PATIENT SAFETY SERIES

Outcomes from a labor and delivery team training program with simulation component

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The impetus for pursuing teamwork training in health care originated in the 1999 Institute of Medicine report, *To Err Is Human: Building a Safer Health System*.[1] This report emphasized the high incidence of medical errors in the US health system leading to iatrogenic patient morbidity and mortality. The Quality Interagency Coordination Task Force was established to develop a federal plan for reducing the number and severity of medical errors. Among its recommendations was the adaptation of crew resource management (CRM) training, part of team training, to medicine.

Derived from the military and aviation industries, the principles of team structure and closed-loop communication provide powerful tools in the high-risk, high-stakes environment of acute medical care. For over a decade, CRM has been applied in a variety of medical settings evaluating the ability to reduce medical error and improve patient safety.[2-12] In addition, support for the use of medical simulation has gained momentum, most

frequently for task training and clinical care of critically ill patients.[13,14] Although medical simulation is less commonly used to teach the principles of CRM, the development of simulation-based team training programs is on the rise.[15,16]

The use of simulation is growing in obstetrics. Training has usually been oriented toward provider skill development, focusing on a high-risk condition rather than developing comprehensive teamwork skills. Recent studies in the obstetrics literature have shown modest improvement in outcomes using CRM-based team training[7,17] alone. Evaluating team training with the addition of simulation training with CRM training is still to be evaluated.[15] The current study was undertaken to evaluate the implementation of a CRM-based curriculum that included simulation training on an active labor and delivery (L&D) unit. The evaluation incorporated assessments of provider attitudes and the patient experience, as well as objective medical outcomes. The objective of the project was to determine whether implementing an L&D unit team training program with simulation training improves patient outcomes as well as perceptions of safety and communication.

Materials and methods

Over the course of 30 months (July 2006 through December 2008), a prospective evaluation of CRM combined with simulation training to assess the impact on patient safety, provider attitudes, and

We evaluated the implementation of a labor and delivery unit team training program that included didactic sessions and simulation training with an active clinical unit. Over an 18-month follow-up time period, our team training program showed improvements in patient outcomes as well as in perceptions of patient safety including the dimensions of teamwork and communication.

Key words: labor and delivery, obstetrics outcomes, patient safety, team training

patient outcomes was planned and implemented on an L&D unit with approximately 9200 births each year. Patient and provider data evaluating teamwork and patient safety perceptions were collected prior to initiating the training and compared with subsequent data collected 1 year later. Patient outcomes were assessed using data collected quarterly for 8 quarters prior to initiating the program and for 6 quarters after implementing the program. All survey information was collected anonymously. Institutional review board approval was obtained to address any possible staff concerns and assure the integrity of the deidentified data collection system (Women and Infants Hospital of Rhode Island no. 06-0129).

The L&D team training planning committee consisted of risk managers and hospital administrators, as well as nurse managers, staff nurses, midwives, obstetricians (OBs), and anesthesiologists. The clinical simulation experts at the Rhode Island Hospital Medical Simulation Center provided guidance. The MedTeams team coordination course, provided by Dynamics Research Corp (Andover, MA) was selected as the CRM curriculum for teamwork training. A train-the-trainers approach was used that consisted of 2 days of didactics and hands-on training provided by staff from Dynamics Research Corp. During these sessions the future trainers, primarily physicians and nurses, learned

about the philosophy of CRM as well as the design of the MedTeams curriculum. Instruction was provided regarding the best way to teach and convey the concepts of the program to the L&D unit staff. The didactic portion of the curriculum was delivered to the L&D unit staff by the nurse-physician training pairs.

Participants in both the classes and the simulations included members of the hospital physician staff who practiced obstetrics, certified nurse midwives, obstetrics and gynecology resident physicians, anesthesiology staff physicians, anesthesia certified nurse anesthetists, anesthesia registered nurses, L&D nurses, and unit secretaries.

