves several days of classroom training. In previous research, we found that four key behaviors are responsible for the majority of team and communication failures during critical events.[12,28] We focused specifically on the following behaviors to develop a condensed curriculum for critical skills that are necessary for effective communication in safety-critical environments: situational awareness, standard communication of Situation-Background-Assessment-Recommendation-Readback (SBAR-R), closed-loop communication, and shared mental model. The full format and techniques of our condensed curriculum are explained elsewhere.[30] A 30-minute audiovisual webinar presentation of these four key TeamSTEPPS skills was developed for the participants. The webinar used a combination of visual prompts, audio narration of key elements, and a video of simulated scenarios. The participants completed a 10-item test at the conclusion of the didactic training, with a 90% score as a target to track learner comprehension.

We created obstetrical emergency scenarios based on incidents abstracted from actual sentinel events for use in the in-situ simulation team training sessions. We used an event-set methodology in the simulation scenario that incorporated the same key TeamSTEPPS behaviors from the didactic training.

Previous work describes the development, categorization and validation of an evaluation tool for assessing near misses and active failures by collecting, analyzing, and validating 36 simulations of emergency C-sections in a 390-bed community hospital.[26] Following Reason's model,[i] these "breaches" in patient safety barriers were categorized according to active failures (standardized communication, situational awareness and shared mental model) and latent conditions (process design and compliance with policy and procedure).

In-Situ Simulation. The in-situ simulation for perinatal critical events consisted of five components: (a) briefing, (b) in-situ simulation, (c) debriefing, (d) rapid-cycle follow-through with process improvements, and (e) repetition to reinforce skills and create resiliency.[32] During the briefing, participants who were directly involved in the simulation were educated about the simulation scenarios. The simulated patient was followed from triage, through labor and the operating room (OR), and then to the recovery area. The simulation, which typically ran 30 to 45 minutes, was initiated in a manner similar to a typical handoff, with a brief history from one provider to the next. A two-hour

Table 1. Hospital and Labor and Delivery Staff Demographics*					
Hospital					
	Beds	**L&D Beds**	**Level 1 Nursery**	**Births/Year**	**Population Served**
Full Intervention	50	6	Yes	380	Rural/Suburban
Didactic Training	66	6	Yes	889	Rural/Suburban
Control	55	5	Yes	500	Rural/Suburban
Staff					
	ObGyn	**Family Practitioners**	**Pediatricians**	**RNs**	**CRNAs**	**MDAs**
Full Intervention	5	2	5	18	5	1
Didactic Training	5	12	5	30	8	0
Control	3	9	4	17	5	0

* L&D, labor and delivery; ObGyn, Obstetrics/Gynecology; RN, registered nurse; CRNA, certified registered nurse anesthetist; MDA, physician assistant.

debriefing session, with the use of advanced debriefing techniques, was held immediately following each simulation.[33,34] Eleven simulation training sessions were conducted at the simulation treatment hospital from September 2007 through February 2008.

Scenarios and triggers were taken from actual occurrences in the hospital unit. We used an event-set methodology[36] to develop scenarios for uterine rupture, placental abruption, and post-partum hemorrhage. The event sets specified phases for each of the three scenarios. Five clinical triggers were designed to prompt NTS behaviors: situational awareness, shared mental model, closed-loop and SBAR-R[29] communication, leadership and teamwork, and latent conditions.*

MEASURES

We prospectively collected data on perinatal morbidity and mortality as well as culture of safety (COS).

Outcomes. To measure perinatal outcomes at each hospital, we used the Weighted Adverse Outcomes Score (WAOS), calculated quarterly. WAOS is a quality indicator developed to evaluate the effects of teamwork on obstetric care.[35] The WAOS, constructed from a set of 10 weighted outcome measures, is a summary metric representing the average adverse event score per delivery.[23] Unlike other obstetric outcome measures,[36] the WAOS weighting system adjusts for the severity of adverse events. WAOS data were electronically collected from hospital records.

Culture of Safety. To measure subjective impressions of the COS, we administered the Safety Attitudes Questionnaire

(SAQ)[37] to all obstetricians, pediatricians, anesthesiologists, nurses, and ancillary staff at each hospital before and after a one-year period of intervention. This 5-point Likert-scale questionnaire, with 38 items in seven scales, is one of the primary measures used for assessing culture of safety (COS)[38] has been administered in multiple settings and has established reliability and validity. We used the 38-item version of the total scale, modifying the demographic items to fit perinatal staff and units.

STATISTICAL ANALYSIS

We conducted two sets of analyses. In the first set, we used control chart analysis and statistical process control (SPC) to analyze process performance.

Control Chart Analysis and Statistical Process Control. SPC and control chart methods, which quantify how a process performs over time, are being increasingly used in health care.[39–41] Control charts are time-series representations of data used to track the consistency of calculated statistical information generated from a variety of data sampling strategies.[42–44] The usefulness of control charts resides in their ability to detect significant changes in a process; if special cause is detected in the process, then action can be directed at eliminating this form of variation.[29,45] Control charts analyze a time-ordered sequence to track a process to determine the type of variation present[29] and whether the process meets desired performance targets.[46] This technique was especially appropriate for our study because it enabled us to determine the longitudinal trends regarding perinatal morbidity at the three hospitals and whether a process shift (statistically significant change that is indicative of lasting alteration in performance) occurred as a result of the intervention. We used an XMR chart based on the interval-level measurement and number of observations in subgroups.[46] We conducted five tests to

---

* Situational awareness, shared mental model, closed-loop communication, SBAR, and leadership are defined in Agency for Healthcare Research and Quality: *TeamSTEPPS® Instructor Guide Glossary.* http://www.ahrq.gov/teamsteppstools/instructor/reference/glossary.htm (last accessed Jun. 29, 2011).

assess the presence of special-cause variation (if any type of special cause is detected, the process is considered unstable and, therefore, unpredictable).

Bivariate and Multivariate Relationships. The second set of analyses examined bivariate and multivariate relationships between our key study variables. We used Wilcoxon's rank sum test to compare independent samples from the pre-intervention and post-intervention periods in an effort to determine whether the data provided evidence of a normal distribution so parametric tests could be used[46]; we used the chi-square test and Fisher's exact test when sample sizes were below five.[48]

Results

OUTCOMES

The four-year trends in perinatal outcomes in the three hospitals were examined by plotting and analyzing the quarterly WAOS for all hospitals using an SPC approach[46] to measure process performance using a time-series analysis.

The individual run charts, as shown in Figure 1 (right), indicated no special cause in either the control group or the didactic-only condition. There was, however, special-cause variation in the full-intervention condition, as demonstrated by a long run immediately subsequent to the first simulation trial in the first quarter of 2007. The run chart analysis indicates wide variability for both the control group and the didactic-only condition. The variation in the full-intervention group was substantially reduced during the postintervention period.

As a result of the special cause detected in the full-intervention condi-

**Run Chart Analysis for Weighted Adverse Outcome Scores, January 2005–December 2008**
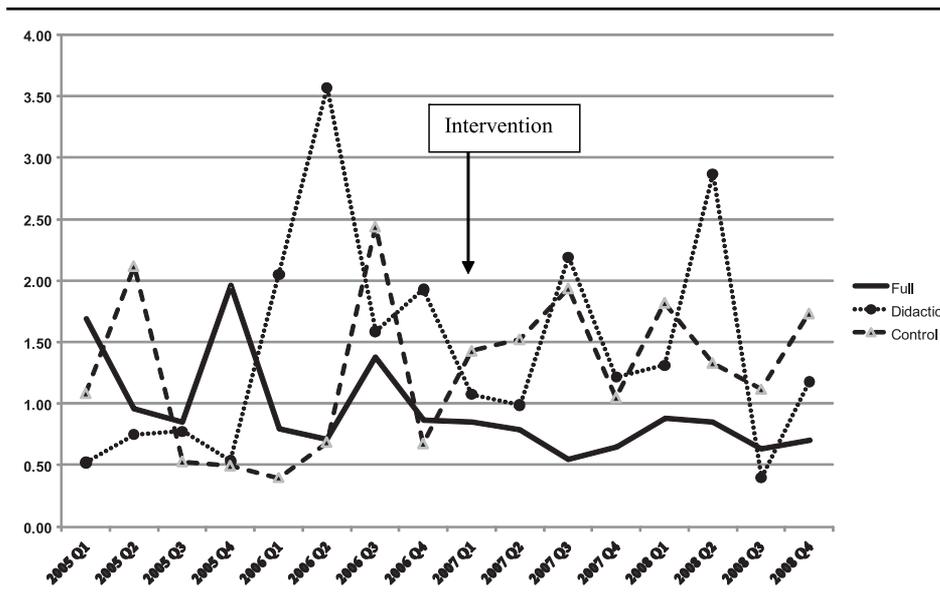
Figure 1. *The individual run charts indicate no special cause in either the control group or the didactic-only condition (the center lines are excluded for clarity). There was, however, special-cause variation in the full-intervention condition, as demonstrated by a long run immediately subsequent to the first simulation trial in the first quarter (Q1) of 2007.*

XMR Control Chart Analysis for Weighted Adverse Outcome Scores (WAOSs) and Moving Ranges for Full-Intervention Hospital, January 2005–December 2008
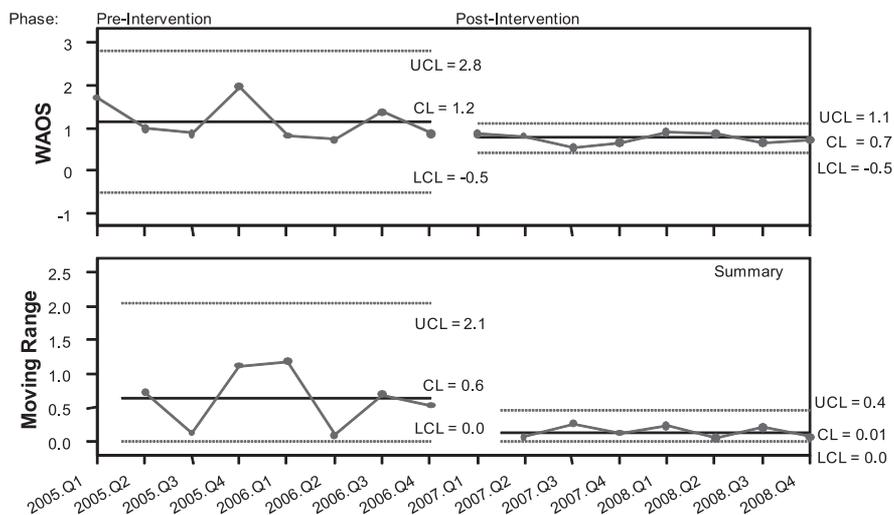

Figure 2. *The moving range chart (bottom) indicates stable variation, with no special cause in either the pre- or postintervention phases. The individual control chart (top) shows that both the pre- and postintervention processes were stable, with a process shift representing 37% reduction in perinatal harm. UCL, upper control limit; CL, control limit; LCL, lower control limit.*

Table 2. Pre-Intervention and Postintervention WAOS Means (and Standard Deviations)*			
Hospital	Pre-intervention Mean (SD)	Postintervention Mean (SD)	% Change (Pre to Post)
Full Intervention	1.15 (0.47)	0.72 (0.12)	−37.4%†
Didactic-Only	1.46 (1.05)	1.45 (0.82)	−1.0%
Control	1.05 (0.79)	1.50 (0.35)	+42.7%

* WAOS, Weighted Adverse Outcomes Score; SD, standard deviation.
† Significant at the .05 level.

tion, we concluded that a process shift occurred after the intervention and further analyzed the process shift, as shown in the XMR control chart (Figure 2, page 360). The moving range chart indicated stable variation, with no special cause in either the pre- or postintervention phases. The individual control chart showed that both the pre- and post-intervention processes were stable, with a process shift representing 37% reduction in perinatal harm. Figure 2 also indicated reduced process variation during and after the intervention period.

Table 2 (above) shows the results of a t-test performed to compare pre- and post-intervention WAOS means for all three hospitals in the study. As indicated by the SPC analysis, the only significant change observed was for the full-intervention condition. The WAOS in the full-intervention condition was 1.15 pre-intervention, decreasing to 0.72 postintervention, a 37% decrease in this measure of perinatal harm.

CULTURE OF SAFETY

Confirmatory factor analysis, performed on both pre- and postintervention COS data sets, confirmed the seven-scale structure of the instrument. All baseline perceptions of safety were generally high at all three hospitals. The results show no change in safety attitudes during the two-year period of the study for either the control group or didactic-only condition, with an increase in teamwork for the full-intervention hospital at the .05 level. However, the statistical significance no longer held when a Bonferroni adjustment was applied to the level of significance.

DISCUSSION

The major objective of this study was to examine the impact of two interdisciplinary team training methods on perinatal outcomes. The primary finding indicates that the full intervention (in-situ simulation and didactic training) resulted in a 37% improvement in WAOS in an eight-quarter period. To our knowledge, this is the first time a reduction in perinatal harm has been shown to occur in a controlled trial. Although several studies have shown changes in the WAOS scores,[17] these have been nat-

ural histories and case studies. Analysis of variance also shows that the didactic-only hospital started with a slightly higher WAOS than the other two sites. The full-intervention hospital's variance was significantly lowered from a baseline low level to begin with, and the variance was stabilized.

In terms of the study's second objective—to examine the effect of team training on perceptions of COS—we found no significant improvement. It may be possible that a longer lag time is needed to show the influence of in-situ simulation on COS. Baseline perceptions of safety were high, indicating a potential ceiling effect limiting improvement. It is also plausible that the relationship between team training and safety culture is weak and that training does not necessarily positively affect safety culture, especially in the short term. Finally, it is possible that more training/simulation would have been necessary to show improvement in safety culture. Additional research is needed to address this question.

