Available online at www.sciencedirect.com

Resuscitation Plus

journal homepage: www.elsevier.com/locate/resuscitation-plus

Experimental paper

A recorder/time coach decreases time errors during neonatal resuscitation: A randomized, simulation-based clinical trial

Nicole K. Neveln, Mona Khattab, Joseph L. Hagan, Regine M. Fortunov, Nathan C. Sundgren *

Abstract

Aim: To evaluate the effects of a hands-off recorder/time coach versus an additional hands-on healthcare provider on Neonatal Resuscitation Program (NRP) algorithm compliance and team member workload in neonatal resuscitations.

Methods: Two interventions were studied using a 2 × 2 factorial design: an additional hands-on team member and the presence of a designated, hands-off recorder/time coach. The recorder/time coach documented interventions and delivered pre-specified prompts at defined points during the resuscitation. The primary outcome was cumulative time error. Secondary outcomes were time to first dose of IV epinephrine, overall team performance as assessed by the Neonatal Resuscitation Performance Evaluation (NRPE) score, and workload assessed by the NASA Task Load Index (NASA TLX).

Results: 64 teams were studied. Teams with a recorder had a significantly lower cumulative time error compared to teams without a recorder ($p < 0.001$). An additional hands-on team member did not change cumulative time error. There was no difference in time to first dose of IV epinephrine or NRPE score in these comparisons. Ad-hoc analysis did reveal a significant increase in time to IV epinephrine in teams with the minimum of four total members ($p = 0.025$). A recorder/time coach increased team leader NASA TLX overall workload score ($p = 0.047$), but an additional hands-on team member did not.

Conclusion: A designated, hands-off recorder/time coach improved compliance by decreasing cumulative time error in teams performing complex simulated neonatal resuscitations.

Keywords: Neonatal, Resuscitation, Team size, Coaching, Workload, Recorder

Introduction

During neonatal resuscitation, a team of healthcare providers must perform technical and cognitive tasks under intense time pressure. The Neonatal Resuscitation Program (NRP) algorithm is fast-paced with frequent evaluation and decision points and this complexity can result in deviations from the algorithm.[1,2] One study found a 54% noncompliance rate in NRP steps during resuscitation at high-risk deliveries.[3] Another study found a 23% noncompliance rate with failure to auscultate heart rate and/or breath sounds when indicated as the most repeated error.[1] Neonatal resuscitation teams could benefit from assistance in adhering to the NRP algorithm and coaching improves pediatric resuscitation guidelines compliance.[4]

NRP does not specify the optimal team size. The Textbook of Neonatal Resuscitation recommends having at least two qualified healthcare providers at high-risk deliveries and states four or more will likely be required for a full resuscitation.[2] However, the size of the newborn limits the number of healthcare providers that can be hands-on during resuscitation.[2,5] Additional healthcare providers take on roles including medication management and event recording, but the optimal role distribution is unknown. A designated recorder is ideally positioned to also act as a time coach and prompt teams to perform certain actions.

* Corresponding author at: Division of Neonatology, Department of Pediatrics, Baylor College of Medicine, One Baylor Dr., Houston, TX 77030, United States.

E-mail address: ncsundgr@texaschildrens.org (N.C. Sundgren).

https://doi.org/10.1016/j.resplu.2023.100411

Received 21 March 2023; Received in revised form 17 May 2023; Accepted 2 June 2023

Since the optimal team size and role distribution in neonatal resuscitation is unknown, our study evaluates the effects of a designated, hands-off recorder/time coach versus an additional hands-on team member in complex neonatal resuscitations.

Methods

This study was approved by the Baylor College of Medicine Institutional Review Board, protocol number H-46829. Expanded methods section available (Supplement File).

Study participants

Healthcare providers from Texas Children's Pavilion for Women Hospital's expert NRP-trained resuscitation team were recruited between October 2020 and March 2022 as part of the *in situ* simulation program.

Intervention

Two interventions were studied using a 2 × 2 factorial design: an additional hands-on team member and the presence of a designated, hands-off recorder/time coach.

The NeoCHART+™ mobile tablet application was used in this study. NeoCHART+™ allows healthcare providers to document resuscitation events on one tablet while simultaneously displaying timing information for the resuscitation team on a second tablet. In teams randomized to have a recorder present, the recorder documented interventions while a second tablet visible to the hands-on team displayed time since birth, time since respiratory support was started, time since chest compressions were last started, and time since the last dose of epinephrine was administered (Fig. 1). The recorder also acted as a time coach and delivered pre-specified prompts at specific time points during the resuscitation (Table 1). The recorder was able to answer questions related to timing of interventions if asked but did not provide hands-on assistance. For teams randomized to have no recorder, study personnel documented the resuscitation using NeoCHART+™ but did not provide prompts or answer questions and the second tablet was removed from view.