Each didactic portion lasted approximately 4 hours, and was followed 3-7 days later by a 4-hour high-fidelity medical simulation and debriefing session. Fifteen sessions were scheduled to accommodate the entire L&D unit staff (day, afternoon, night, and weekend shifts). The goals of the simulation experience were to demonstrate the impact of CRM principles, and to enable participants to recognize how changes in their communication behaviors could affect patient care. A Gaumard obstetrical manikin (Noelle 565; Gaumard, Miami, FL) was integrated with a standard patient actor to simulate a live patient interaction. In-room facilitators guided participants through the scenario. Two different patient care scenarios were crafted to elicit the myriad of interactions among patients, clinicians, family members, and nonclinician health team members. Each scenario was scripted to require coordinated efforts and effective communication among nurses, midwives, secretaries, anesthesiologists, and OBs. Situation updates, transfers of leadership, and medication clarifications were essential components of the team's interactions. Discussion with the patient and her family member was also an essential part of the scenario.

Each training session divided the group into 2 teams. One team participated in the first scenario while the second team acted as observers. After the first scenario was run and debriefed, the observers and participants exchanged roles. The second scenario was then run

and debriefed. Each scenario was videotaped. All participants and observers took part in the debriefing session for each scenario. The videotape was used to guide the discussion. The debriefing focused on the clarity of communications with the goal of providing insight into current behaviors, and illustrating how standardized, closed-loop communications, adapted to their current practice, could prevent patient harm. The videotaped scenarios were destroyed for privacy protection immediately following the last debriefing.

Evaluation measures

To assess provider attitudes and perceptions of patient safety, we used a nationally recognized assessment tool, the Agency for Healthcare Research and Quality (AHRQ) Hospital Survey on Patient Safety Culture.[18] The survey was modified to reflect the L&D unit organizational structure while maintaining the integrity of the survey questions. The survey was administered to physicians, nurses, and administrative staff prior to initiating CRM training (February through May 2007) and 6 months after the L&D unit implemented the program (February through April 2008).

Data from the safety culture surveys were analyzed according to the documentation provided by AHRQ.[18] The survey questions were grouped into 14 dimensions reflecting different aspects of safety culture. Each dimension was summarized as the number of positive responses divided by the number of questions in the domain. Positive responses included "strongly agree" and "agree" or "most of the time" and "always," or, for negatively worded questions, "strongly disagree" and "disagree" or "never" and "rarely." Surveys were excluded from analysis if <50% of questions were answered (6 of 193 pre-CRM and 2 of 122 post-CRM surveys) or if the responses were invariant (1 of 193 pre-CRM surveys). After these exclusions, 186 (96%) pre-CRM surveys and 120 (98%) post-CRM surveys remained for analysis. The proportion of positive responses in each dimension was compared between pre- and post-CRM surveys by the χ^2 test. Test statistics and 95%

confidence intervals (CIs) were corrected for within-person clustering at each time point by Taylor series variance estimation. Individual questions on the surveys were compared by Fisher exact test. The analysis was repeated separately for OBs/perinatologists and L&D nurses. The surveys were anonymous to enhance participation; therefore, a paired data analysis was not possible. P values < .05 were considered statistically significant. Software (SAS, version 9.1; SAS Institute, Cary, NC) was used for data analysis.

The patient perspective on the culture of communication on the L&D unit was assessed by a survey that was modified from the MedTeams Quality of Care Survey. The patient surveys were distributed for 5 consecutive weeks in January through February 2007, which was prior to CRM training and for 5 weeks in January through February 2008, which was 6 months after the program's implementation.

The Adverse Outcomes Index (AOI), a composite score of clinical outcomes, was evaluated quarterly with the 8 quarters prior to initiating the CRM team training program as the control time frame and 6 quarters following implementation as the outcome time frame. The 2 quarters during the time of implementing the CRM training were not included. The AOI has been used in previous studies evaluating obstetric unit team training programs[7] and includes the number of deliveries identified with an adverse event divided by the total number of deliveries. The 10 types of adverse events are: maternal death, intrapartum or neonatal death of a neonate >2500 g (excluding cases with a congenital anomaly or fetal hydrops), uterine rupture, unexpected internal or external maternal transfer to an intensive care unit for a postpartum complication, birth trauma, return to the operating room or L&D, admission of neonate >2500 g and >37 weeks to neonatal intensive care unit within 1 day of birth for >24 hours (excluding cases with a congenital anomaly or fetal hydrops), Apgar score at 5 minutes <7 (excluding cases with a congenital anomaly or fetal hydrops), maternal blood transfusion,

and third- or fourth-degree perineal laceration. These data and information were provided by the National Perinatal Information Center Quality Analytic Services, Providence, RI.