People consistently make errors, not because they are incompetent, uncaring, or careless, but because of the complicated systems in which they work[31] and the lack of training in NTS.[8] Mistakes are evidence of a faulty system, not necessarily human failing.[49] Although failures are inevitable, hazards and errors can be anticipated, and processes can be designed both to avoid failures and to prevent patient harm when a failure occurs.[50] Although some initial research on evaluating COS in health care settings has been promising,[51,52] there are few examples of a proven relationship between COS and health care outcomes,[53] and no controlled trials to test such relationships. In safety-critical industries, a process is carefully designed, tested, audited, and monitored on an ongoing basis using sophisticated process engineering techniques.[54] Although the importance of process design has become increasingly recognized for health care,[55,56] the application of rigorous quality improvement methods and techniques for high reliability and safety is not yet firmly in place.[57] A fundamental goal of quality improvement is to improve process performance by distinguishing between routine (common-cause) and unusual (special-cause) variation to determine

the type of interventions necessary to achieve sustainable change.[58]

This article makes several contributions to the field of patient safety. As suggested by the literature review, it is the only study with a scientific design to document an actual reduction in adverse events based on an experiential simulation interdisciplinary team training protocol. Previous research using didactic training showed a 32% improvement in perinatal outcomes,[38] while an interdisciplinary training protocol in six obstetrics emergency drill stations found a reduction in two measures of neonatal harm (five-minute Apgar and hypoxic-ischemic encephalopathy).[59] However, the former study did not use simulation training, and the later study was a retrospective five-year cohort observational study that excluded selected high-risk deliveries and did not measure maternal outcomes. Our findings of improved perinatal outcomes in only the simulation group, with a lack of improvement in culture of safety across intervention groups, suggests that experiential training is critically important in changing the behavior of practicing professionals. Likewise, the findings raise questions regarding the role of didactic training as a stand-alone for altering behavior by practicing health care professionals. This is consistent with fundamental adult learning theories, which emphasize building experiential strategies on underlying didactic concepts.[60]

This study's findings also suggest an important role for applied in-situ simulation as both an effective assessment tool and interdisciplinary team training strategy. Not only does in-situ simulation assist health care workers and managers in assessing safety and team functioning, it is equally effective, the findings suggest, in training teams to improve performance on NTS. Debriefing and experiential learning play an important role in training teams, and simulation techniques provide a level of experiential learning beyond what is possible with didactic training. Experienced practitioners have a thorough grasp on technical skills, but often lack training, competence, and insight into their NTS, mastery of which is essential for improving reliability in health care organizations. Although simulation has been extensively used in simulation laboratories, it is not nearly as common in the actual patient unit, where teams deliver care and process flaws lurk undetected and unrecognized until they make themselves known by combining with other factors to cause injury.[61] This study suggests an important and expanded role for simulation techniques in improving the quality and safety of health care delivery processes. Simulation training techniques for NTS must be moved out of the laboratory and become part of the mainstream processes by which health care professionals are educated.

Limitations

The improved outcomes in the full-intervention hospital were the result of 11 simulation sessions. In contrast, only one didactic TeamSTEPPS session was held, and we did not examine whether the success achieved with multiple simulations could also be achieved with repetitive didactic sessions without the use of simulation. In addition, personnel departed and were hired during the course of this study at all three settings, and there was no assessment of the impact of these changes in professional staff. Although the hospitals randomly were assigned to each intervention, there were some differences that might have affected the outcomes, as suggested by a cluster analysis, such as number of births for obstetricians as compared to those for family practitioners. There is no way to know whether the reported effects can be attributed to other influences in this study. Given the difficulties of this type of design, there may be possible contamination effects (such as change of policy or change in personnel). The improved outcomes could be related to the greater willingness of a smaller, less busy obstetrical unit in which care is predominantly provided by obstetricians more willing to embrace the team concepts irrespective of the in-situ simulation intervention. This study was conducted in three smaller hospitals in suburban/outer rural areas, and the application of these findings to other settings is limited. Many features of larger hospitals, including less consistency between teams, more complex care processes, and higher-risk patients, were not explored in the settings where this study occurred. Moreover, the in-situ simulation is by definition, a replication of a critical event, not the event itself. No postsimulation assessment of the participants was conducted to determine the extent of perceived authenticity of the simulation experience. In addition, it is possible that the didactic TeamSTEPPS curriculum, which represented an abbreviated version of the four-to-six-hour workshop provided in a conventional TeamSTEPPS training session, did not constitute an adequate test of the TeamSTEPPS program. Finally, although there were no other safety initiatives going on in the obstetrics units of the participating hospitals, we are unaware of broader hospital-level safety initiatives that could have affected the perception of COS or the outcome data.

Conclusion

Although no hazardous industry has waited for unequivocal proof of the benefits of simulation training,[62] there has been little evidence that simulation training improves patient care.[17,27,63] This cohort study provides evidence that interdisciplinary in-situ simulation training is effective in decreasing perinatal morbidity and mortality for perinatal emergencies at a small-sized

community hospital. In-situ simulation is important for both the training of NTS and improving process design by uncovering latent conditions. This model of training should be further adapted for implementation at larger institutions and considered for application to other similar critical care scenarios. ▪ J

William Riley, Ph.D., is Associate Dean, University of Minnesota School of Public Health, Minneapolis. **Stanley Davis, M.D., i**s Medical Director of Teamwork and Simulation, Fairview Health Services, Minneapolis. **Kristi Miller, R.N., M.S.,** is System Director, Clinical Safety, Fairview Health Services. **Helen Hansen, Ph.D., R.N.,** is Associate Professor, University of Minnesota School of Nursing. **Francois Sainfort, Ph.D.,** is Professor, University of Minnesota School of Public Health. **Robert Sweet, M.D.,** is Associate Professor, Urologic Surgery Department, University of Minnesota Medical School. Please address correspondence to William Riley, riley001@umn.edu.

References

1. Leape L.L., et al.: Incidence of adverse events and negligence in hospitalized patients: Results of the Harvard Medical Practice Study II. *N Engl J Med* 324:377-384, Apr. 1991.
2. The Joint Commission: Sentinel Event Alert: Preventing infant death and injury during delivery. *Sentinel Event Alert,* Issue 30. Jul. 21, 2004. http://www.jointcommission.org/assets/1/18/SEA_30.PDF (last accessed Jun. 22, 20119).
3. Reinertsen J.L., et al.: Keeping our promises: Research, practice, and policy issues in health care reliability. *Health Serv Res* 41:1535–1538, Aug. 2006.
4. World Health Organization: *Neonatal and Perinatal Mortality*: *Country, Regional and Global Estimates.* 2004. http://www.who.int/making_pregnancy_safer/publications/neonatal.pdf (last accessed Jun. 22, 2011).
5. Mathews T.J., et al.: Infant mortality statistics from the 2005 period linked birth/infant death data set. *Natl Vital Stat Rep* 57:1–32, Apr. 2008
6. Yule S., et al.: Surgeons' non-technical skills in the operating room: Reliability testing of the NOTSS Behavior Rating System. *World J Surg* 32:548–556, Apr. 2007.
7. Paisley A.M., et al.: Validity of surgical simulation for the assessment of operative skill. *Br J Surg* 88:1525–1532, Nov. 2001.
8. Flin R., et al.: *Safety at the Sharp End*. Burlington, VT: Ashgate Publishing Company, 2008.
9. Institute of Medicine: *To Err Is Human*. Washington, D.C.: National Academy Press, 2000.
10. Rice-Simpson K., et al.: Adverse perinatal outcomes: Recognizing, understanding & preventing common accidents. *AWHONN Lifelines* 7:224–235, Jun.–Jul. 2003.
11. Reason J.: Understanding adverse events: The human factor. In Vincent C. (ed.): *Clinical Risk Management: Enhancing Patient Safety.* London: BMJ Books, 2001, pp. 9–30.
12. Riley W., et al.: Detecting breaches in defensive barriers using in-situ simulation for obstetric emergencies. *Qual Saf Health Care* 19(suppl. 3):i53–i56, Oct. 2010.
13. Baker D., et al.: The relation between teamwork and patient safety. In Carayon P. (ed.): *A Handbook of Human Factors and Ergonomics in Health Care and Patient Safety.* Mahwah, NJ: Lawrence Erlbaum, 2007.
14. Gaba D.M.: The future vision of simulation in health care. *Qual Saf Health Care* 13(supp. 1):i2–i10, Oct. 2004.
15. Leape L.L., et al.: Five years after To Err Is Human: What have we learned? *JAMA* 293:2384–2390, May 18, 2005.
16. Institute of Medicine: *Crossing the Quality Chasm.* Washington, D.C.: National Academy Press, 2001.
17. Robertson B., et al.: Simulation-based crisis team training for multidisciplinary obstetric providers. *Simul Healthc* 4:77–83, Summer 2009.
18. Dunn E.J., et al.: Medical team training: Applying crew resource management in the Veterans Health Administration. *Jt Comm J Qual Patient Saf* 33:317–325, Jun. 2007.
19. Gaba D.M., et al.: Simulation-based training in anesthesia crisis resource management: A decade of experience. *Simul Gaming* 32:175–193, Jun. 2001.
20. Shapiro M.J., et al.: Simulation based teamwork training for emergency department staff: Does it improve clinical team performance when added to an existing didactic teamwork curriculum? *Qual Saf Health Care* 13:417–421, Dec. 2004.
21. Thomas E.J., et al.: Teaching teamwork during the Neonatal Resuscitation Program: A randomized trial. *J Perinatol* 27:409–414, Jul. 2007.
22. Nielsen P.E., et al: Effects of teamwork training on adverse outcomes and process of care in labor and delivery. *Obstet Gynecol* 109:48–55, Jan. 2007.
23. Freeth D., et al.: Multidisciplinary obstetric simulated emergency scenarios (MOSES): Promoting patient safety in obstetrics with teamwork-focused interprofessional simulations. *J Contin Educ Health Prof* 29:98–104, Spring 2009.
24. Lamb D.: Could simulated emergency procedures practiced in a static environment improve the clinical performance of a Critical Care Air Support Team (CCAST)? A literature review. *Intensive Crit Care Nurs* 23:33–42, Feb. 2007.
25. Chaer R.A., et al.: Simulation improves resident performance in catheter-based intervention: Results of a randomized, controlled study. *Ann Surg* 244:343–352, Sep. 2006.
26. Riley W., et al.: The nature, characteristics and patterns of perinatal critical events teams. In *Advances in Patient Safety: New Directions and Administrative Approaches,* pp. 131–144. Washington, D.C.: Agency for Healthcare Research and Quality, 2008. http://www.ahrq.gov/downloads/pub/advances2/vol3/advances-riley_58.pdf (last accessed Jun. 23, 2011).
27. Jha A.K., et al.: Simulator-based training and patient safety. In Shojania K.G., et al. (eds.): *Making Health Care Safer: A Critical Analysis of Patient Safety Practices.* Evidence Report/Technology Assessment, No. 43. Agency for Healthcare Research and Quality, 2001. http://archive.ahrq.gov/clinic/ptsafety/chap45.htm (last accessed Jun. 23, 2011).
28. Miller K.K., et al.: In-situ simulation: A method of experiential learning to promote safety and team behavior. *J Perinat Neonatal Nurs* 22:105–113, Apr.–Jun. 2008.
29. Agency for Healthcare Research and Quality: *TeamSTEPPS®: National Implementation.* http://teamstepps.ahrq.gov/index.htm (last accessed Jun. 23, 2011).
30. Riley W., et al.: A model for developing high reliability teams. *J Nurs Manag* 18:556–563, Jul. 2010.
31. Reason J.: Human error: Models and management. *Br Med J* 320(7237):768–770, Mar. 18, 2001.
32. Miller K., et al.: Identifying key nursing and team behaviors to achieve high reliability. *J Nurs Manag* 17:247–255, Mar. 2009.
33. Hamman W.R.: The complexity of team training: What we have learned from aviation and its applications to medicine. *Qual Saf Health Care* 13(suppl. 1):i72–i79, Oct. 2004.
34. Hamman W.R.: Will simulation fly in medicine as it has in aviation? *Qual Saf Health Care* 13:397–399, Jul. 2004.
35. Mann S., et al.: Assessing quality in obstetrical care: Development of standardized measures. *Jt Comm J Qual Patient Saf* 32:497–505, Sep. 2006.

36. Novicoff W.M., et al.: Initial development of a system-wide maternal-fetal outcomes assessment program. *Am J Obstet Gynecol* 183:291–300, Aug. 2000.

37. Sexton J.B., et al.: The Safety Attitudes Questionnaire: Psychometric properties, benchmarking data, and emerging research. *BMC Health Serv Res* 6:44–49, Apr. 2006.

38. Pratt S.D., et al.: Impact of CRM-based team training on obstetric outcomes and clinician's patient safety attitudes. *Jt Comm J Qual Patient Saf* 33:720–725, Dec. 2007.

39. Woodall W.H.: The use of control charts in health-care and public-health surveillance. *J Qual Tech* 38(2): 89–104, Apr. 2006.

40. Boe D.T., Riley W., Parsons H.: *Am J Public Health* 99:1619–1625, Sep. 2009.

41. Lee K., McGreevey C.: Using control charts to assess performance measurement data. *Jt Comm J Qual Improv* 28:90–101, Feb. 2002.

42. Wheeler D.J.: *Understanding Variation: The Key to Managing Chaos,* 2nd ed. Knoxville, TN: SPC Press, 2000.

43. Zimmerman S.M., Icenogle M.L.: *Statistical Quality Control Using Excel,* 2nd ed. Milwaukee: ASQ Quality Press, 2003.

44. Hart M.K., Hart R.F.: *Statistical Process Control for Health Care.* Duxbury, MA: Thomson Learning, 2002.

45. Carey R.G.: *Improving Healthcare With Control Charts: Basic and Advanced SPC Methods and Case Studies*. Milwaukee: ASQ Quality Press, 2003.

46. Le C.T.: *Introductory Biostatistics*. Hoboken, NJ: John Wiley & Sons Inc., 2003.

47. Wheeler D.J.: *Advanced Topics in Statistical Process Control: The Power of Shewhart's Charts.* Knoxville, TN: SPC Press, 2004.

48. McClave J.T., Sincich T.: *Statistics,* 8th ed. Upper Saddle River, NJ: Prentice-Hall Inc., 2000.

49. Nolan T., et al.: *Improving the Reliability of Health Care.* IHI Innovation Series white paper. Boston: Institute for Healthcare Improvement, 2004. (available at http://www.IHI.org)

50. Institute of Medicine: *Patient Safety: Achieving a New Standard for Care.* Washington, D.C.: National Academy Press, 2004.

51. Pronovost P.J., et al.: Evaluation of the culture of safety: Survey of clinicians and managers in an academic medical center. *Qual Saf Health Care* 12:405–410, Dec. 2003.

52. Firth-Cozens J.: Evaluating the culture of safety. *Qual Saf Health Care* 12:401, Dec. 2003.

53. McFerran S., et al.: Perinatal patient safety project: A multicenter approach to improve performance reliability at Kaiser Permanente. *J Perinat Neonatal Nurs* 19:37–45, Jan.–Mar. 2005.

54. Montgomery D.C.: *Introduction to Statistical Quality Control,* 5th ed. Hoboken, NJ: John Wiley & Sons Inc., 2005.

55. Institute of Medicine: *To Err Is Human: Building a Safer Health System.* Washington, DC: National Academy Press, 2000.

56. Berwick D.M.: *Escape Fire: Designs for the Future of Healthcare*. San Francisco: John Wiley & Sons, 2002.

57. Wachter R.M.: Patient safety at ten: Unmistakable progress, troubling gaps. *Health Aff (Millwood)* 29:65–173, Jan.–Feb. 2010.

