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# Impact of Simulation-Based Closed-Loop Communication Training on Medical Errors in a Pediatric Emergency Department

**Maria Carmen G. Diaz, MD, FAAP, FACEP[1]**
**and Kimberly Dawson, BSN, RN, CPEN, TCRN, EMT[1]**

## Abstract

Closed-loop communication (CLC) promotes a shared understanding of information. The authors hypothesized that simulation-based CLC training would improve staff perceptions of CLC ability and decrease medical errors. Participants experienced 2 hands-on CLC simulations one month apart. A retrospective chart review of Emergency Severity Index (ESI) 1 patients was conducted 4 months pre and post CLC simulation-based training. Seventy simulations were held over 13 weeks. Staff perceptions of CLC ability improved and were sustained after one month. Nine ESI 1 patients were seen pre CLC, and 9 post; 8/9 pre-CLC ESI 1 patients had medical errors, with 19 total errors noted; 5/9 post-CLC ESI 1 patients had medical errors, with 5 total errors noted (rate ratio [99% CI] = 3.8 [1.4, 10.2]; *P* = .008). This simulation-based CLC training curriculum improved staff perceptions of their CLC ability and was associated with a significant decrease in the number of medical errors in ESI 1 patients.

## Keywords

simulation, closed-loop communication, pediatric emergency department

Effective teamwork and communication are key elements of patient safety.[1,2] This is especially true in the emergency department (ED) where patient volume, acuity, and the intermingling of a large interprofessional staff can make clear, effective, and timely communication challenging. Additionally, ED resuscitation teams often need to come together quickly and coordinate tasks rapidly, accurately, and efficiently in order to perform life-saving interventions. Thus, teamwork and clear communication are paramount in these emergent scenarios[3,4] and serve as the foundation for the team's structure, collaboration toward a common goal, and task performance.[5] Ineffective communication has been associated with medical errors and poor outcomes.[6,7] ED teams must work together to avoid these preventable complications.

Closed-loop communication (CLC) promotes clarity and a shared mental model by allowing team members to verbalize, confirm, and close the loop about their understanding of information.[8-10] Verbal feedback is needed in CLC because it ensures that the team members understand the message. There are several crucial steps to CLC. (1) The sender of the message verbally transmits the message (call-out). (2) The sender of the message directs the message to a specific person or role. Messages or orders of "can someone get me . . ." may go unheard if not directed to a specific person or role, or multiple people may attempt to perform the same task simultaneously if there is no clarity about who will or should perform the task. This leads to unnecessary redundancy and ineffective use of resources. (3) The receiver of the message must verbally acknowledge receipt of the message. (4) The receiver needs to verbally confirm that what he/she heard was what the sender of the message actually said (check-back). (5) The sender verbally verifies that the message was received and interpreted correctly by the receiver of the message (loop closure).

Simulation provides a safe learning environment that offers the participant the opportunity for deliberate practice followed by facilitated feedback and reflection on performance. Deliberate practice leads to mastery learning through constant skill improvement rather than just skill maintenance. This is accomplished through robust, consistent educational interventions that are founded in

[1]Nemours/Alfred I. du Pont Hospital for Children, Wilmington, DE

**Corresponding Author:**
Maria Carmen G. Diaz, MD, FAAP, FACEP, Nemours Institute for Clinical Excellence, Nemours/Alfred I. du Pont Hospital for Children, 1600 Rockland Road, Wilmington, DE 19803.
Email: mcdiaz@nemours.org

information processing and the behavioral theory of skill acquisition and maintenance.[11,12] This is ideal for critical, nontechnical skills such as teamwork and communication training.[13]

The objective was to create a simulation-based training curriculum that would promote CLC among the multidisciplinary members of a pediatric emergency department (PED). The investigators also wanted to determine the baseline medical error rate (pre CLC) and the post-CLC implementation medical error rate for Emergency Severity Index (ESI) Level 1 patients seen in the PED. The goal was to use this information to determine if the simulation-based CLC training provided had an impact on medical errors during actual patient care, as documented in the electronic medical record (EMR).