Results

Of the 256 staff members affiliated with the L&D unit in 2007, 72% participated in the CRM and simulation training program. In evaluating the effectiveness of the overall team training program, 186 staff members participated in the pre-CRM evaluation and 120 staff members participated in the post-CRM evaluation. Although the number of staff members participating in the survey differed, the distribution across staff positions was similar comparing the pre- and post-evaluation time frames (Table 1). No significant differences in respondents' sex, race/ethnicity, or years worked on the L&D unit were noted.

Comparing the responses to the Hospital Survey on Patient Safety Culture using the composite scores for the AHRQ safety dimensions, we found that overall, the frequency of event reporting and the overall perception of safety did not change significantly. The implementation of the CRM program improved many dimensions of the safety culture focused on the L&D unit (Table 2); however, this was not necessarily the case for dimensions focused on the hospital-wide culture. For the L&D unit-level dimensions, the responses post-CRM improved from baseline with regard to the dimension addressing organizational learning and continuous improvement, teamwork within the hospital unit, communication openness, and nonpunitive response to error. The dimensions with limited or no improvement were concentrated in areas concerning the hospital-wide interactions that were not part of the L&D unit-specific CRM training.

To understand the components of the safety dimensions, we show examples of specific questions that are included in the AHRQ composite safety culture dimensions and explore differences in responses between L&D registered nurses

and OBs (Table 3). For the overall perception of safety dimension, registered nurses were less likely to disagree post-CRM training with the question, "It is just by chance that more serious mistakes don't happen around here" compared with OBs. For frequency of event reporting, the OBs had a smaller proportion reporting events compared with registered nurses. For the dimensions of communication openness, teamwork within the hospital unit, and feedback and communication about error, all staff as well as OBs and registered nurses had increases in the proportion responding

positively to the representative question post-CRM. In the dimension of nonpunitive response to error, the proportion of all staff, OBs, and registered nurses disagreeing with this question increased post-CRM. The communication dimension had a significantly positive change for all staff and registered nurses post-CRM.

For the patient survey, 519 patients responded pre-CRM and 476 patients responded post-CRM. Each survey captured approximately 70% of patients experiencing a delivery through the L&D unit during the specific survey

TABLE 1
Characteristics of survey respondents

Respondent characteristic	Pre-CRM (n = 186)	Post-CRM (n = 120)	P value
	No. (%)	No. (%)	
Staff position	(n = 181)	(n = 119)	.8
Obstetrician/perinatologist	53 (29)	32 (27)	
Labor and delivery RN	67 (37)	49 (41)	
CNM	11 (6)	5 (4)	
Anesthesiologist	10 (6)	6 (5)	
CRNA/anesthesia RN	16 (9)	7 (6)	
Resident physician/fellow	24 (13)	20 (17)	
Sex	(n = 174)	(n = 116)	1.0
Male	31 (18)	20 (17)	
Female	143 (82)	96 (83)	
Ethnicity	(n = 181)	(n = 117)	.9
Hispanic	3 (2)	2 (2)	
Black, non-Hispanic	4 (2)	4 (3)	
White, non-Hispanic	150 (83)	95 (81)	
Asian/Pacific Islander	5 (3)	5 (4)	
Multiethnic	6 (3)	3 (3)	
Prefer not to say	13 (7)	8 (7)	
Years worked in labor and delivery	(n = 182)	(n = 120)	.8
<1	16 (9)	7 (6)	
1-5	45 (25)	34 (28)	
6-10	27 (15)	17 (14)	
11-15	29 (16)	16 (13)	
≥16	65 (36)	46 (38)	

No. who responded to each question is in parentheses. Totals may not sum to 100% due to rounding.

