The Nature, Characteristics and Patterns of Perinatal Critical Events Teams

William Riley, PhD; Helen Hansen, PhD, RN; Ayse P. Gürses, PhD; Stanley Davis, MD; Kristi Miller, RN, MS; Reinhard Priester, JD

Abstract

The Institute of Medicine has released several important reports strongly recommending team training to improve patient safety. Most team theory assumes that teams are stable, and leadership is constant. However, there are numerous instances in health care where teams are not stable, and leadership is constantly changing. A growing body of evidence has documented the complexity of interdisciplinary health care teams, particularly in critical events. This study uses *in situ* simulation to better understand the nature, characteristics, and the communication patterns of health care teams. We conducted 35 obstetrics emergency simulations at six different hospitals, involving over 700 physicians, nurses, and support staff. These simulated emergencies were videotaped, and 16 were analyzed extensively by medical, human factors, and safety experts. Our findings indicate that during health care emergencies, critical events teams are not stable, and their leadership changes constantly. Important areas for team training and future study are identified.

Background

Within the last decade, interest in communication patterns and performance of health care teams has re-emerged. A growing body of evidence indicates that interprofessional team communication plays a significant role in ensuring patient safety during critical events. In the early 1990s, research on nurse-physician interactions on critical care units indicated that nurse-physician communication and collaboration had an important effect on patient morbidity and mortality, establishing a link between critical care team performance and patient outcomes.[1, 2, 3] Recent research, using the concepts of crisis resource management (CRM) (derived from crew resource management in aviation) and critical event team training (CETT) (primarily in health care), has refocused attention on the complexity of interprofessional health care team composition, leadership, communications, and performance. CRM and CETT have also provided a conceptual foundation for understanding team performance during critical events in health care.

In its examination of medical errors and patient safety, the Institute of Medicine (IOM)[4, 5, 6] concluded that although important, the nature, characteristics, and communications patterns of health care teams remain poorly understood. The IOM indicated that the quality of communication among health care team members varies significantly and that this variability has

serious consequences for patient safety. For health care organizations and professionals to improve their performance in critical events, team dynamics must be understood better, and strategies for more effective communication must be described. Although interprofessional teams consist of individuals who are expert in their respective disciplines, they do not always bring effective interprofessional skills to the team. A "team of experts" is not necessarily an "expert team."[7]

In this paper, we present findings from an observational study about the nature, characteristics, and communication patterns of interprofessional, critical events teams as they form and reform during critical obstetrical events. Unlike conventional teams, these teams come together to perform a specific task, and they reform when the task or mission changes significantly. We examined the videotaped performance of these critical events teams in 16 *in situ* simulations of obstetric emergencies. Critical events teams, which are also referred to as contingency teams,[8] temporary teams,[9] action teams,[10] or rapidly formed teams[11] change their structure dynamically in response to stressful and unpredictable circumstances, assembling for a limited time, based on the task requirements of the emergent situation, and disbanding once the emergency is over. In this paper, these teams will be referred to as "critical events teams."

We used high fidelity, *in situ* simulation—simulations in the real-life clinical setting—to examine patterns of team communication and performance during obstetric critical events. Our aims were to describe the stages of team formation and reformation (points at which the team assembles, reconfigures, or reassembles to complete a task during a critical event); the team composition at each stage; team situational awareness, shared mental model, establishment and transfer of leadership and teamwork, closed-loop communication, SBAR-R; and latent conditions.

We selected obstetrics crises to study team performance for several reasons:

- They occur in a compressed timeframe, typically lasting less than 30 minutes from the time an emergency is declared, until the baby is delivered by cesarean section (C-section).
- They can be readily replicated with *in situ* simulation.
- Team communication failures can be readily observed and documented through video.
- Root cause analysis indicates that over 70 percent of sentinel events in obstetrics result from communication failures and poor team functioning.[12] Although tremendous advances in perinatal outcomes have occurred over the past 40 years, the incidence of serious injury remains high at 6.3 birth traumas per 1,000 live deliveries.[13]
- Team and leadership communication patterns found during obstetrics crises are similar to those among members of other types of health care teams.

