Communication Patterns During Routine Patient Care in a Pediatric Intensive Care Unit: The Behavioral Impact of In Situ Simulation

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Objective: Effective communication minimizes medical errors and leads to improved team performance while treating critically ill patients. Closed-loop communication is routinely applied in high-risk industries but remains underutilized in healthcare. Simulation serves as an educational tool to introduce, practice, and appreciate the efficacy of closed-loop communication.

Methods: This observational before-and-after study investigates behavioral changes in communication among nurses brought on by simulation team training in a pediatric intensive care unit (PICU). The communication patterns of PICU nurses, who had no prior simulation experience, were observed during routine bedside care before and after undergoing in situ simulation.

One month before and 1 and 3 months after simulation (intervention), 2 trained raters recorded nurse communications relative to callouts, uttered by the sender, and callbacks, reciprocated by the recipient. The impact of simulation on communication patterns was analyzed quantitatively.

Results: Among the 15 PICU nurses included in this study, significant changes in communication behavior were observed during patient care after communication-focused in situ simulation. The PICU nurses were significantly less likely to let a callout go unanswered during clinical routine. The effect prevailed both 1 month ($P = 0.039$) and 3 months ($P = 0.033$) after the educational exposure.

Conclusions: This observational before-and-after study describes the prevalence and pattern of communication among PICU nurses during routine patient care and documents PICU nurses transferring simulation-acquired communication skills into their clinical environment after a single afternoon of in situ simulation. This successful transfer of simulation-acquired skills has the potential to improve patient safety and outcome.

Key Words: patient safety, simulation, communication, pediatric intensive care unit

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In the United States, an estimated 210,000 to 400,000 people die annually as a consequence of medical errors.[1] The Joint Commission data indicated that more than 70% of all reported errors in sentinel events are caused by ineffective communication.[2] Recent Joint Commission data confirmed that communication failures are account for more than half of the causes of sentinel events.[3] Communication difficulties between physicians and nurses in the intensive care unit frequently relate to weak safety culture and human errors.[4,5] Miscommunication leads to everyday mishaps, medical errors, and adverse events.[6–8] Nontechnical skill team training can increase directed commands.[9] A recent randomized case-control study found a correlation between team performance and directed commands during cardiac arrest.[10] The quality of resuscitation performance correlates with the quality of communication during the event.[11]

Closed-loop communication (CLC) involves the exchange of information between a sender and a recipient with confirmation that the sender's message has been received and interpreted as intended.[12,13] Specifically, CLC is composed of the following steps: (1) the sender initiates a message and (2) the recipient receives the message, interprets it, and confirms its receipt (Fig. 1). Some authors add a third step in which the sender verifies that the message was received and interpreted as intended.[13,15] This standardized communication scheme strives to catch the attention of all team members by increasing awareness of what has already been done and what still needs to be done.[16,17] Ultimately, CLC aims to enhance clarity in communication and to reduce the risk of errors.[14,18]

Landmark studies have linked simulation in medical education to both enhanced team performance and improved patient outcome.[19–24] This is in concert with the introduction of crew resource management in aviation increasing flight safety operations.[25,26] Simulation aids in perfecting the use of CLC and when practiced regularly strengthens the unimpeded transfer of information during hectic and critical situations.[13,27] Blindfolding the team leader is an effective intervention for practicing CLC, as it forces simulation participants to focus on communication skills and role clarity.[28] Residents who were blindfolded during simulation code training found the exercise beneficial for improving communication.[29–31]

Kirkpatrick's 4-level taxonomy evaluation model is used to evaluate the effectiveness of training programs.[32] Most simulation-based educational studies aiming to improve communication skills are at Kirkpatrick levels 1 to 2a (reaction and learning),[33–35] whereas studies investigating the behavioral impact of simulation at the bedside remain scarce.[36] A recent hospital survey on patient safety concluded that training that involved the adoption of team behaviors was correlated with perceived safety culture.[37]

This observational before-and-after study investigates the extent to which the benefits of simulation can be transferred to the bedside and measures the impact on staff behavior during clinical routine (Kirkpatrick level 3). Specifically, we investigated whether full-scale in situ simulation focusing on communication is able to change communication behavior promoting reliable and discouraging unreliable communication. We observed communication patterns among pediatric intensive care unit (PICU) nurses during