58. Lighter D.E., Fair D.C.: *Quality Management in Health Care: Principles and Methods,* 2nd ed. Sudbury, MA: Jones & Bartlett Publishers, 2004.

59. Draycott T., et al.: Does training in OB emergencies improve neonatal outcome? *BJOG* 113:177–182, Feb. 2006.

60. Knowles M.S.: *Andragogy in Action: Applying Modern Principles of Adult Education*. San Francisco: Jossey-Bass, 1984.

61. Maran N.J., et al.: Low- to high-fidelity simulation: A continuum of medical education? *Med Educ* 37:22–28, Nov. 2003.

62. Gaba D.M.: Improving anesthesiologists' performance by simulating reality. *Anesthesiology* 76:491–494, Apr. 1992.

63. Rodriguez-Paz J.M., et al.: Beyond "see one, do one, teach one": Toward a different training paradigm. *Qual Saf Health Care* 18:63–68, May 2009.

Teamwork and Communication

Evaluating Efforts to Optimize TeamSTEPPS Implementation in Surgical and Pediatric Intensive Care Units

Celeste M. Mayer, Ph.D., R.N.; Laurie Cluff, Ph.D.; Wei-Ting Lin, R.N., Ph.D.; Tina Schade Willis, M.D.; Renae E. Stafford, M.D., M.P.H.; Christa Williams, R.N., B.S.N.; Roger Saunders, R.N., M.S.N., N.E.A.-B.C.; Kathy A. Short, R.R.T., R.N.; Nancy Lenfestey, M.H.A.; Heather L. Kane, Ph.D.; Jacqueline B. Amoozegar, M.S.P.H.

Teamwork training is a well-established practice in high-risk environments such as military operations and aviation[1] and is likely one of the factors that has led to a significant reduction in commercial aviation accidents.[2] In health care, the Institute of Medicine[3] has recommended establishing interdisciplinary team training programs as one means to improve patient safety. Optimum team performance in health care can only be achieved when team members clearly understand the goal and performance expectations and communicate through shared language. This kind of teamwork does not occur consistently in health care, as reflected in the identification of communication breakdowns and inadequate leadership as leading contributing factors to sentinel events.[4]

The TeamSTEPPS® system was developed specifically for health care professionals by the U.S. Department of Defense's Patient Safety Program in collaboration with the Agency for Healthcare Research and Quality (AHRQ) on the basis of 20 years of research on team training from the military, aviation, and health care. TeamSTEPPS, which has been implemented in a variety of clinical settings,[5,6] focuses on four core areas of competency: team leadership, situation monitoring, mutual support, and communication.[7]

In September 2007 we were awarded a two-year AHRQ contract (TeamSTEPPS: Adoption in Action) to implement TeamSTEPPS in two microsystems and evaluate its effect on team performance and patient outcomes. We selected the pediatric intensive care unit (PICU) and the surgical intensive care unit (SICU) for implementation because both units are high-intensity, complex environments with strong physician/nurse leaders who had successfully led organization change at our institution. Because maximizing the potential for early success would be valuable for future organizational spread, these two units were selected, as they fit the description of early-adopter units.[8,9]

Given the comprehensiveness of the TeamSTEPPS training system, we believed that all aspects of teamwork would be im-

Article-at-a-Glance

Background: An evidence-based teamwork system, TeamSTEPPS®, was implemented in an academic medical center's pediatric and surgical ICUs.

Methods: A multidisciplinary change team of unit- and department-based leaders was formed to champion the initiative; develop a customized action plan for implementation; train frontline staff; and identify process, team outcome, and clinical outcome objectives for the intervention. The evaluation consisted of interviews with key staff, teamwork observations, staff surveys, and clinical outcome data.

Results: All PICU, SICU, and respiratory therapy staff received TeamSTEPPS training. Staff reported improved experience of teamwork posttraining and evaluated the implementation as effective. Observed team performance significantly improved for all core areas of competency at 1 month postimplementation and remained significantly improved for most of the core areas of competency at 6 and 12 months postimplementation. Survey data indicated improvements in staff perceptions of teamwork and communication openness in both units. From pre- to posttraining, the average time for placing patients on extracorporeal membrane oxygenation (ECMO) decreased significantly. The average duration of adult surgery rapid response team events was 33% longer at postimplementation versus pre-implementation. The rate of nosocomial infections at postimplementation was below the upper control limit for seven out of eight months in both the PICU and the SICU.

Conclusions: The implementation of a customized 2.5-hour version of the TeamSTEPPS training program in two areas—the PICU and SICU—that had demonstrated successful ability to innovate suggests that the training was successful.

proved and that this change would be reflected in both process and outcome measures related to discrete patient care events requiring teamwork, specifically adult and pediatric rapid response team (RRT) calls and extracorporeal membrane oxygenation (ECMO). We also thought that improved teamwork would improve the day-to-day patient care activities that affect nosocomial infection rates. This article describes the implementation of the project.

Methods

SETTING AND PARTICIPANTS

The PICU is a 20-bed facility with all areas of pediatric medical and surgical subspecialty care available. The SICU is a 16-bed unit that provides care to critically ill adult surgical patients. The units include the physician, nurse, and respiratory therapist teams that respond to pediatric or adult surgical RRT calls and are the only two units in the hospital performing ECMO.

When implementation began, the PICU and SICU had 5 and 7 attending physicians and 80 and 77 nursing staff, respectively. We included respiratory therapy staff (90 therapists) in the implementation because of their critical team role in both units.

INTERVENTION DESIGN AND IMPLEMENTATION

The intervention followed the seven evidence-based success factors for preparing, implementing, and sustaining a team training initiative, as described by Salas and colleagues[10] (Table 1, page 367).

Using the TeamSTEPPS Implementation Guide,[11] we developed a customized action plan for implementing TeamSTEPPS in the PICU and SICU. We established a 17-member change team of 5 PICU and SICU nurses (managers [R.E.S., C.W] and staff), 6 physicians (medical directors [T.S.W., R.E.S] and fellows), 5 respiratory therapists (director [K.A.S] and staff) and the patient safety officer [C.M.M]. All change team members completed 2.5-day TeamSTEPPS Master Training at one of the National Implementation Resource Training Centers and committed to teaching and ongoing coaching of TeamSTEPPS to frontline staff.

The change team met biweekly to complete the action planning process and served as the steering group for the implementation, trainers of frontline staff, and unit-based coaches after the training. To complete training for all PICU, SICU and respiratory therapy staff, the team provided more than 40 group training sessions, with 5 to 10 participants in each, during an 8-week period.

The change team customized the TeamSTEPPS fundamen-

tals curriculum[11] to develop a training program for frontline staff that required minimal time away from the bedside (Appendix 1, available in online article). The change team determined that minimizing staff time away from clinical work required creative redesign of the training approach and hoped to offset any potential diminished training impact with careful attention to the success factors for implementing a team training initiative and providing informal on-the-job reinforcement. Although the TeamSTEPPS fundamentals curriculum is designed as a 4- to 6-hour course, the TeamSTEPPS developers acknowledge that little is known about the best approach to teaching the material.[12] In addition, a recent review of approaches of classroom-based team training identified wide variation in training design.[13] In part, this project and its results are a test of our specific customization.

EVALUATION METHODS

During the planning stage, the change team set process, team outcome, and clinical outcome objectives for the intervention and indicators for assessing progress toward objectives. The multimethod pre- and postimplementation evaluation included the following four components:

1. Interviews with key staff involved in and affected by the TeamSTEPPS initiative
2. Direct observations of teamwork
3. Organizational staff surveys
4. Clinical outcome data
Table 2 (page 367) lists the objectives, assessment methods, and data collection timing for the project.

Staff Interviews. Using semistructured interview guides, we conducted pre- and postimplementation interviews addressing components of teamwork aligned with the training and our outcome objectives, including foundation (for example, vision, mission, goals); functioning (cohesiveness, efficiency of team meetings); performance; skills; leadership; climate and atmosphere (trust, morale); and identity (individual sentiments about the team's image and dynamics). We interviewed a cross-section of staff in various roles in the SICU and PICU (Table 3, page 368). Because the interviews were intended to provide rich qualitative data about the impact of the TeamSTEPPS implementation at the group level, we did not attempt to interview the same individuals at both times, although there was some overlap. We also interviewed the patient safety officer and the project's clinical observer to learn about their observations related to TeamSTEPPS implementation. Our goal for these interviews was to gain a more in-depth understanding of the staff's perception of teamwork within the respective unit and potential opportuni-

Table 1. Implementation Strategies for Team Training Success Factors*

Success Factor	Implementation Strategy
1. Align team training objectives and safety aims with organizational goals.	Communication to organizational leaders and unit staff linked potential impact of teamwork on meeting organizational goals for employee satisfaction, patient satisfaction, and quality of care.
2. Provide organizational support for the team training initiative.	The patient safety officer and a program manager each dedicated 40% effort to this project. Physician, nurse, and respiratory therapy senior leaders approved change team members' time on the project. Continuing education units for nurses, physicians, and respiratory therapists was approved and provided.
3. Get frontline care leaders on board.	Both formal and informal unit leaders were recruited for active involvement in the project, either through inclusion in change team or determining best approach and timing for training. Individuals were recognized for involvement by wearing TeamSTEPPS badges that identified them as Team-STEPPS Master Trainers (Coach badge) or participants (Ready badge).
4. Prepare the environment and trainees for team training.	Before training and during regular staff meetings, we provided trainees with information about why the unit was selected, what training would be provided, and expected outcomes. In addition, TeamSTEPPS was framed as a way to standardize and increase consistency of already good team performance as opposed to implementation for remediation purposes.
5. Determine required resources and time commitment and ensure their availability.	Training sessions were scheduled at times that would minimize schedule disruptions for staff and were offered on all shifts and days of the week. If needed, overtime training hours were budgeted and approved.
6. Facilitate application of trained teamwork skills on the job.	Staff were trained together in interdisciplinary groups to remove hierarchy barriers. The training included an opportunity to practice, and, following training, unit-based change team leaders modeled and encouraged use of TeamSTEPPS skills. Multiple reinforcement aids were developed and used (for example, chocolates with TeamSTEPPS labels were handed out after good teamwork events and TeamSTEPPS note cards were printed to provide a handwritten note of recognition for good teamwork).
7. Measure the effectiveness of the team training program.	Metrics of success were identified early and periodically reported back to staff. Training effectiveness was measured on multiple levels.

* The team training success factors were described in Salas E., et al.: What are the critical success factors for team training in health care? *Jt Comm J Qual Patient Saf* 35:398–405, Aug. 2009.

Table 2. Objectives, Assessment Methods, and Data Collection Timing*

Objectives	Assessment Methods	Data Collection Timing
Process Objectives		
All PICU and SICU staff will receive TeamSTEPPS training.	Using records of attendance, count the number of staff from each unit who attended training sessions.	Completion of staff training
Team Outcome Objectives		
Improve teamwork performance.	Interviews, clinical observation	Baseline pre-training; posttraining at 1, 6, and 12 months posttraining
Improve staff perceptions of teamwork	Survey data from HSOPSC, EOS,and NDNQI	HSOPSC (Jul. 2006, Jun. 2008, Dec. 2009) EOS (Jun. 2007, Apr. 2008, Jul. 2009) NDNQI (Sep. 2007 and May 2009)
Clinical Outcome Objectives		
Decrease in the average time for placing patients on ECMO	Clinical timing data	Six months pre-training versus same six-month posttraining (Dec. 2007–May 2008 versus Dec. 2008–May 2009)
Decrease in the average time for SICU RRT events only	Clinical timing data	Six months pre-training versus same six-month posttraining and 12 months posttraining (Dec. 2007–May 2008 versus Dec. 2008–May 2009 and Jun. 2009–Nov. 2009)
Decrease in nosocomial infections	Clinical infection data	Eight months pre-training versus same eight-month posttraining (Dec. 2007–May 2008 versus Dec. 2008–May 2009)

* PICU, pediatric ICU; SICU, surgical ICU; HSOPSC, Hospital Survey on Patient Safety Culture; EOS, Employee Opinion Survey; NDNQI, National Database on Nursing Quality Indicators Survey; ECMO, extracorporeal membrane oxygenation; RRT, rapid response team.

Table 3. Number of Interview Participants by Primary Role and Unit at Baseline and Postimplementation*					
	No. of Pre-Implementation Interviews		No. of Postimplementation Interviews		Total
	PICU	SICU	PICU	SICU	
Nurses	3	3	4	4	14
Physicians	3	3	3	3	12
RTs	2	2	1	1	6
Total	8	8	8	8	32

* PICU, pediatric ICU; SICU, surgical ICU; RT, respiratory therapist.

ties for improvement. Interviews covered implementation issues with the staff involved in and affected by the actual implementation process.

With the participants' permission, we recorded the interviews using digital audio recorders. Detailed transcripts capturing the language used by participants were generated following each interview for analysis. We coded the interview transcripts using NVivo 8 (QSR International, Cambridge, Massachusetts). The coding scheme used the same themes as the interview guides, and we created free nodes to capture emerging themes.

Clinical Observation of Teamwork Performance. A master TeamSTEPPS-prepared nurse [W.T.L.] served as the project's clinical observer. The observer's medical training background equipped her with a thorough understanding of the targeted team procedures and medical terminology. She attended change team meetings, TeamSTEPPS master training, and some of the instructor-led TeamSTEPPS training sessions conducted by the master trainers.

Observations of distinct team activities in the PICU and SICU were conducted at three months before the start of TeamSTEPPS training ($n = 56$), and then at 1($n =38$), 6 ($n = 47$), and 12 ($n =54$) months posttraining. Team activities included RRT, ECMO, admissions, and rounds. Observations were scored using the Teamwork Evaluation of Non-Technical Skills (TENTS)[14] observation tool, which has a five-point rating scale of six elements (Table 4, page 369). At the time of the project, several similar observation tools were publically available, yet none had (at press time) or has published validity and reliability testing. The TENTS tool focus matched the four core teamwork competencies and used the TeamSTEPPS language in the exemplars for the four core teamwork competencies. Before making the baseline observations, the clinical observer and the patient safety officer jointly observed five team events to calibrate themselves on the TENTS observation tool and to check their interrater reliability. They contacted the primary author of the TENTS tool for clarification on a few points. Their interrater

agreement was 96%. As a reliability check before the 12-month observation period, the raters again jointly observed four team events and found their interrater agreement to be 71%. Although the clinical observer completed all the observations used for analysis, the dual observations served as a check for unintended observer bias that may have developed over time.