Concepts and Framework

Recent work in CRM and CETT has provided a conceptual foundation for this study. An interprofessional health care team consists of two or more individuals who perform some work-related task, have a shared past and foreseeable future, and share a common fate.[14, 15] Teamwork is a composite of behaviors that facilitate effective team member interaction[16] throughout the performance of a team task. In addition to expert technical skills, team members must possess specific nontechnical knowledge, skills, and attitudes (e.g., monitoring each other's

performance); knowledge of one's own and one's teammates' responsibilities; and a positive disposition toward working as a team.[17, 18, 19]

Conventional team theory assumes most professional teams are established formally and intentionally and have extensive training and stable membership.[14] It includes nuanced analyses of team evolution, such as stages of forming, norming, storming, and performing;[20] team development and leadership;[21] and situational leadership.[22] However, conventional team theory does not adequately describe the dynamics of contingency teams common in health care emergencies. A core team is a group of caregivers who work independently to manage a set of assigned patients from point of assessment to disposition; a contingency team is a time-limited team formed for specific, circumscribed events and is composed of members from various teams.[23]

The members of critical events teams might or might not be familiar with each other or each other's work and communication styles.[9] Health care teams have demonstrated remarkable abilities to function together, even without a prolonged process of team building.[24] However, the patterns of a critical events team's performance are far less predictable than those of a conventional team. These patterns are not well understood, and therefore, training of such teams has not been grounded in a scientific understanding of effective nontechnical teamwork behavior.[25]

In order to examine the performance of critical events teams, we applied the evidence-based teamwork framework developed for AHRQ's TeamSTEPPS®[26, 27] training program. In this paper, the term "nontechnical teamwork behavior" refers to a team's performance relative to five core concepts: situational awareness, shared mental model, establishing leadership, transfer of leadership, and closed-loop communication.

Methods

This descriptive study used content analysis of 16 randomly selected videotapes taken at 35 *in situ* simulations. The settings were the perinatal units and operating rooms of six hospitals of the Fairview Health System in Minnesota. Table 1 shows the hospitals, annual number of deliveries, and the *in situ* simulation trials held at each facility.

Table 1. Participating hospitals and number of *in-situ* simulation trials

Hospital	Description	Annual deliveries	Number of simulations (used in study)
A	Suburban	~3,200	10 (4)
B	Major teaching	~3,300	6 (1)
C	Rural	~500	5 (3)
D	Suburban	~3,000	7 (3)
E	Rural	~700	4 (2)
F	Rural	~900	4 (3)
Total		~11,600	36 (16)

In developing the *in situ* program, we secured all necessary approvals to conduct the research and invested significantly in audiovisual recording capability. Fairview Health Systems committed substantial resources by reserving operating rooms, perinatal rooms, and space for observation and debriefing. The private medical staff voluntarily participated in the *in situ* simulation training, while nursing staff and support staff rotated into the training during scheduled work hours.

Subjects

The *in situ* simulations involved two classes of personnel from the hospital staff: direct team members and indirect team members. We recruited direct team members, and they were informed about the *in situ* simulation ahead of time and agreed voluntarily to participate in a simulation trial. Each simulation included an obstetrician, labor and delivery nurses, neonatal nurse practitioners, an anesthesiologist, certified registered nurse anesthetists (CRNA), a health unit coordinator, and operating room staff. During the team briefing prior to each simulation, direct team members were instructed to call upon any indirect team members, such as blood bank and laboratory staff, backup surgeons, central supply, extra personnel, code teams, language interpreters, and respiratory therapists to treat the patient, just as they would during a true obstetric emergency. Indirect team members did not know in advance about the simulation or their possible involvement. Each simulation involved an average of 20 individuals. Overall, approximately 700 medical and hospital staff participated in the simulations.