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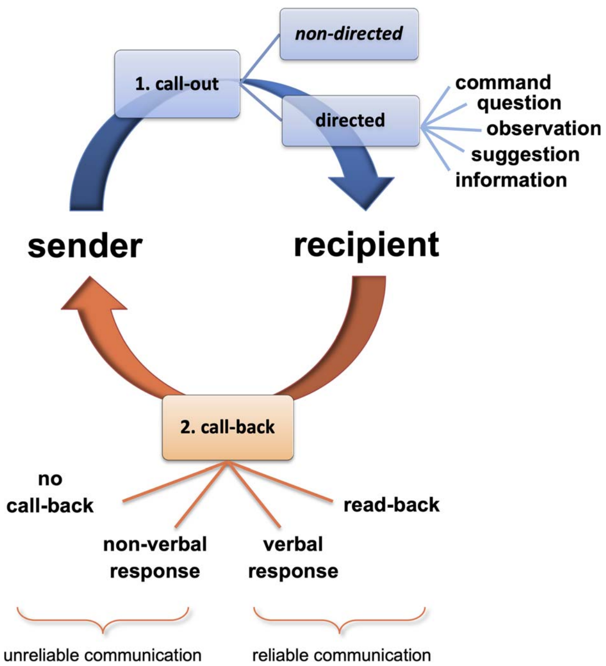

FIGURE 1. Communication loop (illustration adapted from Härgestam et al,[14] 2013). Closed-loop communication involves 2 steps: (1) the sender initiates a message (callout) and (2) the recipient receives the message, interprets it, and acknowledges its receipt (callback). A callout can either be directed to a person or nondirected "out in the air." Directed callouts are categorized into 5 subcategories. Callbacks are categorized into 2 reliable and 2 unreliable subcategories.

routine patient care before and after the introduction of PICU embedded simulation.

METHODS

Ethics

The study was approved by the Cantonal Ethics Committee of Bern (Req-2017-00202) and registered at ClinicalTrials.gov (NCT03600298).

Study Population

Written informed consent was obtained from 15 PICU nurses of Bern University Children's Hospital before enrollment into the study. Inclusion criteria are as follows: PICU nurses unfamiliar with in situ simulation, scheduled to participate in PICU simulation during the 6-month observation period, and having consented to being observed during routine patient care. Participants with previous simulation experience were excluded from the study.

Study Design

In this before-and-after observational trial, participating PICU nurses were observed during day and evening shifts while caring for patients at 3 points in time: 1 month before simulation exposure (phase I), 1 month after (phase II), and 3 months after (phase III) the simulation (Fig. 2).

The study was carried out over a 6-month period and coincided with the introduction of in situ simulation to the PICU. Leading up to this study, simulation training was not established in the department of pediatrics and virtually unheard of among the entire nursing staff.

In Situ Simulation

The simulation sessions lasted 4.5 hours and consisted of a 1-hour introduction and 3 clinical scenarios that were each followed by a video-assisted debriefing. Applying the flipped classroom[38–41] approach, team members were e-mailed 2 crisis resource management (CRM) reading assignments,[42,43] our own literature derived a list of CRM key points and asked to watch a team a concept training video before the simulation.[43–45] During simulation introduction, nontechnical skills, including CLC, were reviewed and practiced as a group activity. The importance of applying CRM skills in every clinical situation including acute-critical and routine situations was stressed throughout all sessions.

During the 3 scenarios, teams consisted of 3 registered nurses (all of whom were completely unfamiliar with in situ simulation and had never participated in a scenario), a PICU attending physician (team leader) and a pediatric or anesthesia resident. The latter two did not participate in the study, as they previously participated in simulation sessions. They were also unaware of the fact that some of the nurses were participating in the study.

Simulations were composed of 3 scenarios: the first case covered hyperkalemia with ensuing ventricular tachycardia in a neonate. After the debriefing of the first scenario, participants were once again subjected to the identical scenario, with the succinct difference being that the team leader, attending physician, was blindfolded. All simulation participants had no prior knowledge of this additional communication challenge. This was done with the intention of prompting team members to use effective and clear communication, preferably CLC. The subsequent debriefing focused on how blindfolding impacted the application of CRM, communication in particular. The final scenario dealt with an infant experiencing hemolytic uremic syndrome accompanied by his distraught parent. The main goal of the in situ simulation course was to provide an opportunity to practice CRM in a familiar environment accentuated with an unexpected challenge to their communication, namely, a blindfolded team leader.