The investigators hypothesized that simulation-based training sessions about CLC would improve PED staff perceptions of their ability to close the loop in communication. A secondary hypothesis was that CLC training would lead to a decrease in the number of medical errors that occurred in the PED post implementation of the training curriculum.

## Methods

This study took place in the PED of Nemours/Alfred I. duPont Hospital for Children in Wilmington Delaware. This PED is a level 1 Pediatric Trauma Center with an annual volume of approximately 60 000 patient visits. All pediatric emergency medicine attending physicians, fellows, physician assistants (PAs), registered nurses (RNs), and technicians were eligible to participate. The study had 2 phases: (1) a simulation-based closed-loop training curriculum and (2) a retrospective chart review. The study was approved by Nemours' Institutional Review Board.

### *Phase I: Simulation-Based Closed-Loop Training Curriculum*

All PED staff were required to watch 3 videos of simulated resuscitation scenarios: one with team members using poor CLC, another using good CLC, and the third with the team leader blindfolded with the team using clear, seamless CLC. Immediately after each video, the principal investigator facilitated an interactive discussion about the value of CLC. This discussion highlighted pros and cons of the approaches seen in each video as well as each approach's potential impact on patient safety and quality of care.

Staff then participated in 2 different simulations. The first simulation occurred one month after the video review and facilitated discussion. This simulation was 15 minutes in length and involved 3 to 4 team members. Each team had at least 1 physician, 1 PED RN, and 1 PED technician. This simulation focused on targeted individualized training about proper CLC techniques. Participants were told up front that this was a CLC training simulation. The investigators reviewed CLC key concepts, and then participants were informed that they had 30 seconds to prepare for an incoming unresponsive 6-month-old with weak pulses. After 30 seconds, the simulated patient arrived, and the participating team had to assess and manage the patient. The scenario ended when 1 dose of epinephrine was ordered and given. The investigators then conducted a debrief that focused on the CLC techniques utilized during the preparation, patient arrival, and resuscitation phases of the simulation as well as opportunities for improvement. Investigators highlighted each team member's role and how CLC impacts that individual's performance as well as the performance of the rest of the team.

The second simulation was an hour-long medical resuscitation that utilized a 6-member team and required an integrated use of CLC throughout the resuscitation. Teams consisted of 1 PED attending, 1 PA or fellow, 3 RNs, and 1 technician. Teams were told up front that this was a medical resuscitation. Teams were given 30 seconds to prepare for a child with stable supraventricular tachycardia. Shortly after patient arrival, the patient became unstable. The scenario ended when the team successfully performed synchronized cardioversion on the patient twice. The investigators then conducted a debrief that focused on the CLC techniques utilized during the preparation, patient arrival, and resuscitation phases of the simulation as well as opportunities for improvement. This debrief also emphasized the importance of integrating CLC in high-stakes, low-frequency events and how this concept also may be applied to daily tasks. This hour-long simulation occurred one month after the 15-minute simulation session.

Using a 1 to 10 Likert scale, staff rated their perceptions about their own and their team's CLC ability prior to (pre) and immediately after the 15-minute simulation (post 1), and immediately after the hour-long simulation (post 2). Participants were asked to rate each of 5 specific elements of CLC during each survey: use of clear call-outs, if call-outs were directed to a specific person, if orders were acknowledged, if check-backs were utilized, and if loops were closed.

### *Phase II: Chart Review*

The investigators then conducted a retrospective chart review of all ESI level 1 ED patients seen 4 months pre and post CLC training to assess the number of medical errors during each time frame. Investigators searched the EMR (EPIC; Epic Systems Corporation, Verona, Wisconsin) by date and ESI level. ESI level 1 patients seen during these time frames were identified, charts were reviewed, and data were extracted directly from EMR documentation. This 4-month time frame was

**Table 1.** Survey Respondent Characteristics: Number Participating and Years of Experience.

| Role | Pre | Post 1 | Post 2 | P |
|---|---|---|---|---|
| Physician (attending/fellow) | 12 | 12 | 15 | .9323[a] |
| Nurse | 50 | 61 | 46 | |
| Technician | 24 | 27 | 27 | |
| Physician assistant | 5 | 5 | 4 | |
| Role not identified on survey | 21 | 4 | 0 | |
| Years of experience, mean (SD) | 5.8 (5.5) | 6.1 (5.5) | 6.2 (5.8) | .831[b] |

[a]$\chi^2$.
[b]Analysis of variance.