Scenarios and Event Sets

Our *in situ* simulations were based on three scenarios composed of six to eight validated event sets. We created each scenario based on sentinel events that occurred within the previous 5 years at the six participating hospitals. Each scenario was designed to prompt nontechnical teamwork behavior. The event sets were designed to prompt behavioral markers or nontechnical behaviors that contribute to a team's performance in a given situation.[28, 29] Behavioral markers for situational awareness, shared mental model, establishment and transfer of leadership, teamwork, and closed-loop communication[8] are provided in Table 2. Definitions of several of these behavioral markers were adapted from existing literature.[23, 30, 31, 32]

In this study, we defined the "leader" as a person who is physically present and performs three specific tasks: (1) prioritizes decisions, (2) coordinates activities, and (3) communicates a shared mental model. "Leadership transfer" is an explicit handoff of leadership from one team member to another. "Situational awareness" is conscious recognition of salient factors and conditions that contribute to safe practice; it comes from monitoring one's surroundings and continuously facilitating the design and redesign of the care plan with changing conditions. "Closed-loop communication" consists of verbal exchanges between parties who acknowledge receipt of information with reciprocal verbal interactions, in which there are no failures in exchange of key information, and recommendations are acknowledged. A "shared mental model" is a common understanding of the situation and plan by all members of the team.

Table 2. Behavioral markers included in the observation instrument

Behavioral marker	Definition	Examples
Establishing leadership	A participant who is physically present and performs three specific tasks:1) prioritizes decisions, 2) coordinates activities, and 3) communicates a shared mental model	• Assigns tasks • Gives instructions • Gives orders • Clarifies roles
Leadership transfer	Explicit handoff of leadership from one team member to another	Between surgeon and anesthesiologist at the initiation of surgical procedure
Situational awareness	Conscious, accurate recognition of salient factors and conditions in one's current environment	Managing distractors
Closed-loop communication	Verbal exchanges in which parties acknowledge receipt of information and assure that the exchange is resolved and complete	• Questions answered • Answers acknowledged verbally
Shared mental model	A common understanding of a problem and the plan	• Verbalize plans and rationale • Call outs

Data Collection and Analysis

We conducted 35 *in situ* simulations at six hospitals over a 13-month period from January 2006 to February 2007. All simulation trials were videotaped for use in debriefings and for content

analysis by the researchers. Cameras and microphones were strategically placed to capture physical and verbal action and interactions during the simulations. Due to the time intensive nature of the analysis, we randomly chose 16 of the 35 *in situ* simulations for study. Specifically, we selected videotapes from each of the six study sites without prior knowledge of the trial drawn for analysis.

We used the video recordings of the *in situ* simulation trials to study the critical events teams during the emergency C-sections. Video recordings have been used to study team performance successfully.[33, 34, 35, 36] Unlike direct observations,[37] video recordings allow close scrutiny and repeated inspection. Furthermore, they capture much of the richness of human interactions and of the context in which activities are studied.

To analyze the videos, we used an assessment instrument with three sections: (1) five behavioral markers, (2) duration of each stage of the obstetrics crisis, and (3) the number and type of team members at each of six stages.

The assessment instrument was developed based on an in-depth analysis of the existing literature[9] and the results of four expert group meetings. The expert group consisted of two physicians (including one obstetrician), two nurses (one maternal-child CNS and one PhD-prepared nurse researcher), and two human factors engineers.

After the initial development of the assessment instrument, the expert group reviewed five randomly selected video recordings (these were not used in the actual data analysis) to test and validate the instrument. Based on the findings of the pilot testing, the group modified and finalized the assessment instrument.

We conceptualized three ways to measure "leadership transfer": (1) explicit, (2) implicit observable, or (3) failed to observe due to assessment limitations. "Team formation" occurred when an interprofessional group of individuals with special expertise assembled to execute a specific task, whereas "team reformation" occurred when team membership changed in a significant way by the addition or deletion of team members and a significant change in the task. Through a cycle of team formation and team reformation, a critical events team assembles and then adds and releases members as appropriate to the situation. Each behavioral marker was scored using the following scale:

- "0" Behavior occurred at or below 50 percent of the times when prompted by the event set.
- "1" Behavior occurred between 50 percent and 90 percent of the times when prompted by the event set.
- "2" Behavior occurred more than 90 percent of the times when prompted by the event set.

A score was assigned for each behavior at each stage through consensus among the raters present. Each rater scored independently; then the raters discussed the rating and achieved agreement. Every session included at least one research team physician and one research team nurse.