In all team events, some manifestation of the four core teamwork competencies should be observable. To test whether the observed team performance had significantly improved, we ran separate regression models for each of the six elements as the dependent variable. The ratings from the PICU and SICU were combined because the greater number of observations provided the power needed for the analyses and because there is no theoretical basis for expecting TeamSTEPPS to affect one unit differently than the other unit. In fact, preliminary analyses of baseline observations found no significant differences in teamwork between the two units. In each model, the unit (PICU versus SICU), the size of the team, and the type of team procedure observed was controlled. In addition, during the study period, team members remained constant in their roles in both units.

Organizational Staff Surveys. Independent of the TeamSTEPPS intervention, the hospital administered three surveys during the project: the AHRQ Hospital Survey on Patient Safety Culture (HSOPSC),[15] an employee opinion survey (EOS),[16] and the National Database of Nursing Quality Indicators (NDNQI) Survey[17] (Table 5, page 369).

■ The HSOPSC measures dimensions that contribute to the perception of a patient safety culture and is completed by physicians and all other staff. A dimension score is composed of responses to three or four questions.

■ The EOS assesses staff (but not physician) opinions and concerns about the strengths and weaknesses of the work unit.

■ The NDNQI Survey assesses job satisfaction, job plans for next year, perceived quality of care, unit orientation, hospital recommendation, and other issues.

The surveys were administered in their entirety at each indi-

Table 4. Elements of the Teamwork Evaluation of Nontechnical Skills Observation Tool	
Element	**Behaviors Observed**
Communication	Asks questions, uses appropriate critical language
Leadership	Establishes event leader, delegates as appropriate
Situation monitoring	Visually scans environment, cross monitors activities
Mutual support/assertion	Secures additional resources, supports others
Overall teamwork	How well the team performs together overall
Overall leadership	The team's response to the team leader overall

Table 5. Survey Administration Dates, Sample Size, and Response Rate*				
			Sample Size (Response Rate)	
Survey	**Intervention Stage**	**Administration Date**	**PICU**	**SICU**
EOS	Pre-implementation	Jun. 2007	50 (67%)	34 (47%)
	Midimplementation	Apr. 2008	29 (36%)	37 (48%)
	Postimplementation	Jul. 2009	35 (41%)	30 (37%)
HSOPSC	Pre-implementation	Jun. 2006	18 (21%)	18 (22%)
	Midimplementation	Jun. 2008	35 (39%)	37 (43%)
	Postimplementation	Dec. 2009	47 (50%)	40 (44%)
NDNQI	Pre-implementation	Sep. 2007	37 (73%)	17 (43%)
	Postimplementation	May 2009	48 (74%)	38 (60%)

* PICU, pediatric ICU; SICU, surgical ICU; EOS, Employee Opinion Survey; HSOPSC, Hospital Survey on Patient Safety Culture; NDNQI, National Database on Nursing Quality Indicators Survey.

cated time frame, but for the purposes of this research, we report results only for the specific dimensions (in the case of the HSOPSC) or specific survey items that most closely relate to teamwork and the outcomes of interest, as follows:

■ The dimensions selected from the HSOPSC were Teamwork Within Units, Overall Perceptions of Safety, and Communication Openness (Cronbach's alpha of .83, .74, and .72, respectively[15]).

■ The items selected from the EOS were Different units work well together, My unit works well together, and Physician and staff work well together.

■ The items selected from the NDNQI were teamwork between co-workers, registered nurse (RN)–RN interactions, and RN–physician (MD) interactions.

Limitations of each survey include the sample size, response rates, and the administration time frames relative to our implementation time frame. Nonetheless, we consider the data as one part of the larger picture of how the environment and staff perceptions changed after these units implemented TeamSTEPPS.

The staff surveys (HSOPSC and EOS) were analyzed using ANOVA and, when appropriate, the Kruskal-Wallis test was used depending on the equal variances of the variables. Pairwise comparisons were also conducted. A group made of a random sample from the entire set of University of North Carolina Health Care System (UNCHCS) HSOPSC responses was created for the same dimensions for use as a comparison group. Only descriptive statistics for the NDNQI survey are provided. The NDNQI values represent modified T-scores with 50 representing the midpoint.

Clinical Outcomes. Hospital-collected performance data were used to analyze change in the three clinical outcomes. Aggregate-level and de-identified clinical data on outcomes included the length of time required from deployment of the ECMO team to placing the patient on ECMO, duration of pediatric and adult RRT events, and the rate (percent of infected patients) of nosocomial infections in the units. The mean number of minutes for RRT activity and the rate of nosocomial infections was calculated to reflect changes in performance pre- and postimplementation. The Mann-Whitney U test was conducted to analyze changes in the ECMO activity.

Table 6. Test Statistics for Observations of Teamwork Performance			
Teamwork Elements	Baseline versus 1 Month	Baseline versus 6 Months	Baseline versus 12 Months
Communication (d = .17–.28)	t (1, 94) = –3.10 p = .0026	t (1, 86) = –1.27 p =.2065	t (1, 81) = –3.06 p = .0030
Leadership (d = .18–.39)	t (1, 99) = –5.61 p < .0001	t (1, 90) = –1.98 p = .0513	t (1, 85) = –5.06 p < .0001
Situation Monitoring (d = .27–.35)	t (1, 101) = –2.80 p = .0061	t (1, 93) = 0.81 p = .4227	t (1, 88) = –1.79 p = .0772
Mutual Support (d = .11–.37)	t (1, 97) = –6.20 p < .0001	t (1, 88) = –2.28 p = .0248	t (1, 82) = –4.67 p < .0001
Overall Teamwork (d = .04–.18)	t (1, 101) = –3.49 p = .0007	t (1, 93) = –0.29 p = .7705	t (1, 88) = –3.78 p = .0003
Overall Leadership (d = .15–.21)	t (1, 99) = –5.49 p < .0001	t (1, 91) = –3.18 p = .0020	t (1, 85) = 4.79 p < .0001

* d = Cohen's d (effect size).

Results

STAFF INTERVIEWS

For almost all staff, postimplementation interviews indicated improved experience of teamwork and evaluation of the implementation as effective. However, for RRT events, in which TeamSTEPPS-trained SICU team members served as RRT responders, SICU staff reported that working with staff who had not been trained in TeamSTEPPS skills was detrimental to teamwork performance.

At baseline, role clarity was seen as an area for improvement in both units. During the postimplementation interviews, several respondents indicated that role clarity had improved along with communication among teams in the PICU and with groups outside the PICU. Most SICU respondents indicated that roles and responsibilities were clearer and that team members often identified themselves as they "enter" an event and have clearer assignments.

The effectiveness of team leadership was described as variable in the pre-implementation interviews, with some staff indicating that the leader of an event was not always identified in a straightforward manner, with the most assertive team member therefore often assuming the leadership role. Perceptions regarding team leadership at postimplementation were more positive in both units, with determination of the leadership role for an event proceeding more deliberately and appropriately. Perceptions of team morale and trust expressed during the postimplementation interviews were more positive than at pre-implementation. Respondents specifically noted improvement in overall communication and the ability to openly communicate concerns.

During the postimplementation interviews, respondents and the clinical observer reported regular use of TeamSTEPPS tools.

Some respondents described improved relations between physicians and nurses and overall improved mutual support.*

CLINICAL OBSERVATION OF TEAMWORK PERFORMANCE

The analyses of observed team performance were conducted using mixed models with four time periods, four team activities (4 to 10 observations of each), and two units. We also controlled for the size of the team. Cohen's d (effect size)—.04–.39—was small to medium.[18] The observed team performance for each of the six elements significantly improved when measured at one month postimplementation (p < .0001–.0061). At six months postimplementation, observed team performance for leadership, mutual support, and overall leadership remained significantly improved from baseline (p < .05, .03, and .002, respectively). The remaining three elements—communication, situation monitoring and overall teamwork——were not significantly different from baseline. The mean TENTS ratings increased again during the 12-month observation and, except for situation monitoring (p = .08), were again significantly improved compared with baseline (p < .0001–.0003; Appendix 2, available in online article; Table 6, above).

ORGANIZATIONAL SURVEYS

HSOPSC. The three HSOPSC dimensions across the three time periods and three areas (PICU, SICU, and the UNCHCS random sample) were analyzed using the Kruskal-Wallis test. Cohen's d—.18–.64—was small to medium. For the PICU, there was no significant change in the median values for Team-

* Full reporting and analysis of the interviews are not provided in this article.

Table 7. NDNQI Survey Results by Teamwork-Related Dimensions for SICU, PICU and All UNCHCS Nursing Units by Time Period*						
	All UNCHCS Nursing Units		PICU		SICU	
NDNQI Indicator Dimensions	**2007**	**2009**	**2007**	**2009**	**2007**	**2009**
Teamwork between coworkers	70	73	78	80	66	73
RN-RN Interactions	66	70	74	77	67	72
RN-MD Interactions	59	61	59	66	57	64

* NDNQI, National Database on Nursing Quality Indicators Survey; PICU, pediatric ICU; SICU, surgical ICU; RN, registered nurse; MD, physician.

work Within Unit over time. However, there was a significant improvement in median values for Overall Perceptions of Safety (F [2, 95] = 4.63, p = .01—2009 better than 2006 and 2008, p < .01) and Communication Openness (F [2, 95] = 22.99, p < .01)—2009 better than 2006 and 2008, both p < .01) (Figure 1, page 372).

For the SICU, there was a significant improvement in the median values for Teamwork Within Unit (F [2, 89] = 0.41, p = .04—2009 better than 2006, p = .02), a significant improvement in median values for Overall Perceptions of Safety (F [2, 89] = 5.39, p = .01—2009 better than 2006, p = .01), and significant improvement in the median values for Communication Openness (F [2, 88] = 16.28, p < .01—2009 better than 2006 and 2008, both p < .01).

Finally, for the comparison group, there was no significant change in the median values for Teamwork Within Unit. There was, however, a significant improvement in the median values for Overall Perception of Safety (x^2 [2, N = 140] = 19.31, p = 0.03—2009 better than 2006 and 2008, both < .01) and Communication Openness (x^2 [2, N = 140] = 28.92, p < .01)—2009 better than 2006 and 2008, both p <. 01.

EOS. Three EOS statements across three time periods, and three areas (PICU, SICU, and the UNCHCS random sample) were analyzed using the Kruskal-Wallis test. For the PICU, there was a significant difference in the values for the statement "My work unit works well together" (F [2, 109]= 3.38, p = .04—2008 better than 2007, p = .03) with no other significant difference seen over time for the other two statements. For the SICU, there was no significant difference in the values for any statements over time. For the UNCHCS random sample, there was a significant difference in the values for the statement "Physicians and staff work well together (x^2 [2, N = 126] = 7.96, p = .02—2009 better than 2007, p < .01) with no other significant difference seen

* The NDNQI survey is a proprietary survey, and raw data were not available for statistical analysis; therefore, only the mean scores were available for review.

over time for the other two statements (Figure 2, page 372). Cohen's d—.16–.28—was small.

NDNQI. Mean scores* from the NDNQI showed small increases postimplementation in nurses' perceptions of teamwork in the PICU and SICU and in RN-RN and RN-MD interactions, with the greatest increases for RN-RN interactions in SICU and RN-MD interactions for both PICU and SICU, as shown in Table 7 (above); changes in the same dimensions for all UNCHCS nursing units are also shown.

CLINICAL OUTCOMES

Average Time for Placing Patients on ECMO. The Mann-Whitney U test was used to analyze the ECMO data. The results indicated that the posttraining number of minutes from the ECMO team activation (decision to place patient on ECMO) to placing a patient on ECMO (mean, 13.96) was a significantly lower time than the pre-training value of 23.00 (z = –2.36, p = .02; Figure 3 [page 373]). Cohen's d—0.34—was small. In interviews, SICU staff described more consistent use of briefing and debriefing (TeamSTEPPS tools) before and after ECMO events. Briefing and debriefing skills were emphasized in both units through modeling behavior and by making easy-to-use guides readily available. One SICU staff member commented as follows:

> At the very beginning, before the patient gets in the room, we have figured out how many nurses we need to take care of the patient, the physician is there, and the two main respiratory therapists are there. The doctor tells everyone who is doing what and when. We start in the very beginning even before the patient gets there.

Length of RRT Events. No significant difference was found in the mean response time for the adult surgery and pediatric RRT from pre- to postimplementation. In postimplementation interviews, many SICU RRT staff reported that it was challenging to use the TeamSTEPPS skills that they had learned when respond-

Pediatric ICU, Surgical SICU, and Overall Mean Scores for Three Dimensions of the Hospital Survey on Patient Safety Culture at Pre- (2007), Mid- (2008), and Postimplementation (2009)
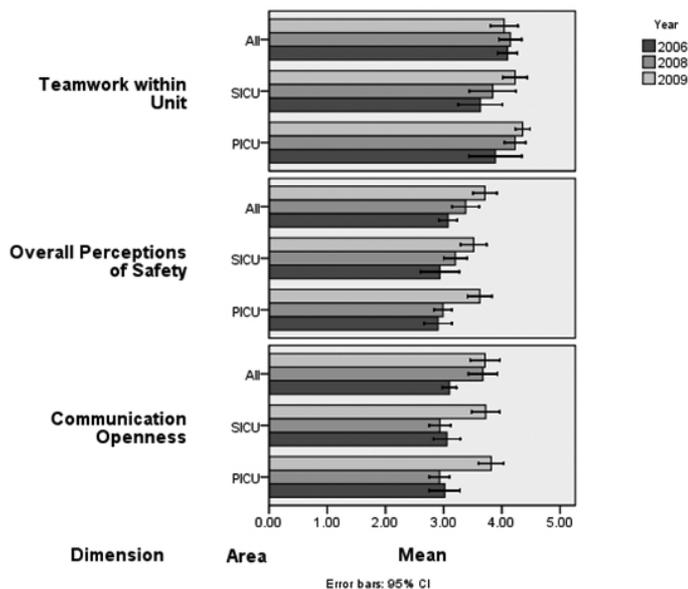

Figure 1. *Significant differences were observed over time in the pediatric ICU (PICU) for Overall Perceptions of Safety and Communication Openness, in the surgical ICU (SICU) for Teamwork within Unit, Overall Perceptions of Safety and Communication Openness, and in the organization overall for Overall Perceptions of Safety and Communication Openness.*

Pediatric ICU, Surgical SICU, and Overall Mean Scores for Three Questions of the Employee Opinion Survey at Pre- (2007), Mid- (2008), and Postimplementation (2009)
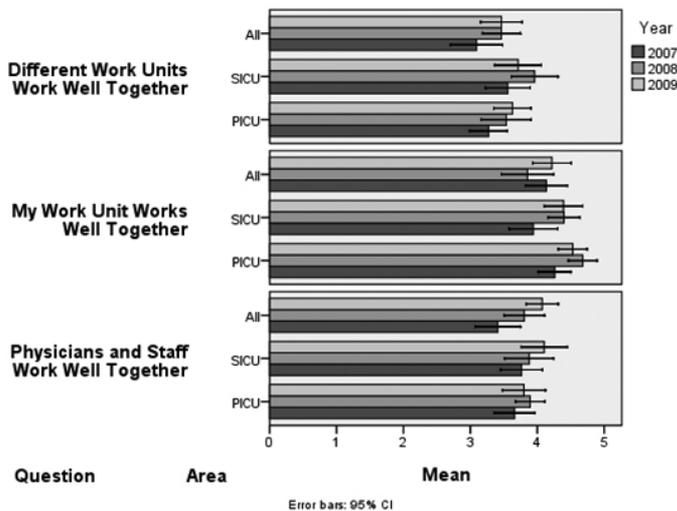
Figure 2. *Significant differences were observed over time in the pediatric ICU (PICU) for "My work unit works well together." No significant differences were seen for the surgical ICU (ICU). In the organization overall, significant differences were observed for "Physicians and staff work well together."*

ing to RRT events involving primary staff at the bedside in areas where staff had not been trained in TeamSTEPPS. One staff member commented as follows:

> With rapid response, it's more difficult because you are on a time constraint, and you are on a floor, and you don't know the nurses and the people involved. There are many more that show up, whereas in the SICU you have the essential people there, and you know everyone, and there is a lot more confusion with rapid responses (especially in the first few minutes) compared to anything that goes on in the SICU.