CNM, certified nurse midwives; *CRM*, crew resource management; *CRNA*, certified registered nurse anesthetist; *RN*, registered nurse.

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Overall safety dimension responses

Safety dimension	Proportion with positive responses (95% CI)[a]		
	Pre-CRM	Post-CRM	P value[a]
Outcome measures			
Frequency of event reporting	32 (27–38)	39 (32–47)	.1
Overall perceptions of safety	40 (35–45)	42 (36–48)	.6
Safety culture: labor and delivery unit			
Supervisor/manager expectations and actions promote safety (nonphysicians)	70 (64–76)	78 (70–86)	.1
Organizational learning–continuous improvement	46 (41–51)	59 (53–65)	.001
Teamwork within hospital unit	63 (59–68)	75 (70–81)	.001
Communication openness	42 (37–48)	59 (52–66)	.001
Feedback and communication about error	24 (20–29)	30 (24–35)	.1
Nonpunitive response to error	16 (13–20)	26 (20–31)	.005
Staffing	47 (43–51)	50 (45–55)	.3
Hospital management support for patient safety	47 (42–52)	54 (47–62)	.1
Safety culture: hospital-wide			
Teamwork across hospital units	24 (20–28)	24 (18–29)	.9
Hospital handoffs and transitions	28 (23–32)	30 (25–36)	.4

CI, confidence interval; *CRM*, crew resource management.

[a] Corrected for within-person clustering of positive responses in each time period.

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time frames (in 2007, 519 of 747; in 2008, 476 of 663). The patient survey showed overwhelming positive responses (>90% positive responses to all 22 questions) to both pre-CRM and post-CRM surveys. The high number of positive responses made it difficult to assess any changes in patient perceptions, as there were no significant differences in responses to questions targeting perceptions of communication between nurses and physicians.

Using 8 quarters of data (quarter 1, 2005 through quarter 4, 2006), we established a baseline pre-CRM AOI score for our institution (Figure, *purple*). We excluded the 2 quarters when staff were being trained and evaluated pre-CRM (quarter 1, 2007 and quarter 2, 2007). The 6 quarters post-CRM (quarter 3, 2007 through quarter 4, 2008) showed a significant decrease in the AOI compared with baseline (Figure, *yellow*). The average AOI score decreased from 0.052 (95% confidence interval, 0.048–0.055)

for the baseline period to 0.043 (95% confidence interval, 0.040–0.047) for the follow-up period.

Comment

Several studies show mixed results from CRM training, with or without the use of medical simulation. In 2008, Nielsen and Mann[17] noted improvements in the AOI, Weighted Adverse Outcome Score, and the Severity Index 4 years after the implementation of teamwork behaviors at Beth Israel Deaconess Medical Center (Boston, MA). Of note, Nielsen et al,[7] published a preliminary article in 2007 showing no clinical improvement, attributing the lack of effect to "inadequate time to implement the intervention, a relatively short follow-up period, and baseline variation between hospitals in the incidence of adverse events." Less frequent are examples of authors who correlate improved patient outcomes with simulation-based training. Draycott et al[14] in 2008 are notable for having

shown improved neonatal outcomes following simulation-based shoulder dystocia training.

Our CRM L&D implementation study demonstrates a correlation of clinically and statistically significant reductions in the obstetrical AOI following the implementation of a CRM training course augmented with high-fidelity medical simulation. High rates of patient satisfaction were maintained, while the staff's impression of the institution's attitude toward patient safety improved.

The types of errors that CRM is designed to address involve communication, decision-making, and conflict resolution.[19,20] A key premise of CRM is to acknowledge that human beings are fallible. To account for the inevitable cognitive overload, miscommunication, or improper decision, a robust system of cross-monitoring must be incorporated. Every member of the team is therefore tasked not only with fulfilling their respective job requirements, but also with monitoring for unanticipated complications and possible mistakes. For cross-monitoring to block and prevent errors, there must be an institutional expectation of shared responsibility for a good outcome, encouraging any team member to voice a concern.