Inter-Rater Reliability

We used the Kappa (κ) statistic to evaluate the inter-rater reliability for each behavior. Two experts viewed the same videos and independently rated team performance using the observation instrument. A $\kappa \geq 0.61$ was considered to be satisfactory.[36]

Results for the inter-rater reliability of the measures in the observation instrument ranged from $\kappa = 0.67$ to 1.00 (Table 3). All measures had a κ value above the satisfactory level (>0.61).

Results

We identified six distinct stages during simulated emergency C-sections. New stages of the critical event scenario were evidenced in significant changes in the team's task. In three phases, the change in task was accompanied by a change in team membership and leadership. The specific tasks associated with the beginning of each stage were:

Table 3. Kappa (κ) scores for each measure of the observation instrument

Behavior marker	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
Situational awareness	1.00	0.79	0.86	1.00	0.75	0.89
Shared mental model	0.81	0.71	0.75	0.84	0.67	0.80
Closed-loop communication	0.76	0.69	0.67	0.71	0.84	0.78
Leadership transfer explicitly conceded	N/A	0.75	0.80	N/A	0.80	0.81
Leadership established	0.89	0.82	0.84	1.00	0.81	0.84

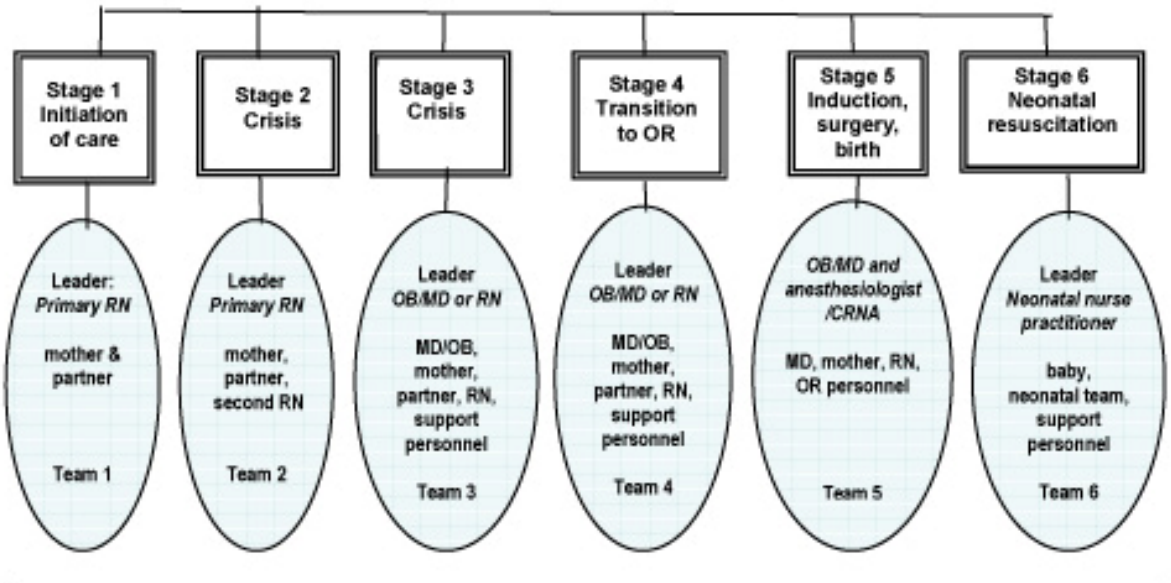
- **Stage 1:** Admission and assessment of patient and fetus.
- **Stage 2:** Identification of clinical crisis.
- **Stage 3:** Declaration of emergency.
- **Stage 4:** Induction.
- **Stage 5:** Surgical procedure.
- **Stage 6:** Infant resuscitation.

Figure 1 illustrates the six stages of the critical event, including the composition and leadership of each team as it formed or reformed. In Stages 1 and 2, the task changed: the team included the nurse, patient, and spouse or partner; the RN maintained leadership. In Stage 3, the task changed: the team composition changed, and leadership transferred from RN to the surgeon. In Stage 4, the task changed: the team expanded somewhat, and the leadership remained with the surgeon. In Stage 5, the task changed: the team expanded considerably, and leadership transferred from surgeon to anesthesiologist (or CRNA) and back to the surgeon. In Stage 6, the task changed, and the neonatal team was formed: the neonatal nurse practitioner assumed leadership for the infant's care. The modal group membership ranged from as few as three individuals (Stages 1 and 2) to a high of 13 (Stages 4 and 5).