Nosocomial Infections. Nosocomial infections were expected to decrease because infection prevention measures require coordinated teamwork and communication. For both the SICU and PICU, the percentage of infections was lower than the 2009 upper control limit (UCL) for seven of the eight postimplementation months. (We selected the same months to account for sea-

sonal variation.) Both units are actively engaged in multiple improvement projects designed to reduce infections. The contribution of teamwork, however, is expected to be complimentary to these efforts.[19]

As shown in Figure 4 (page 373), the rate of infected patients per month in the PICU decreased in all postimplementation months except for April 2009. As shown in Figure 5 (page 373), the percent of infected patients per month in the SICU decreased in the postimplementation months of December, January, and February 2009.

Discussion

The implementation of a customized 2.5-hour version of the TeamSTEPPS training program in two areas—the PICU and SICU—that had demonstrated successful ability to innovate suggests that the training was successful. The interview data analysis indicates that implementation was perceived positively. Following implementation, significant improvements were found postimplementation at 1 month and 12 months for teamwork behavior via observations of a variety of teamwork events,

Mean Time from Activation of Extracorporeal Membrane Oxygenation (ECMO) Team to Starting ECMO for Pre- and Postimplementation
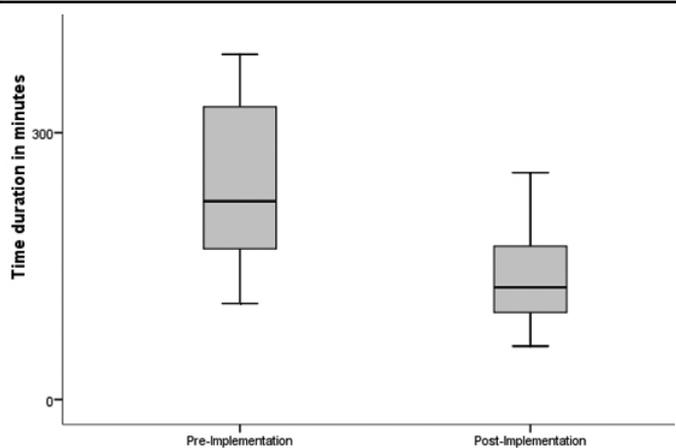
Figure 3. *The mean time from extracorporeal membrane oxygenation (ECMO) team activation to starting the patient on ECMO in the pediatric ICU (PICU) and surgical ICU (SICU) significantly decreased from the pre- to postimplementation time period.*

## Nosocomial Infections in the Pediatric ICU (PICU) Pre- and Postimplementation, November 2007–June 2009
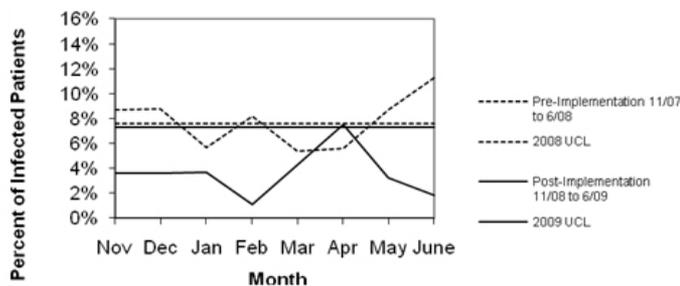
Figure 4. *The percent of infected patients per month in the PICU decreased in all postimplementation months except April.*

and at 12 months for an ECMO team process measure. Organizational survey data across three surveys and three time periods also indicated a positive change in the perception of dimensions and items associated with teamwork.

Although training sessions of similar duration have led to positive outcomes,[5,20] the majority of studies have used more than four hours of training.[13,21] An increase in employee perception of teamwork has been found elsewhere,[5,22] yet this is the first study

Nosocomial Infections in the Surgical ICU (SICU) Pre- and Postimplementation, November 2007–June 2009
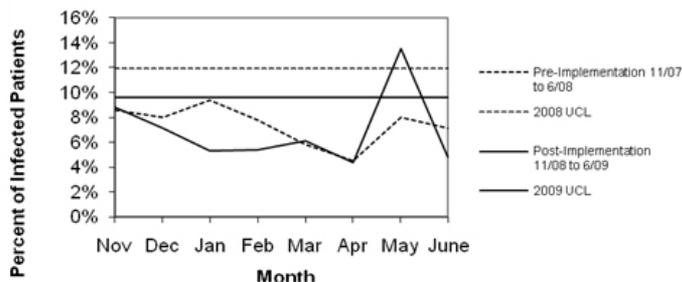
Figure 5. *The percent of infected patients per month in the SICU decreased in the postimplementation months of December, January and February 2009*

to report findings on an extended basis (at 12 and 18 months) after implementation. Another first in this study is a second and third postimplementation observation period, which revealed a drift back to baseline, followed by subsequent improvement after teamwork behavior reinforcements. Finally, improvements in process efficiency were noted in ECMO start time, much as has been previously reported,[20–24] but the improvement in efficiency was not found with RRTs.

Limitations

Limitations include the lack of a control group for all measures of success. However, in the case of the survey data we were able to use either all or a sample of all respondents excluding PICU and SICU respondents for comparison. In addition, variation in perception and clinical outcomes can be affected by a variety of other organizational influences and improvement initiatives, so that a direct causal relationship between positive changes and the TeamSTEPPS quality improvement project cannot be determined. Analysis of observational data is limited by the lack of a tested observation tool and, in the case of this study, a single observer.

Conclusions

This study adds to the body of knowledge supporting the implementation of the TeamSTEPPS in health care. Our implementation approach demonstrates the effectiveness of using the TeamSTEPPS action planning steps and education material as the basis for a streamlined training program. **J**

Celeste M. Mayer, Ph.D., R.N., is Patient Safety Officer, University of North Carolina Health Care, Chapel Hill, North Carolina. **Laurie Cluff, Ph.D.,** is Research Psychologist, RTI International, Research Triangle Park, North Carolina. **Wei-Ting Lin, R.N., Ph.D.,** formerly Doctoral Student, School of Nursing, University of North Carolina, is Assistant Professor, College of Nursing, Kaohsiung Medical University, Kaohsiung, Taiwan. **Tina Schade Willis, M.D.,** is Assistant Professor, Anesthesiology and Pediatrics; Division Chief of Pediatric Critical Care Medicine; Medical Director of Pediatric Intensive Care Unit and ExtraCorporeal Life Support Program; and Co-Director, North Carolina Children's Hospital Center for Clinical Excellence, University of North Carolina. **Renae E. Stafford, M.D., M.P.H.,** is Assistant Professor, Chief of Surgical Critical Care, Division of Trauma and Critical Care; Associate Program Director, General Surgery Residency; Surgical Critical Care Fellowship Director, University of North Carolina School of Medicine; and Medical Director, Surgical Intensive Care Unit, University of North Carolina Hospital. **Christa Williams, R.N., B.S.N.,** is Nurse Manager, Surgical Intensive Care Unit, University of North Carolina Hospital. **Roger Saunders, R.N., M.S.N., N.E.A.-B.C.,** is Nurse Manager, Pediatric Intensive Care Unit, University of North Carolina Children's Hospital. **Kathy A. Short, R.R.T., R.N.,** is Director, Respiratory Therapy, University of North Carolina Hospitals. **Nancy Lenfestey, M.H.A.,** is Health Policy Research Associate, RTI International; **Heather L. Kane, Ph.D.,** is Health Services Analyst; and **Jacqueline B. Amoozegar, M.S.P.H.,** is Health and Social Organizations Research Analyst. Please address correspondence to Celeste Mayer, cmayer@unch.unc.edu.

References

1. Baker D.P., et al.: *Medical Teamwork and Patient Safety: The Evidence-based Relation.* Literature Review. AHRQ publication no. 05-0053, Apr. 2005. Agency for Healthcare Research and Quality, Rockville, MD. http://www.ahrq.gov/qual/medteam/ (last accessed Jun. 28, 2011).
2. Helmreich R.L., Foushee H.C.: Why Crew Resource Management? Empirical and theoretical bases of human factors training in aviation. In Weiner E.L., et al. (eds.): *Cockpit Resource Management.* Burlington, MA: Elsevier Science and Technology Books, 1995, pp. 3-45.
3. Institute of Medicine: *To Err Is Human: Building a Safer Health System.* Washington, DC: National Academy Press, 2000.
4. The Joint Commission: *Improving America's Hospitals: The Joint Commission's Report on Quality and Safety.* Nov. 2007. http://www.jointcommission.org/assets/1/6/2007_Annual_Report.pdf (last accessed Jun. 28, 2011).
5. Weaver S.J., et al.: Does teamwork improve performance in the operating room? A multilevel evaluation. *Jt Comm J Qual Patient Saf* 36:133–142, Mar. 2010.
6. Stead K., et al.: Teams communicating through STEPPS. *Med J Aust* 190(11 suppl.):S128–S132, Jun. 2009.
7. Clancy C.M., Tornberg D.N.: TeamSTEPPS: Assuring optimal teamwork in clinical settings. *Am J Med Qual* 22:214–217, May–Jun. 2007.
8. Fraser S.W.: *Accelerating the Spread of Good Practice: A Workbook for Health Care.* West Sussex, UK: Kingsham Press, 2002.
9. Rogers E.M.: *Diffusion of Innovations,* 4th ed. New York City: The Free Press, 1995.
10. Salas E., et al.: What are the critical success factors for team training in healthcare? *Jt Comm J Qual Patient Saf* 35:398–405, Aug. 2009.
11. Agency for Healthcare Research and Quality: *TeamSTEPPS®: Implementation Guide.* http://www.ahrq.gov/teamsteppstools/instructor/essentials/implguide.htm (last accessed Mar. 11, 2010).
12. Agency for Healthcare Research and Quality: *TeamSTEPPS® Course Management Guide.* http://www.ahrq.gov/teamsteppstools/instructor/essentials/coursemgmt.htm#course (last accessed Jun. 27, 2011).
13. Rabøl L.I., Østergaard D., Mogensen T.: Outcomes of classroom-based team training interventions for multiprofessional hospital staff: A systematic review. *Qual Saf Health Care* 19:1–11, Dec. 2010.
14. Hohenhaus S.M., et al.: A practical approach to observation of the emergency care setting. *J Emerg Nurs* 34:142–144, Apr. 2008.
15. Agency for Healthcare Research and Quality: *Hospital Survey on Patient Safety Culture.* Mar. 2011. Rockville, MD. http://www.ahrq.gov/qual/patientsafetyculture/hospsurvindex.htm (last accessed Jun. 28, 2011).
16. Morehead: *Workforce Commitment Survey: Transforming Employee Opinion Data into Knowledge and Action.* http://www.moreheadassociates.com/products/workforce-commitment (last accessed Jun. 28, 2011).
17. NDNQI®: *National Database of Nursing Quality Indicators.* https://www.nursingquality.org/ (last accessed Jun. 28, 2011).
18. Cohen J.: *Statistical Power Analysis for the Behavioral Sciences,* 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates, 1988.
19. Personal communication between an author [C.M.M.] and Emily E. Sickbert-Bennet, Ph.D., M.S., C.I.C., Public Health Epidemiologist/Director of Surveillance Programs, and Vickie Brown, R.N., M.P.H., C.I.C., Associate Director, Hospital Epidemiology, University of North Carolina Health Care System, Chapel Hill, North Carolina, Jan. 13, 2011.
20. Thomas, E.J., et al.: Team training in the neonatal resuscitation program for interns: Teamwork and quality of resuscitations. *Pediatrics* 125:539–546, Mar. 2010.
21. McCulloch P., Rathbone J., Catchpole K.: Interventions to improve teamwork and communications among healthcare staff. *Br J Surg* 98:469–479, Apr. 2011.
22. Neily J., et al.: Medical team training and coaching in the veterans health administration: Assessment and impact on the first 32 facilities in the programme. *Qual Saf Health Care* 19:360–364, Aug. 2010.
23. Capella J., et al.: Teamwork training improves the clinical care of trauma patients. *J Surg Educ* 67:439–443, Nov.–Dec. 2010.
24. Wolf F.A., Way L.W., Stewart L.: The efficacy of medical team training: Improved team performance and decreased operating room delays. A detailed analysis of 4863 cases. *Ann Surg* 252:71–79, Sep. 2010.