Measurements

Participant characteristics including sex, age, and work experience were recorded. Two trained raters, members of the study team, simultaneously yet independently monitored communication between the study participants and other healthcare professionals in the PICU. Study participants (PICU nurses) were aware that they were being observed but did not know what they were being observed for. Conversations between study participants and patients, their relatives, interpreters, as well as phone calls were not recorded.

The communication patterns were recorded as graphically illustrated in Figure 1 but limited to the nurses that had consented to participate in the study. Nurses were observed until 60 minutes of communication per study participant had been recorded. Each communication separated by more than 1 minute of silence was counted as a new communication, referred to as "communication unit" in this study. The tallied communications had to amount to at least 1 hour of communication for each observed nurse. Communication was defined as a "callout" when information was transferred from a sender to a recipient and as a "callback" when reciprocated by a recipient to a sender.[13,14] Callouts were classified as either directed or nondirected. Communication was defined as a "callout" when information was transferred from a sender to a recipient and as a "callback" when reciprocated by a recipient to a sender.[13,14] Callouts were classified as either directed or nondirected.[46] Nondirected callouts were distinguished from directed callouts by assessing whether the callout had been directed to a specific person by uttering their name or function or by using nonverbal clues including eye contact, gaze direction, gestures, vocal nuances, facial

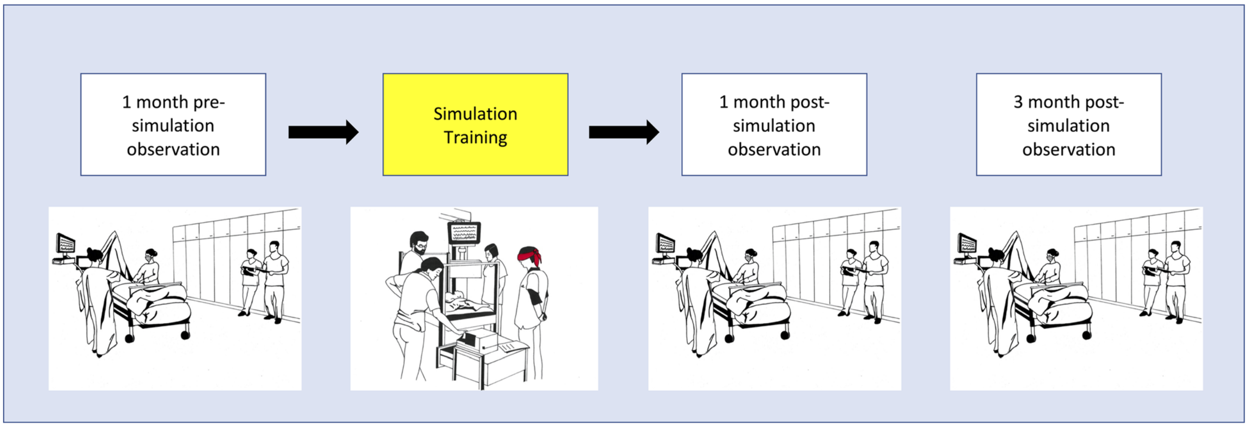

FIGURE 2. Participating PICU nurses were observed during day and evening shifts while caring for patients at 3 points in time: 1 month before simulation exposure (phase I), 1 month after (phase II), and 3 months after (phase III) the simulation.

expression, and posture ensuring that the recipient was unequivocally recognizable.[6,9,46–49] Directed callouts were subcategorized as commands/suggestions, questions, and observations/information.[14,46] Callbacks were subcategorized as (1) no callback (no response to sender's callout), (2) nonverbal response (recipient acknowledged sender's callout nonverbally or executed the commanded task,[46] e.g., callout "Shall I get the code cart?"—callback "Aha" or nodding), (3) verbal response (recipient answered sender's callout without repeating it),[46] and (4) read-back (recipient repeated sender's callout literally or analogously).[46] We defined the former two as unreliable communication and the latter two as reliable communication (Fig. 1). Communication patterns included directed and nondirected callouts, as well as the 4 different callback subcategories[14,46] and the percentage of callbacks per directed callout.