The Stage 1 team comprised the mother, a spouse or partner, and a primary nurse (RN). The key tasks at this stage were introduction and identification of team members, creation of relationships and trust, and initial assessment of the mother's presenting condition. Stage 1 ended with continuation of the original triad, the arrival of a second RN or, in some cases, a family practice physician.

The Stage 2 team predominantly included the mother, a spouse or partner, the primary RN, and in some cases, an RN who arrived to assist. This stage was characterized by unfavorable changes in the mother's and fetus's clinical condition. The outcome of this stage was contact with the obstetrician or family practice physician to request his or her physical presence and to assume leadership in the impending medical crisis.

The Stage 3 team was reconfigured to add the obstetrician and or family practice physician. At this stage, the mother's condition worsened; decisions were made regarding necessary



Variable		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
Number of people	Mean	3.4	4.58	6.13	7.9	12.6	7.79
	Mode	3	4	6	7	13	8
	SD	0.63	1.38	1.12	2.89	2.06	4.04
	Min-max	3-5	1-6	4-9	5-15	9-15	4-19
Duration (min)	Mean	6:56	7:37	6:23	3:09	7:52	10:48
	Min-max	2:19-13:20	0:49-31:24	1:15-12:42	0:53-6:32	3:16-22:32	1:37-22:02

Figure 1. Stages of team formation and reformation with selected team characteristics.

emergency measures; and planning for an emergency intervention occurred. This stage was characterized by high team coordination and communication demands. Stage 3 ended with the calling of a Code C-section.

The Stage 4 team included the mother, spouse or partner, at least two RNs, the obstetrician, and additional personnel, who responded to the growing crisis. Stage 4 was focused on preoperative preparation of the mother for immediate transport to the OR. This stage ended at the time of entrance to the operating room. The Stage 5 team was substantially reformulated. In addition to the mother, obstetrician, the primary RN and/or an RN circulating nurse, the entire operating room staff was present, including an anesthesiologist and/or CRNA, OR technicians, and the neonatal team. This stage was distinguished by two tasks: anesthesia induction and the surgical procedure to deliver the infant. The exchange of leadership from MD/OB to anesthesiologist or CRNA and back, the initiation of the surgical procedure, and the birth of a compromised infant were important leadership and team-formation and reformation incidents. Stage 6 focused on the neonatal team. The neonatal nurse practitioner assumed leadership of this team. The main task for this team was initiation of the infant Code Blue and resuscitation. This stage ended with the stabilization of the infant.

Team Behaviors

After establishing the stages of the team formation and reformation, we examined the performance of key behavioral markers in rapidly formed teams. Table 4 shows five team behaviors classified by stage of team formation, according to the percentage of time that the behavior occurred in relation to the number of times the behavior was prompted (or called for) during the stage.

Table 4. Proportion of "excellent" behavioral markers by stage (%)

Behavior marker	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Average
Establishing leadership	69	54	64	60	36	64	58
Leadership transfer	N/A	14	13	N/A	27	22	20
Situational awareness	69	58	67	56	44	57	50
Closed-loop communications	19	17	40	27	0	25	21
Shared mental model	44	33	40	50	25	17	36

These findings indicate that leadership and situational awareness were maintained at a better than 50 percent level across all stages. However, neither leadership transfer nor closed-loop communication reached an incidence level of 50 percent. At Stages 2 and 4, overall team behaviors were at their lowest. These two stages involved significant changes in task and reconfiguration of the teams. During Stages 3 and 4, where the emergent nature of the crisis was most evident, the overall team behaviors bumped up to nearly the 50 percent level. At Stage 5, team behaviors declined as the team prepared to move the mother to the operating room. In Stage 6, we observed substantial improvement in team leadership (from 36 to 64 percent) and closed-loop communication (from 0 to 25 percent).