Online-Only Content

Appendix 1. Comparison of the TeamSTEPPS Fundamentals Course* and Customized TeamSTEPPS Course		
Points for Comparison	**TeamSTEPPS Fundamentals Course**	**Project Customized Course**
Time required	Options: ■ 4- to 6-hour session delivered at once ■ Divided in 2 sessions ■ Divided in 7 sessions	■ 1-hour self-directed online video (could be viewed during work or at home) covering the importance of teamwork for preventing patient harm and the basics of the four core areas of competency: team leadership, situation monitoring, mutual support, and communication ■ 30-minute self-directed reading of two articles[†] ■ 1-hour in-person class that included role play
Material presented	Introduction ■ Why it is important ■ Background and supporting evidence ■ Teamwork basics Team Structure ■ Core/contingency teams ■ Multisystem teams ■ Teamwork characteristics Leadership ■ Types of leaders ■ Role of leaders ■ Resource management ■ Delegation ■ Briefs, huddles, and debriefs ■ Conflict resolution Mutual Support ■ Task assistance ■ Feedback ■ Advocacy, assertion, and conflict resolution tools Communication ■ Effective communication ■ Communication tools ■ Communication challenges Summary ■ Barriers to team effectiveness	All TeamSTEPPS fundamentals material included, except as described below: Team Structure ■ Limited discussion of multisystem team with focus on core and contingency teams Leadership ■ No discussion of conflict resolution—staff are encouraged to take many of the internally offered courses in conflict resolution Mutual Support ■ No discussion of conflict resolution Communication ■ Information exchange tool "I Pass the Baton" not included.
Training modalities used	■ Interactive didactic lecture ■ Video ■ Role play ■ Individual and group exercises	■ Interactive didactic lecture with unit-specific examples ■ Video ■ Unit-relevant role play—intubation event with equipment failure
Learners and ideal size	■ Interdisciplinary and cross functional, max class size 25	■ Interdisciplinary and cross-functional; maximum class size, 10

Online-Only Content 🖱

Appendix 1. Comparison of the TeamSTEPPS Fundamentals Course* and Customized TeamSTEPPS Course (continued)		
Points for Comparison	**TeamSTEPPS Fundamentals Course**	**Project Customized Course**
Facilitators	■ Individual viewed as a leader, member of the training team, an advocate of teamwork	■ Interdisciplinary pairs facilitated in-person class to demonstrate teamwork during facilitation and maximize learners' exposure to change team leaders from implementation units. These facilitators possessed the qualities recommended for TeamSTEPPS fundamentals trainers.
Reinforcement posttraining	■ No recommendations	■ Change team leaders, also unit leaders and part of the implementation unit teams, modeled use of TeamSTEPPS skills and reinforced expectation for use of TeamSTEPPS behaviors on a daily basis. ■ Used reinforcement aids
Tools for learners to use posttraining	■ TeamSTEPPS pocket guide	■ Customized TeamSTEPPS pocket guide, which included all skills taught and names and pager numbers of Master Trainers ■ Paper copies of debriefing forms ■ Paper copies of briefing forms
Reinforcement aids	■ None provided	■ Badges for learners and master trainers ■ Chocolate treats labeled "TeamSTEPPS" or "Go Team-STEPPS" for distributing after good teamwork events ■ Note cards with TeamSTEPPS logo for sending personal recognition notes for observed good teamwork ■ Electronic TeamSTEPPS tips for easy distribution that highlighted four different communication skills

* Agency for Healthcare Research and Quality: TeamSTEPPS® Course Management Guide. Jun. 2006.
http://www.ahrq.gov/teamsteppstools/instructor/essentials/coursemgmt.htm#course (last accessed Jun. 27, 2011).

† Salisbury M., Hohenhaus S.M.: Know the plan, share the plan, review the risks: A method of structured communication for the emergency care setting. *J Emerg Nurs* 34:46–48, 2008; Salas E., et al.: What crew resource management training will not do for patient safety: Unless… *J Patient Saf* 3:62–64, Jun. 2007.

Online-Only Content

Appendix 2. Pediatric ICU (PICU)/Surgical ICU (SICU) TeamSTEPPS Observations

Mean ratings on the Teamwork Evaluation of Non-Technical Skills (TENTS; Hohenhaus S.M., et al.: A practical approach to observation of the emergency care setting. *J Emerg Nurs* 34:142–144, Apr. 2008) constructs across the four observation periods (Scale: 0 = expected but not observed, 1 = observed but poor, 2 = observed but marginal, 3 = observed and acceptable, and 4 = observed and good). Significant improvements over baseline performance in the teamwork constructs were seen at all three postimplementation observation periods.
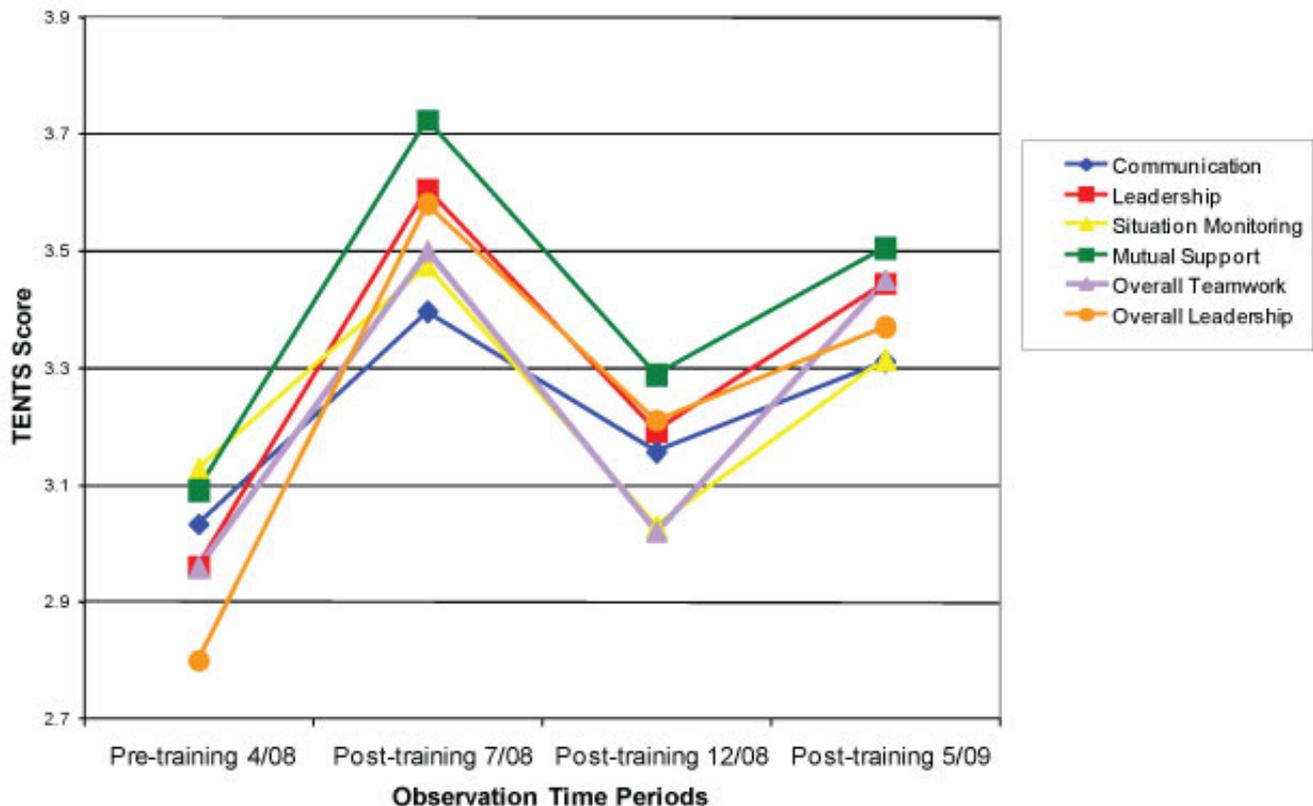
Operations Management

Investigating a Pediatric Hospital's Response to an Inpatient Census Surge During the 2009 H1N1 Influenza Pandemic

William C. Van Cleve, M.D., M.P.H.; Pat Hagan, M.H.S.A; Paula Lozano, M.D., M.P.H.; Rita Mangione-Smith, M.D., M.P.H.

On the morning of Wednesday, November 4, 2009, leaders at Seattle Children's Hospital (SCH) identified a surge in the hospital's inpatient census. The census stood at 245 patients at a hospital with 250 licensed beds, well above SCH's average midnight census of 207 (standard deviation [SD], 20). The surge occurred in the middle of a global pandemic of H1N1 influenza.[1] Hospital leaders became concerned that an influx of patients with influenza, in combination with the hospital's usual load of elective and emergent procedures, would lead to deterioration in service quality. To manage the surge, hospital leaders activated the hospital's pandemic influenza surge plan.

In this article, we review the steps that SCH took to decrease the inpatient census and the results of these efforts in the context of the available literature on the management of hospital surge and describe the subsequent steps that SCH has taken to better manage census surge.

Managing the Surge in Census at Seattle Children's Hospital

SCH is an inpatient pediatric specialty hospital that serves as the only pediatric tertiary care referral center for a five-state region, providing medical, surgical, ICU, psychiatric, and rehabilitation services. Of its 250 licensed beds, 19 are neonatal ICU (NICU), 26 pediatric ICU (PICU)/cardiac ICU (CICU), 20 psychiatry, 12 rehabilitation, and 177 medical/surgical. The majority of care at SCH is provided by full-time academic physicians employed by the University of Washington who supervise teams of resident physicians, with a minority of care being provided by full-time pediatric hospitalists employed by SCH.

Like many health care organizations in the United States, SCH experienced an increase in ED visits during the initial appearance of H1N1 influenza in the late spring of 2009.[2] In response, the hospital prepared a detailed influenza surge plan for a predicted second wave of the pandemic. To manage a crisis that included external (pandemic influenza) and internal (elevated census) factors, SCH leaders used their influenza surge plan in

Article-at-a-Glance

Background: On November 4, 2009, the 250-bed Seattle Children's Hospital (SCH) identified a surge in its census— 245 inpatients, well above the average midnight census of 207. In response, SCH activated its pandemic influenza surge plan in an effort to decrease the inpatient census. Within 16 hours, 51 patients (20.4% of total bed capacity) had been discharged, and inpatient census at SCH decreased to 222 patients.

Methods: As part of a quality improvement project, SCH's response to the surge was investigated, with data drawn from interviews, a review of records created in the course of the surge plan implementation, an e-mail survey of attending physicians responsible for patient discharges, and models examining predictors of hospital discharges.

Findings: Analysis of three years of hospital data (2007–2009) indicated that the high census on November 4 was an uncommon but not unprecedented occurrence. In addition, there was a clear positive association between an evening's census and the number of discharges during the following 24 hours. SCH discharged essentially the same number of patients on November 4 as on previous high-census days when the surge plan was not activated, suggesting that the surge plan did not succeed in creating excess discharges.

Conclusions: Increasingly, evidence indicates that care quality depends on the degree to which hospital resources are sufficient to meet demand. Reverse triage, at least as implemented by SCH on November 4, 2009, is unlikely to represent an effective solution to surge outside of a disaster setting because of its requirement for centralized decision making. SCH has incorporated the results of this review into the way that it collects and analyzes data, manages flow, and responds to inpatient surges.

an attempt to accomplish two overarching goals—(1) to actively decrease the inpatient census and (2) to prepare for changes in operations should the census remain elevated because of an influx of patients with influenza.

The ability of hospitals to detect and manage surge has been a topic of increasing interest during the past decade.[3–5] The process of "reverse triage"—identification of hospitalized patients for whom expedited hospital discharge is safe and ethical—has recently been proposed as a safe and effective mechanism for augmenting a hospital's surge capacity (that is, its ability to manage a sudden increase in the number of patients) during a disaster.[6,7]

Within 16 hours of the activation of the surge plan on November 4, 2009, 51 patients (20.4% of total bed capacity) had been discharged, and inpatient census at SCH decreased to 222 patients (reflecting 28 additional scheduled and emergent admissions). Increased monitoring of census and discharges continued until November 6, 2009, with the census remaining at noncritical levels. As part of the SCH review of the high-census event and reflecting the hospital's commitment to continuous performance improvement,[8] we performed the "check" phase of a Plan-Do-Check-Act cycle.[9]

Methods

In the immediate aftermath of the high-census event, one of the authors [W.V.C.] obtained permission from members of the SCH leadership team to conduct in-person and telephone interviews with residents, attending physicians, hospital leadership, nursing directors, and shift administrators. These interviews, with audio recordings (as reviewed by W.V.C.), led us to pose three questions for further review (*see* Findings). We drew on a variety of data sources, as follows:

1. A thorough review of records created in the course of the surge plan implementation

2. An e-mail survey of the 21 attending physicians responsible for patient discharges on November 4, 2009, which was completed by December 1, 2009. Each attending physician was provided with a list of patients discharged on November 4, 2009, and was asked, for each patient, whether hospital census played any role in the decision to discharge the patient.

3. Analytic and predictive models examining several predictors of hospital discharges, which were created using administrative data for 2007–2010 and the R statistical programming language, version 2.10.1 (The R Project for Statistical Computing; http://www.r-project.org).

The SCH Institutional Review Board (IRB) deemed this project exempt from traditional IRB review.

Findings

QUESTION 1. HOW WAS THE DETERMINATION MADE THAT THE HOSPITAL CENSUS WAS CRITICALLY ELEVATED, AND WHAT STEPS WERE TAKEN AS A RESULT?

At the initial meeting of hospital leaders on November 4, 2009, at approximately 8:00 A.M., the hospital census of 245 patients was discussed. The hospital's 10-bed observation unit, which had been opened to regular inpatients, was full. As part of a regular discharge prediction process on each hospital unit, charge nurses had gathered estimates for the following day's discharges by interviewing the overnight nursing staff. At 4:00 A.M., 26 expected discharges were reported, and 22 scheduled admissions were expected. Noting the high census, the high number of planned admissions, and the low number of expected discharges, the hospital leaders elected to activate the surge plan.

The SCH influenza surge plan was developed in leadership meetings during the summer of 2009 and communicated both via meetings with nursing and physician leaders across the hospital's clinical divisions and through e-mails sent to the nursing staff. The influenza plan consisted of three levels. The first level was activated when H1N1 was noted to reappear in the community in the fall of 2009. The second level, which was activated on November 4, escalated the hospital's response, while a third level, which was not activated, would have declared an internal/external state of disaster.

As part of the activation of level two, a command center was opened, and regular meetings between hospital leaders from multiple departments were established to more effectively coordinate hospital efforts. Preparations were made to house patients in nontraditional bed spaces (for example, procedure rooms). Specific steps relating to management of probable increased illness and absenteeism by hospital staff were described. Immediately following the decision to activate the surge plan, which was made between 9:00 A.M. and 10:00 A.M., hospital leaders visited all clinical units to alert nurses, residents, and attending physicians to the hospital's status, and asked them both to discharge patients more rapidly and to try to identify additional discharges where possible. This physical visit to the site of work for observation and direct communication with workers is a central tenet of the hospital's stated philosophy of continuous performance improvement.[8]

At SCH, attending physicians are expected to see their patients each day, including the day of discharge. Importantly, no specific instructions regarding changes to discharge criteria were described either by the surge plan or by hospital leaders during their visits to clinical units. Rather, hospital leaders stressed the

| Table 1. Attending Physicians' Responses as to Whether "The Hospital Census Played Any Role, However Small," in Their Decision to Discharge a Patient* |||
Service	Discharges	Discharges In Any Part Attributed to Census
General Pediatrics	14	1
Specialty Pediatrics	10	0
HemeOnc/BMT	5	2
NICU	1	0
IPU	3	0
Medically Complex	2	0
General Surgery	1	0
Specialty Surgery	7	0
Observation	8	0
Total	51	3

* HemeOnc, hematology/oncology; BMT, bone marrow transplant; NICU, neonatal ICU; IPU, inpatient psychiatric unit.

importance of creating capacity and offered to assist in addressing any barriers to discharge. In addition, the hospital's surgeon-in-chief and physician-in-chief, reviewing all scheduled surgeries and admissions, respectively, concluded that 3 of the 40 elective surgeries were considered appropriate for cancellation because of concerns regarding the availability of postoperative beds. Our review of hospital administrative records also indicated that one psychiatry patient was diverted on November 4, presumably because of the high census.