Quick updates, team huddles, or planning meetings contribute to the shared mental model of a situation or plan, while closed-loop communications (check-backs, call outs, task delegation to specific individuals) protect the flow of information. This team structure and climate promotes the ability of all team members to work efficiently and collaboratively for the benefit and safety of the patient. Teaching CRM to medical professionals requires an active training process that specifically focuses on the applicable teamwork skills. The training must include a program of reinforcement to strengthen newly learned behaviors and prevent their gradual diminishment.[21]

This L&D CRM training program drew strength from multiple sources: multidisciplinary involvement of clinical and nonclinical staff, high participation rates, administrative support, and longitudinal data assessment before and after

implementation. The data collection included preintervention and postintervention assessments of the Safety Attitude Questionnaires and patient feedback surveys, as well as patient outcomes through the AOI (2005 through 2008). The independent tracking of clinically relevant data permitted the temporal correlation of a safety-based intervention in the work environment with a demonstrated benefit of improved patient outcomes.

The degree of departmental participation and multidisciplinary nature of the training were the direct result of senior administrative support and pressure for the program's implementation. Not only were OBs, nurse midwives, anesthesiologists, and nurses involved, but nursing assistants and unit secretaries as well. The involvement of nonclinicians, especially unit secretaries, reflected the crucial nonmedical links in the communication chain that can impact patient care.

The high participation rates (55% for nurses, to a high of 100% for the anesthesiologists; 89% of OBs) meant that the vast majority of staff underwent a shared learning experience, creating a common vocabulary and frame of reference for the application of the CRM principles. Institutional support for participation reinforced the attitude that these concepts were to be regarded as important, that it was the responsibility of the staff to understand, adopt, and apply them. To accommodate the staff, lectures and training sessions were arranged to cover all 3 shifts. The creation of internal champions, who delivered the didactic sessions, meant that a solid core of staff within the department became well versed in the CRM concepts, positioning them to provide posttraining reinforcement and coaching to those who were not able to participate.

The medical simulation and debriefing focused on team behaviors, not clinical performance, thus creating a more constructive atmosphere, offsetting the naturally defensive reaction often seen as people watch themselves on video in the company of their peers.

The limitations of this study include an inability to discern patient satisfaction because of the high rates of satisfac-

TABLE 3
Comparison of safety dimension responses

Safety dimension/Question	No./total (%) Pre-CRM	Post-CRM	P value
OVERALL PERCEPTIONS OF SAFETY			
It is just by chance that more serious mistakes don't happen around here			
Strongly disagree/disagree			
All staff	73/185 (39)	42/119 (35)	.5
OB	26/53 (49)	15/31 (48)	1.0
RN	28/66 (42)	13/49 (27)	.1
FREQUENCY OF EVENT REPORTING			
When a mistake is made that could harm a patient, but does not, how often is it reported?			
Always/most of the time			
All staff	82/170 (48)	66/110 (60)	.07
OB	16/49 (33)	13/30 (43)	.3
RN	39/64 (61)	34/47 (72)	.2
COMMUNICATION OPENNESS			
Staff will freely speak up if they see something that may negatively affect patient care			
Always/most of the time			
All staff	106/185 (57)	86/119 (72)	.008
OB	28/53 (53)	22/31 (71)	.1
RN	42/66 (64)	41/49 (84)	.02
TEAMWORK WITHIN HOSPITAL UNIT			
When one area of labor and delivery gets really busy, others help out			
Strongly agree/agree			
All staff	102/182 (56)	80/118 (68)	.04
OB	28/53 (53)	23/31 (74)	.07
RN	36/65 (55)	32/49 (65)	.3
FEEDBACK AND COMMUNICATION ABOUT ERROR			
In this unit, we discuss ways to prevent errors from happening again			
Always/most of the time			
All staff	60/184 (33)	57/118 (48)	.008
OB	9/53 (17)	14/31 (45)	.01
RN	29/67 (43)	25/49 (51)	.5
NONPUNITIVE RESPONSE TO ERROR			
When an event is reported, it feels like the person is being written up, not the problem			
Strongly disagree/disagree			
All staff	27/184 (15)	29/118 (25)	.03
OB	8/53 (15)	9/31 (29)	.2
RN	14/66 (21)	17/49 (35)	.1
COMMUNICATION			
Decisions are made on the labor and delivery unit using input from all relevant personnel			
Strongly agree/agree			
All staff	87/185 (47)	83/119 (70)	< .0001
OB	31/53 (58)	23/32 (72)	.3
RN	23/67 (34)	32/48 (67)	.0007

CRM, crew resource management; OB, obstetrician; RN, registered nurse.