**Table 2.** Survey Responses.[a]

| | Pre | Post 1 | Post 2 | P[b] |
|---|---|---|---|---|
| Clear call-out | 6.6 (1.3) | 9.2 (1.1) | 8.8 (1.1) | <.0001 |
| Call-out directed to specific person | 6.0 (1.6) | 9.4 (1.0) | 8.2 (1.8) | <.0001 |
| Orders acknowledged | 3.0 (0.8) | 9.1 (1.1) | 8.8 (1.1) | <.0001 |
| Check-back utilized | 7.5 (2.0) | 9.1 (1.1) | 8.8 (1.3) | <.0001 |
| Loop closed | 6.3 (1.9) | 9.3 (1.1) | 8.6 (1.3) | <.0001 |

[a]Likert scores shown as mean (SD).
[b]Analysis of variance.

chosen given the onboarding of a large number of new staff 4 months after completion of the simulation-based training curriculum. ESI 1, the highest acuity, patients were chosen because they have the highest likelihood of need for multiple interventions, medications, and resuscitation. Medical errors, as noted in the review of the documentation, were categorized into the following types: medication (eg, wrong dose), equipment (eg, wrong size), and vital signs (eg, discrepant or lacking values). The total number of medical errors was tallied as a sum of the medication, equipment, and vital signs errors.

### *Data Analysis*

Survey data were analyzed using analysis of variance, $\chi^2$, and *t* tests as appropriate. Poisson regression was used to compare error rates between the pre and post CLC periods. In cases where no error was noted during the post-CLC period, the *P* value was generated using the Fisher Exact test.

## Results

### *Phase I: Simulation-Based Closed-Loop Training Curriculum*

Participants included PED attendings, PAs, fellows, RNs, and technicians. Distribution of participant types may be found in Table 1. There was no significant difference among respondent roles across survey periods ($P$ = .9323), and no significant difference among years of experience ($P$ = .831).

**Table 3.** *P* Values: Analysis of Whether or Not Post-Simulation Period Response Is Sustained Between Earlier and Later Surveys.

| | P[a] |
|---|---|
| Clear call-out | .01 |
| Call-out directed to specific person | <.0001 |
| Orders acknowledged | .05 |
| Check-back utilized | .03 |
| Loop closed | .0001 |

[a]t Test.

Seventy CLC simulations were conducted over the span of 13 weeks: forty 15-minute sessions and 30 hour-long sessions. Participant survey responses may be found in Table 2. This table details mean Likert scores prior to the first simulation (pre), after the 15-minute simulation (post 1), and after the hour-long simulation (post 2). As noted in Table 2, *P* values for all 5 CLC elements reached significance. Table 3 shares *P* values to indicate whether or not the post-simulation period response was sustained between earlier and later surveys. Four out of the 5 CLC elements had *P* values <.05; "orders acknowledged" had *P* =.05.

**Table 4.** Comparison of Medical Errors in ESI 1 Patients Pre and Post CLC Training.

| | Pre CLC (8 patients with errors) | Post CLC (5 patients with errors) | Rate Ratio (99% CI) | *P* |
|---|---|---|---|---|
| Medication error | 12 | 1 | 12.0 (1.56, 92.3) | .017[a] |
| Equipment error | 4 | 4 | 1.0 (0.3, 4.0) | .99[a] |
| Vital Signs error | 3 | 0 | | .21[b] |
| Total number of errors | 19 | 5 | 3.8 (1.4, 10.2) | .008[a] |

Abbreviations: CLC, closed-loop communication; ESI, Emergency Severity Index.
[a]Poisson regression.
[b]Fisher exact test.