QUESTION 2. DID PHYSICIANS ENGAGE IN A PROCESS OF "REVERSE TRIAGE" TO INCREASE INPATIENT SURGE CAPACITY?

Initially, the discrepancy between the 26 expected discharges and the 51 discharges observed was cited as a strong justification for the success of the surge plan. In the course of the interviews, it became clear that although nurse managers understood that the initial number of expected discharges was an underestimate and that this underestimation was part of a consistent pattern, hospital leaders did not understand (before November 4) the consistent downward bias of this estimate.

To answer this question objectively, we examined the responses to our survey of attending physicians (Table 1, above), for which there was a 100% response rate. Physicians attributed only 3 (6%) of the 51 discharges to concerns regarding the hospital's census. None of the discharged patients were readmitted in the following seven days, nor did our review of hospital records indicate an excess number of discharges on November 5

or 6, as would have been expected had physicians reacted to the hospital's request for increased discharges by altering their patterns of care delivery. Unfortunately, because the data did not include the distribution of discharge times on days other than November 4, we were unable to definitively exclude the possibility that discharges occurred earlier in the day on November 4 than was typical at SCH during 2009.

The responses to this survey were in agreement with sentiments expressed during our initial postevent interviews and highlight physicians' beliefs that the majority of discharges on November 4 were expected discharges rather than "additional" discharges that occurred as a result of the activation of the hospital surge plan. Yet because of a concern that this conclusion could be subject to recall and attribution biases, we attempted to examine this claim more robustly in Question 3.

QUESTION 3. WERE MORE PATIENTS DISCHARGED ON NOVEMBER 4, 2009, THAN ON OTHER SIMILAR HIGH-CENSUS DAYS?

Using three years of administrative hospital data (2007–2009), we investigated the relationship between hospital census at 11:59 P.M. (midnight) and the number of discharges during the following day (Figure 1, page 379). Two important observations emerged. First, the high census on November 4 was an uncommon but not unprecedented occurrence. Second, the scatterplot, as shown in Figure 1, indicates a clear positive association between an evening's census and the number of discharges during the following 24 hours. Using a linear model with adjustment for day of the week and a simple linear spline to account for possible points of inflection in response to increasing hospital census, a 95% prediction interval (PI) suggested that 26 discharges would have been an unexpectedly low number for a day such as November 4. The model-predicted mean number of discharges for a Wednesday with a previous evening census of 245 was 49 (95% PI:34–64).

Discussion

In the course of a detailed review of the decisions made and actions taken on a day when hospital operations were challenged and hospital leaders took extraordinary steps to manage a crisis, we have uncovered evidence that questions the effectiveness of the hospital's efforts. Despite an attempt to aggressively decrease census to create additional surge capacity, our survey and model indicate that SCH discharged essentially the same number of patients on November 4, 2009, as it had on previous high-census days when no activation of the surge plan took place. In recent years, several studies have highlighted the importance

Relationship between 11:59 P.M. Census and the Number of Discharges Observed on the Following day (2007–2009), Plotted Using Hexagonal Binning
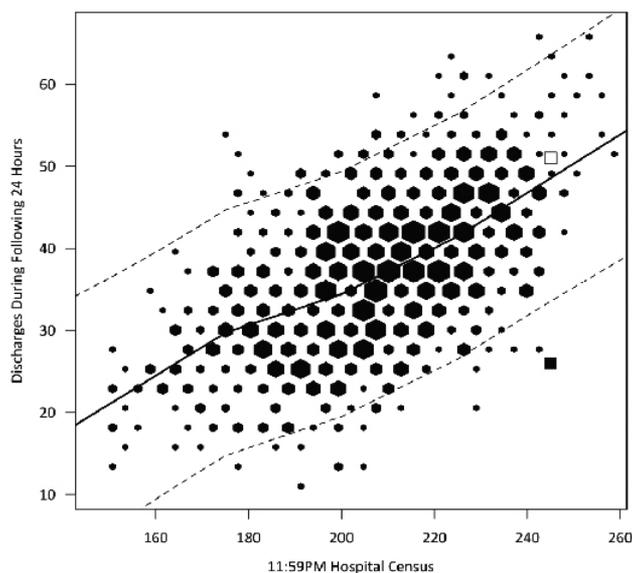
Figure 1. *A linear model predicting discharges using 11:59 P.M. census and day of the week is represented by the heavy black line. A 95% prediction interval (for Wednesdays) is plotted using dashed lines. The initial estimated number of discharges on November 4, 2009, is marked with a filled square. The observed number of discharges on November 4, 2009, (51) is marked with an open square.*

of active census management in both disaster and non-disaster settings.[6,7,10] A robust literature also exists to support the contention that mismatches between hospital capacity (broadly defined as the ability to accomplish care processes) and patient severity lead to inferior outcomes for hospitalized adults and children.[11–15] Similarly, the increased crowding of emergency departments (EDs) in the United States has been accompanied by multiple studies indicating that it is associated with decreased quality of care[16–21] and increased rates of patients leaving without being seen by a physician.[22,23] These studies, in combination with the now standard recommendations that hospitals prepare for disasters by increasing inpatient capacity,[24] seem to justify SCH's attempts to decrease its inpatient census during the H1N1 influenza pandemic. Unfortunately, evidence also indicates that pediatric hospitals do not acutely respond to surges in census, raising the question of why they do not and what can be done to improve their performance.[25]

If our data reflect a true lack of effect of the hospital's efforts to lower census, why did the request for reverse triage fail to gen-

erate an increased number of discharges? One possibility is that SCH generally operates very efficiently and discharges patients as soon as is practical from a medical and ethical standpoint. We find this possibility plausible but unlikely. An estimated 16%–44% of patients may be suitable for discharge in a disaster,[6,7] although estimates are typically based on simulation and retrospective data, meaning that they review what "would have happened" had a patient been discharged in a disaster rather than the more clinically oriented question of "what did happen?" because of an observed early discharge. In addition, estimates of discharge capacity generally exclude pediatric patients because children and infants are considered "special populations." Determining whether specialty hospitals like SCH possess the degree of flexible surge capacity identified by previous authors would be an important step in both regional and institution-specific disaster planning.

Assuming that excess potential discharges were possible at SCH on November 4, why did they fail to occur? One potential explanation is that hospital leaders wanted to increase capacity but not so dramatically as to create a feeling of panic or generate conflict with physicians who might have disagreed regarding discharge decisions. Support for this explanation comes from the way in which hospital leaders presented their request. Rather than implementing a central system for reverse triage or publishing a list of requirements for patients to remain hospitalized, they left decision making in the hands of individual attending physicians. This flexible approach to reverse triage stands in direct contrast to the centralized and protocol-driven "command and control" approach to decision making recommended in disaster settings[26–28] and highlights the hospital's attempt to manage a potential crisis *without* declaring an overt disaster. Without an objective standard for which patients were appropriate for discharge, individual physicians at SCH were left to their own devices, a situation that would generate unacceptable levels of uncertainty and inefficiency in a true disaster. Put another way, because the hospital never declared a disaster and systematically implemented reverse triage, it is unsurprising that there is little evidence that "extra" discharges actually occurred.

The decision not to discharge a hospitalized patient to make room for patients arriving during a disaster can be couched in terms of an ethical conflict, centered in the concept of "lifeboat ethics," in which a constrained resource must be apportioned to those to whom it would provide the most benefit.[29] An attempt to apportion care in this fashion at SCH would be complex, in that it is the sole regional provider of complex care to the same special populations excluded in previously reported rationing simulations and exercises. Still, evidence suggests that during a

prolonged influenza epidemic, bed shortages in certain highly needed units, such as ICUs, in pediatric hospitals may occur.[30] Furthermore, while limiting or discontinuing care for currently hospitalized children during a pandemic may be difficult, it has the potential to decrease population-level mortality.[31] Objective approaches such as those used by Kelen and colleagues[7] may be of benefit at specialty hospitals like SCH, but such objective criteria and the increase in surge capacity that might be expected at pediatric hospitals with their application have not been studied.[32] Until such time as objective criteria for which patients are safe for early discharge are created, the choice by SCH leaders to leave discharge decisions in the hands of providers who knew their care best seems reasonable but may have led to a smaller number of discharges than would have been needed during a more severe emergency.

Responding to This Investigation

As a learning organization,[33] SCH has incorporated the results of this internal review into the way that it collects data, manages flow, and responds to inpatient surges.

UNDERSTANDING BIASED DISCHARGE PREDICTIONS

Hospital leaders were surprised to learn that nurses knew that the downwardly biased number of discharges predicted on November 4 was part of a consistent pattern of underestimation. To better understand the potential bias in information required to make decisions about the hospital status, SCH began to record the daily nursing estimates of expected discharges. The distribution of the daily differences between nursing estimates and actual discharges from 2010, as depicted in Figure 2a (page 381), is notable both for the rarity—that is, only three days in this one-year period—of overestimation and the relatively large variability in prediction errors. In an attempt to improve on the variability and bias in nursing estimates, a multivariate model similar to that used to create Figure 1 was created using hospital census as well as the number of unscheduled and scheduled admissions on the previous day. A comparison of the predictions made by this model and those made by nurses is displayed in Figure 2b (page 381). The model's error and bias are less than those of hospital nurses, in particular on high census days. Although the nurses rarely overestimate the number of discharges, the model does so on approximately 50% of days.

SCH hospital leaders are now seeking to determine how best to incorporate this information into decision making and are collecting additional information to better understand the reasons why SCH nurses so consistently underestimate the number of patients who will be discharged each day. In addition, the hos-

pital is working to determine whether specific types of patients are overrepresented in the "undercounted" discharges, so it can more accurately predict its reserve capacity.

IMPROVING FLOW

True reverse triage, which implicitly requires central authority over clinical decision making, represents perhaps the most dramatic approach in a spectrum of tools available to manage surge. To prevent the need for reverse triage, SCH has focused its attention on improving patient flow so that the hospital operates more efficiently.[10] As an example, to improve patient and family experience and also to more effectively target the ED's resources toward triage and treatment of emergencies, the SCH board of directors identified length of stay in the ED for admitted patients as a hospitalwide improvement goal for fiscal year 2010 (October 2009–September 2010). As a result of these efforts, mean ED length of stay fell by 13%—from 290 minutes to 257 minutes. Another approach the hospital has taken to improve patient flow has been to expand the schedule for elective surgeries to include Saturdays. During 2010, approximately 3.4% of ambulatory surgeries at SCH were performed on Saturday, thereby smoothing the unequal flow of cases created by the typical five-day operating room schedule.

MANAGING SURGE

Although improved patient flow may decrease the frequency of surges, SCH has also acted to improve its performance during periods of high census. When a surge is detected, SCH activates a revised surge protocol that involves staff at many levels throughout the hospital. As an example, during a recent surge in census that occurred in February 2011, the shift administrator established regular huddles at four-hour intervals with charge nurses and the chief medical resident to discuss expected admissions, pending discharges, and bed-availability issues. The shift administrator also regularly updates an operations board visible throughout the ED so that doctors and nurses there are aware of the hospital's bed status. If initial steps do not result in a drop in census, the pediatrician-in-chief becomes involved in all requests for interhospital transfers and has the option to activate a "Treat and Transfer" protocol. This protocol, applied to any potential admission to SCH (even to patients presenting to the ED), balances the patient's severity of illness, his or her potential for requiring subspecialty care available only at SCH, and the hospital's bed availability. The pediatrician-in-chief has established relationships with other pediatric inpatient facilities in the region and can work with physicians at those facilities to determine whether an appropriate alternate site for admission exists.

Distributions of Errors in Discharge Prediction

A.

Distribution of Underpredicted Discharges Based on Nursing Estimates
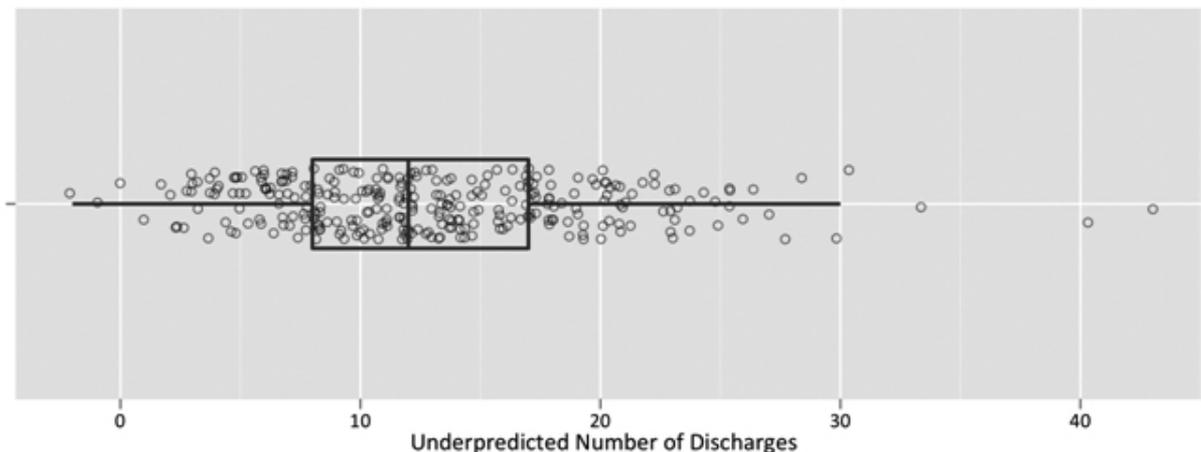
B.