Each participant's verbal utterance was counted as either coming from or responding to a sender. This meant that callouts uttered by a study participant, when acting as a sender, were recorded separately from the callbacks the same study participant uttered when acting as a recipient. Communication patterns were also recorded and coded according to the stress intensity of the clinical situation (1 = daily routine, 2 = enhanced activity, 3 = acute/critical situation).

Statistics and Data Analysis

Because of the observational nature of the study, the available convenience sample of simulation participants was used as the study population. No formal sample size calculation was conducted.

The primary outcome callback is a multinomial outcome with 4 levels: read-back, verbal, nonverbal, and no callback. We used a fully parametrized multinomial logistic regression model with callout, phase, sender, and all possible interactions among the three as explanatory variables, with a cluster-robust variance estimation within participant to correct for potential correlation of responses within the same participant. Presented proportions and 95% confidence intervals (CI) were calculated form this model, because of the hierarchical structure of the data.

In the second step, we fitted binomial logistic regression models to each callback category, including callout, phase, sender, and all possible interactions among the three as explanatory variables, with a cluster-robust variance estimation within participant to correct for potential correlation of responses within the same participant. We tested for a change in overall callback pattern (based on the multinomial model) and for each callback category (based on the logistic models) over all 3 phases and pairwise between each phase. We repeated this procedure within sender and recipient and within each callout category within sender or recipient. *P* values were adjusted for multiplicity by controlling the false discovery rate based on the procedure of Benjamini-Hochberg.[50] With a cutoff of 0.05 on the adjusted *P* values, the false discovery rate will be controlled at 5%.

The secondary outcome directed callouts was analyzed using binomial logistic regression with sender, phase, and their interaction as explanatory variables and a cluster-robust variance estimation within participant. We calculated proportions and 95% CI from the model and tested for differences over all phases and pairwise between each phase. *P* values were adjusted for multiplicity by controlling the false discovery rate based on the procedure of Benjamini-Hochberg.

Multinomial and binomial logistic regressions were calculated using Stata 14.2 (StataCorp, College Station, TX). Adjustment for multiplicity and figures was done in R Version 3.5.3 (R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/).

RESULTS

Fourteen female and 1 male nurse participated in the study. No physicians were included, as all had previously participated in simulation. The mean age was 40 years (SD = 8.1), with an average of 17 years (SD = 6.9) of professional and 10.5 years (SD = 8.1) of PICU experience.

Two raters observed 848 communication units over a period of 122 hours gathering 60 minutes of communication per study participant.

Directed callouts were recorded 15 to 30 times more often than undirected callouts. During the observation period, the prevalence of directed callouts increased significantly from an average of 94% to an average of 97% ($P = 0.023$).

A significant overall change in communication behavior was noted over the 3 observation phases ($P = 0.006$) with the most noticeable impact occurring between phases I and II ($P = 0.004$). The changes were mirrored by the significant overall reduction in no-callback responses ($P = 0.028$) observed between phases I and II (from 5% to 2%, $P = 0.039$) and between phases I and III (from 5% to 1%, $P = 0.033$). See Table 1.

The described overall changes in communication behavior observed over the 3 phases were significant for senders ($P < 0.001$) and recipients ($P = 0.044$). They were observed between phases I and II for both senders ($P = 0.028$) and recipients ($P = 0.009$)

TABLE 1. Proportion (in Percentages) of Read-Backs, Verbal Callbacks, Nonverbal Callbacks, or No Callbacks Over the 3 Phases With 95% CIs

	Proportion (95% CI)			P			
	Phase I	Phase II	Phase III	Overall Change	I Versus II	I Versus III	II Versus III
Overall				0.006	0.004	0.13	0.49
Read-back	4 (2–5)	5 (3–6)	5 (4–6)	0.52	0.30	0.52	0.80
Verbal	75 (71–79)	78 (75–82)	76 (72–79)	0.21	0.11	0.70	0.19
Nonverbal	17 (13–21)	15 (11–20)	18 (15–21)	0.20	0.14	0.99	0.17
No callback	5 (3–6)	2 (1–2)	1 (1–2)	0.028	0.039	0.033	0.93

P values were adjusted for multiplicity using the false discovery rate.

but only for senders between phases I and III ($P < 0.001$). Among senders, this was paralleled by a significant reduction in no-callback responses between phases I and II (from 6% to 2%, $P = 0.005$) and between phases I and III (from 6% to 2%, $P < 0.001$). See Table 2.