### *Phase II: Chart Review*

Nine ESI 1 patients were seen pre CLC and 9 post. Review of the documentation revealed that 8/9 (88.9%) pre-CLC ESI 1 patients had medical errors, whereas 5/9 (55.6%) post-CLC ESI 1 patients had medical errors. Data on total numbers of medical, medication, equipment, and vital signs errors are shown in Table 4.

## Discussion

This study showed that the simulation-based CLC training curriculum improved staff perception of their ability to close the loop in communication. Additionally, these findings were sustained over one month (post 1 vs post 2) with call-out directed to a specific person and loop closure as the elements with the most significant *P* values.

The investigators chose to show 3 videos of simulated resuscitations at the start of the curriculum because it was felt that this would be an interactive way to introduce CLC concepts to a large number of staff. This allowed for meaningful discussion among participants and heightened awareness of the importance of CLC. The investigators specifically chose to include a video of a simulated resuscitation with the team leader blindfolded to emphasize that seamless CLC requires clear verbalization and active listening skills from all team members.[14] Additionally, this blindfolded team leader scenario may mimic real life in the PED when a newborn or young infant requires resuscitation. In these specific situations the team leader standing at the foot of the bed may not be able to fully see the actual patient given the patient's size and number of staff needed around the patient to perform the resuscitation. The investigators also chose to have staff participate in 2 different hands-on simulations. This was the most practical way to reach the large number of staff while setting the teams up for success. The initial simulation session was used to provide deliberate practice opportunities for a smaller number of participants. The second simulation session was used to help reinforce the principles taught during the video review and the initial simulation session. This second session allowed participants to integrate CLC skills learned in a real-life scenario that is often seen in the PED. Results demonstrate that staff felt that the staff completed all 5 elements of CLC after each simulation.

Results also show that the CLC curriculum reduced medical error rates for ESI 1 patients with a significant reduction in medication errors. ESI 1 patients were chosen intentionally because any medical error in these patients has the potential to be life-threatening. These patients have the highest likelihood for multiple resuscitative interventions and medications.[15] The 4-month time frame was chosen for the chart review because of a large influx of new staff. The aim was to ensure that the analysis of errors included CLC training curriculum participants and not the new staff who had not yet undergone this training curriculum. As noted in Table 4, the equipment error rate remained the same pre and post CLC training. Equipment errors noted in the chart review included wrong size tube or depth of tube insertion for patient age. It is possible that these errors were not related to failure of CLC and were caused by knowledge gaps or patient-specific circumstances not captured in the EMR.

The primary limitation of this work is that this study assessed documentation as a surrogate for actions and critical decision making. The quality of care that actually was delivered and what was documented may diverge, and lack of documentation may not necessarily represent less than optimal delivery of care. Additionally, participants were exposed to only 2 CLC simulations. Studies have shown the benefits of repetitive practice using simulation.[16,17] Another limitation is the number of ESI 1 patients seen. With only 9 patients pre CLC and 9 post, performance on 1 patient may have impacted overall data for each subset. However, given that all of these were high-acuity critically ill patients requiring resuscitation, the investigators felt that the presence or absence of even 1 error was clinically significant.

CLC can prevent errors and improve patient safety and outcomes. Simulation-based training can help promote CLC in a PED and reduce medical error rates.

## Conclusions

This study shows that simulation is an effective tool to teach CLC and improved staff perception of their ability to close the loop in communication. Ongoing training is needed to ensure that the skills are sustained. Additionally, this simulation-based CLC training program was associated with a significant decrease in the number of medical errors that occurred in ESI 1 patients seen in the PED. Further studies are needed to assess adherence to checklists that detail seamless CLC and analyze the presence/absence of medical errors in real time. Further studies also are needed to ensure that this training is reproducible and translates across sites and institutions.


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### ORCID iD

Maria Carmen G. Diaz https://orcid.org/0000-0002-5086-833X


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