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FIGURE
Results of Adverse Outcomes Index (AOI)
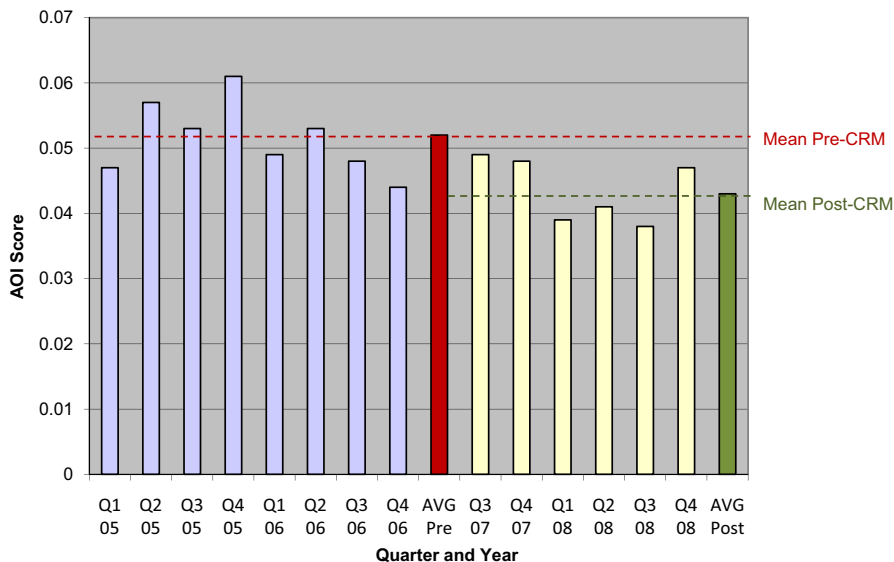
Note that Q1 and Q2 for 2007 are not included because this was during the time of initial evaluation and training.

AVG, average; *CRM*, crew resource management; *Q*, quarter.

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consideration should be given to adopting CRM with simulation training for obstetrical units. ∎

tion in the pre-CRM training period. The study was designed to evaluate the effectiveness of implementing an L&D CRM program on an active obstetrical unit and as such, the results cannot be interpreted as a randomized controlled trial. The post-CRM evaluation staff response was lower than the pre-CRM evaluation response. This may impact our study findings for the Hospital Survey on Patient Safety Culture, however the AOI findings are not affected by staff response.

As with many other training programs, the next challenge is sustaining what is learned. Operational changes such as unit rounds at a departmental white board have helped reinforce the concept of team structure. Online refresher courses have been adopted. Didactic and simulation-based courses for new personnel are in progress, to prevent the dilution of the pool of trained personnel. Our evaluation offers an example of a unit-wide patient safety initiative incorporating a simulation-based, CRM training program that produced a statistically significant improvement in obstetrical clinical outcomes.

Although this study was not designed to determine which element of CRM training with simulation training was responsible for the overall improvement, understanding the elements and how they worked together is important for future research and implementation. Of note, while Nielsen and Mann[17] reported a 12-month training period with similar decrease in adverse outcomes, our training program was completed in 2 months. While a direct comparison of the training costs vs clinical improvements is challenging, achieving similar results with a significantly shorter training time is certainly worth consideration. A shorter training time may call for the inclusion of simulation with CRM training.

This study is unique in its focus on implementing and evaluating the effectiveness of CRM combined with simulation training on an active obstetrical unit. The program was noted to have an impact on patient outcomes as well as provider attitudes. Using the combination of a didactic approach to CRM with the addition of simulation training enhanced the potential for learning and culture change in the L&D unit. Given the success of the program,

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