Discussion

Critical event teams in health care face significant complexity and time pressures, which challenge safe patient care. Our findings indicate six distinct stages of team formation and reformation within an obstetrics emergency, during which team membership was fluid. Unlike with conventional teams, these findings show that the critical events teams for obstetrical emergencies were not constant. Regrouping occurred from one stage of care to another, assuring that the right personnel were available to do the right thing at the right time. These teams formed and reformed without the luxury of deliberate selection, lacking a shared history as a team, and exhibiting minimal stable team member composition within a single event or over several critical events.

The temporary nature of rapidly developing teams during a critical event creates difficulties in applying traditional leadership definitions. To accommodate their special nature, we emphasize

the importance of the leader as the person who is physically present and who prioritizes decisions, coordinates activities, and communicates a shared mental model. This was essential because in our study, only a leader who was physically present could establish a shared mental model effectively for the team. Without a shared mental model, team performance deteriorated, and safe patient care was jeopardized.

The only individual present at each stage in every simulation trial was the mother. This finding indicates that including the mother as a team member was an essential aspect of delivering patient-centered care,[5] while using all resources available to the team[38] for ensuring safety and optimal care. To what extent this is fully recognized and utilized to the greatest patient safety benefit is an unresolved issue.

The findings show that one consistent leader was not present throughout the entire critical event. At each stage, leadership was established by different individuals on the team and transferred between team members in predictable ways. Leadership transfer occurred continuously throughout an obstetrics emergency. For example, in Stage 1, the primary nurse was always the team leader, and this leadership was transferred to the obstetrician upon entering the patient's room at the beginning of Stage 3. At this moment, the nurse was the leader with current situational awareness that had to be transmitted during the leadership transfer. Leadership was established in an "excellent" manner 58 percent of the time during these six stages of team formation and reformation, yet "excellent" leadership transfer was performed only 20 percent of the time.

The performance of these teams throughout the critical event was sporadic and uneven. The patterns of "excellent" team performance regarding situational awareness, closed-loop communication, and shared mental model were not consistently observed (overall average of 50 percent, 21 percent, and 36 percent, respectively). This lack of highly reliable performance could be a function of the complexity of the team dynamics in a critical event. Traditional team training theory is based on the assumption that teams train together until they achieve high performance. However, in critical events, the number of teams potentially needing training is impossibly large.

For example, Figure 2 shows that in the labor and delivery unit of one of the hospitals in this study, 208 total staff members made up the six categories. At least one person from each of these disciplines was called upon to participate as a member of a critical events team during an obstetrics emergency. This yields a total of *381 million possible combinations* of teams that could respond to a critical event, suggesting that any team consisting of the same individuals is very unlikely to happen more than one time and illustrating the impracticality of training each specific team combination until it achieves high performance.

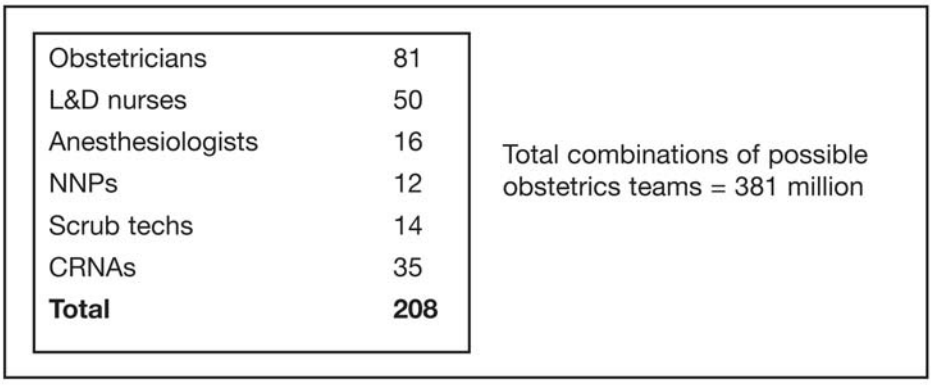


Figure 2. Staff in six categories and total team combinations for an obstetrics emergency.

Decades of research document a science of team performance and team training that is perhaps unknown in health care settings, especially among the medical staff.[25, 39] These findings add to the large body of teamwork research into the nature and complexity of critical events teams in health care. The current study contributes a framework for new theoretical development regarding the nature of team formation and reformation in health care and leadership transfer that occur during each of these phases. Without a better understanding of team behavior in rapidly formed teams and the predictors of leadership transfer, improvements in patient safety and team training are hampered. These results stress the need for individual team members to possess competence in critical events-team behaviors, not just in team-related competencies.