Differences Between Nursing and Model-Based Discharge Prediction
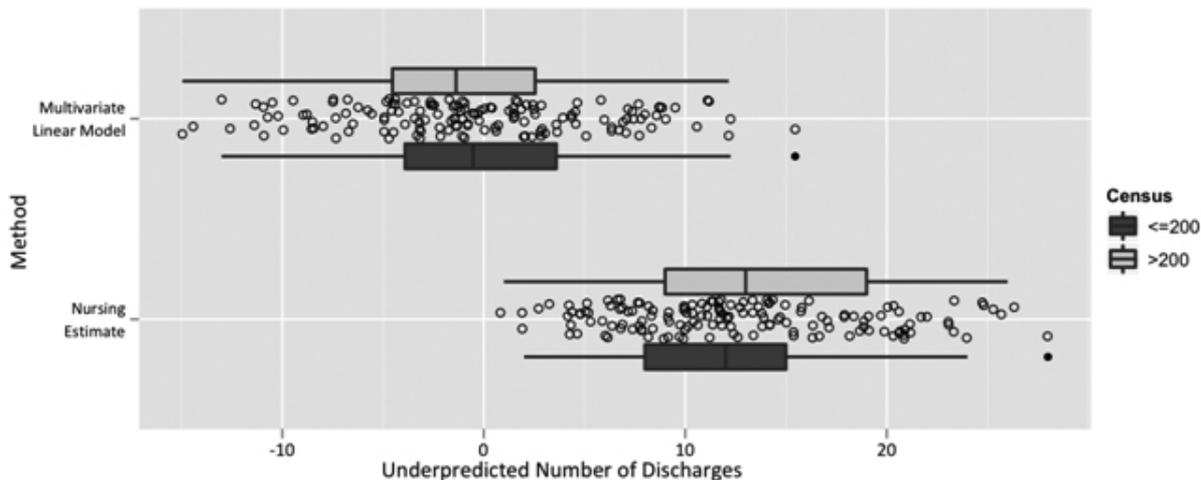
Figure 2. *Panel 2a displays nurses' discharge prediction errors for 2010. Panel 2b compares errors in nursing estimates for a random 50% of 2010 days with complete data to predictions for the same days using a multivariate model trained on the other 50% of the data. Prediction error distributions are further divided into days when the census was > 200 or ≤ 200 (shaded boxplots).*

Finally, as occurred on November 4, inpatient nurses and physicians are encouraged to proactively identify barriers to discharge for admitted patients and to request assistance from hospital leadership if creative solutions are required to expedite safe and medically appropriate discharge.

Conclusion

Increasingly, evidence indicates that the quality of care delivered to patients depends on the degree to which hospital resources are sufficient to meet demand. Reverse triage, insofar as it was attempted by SCH on November 4, 2009, is unlikely to represent an effective solution to surge outside of a disaster setting because of its requirement for centralized decision making. SCH has attempted to integrate the lessons it learned from this experience into a comprehensive plan that both lessens the frequency of surges and more capably manages them when they do occur.

These lessons were learned only through an in-depth investigation of an uncommon event, and the conclusions reached represented both a surprise and an opportunity for the hospital. We would encourage other hospitals, using either internal staff or external consultants, to conduct similar reviews of uncommon events, to ensure that the complete cycle of a quality improvement process can be completed and care delivery continuously improved. **J**

William C. Van Cleve, M.D., M.P.H., formerly Senior Fellow, Quality of Care Research, Department of Pediatrics, University of Washington and Center for Child Health, Behavior, and Development, Seattle Children's Research Institute, Seattle, is a Resident Physician, Department of Anesthesia and Pain Medicine, University of Washington. **Pat Hagan, M.H.S.A,** is President and Chief Operating Officer, Seattle Children's Hospital, Seattle. **Paula Lozano, M.D, M.P.H,** formerly Associate Professor of Pediatrics, University of Washington, is Associate Investigator, Group Health Research Institute, Seattle, and Assistant Medical Director, Preventive Care, Group Health Cooperative, Seattle. **Rita Mangione-Smith, M.D., M.P.H.,** is Professor, Department of Pediatrics, University of Washington, and Center for Child Health, Behavior, and Development, and Seattle Children's Research Institute. Please address correspondence to William Van Cleve, vancleve@uw.edu.

References

1. World Health Organization: *Global Alert and Response (GAR): Pandemic (H1N1) 2009—Update 94.* http://www.who.int/csr/don/2010_04_01/en/ (last accessed Jun. 29, 2010).
2. Miroballi Y., et al.: Novel influenza A (H1N1) in a pediatric health care facility in New York City during the first wave of the 2009 pandemic. *Arch Pediatr Adolesc Med* 164:24–30, Jan. 2010.
3. Kaji A.H., Koenig K.L., Lewis R.J.: Current hospital disaster preparedness. *JAMA* 298:2188–2190, Nov. 14, 2007.
4. The Joint Commission: *Healthcare at the Crossroads: Strategies for Creating and Sustaining Community-wide Emergency Preparedness Systems.* 2003. http://www.jointcommission.org/assets/1/18/emergency_preparedness.pdf (last accessed Jun. 29, 2011).
5. McCarthy M.L., Aronsky D., Kelen G.D.: The measurement of daily surge and its relevance to disaster preparedness. *Acad Emerg Med* 13:1138–1141, Nov. 2006.
6. Kelen G.D., et al.: Creation of surge capacity by early discharge of hospitalized patients at low risk for untoward events. *Disaster Med Public Health Prep* 3(2 suppl.):S10–S16, Jun. 2009.
7. Kelen G.D., et al.: Inpatient disposition classification for the creation of hospital surge capacity: A multiphase study. *Lancet* 368(9551):1984–1990, Dec. 2006.
8. Stapleton F.B., et al.: Modifying the Toyota Production System for continuous performance improvement in an academic children's hospital. *Pediatr Clin North Am* 56:799–813, Aug. 2009.
9. Shewhart W.: *Statistical Method from the Viewpoint of Quality Control.* Washington, DC: The Graduate School, U.S. Department of Agriculture, 1939.
10. Litvak E., et al.: Managing unnecessary variability in patient demand to reduce nursing stress and improve patient safety. *Jt Comm J Qual Patient Saf* 31:330–338, Jun. 2005.
11. Bell C.M., Redelmeier D.A.: Mortality among patients admitted to hospitals on weekends as compared with weekdays. *N Engl J Med* 345:663–668, Aug. 30, 2001. Erratum in: *N Engl J Med* 345:1580, Nov. 22, 2001.
12. Arias Y., Taylor D.S., Marcin J.P.: Association between evening admissions and higher mortality rates in the pediatric intensive care unit. *Pediatrics* 113:e530–e534, Jun. 2004.
13. Chrusch C.A., et al.: High occupancy increases the risk of early death or readmission after transfer from intensive care. *Crit Care Med* 37:2753–2758, Aug. 2009.
14. Hugonnet S., Chevrolet J.-C.C., Pittet D.: The effect of workload on infection risk in critically ill patients. *Crit Care Med* 35:76–81, Jan. 2007.
15. Lorch S.A., et al.: Impact of admission-day crowding on the length of stay of pediatric hospitalizations. *Pediatrics* 121:e718–e730, Apr. 2008.
16. Sills M.R., et al.: Emergency department crowding is associated with decreased quality of care for children with acute asthma. *Ann Emerg Med* 57:191–200, Oct. 2010.
17. Sikka R., et al.: ED crowding is associated with an increased time to pneumonia treatment. *Am J Emerg Med* 28:809–812, Sep. 2010.
18. McCarthy M.L., et al.: Crowding delays treatment and lengthens emergency department length of stay, even among high-acuity patients. *Ann Emerg Med* 54:492–503.e4, Oct. 2009.
19. Pines J.M., et al.: The association between emergency department crowding and adverse cardiovascular outcomes in patients with chest pain. *Acad Emerg Med* 16:617-625, Jul. 2009.
20. Hwang U., et al.: Emergency department crowding and decreased quality of pain care. *Acad Emerg Med* 15:1248-1255, Dec. 2008.
21. Vieth T.L., Rhodes K.V.: The effect of crowding on access and quality in an academic ED. *Am J Emerg Med* 24:787-794, Nov. 2006.
22. Weiss S.J., et al.: Relationship between the National ED Overcrowding Scale and the number of patients who leave without being seen in an academic ED. *Am J Emerg Med* 23:288–294, May 2005.
23. American College of Emergency Physicians: Health care system surge capacity recognition, preparedness, and response. *Ann Emerg Med* 45:239, Feb. 2005.
24. Hick J.L., et al.: Health care facility and community strategies for patient care surge capacity. *Ann Emerg Med* 44:253–261, Sep. 2004.
25. Fieldston E.S., et al.: Children's hospitals do not acutely respond to high occupancy. *Pediatrics* 125:974–981, May 2010.
26. California Emergency Medical Services Authority: *Hospital Incident Command System (HICS).* http://www.emsa.ca.gov/HICS/ (last accessed Jun. 29, 2011).
27. Federal Emergency Management Agency: *National Incident Management System.* Dec. 2008. http://www.fema.gov/pdf/emergency/nims/NIMS_core.pdf (last accessed Jun. 29, 2011).
28. Barbera J., Maintyre A.: *Medical and Health Incident Management (MaHIM) System: A Comprehensive Functional System Description for Mass Casualty Medical and Health Incident Management.* Dec. 2002. http://www.gwu.edu/~icdrm/publications/MaHIM%20V2%20final%20report%20sec%202.pdf (last accessed Jun. 29, 2011).
29. Kraus C.K., Levy F., Kelen G.D.: Lifeboat ethics: Considerations in the discharge of inpatients for the creation of hospital surge capacity. *Disaster Med Public Health Prep* 1:51–56, Jul. 2007.
30. Kanter R.K.: Pediatric mass critical care in a pandemic. *Pediatr Crit Care Med.* Epub Oct. 2010.
31. Kanter R.K.: Strategies to improve pediatric disaster surge response: Potential mortality reduction and tradeoffs. *Crit Care Med* 35:2837–2842, Dec. 2007.
32. Antommaria A.H.M., Sweney J., Poss W.B.: Critical appraisal of triaging pediatric critical care resources during a pandemic: Ethical and medical considerations. *Pediatr Crit Care Med* 11:396-400, May 2010.
33. Senge P.: *The Fifth Discipline: The Art and Practice of the Learning Organization.* New York City: Doubleday/Currency, 1994.

ℹ Information for Authors

The Joint Commission Journal on Quality and Patient Safety serves as a peer-reviewed forum for practical approaches to improving quality and safety in health care. Areas of interest include organizational change and learning, performance improvement, performance measures, evidence-based medicine, timeliness and efficiency, teamwork and communication, and information technology.

Overall Content

Published monthly, *The Joint Commission Journal on Quality and Patient Safety* is a peer-reviewed publication dedicated to providing health care providers and quality and safety professionals with the information they need to promote the quality and safety of health care. *The Journal* invites original manuscripts on the development, adaptation, and/or implementation of innovative thinking, strategies, and practices in improving quality and safety in health care. Case studies, program or project reports, reports of new methodologies or new applications of methodologies, research studies, and commentaries on issues and practices are all considered. No statement in *The Joint Commission Journal on Quality and Patient Safety* should be construed as an official position of The Joint Commission or Joint Commission Resources unless otherwise stated. In particular, there has been no official review with regard to matters of standards compliance.

Submission Guidelines

(also available online at http://www.jcrinc.com/The-Joint-Commission-Journal-on-Quality-and-Patient-Safety/About/)

Feature Articles. Feature articles should not exceed 4,000 words, not including illustrations and references. Articles should consist of background, rationale, methods or implementation, results, and discussion, but this will depend on the nature of the article. When possible, articles should contain case studies or problems and practical solutions. *For manuscripts on the development and testing of interventions to improve the quality and safety of health care, authors are encouraged to use the SQUIRE Publication Guidelines (http://www.squire-statement.org).*

Departments. Manuscripts are invited for the following:

■ *Letters:* Letters can pertain to an article or a department published in *The Journal* or to any issue, topic, or project in quality and safety in health care.

■ *Field Notes* (limit 1,000 words): Field Notes provides a forum for brief papers on works in progress.

■ *Tool Tutorial:* Describes new tools or new uses of tools for any quality or safety activity.

■ *Case Study in Brief* (limit 2,000 words): Case studies describe how organizations address specific quality and safety issues and problems.

■ *Forum:* Commentaries on issues and practices of topical interest.

■ *National Patient Safety Goals:* Addresses implementation of innovative ideas for achieving the requirements associated with the goals.

■ *Front-Line Tips:* This department offers quality and safety tips from practitioners "in the trenches."

Submission Process

An electronic version (Microsoft Word or ASCII format), preferably as an e-mail attachment, is required. By a jointly signed cover letter or by e-mail correspondence, all authors should confirm that the manuscript represents original work that has not been published or is not being considered for publication elsewhere and that they have all contributed to and approve of the manuscript. Copies of any closely related manuscripts, whether published or in development, should also be provided. On manuscript submission, authors are required to disclose any potential conflicts of interest or provide a declaration of no conflicts of interest.

Preparation of Manuscript

Order. Title page, acknowledgments, abstract, text, references, tables, and figures.

Title Page. Include the title of the article; authors' (< 10) names, titles, affiliations, and, if different, the affiliations when the article was written. Grant support that requires acknowledgment must be mentioned on the title page.

Acknowledgments. Obtain permission to reprint or adapt any illustrations published previously; a copy of the signed letter granting such approval must accompany the manuscript. All material reprinted or adapted from previously published literature must be accompanied by the name of the original author, title of the article, title of the journal or book in which it appears, date of publication, and publisher's city and name.

Abstract. Provide a structured abstract of 27 0 words.

Text. Use only standard abbreviations and acronyms; spell out for first use, and use short version thereafter. Use generic names for drugs whenever possible. If using brand names, put in parentheses after first citing generic names.

References. Number references consecutively as they are cited. Sample reference:

1. Makary M.A., et al.: Operating room debriefings. *Jt Comm J Qual Patient Saf* 32:407–410, Jul. 2006.

Consult a sample article. Authors are responsible for accuracy.

Tables and Figures. Cite tables and figures (for example, Table 1, Figure 1) consecutively in text. All tables and figures should have titles and be easily understood; figures should also have short legends (consult a sample issue). When possible, submit artwork as a separate file in the original format (e.g., Excel, PowerPoint, EPS, JPEG, etc.).

Editorial Process

Authors are notified upon receipt of a manuscript and again upon the editorial decision regarding publication.

Manuscript Review. Manuscripts deemed suitable for publication are sent to Editorial Advisory Board members and/or other reviewers. Notification of the editorial decision is usually provided within 8 to 10 weeks. In most cases, manuscripts are accepted conditionally, pending an author's revision of the material.

Copyright. When a manuscript is accepted for publication, the author(s) is required to sign an assignment of copyright ownership to *The Journal.*

Author Approval. Authors are responsible for all statements in articles, including changes made by editors. The liaison author must be available for consultation to answer questions during the editorial procedure and to approve edited copy.

Submit manuscript and related correspondence to

Steven Berman, Executive Editor
The Joint Commission Journal on Quality and Patient Safety
One Renaissance Boulevard
Oakbrook Terrace, Illinois 60181
telephone 630/792-5453; fax 630/792-4453
e-mail: sberman@jcrinc.com

ℹ Information for Readers