DISCUSSION

This study investigated the communication patterns of PICU nurses during patient care before and after first-time simulation exposure. After communication-focused in situ simulation, PICU nurses were significantly less likely to let a callout go unanswered (a so-called no-callback response). This effect prevailed 1 and 3 months after the educational exposure during simulation (Table 1) indicating that the effect was not merely transient. Subanalyses found the reduction in no callbacks to be present among both senders and recipients, but statistical significance was only reached among senders (Table 2).

These results demonstrate simulation having a remarkable and lasting effect on the communication pattern among simulation-naive nurses in the clinical setting by which an unreliable form of communication was discouraged after simulation exposure. Detailed subanalyses revealed this effect to be significantly pronounced among senders. Recipients also showed a decrease in no-callback responses; however, because of the limited number of observations, statistical significance could not be demonstrated.

In the clinical setting, the observed nurses acted both as senders and as recipients of callouts, whereas during simulation, callouts usually originated from the team leading physicians rendering nurses more likely to be on the receiving end of a callout in which they were the recipients, rather than the senders of callouts. After simulation, we observed that nurses showed increasing success at discouraging no callbacks (Table 1), especially when in the role of a sender (Table 2). This is likely a translational effect, in which participating nurses, who primarily functioned as recipients of callouts during the simulation, seemed to discourage no callbacks in the subsequent clinical settings.

The no-callback rate overall as well as among only senders showed increasing significance over time pertaining to the differences between phases I and II compared with the differences between phases I and III (Tables 1, 2). This might be explained by the fact that during the introduction of in situ simulation to the PICU, simulation sessions were also ongoing among staff who was not participating in the study, leading to a growing number of more than 60 PICU nursing staff becoming "inoculated" with communication and other nontechnical skills. Over time, the PICU staff as a whole became increasingly familiar with CLC allowing for a contagious "herd-immunity–like" effect to occur by which the nonstudy participating PICU staff influenced the study participating portion of PICU staff and vice versa.

This study does not answer how soon after simulation, nontechnical communication skill training should be refreshed but suggests that

TABLE 2. Proportion (in Percentages) of Read-Backs, Verbal Callbacks, Nonverbal Callbacks, or No Callbacks Over the 3 Phases With 95% CIs for Sender and Recipients, Respectively

	Percentage (95% CI)			P			
	Phase I	Phase II	Phase III	Overall Change	I Versus II	I Versus III	II Versus III
Sender							
Overall				<0.001	0.028	<0.001	0.57
Read-back	4 (2–7)	5 (3–6)	5 (4–7)	00.70	0.50	0.52	0.98
Verbal	74 (68–80)	80 (77–84)	78 (73–83)	00.29	0.14	0.34	0.24
Nonverbal	15 (10–20)	13 (9–16)	15 (11–20)	00.35	0.25	0.86	0.25
No callback	6 (3–9)	2 (1–3)	2 (1–2)	<0.001	0.005	<0.001	0.96
Recipient							
Overall				00.044	0.009	0.80	0.57
Read-back	3 (2–5)	4 (3–6)	5 (4–6)	00.54	0.34	0.76	0.70
Verbal	75 (71–78)	76 (72–79)	73 (69–77)	00.33	0.19	0.80	0.31
Nonverbal	19 (15–23)	19 (15–23)	20 (16–24)	00.19	0.15	0.86	0.28
No callback	3 (2–5)	1 (1–2)	1 (0–2)	00.50	0.30	0.52	0.84

P values were adjusted for multiplicity using the false discovery rate.

the interval may be shorter than with technical skills, such as resuscitation skills, which have been shown to deteriorate 6 months after training or sooner.[51–57]