Implications

Our study of rapidly formed critical events teams helps explain where certain team and leadership behaviors might fail.

- First, certain types of critical events teams do not have stable leadership, and the different leaders in the respective stages should know their responsibility for maintaining situational awareness, creating a shared mental model for the other team members, and transferring leadership. Unlike conventional teams, critical event team membership is not constant. The nature of team formation and reformation, combined with leadership transfer, requires substantially different training in team communication in order to improve closed-loop communication, maintain situational awareness, and sustain a shared mental model.

  Many of the teams in health care do not meet the criteria of a stable team, and training curriculums for such teams should identify specific areas of team failures. The AHRQ TeamSTEPPS™ curriculum is a comprehensive team training resource. It has a number of specific training areas that can serve as effective countermeasures to the team failures found in this research.[23] A critical events team is a random collection of highly trained professionals, but they might not know each other, might not have worked together previously, and will likely never perform together again in exactly the same work team configuration. Although a critical events team might have a single physician who is responsible, the team structure and leadership configuration is far more complicated than the relationship between a single leader and multiple team members.

- Second, policies and procedures in hospital operating rooms are extensively developed for staff members, but our experience suggests that many are based on the assumption of conventional teams. Operating room policies and procedures might not take into account the various stages of formation and reformation that occurs with critical events teams, causing some policies and procedures to be ignored, forgotten, or not enforced. For example, policies for responding to latex allergy did not provide a means to ensure that the procedure was communicated and implemented during a critical event in the operating room.

- Third, these findings raise the question of what relationship exists between certain characteristics of critical events teams and patient safety. Improved patient safety requires an accurate understanding of team structure and flow at the microsystem level, so that effective interprofessional team training programs can be designed. We recommend more study to understand how critical events teams are different from conventional teams and what team training is needed for each.

- Fourth, hospital work environments might not acknowledge that critical events teams progress through various stages of team formation and reformation. Future research is needed on how to design hospital processes to improve the performance of critical events teams.

- Fifth, using *in situ* simulation, our research helps to better understand the nature and complexity of health care teams and to recommend effective countermeasures through improved team training. Simulation is also a powerful training tool, and applications of *in situ* simulation for training of critical events teams to improve communication should be explored to determine its effectiveness for this type of training. It is not enough to merely identify these behaviors; they also must be corrected by the critical events teams and avoided in the future.[39, 40]

- Sixth, in conventional teams it might be possible that implicit communication is sufficient for team members to effectively communicate with each other. However, in critical teams, our observations show that implicit communication can be ineffective and possibly dangerous for patient safety. For example, we observed many instances in leadership transfer where the leader made certain assumptions that were erroneous.

Conclusion

We studied *in situ* simulations, rather than actual obstetric crises. Although we endeavored to achieve high fidelity, a simulation does not replicate every aspect of team behavior during a real crisis. During a simulation, "simisms" can arise, which require the participants to suspend disbelief. In addition, some participants might not engage fully in the simulation, which could affect the findings and lead to inaccurate or incomplete conclusions.

The stages identified in this research are based on behavioral markers that emerged from our study of the team formation and reformation patterns observed on the video tapes. These stages could be an artifact of the research design and need further validation by observing real emergency C-sections. In addition, these findings are based on behavioral markers that the researchers were able to observe. It is possible that certain behaviors occurred but were not

measured because of the limitations of our measurements. At the same time, more complications/crisies could occur in real life situations.

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Author Affiliations

Division of Health Policy and Management, School of Public Health, University of Minnesota (Dr. Riley, Dr. Gürses, Mr. Priester); School of Nursing, University of Minnesota (Dr. Hansen); Fairview Health Services (Dr. Davis, Ms. Miller).

Address correspondence to: William Riley, PhD, Associate Dean, School of Public Health, University of Minnesota, 420 Delaware Street SE, MMC 729, Minneapolis, MN 55455; telephone: 612-625-0615; e-mail: riley001@umn.edu.

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