Teamwork and decision making benefit from CLC initiated by the team leader,[58] whereas bad timing and poor direction of communication lead to task overload and poor team performance.[59] Blindfolding mitigates sensory overload and encourages the adoption of CLC and other nontechnical skills.[29,36] In the current study, the physician team leader was blindfolded during simulation with the intention of prompting the nonblindfolded team members to change communication behavior promoting the use of more reliable and discouraging the use of unreliable communication and to see whether this exercise would translate into clinical practice. The observed study participants (nurses) themselves were never blindfolded but were instead challenged to respond to a blindfolded team leader during simulation, which constituted the study intervention. The design of this study did not permit differentiation between the effect yielded by blindfolding the team leader and first time the exposure to in situ simulation itself.

The current findings strengthen the assertion that simulation is suitable to teach and rehearse communication. Simulation discourages unreliable communication (Fig. 1) and enables an efficient transfer of acquired effective communication skills into clinical practice.

Communication studies have shown how CLC can make clinical teamwork more efficient and effective.[18,58] Standardizing communication reduces the number of miscommunications in the operating room,[60] leads to better task completion,[9] and reduces errors during neonatal resuscitation.[61] Simulation-based training improves CLC[14,28,29,36,62,63] in simulated settings, which constitute Kirkpatrick level 2.[33,34,64] This study shows the impact of simulation-based communication training on routine patient care in a PICU. The successful transfer of acquired communication skills into the clinical setting after simulation intervention demonstrates a measurable impact on health care provider behavior, which satisfies a recent call for more evidence based Kirkpatrick level 3 simulation research.[14,28,29,35,36,62,63,65] Future simulation studies will need to focus on how simulation influences clinical outcome at Kirkpatrick level 4.

Few studies have compared the ratio of directed with nondirected callouts, and most were conducted in simulated settings. In the clinical setting of our study, communication was dominated by directed callouts by a factor 15 to 30. Davis et al[46] reported a 1:1 ratio of nondirected to directed callouts during code simulation sessions with at least 5 persons present. This difference can be explained by the staged nature of a simulated setting and the stress load imposed by a code scenario. By contrast, the current study observed participants during daily clinical routine in which 97% of observations occurred during low stress intensity (level 1), whereas stress levels during code training are best compared with this study's level 3 "acute and critical situation," which did not occur during any of the observations. In simulated environments, directed communication is associated with increased response rates[9] and increased read-backs.[46] After teamwork-specific simulation training, the ratio of directed to nondirected communication has been shown to increase[9] in simulated environments. This is likely to hold true in clinical environments as well, but more evidence is needed to render a definitive conclusion.

The rate of read-back responses in this study was in the 4% to 5% range and did not increase significantly throughout the observation period. Read-backs to directed callouts during simulation have been reported at rates of 15% to 18%,[18,46] which are substantially higher than the overall read-back rates recorded in this study (Tables 1, 2). We attribute this discrepancy to the different stress intensity levels and the study settings (simulated versus clinical).

A limitation of this study is the small number of study participants at a single study site, which was due to the limited number of simulation-naive PICU nurses. Given the fact that observations occurred during real time patient care, investigators were limited by the constraints imposed by staffing, scheduling, and the challenge to coordinate simulation training. Another limitation was determined by the circumstance that only very little stress level 2 acuity communication was observed. Observations were governed by the capacity of the raters to observe study participants and the relatively low incidence of critical and acute care clinical situations. Furthermore, observations were limited to nurses and did not include other health care providers. This was due to scheduling conflicts.

A strength of this study is that it follows up an entire cohort of simulation-naive PICU nurses over a 6-month period, while observing their ability to transfer acquired communication skills into clinical practice. Their unfamiliarity with simulation allowed us to study the effects of first-time in situ simulation training on communication. This novelty distinguishes this study from other observational studies conducted in both clinical and simulated environments. More studies examining communication during acute or critical patient care situations in the clinical setting with larger multiprofessional cohorts are needed to further understand which components of communication should be stressed during simulation training to improve patient safety and care.

CONCLUSIONS

This observational before-and-after study documents how PICU nurses were able to translate simulation-acquired communication skills into their clinical environment after a single afternoon of in situ simulation training emphasizing CLC. This successful transfer of simulation-acquired competencies has the potential to improve patient care and outcome.

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