Participants were instructed to perform a neonatal resuscitation as if for a real patient. Although a hands-on team member was never assigned to the designated recorder role, teams could choose to document key events and interventions as they would in a real resuscitation. Teams performed resuscitation simulation scenarios using Gaumard Newborn Tory® or SIMCharacters Paul simulators. Both simulators are high-fidelity with features such as heart sounds, breath sounds, and chest rise. We designed four simulation scenarios that required the team to perform the steps of NRP including giving intravenous (IV) epinephrine once. Scenarios varied on need for a volume expander. Following the simulation and debriefing, participants completed the National Aeronautics and Space Administration Task Load Index (NASA TLX).

Every simulation was recorded by two stationary cameras with audio and video. Due to the nature of the study, participants and study personnel could not be blinded. All videos were reviewed by study personnel and data was gathered for outcomes of cumulative time error, time to first dose of IV epinephrine, and NRP Evaluation (NRPE) total score. All videos were scored by one author (NN) for consistency. We have previously demonstrated a high inter-rater reliability of this data.[6]

Randomization

The baseline resuscitation team consisted of four members: team leader (neonatologist, neonatology fellow, or neonatal nurse practitioner), pediatric resident, respiratory therapist, and nurse. Participants were randomized to one of four groups (Fig. 2). A second nurse was available at randomization and filled the additional hands-on provider role or dismissed if the team was randomized to have only four hands-on providers. The recorder role was filled by study personnel.

The PLAN procedure in SAS version 9.4 (SAS Institute Inc.) was used to randomize each simulation session into one of four groups. A block size of eight was used to ensure that the number of sessions

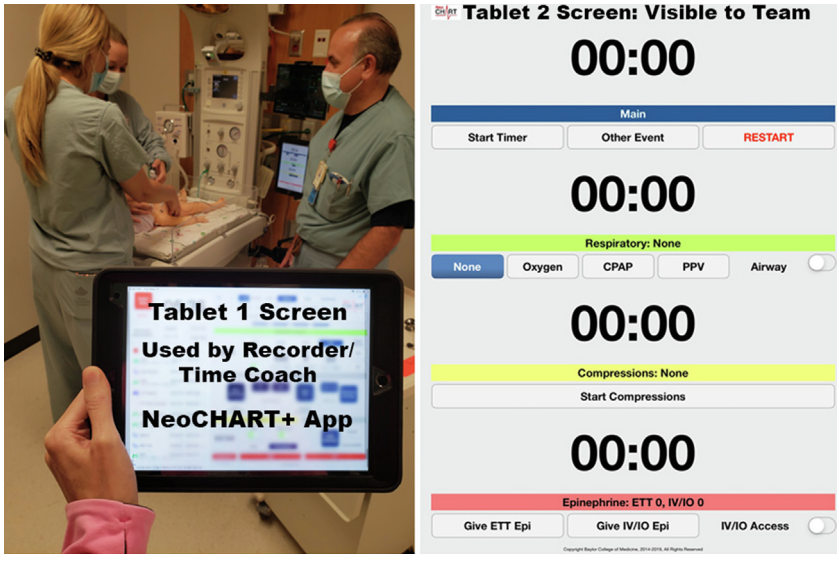

Fig. 1 – Recorder/Time Coach Role. The recorder documented interventions on one tablet. A second tablet was visible to the team which displayed times since last intervention.

Table 1 – Recorder/Time Coach Prompts. The recorder acted as a coach and delivered pre-specified prompts at certain time points during the resuscitation.

Time Point/Event	Prompt
60 seconds of life	"It has been 60 seconds, initiate PPV if apnea, gasping, or heart rate less than 100"
30 seconds after starting alternative airway attempt	"It has been 30 seconds since start of attempt"
60 seconds after chest compressions were initiated	"It has been 60 seconds since starting chest compressions, check heart rate"
60 seconds after dose of IV epinephrine was administered	"It has been 60 seconds since epinephrine was given, check heart rate"

Team Randomization/Group Comparisons		
	No Additional Hands-on HCP	Yes Additional Hands-on HCP
No Recorder	Group 1 (4)	Group 3 (5)
Yes Recorder	Group 2 (4+R)	Group 4 (5+R)

Fig. 2 – Group Randomization. Participants were randomized into teams of 4 or 5 hands-on healthcare providers (HCPs) and into having a recorder (R) present or not. To test the intervention of a recorder, combined groups 1&3 (No Recorder) were compared to combined groups 2&4 (Yes Recorder). To test the intervention of the additional hands-on HCP, combined groups 1&2 (4 Hands-on HCPs) were compared to combined groups 3&4 (5 Hands-on HCPs).

assigned to each group was balanced over time. The group assignments were concealed in sequentially numbered opaque envelopes. The envelope for each session was opened after all five possible participants were recruited and in the simulation space. The order in which the four different scenarios were used was determined by block randomization in a block size of four. Consecutive blocks of the same scenario were not allowed. The randomized simulation scenario was used for eight consecutive sessions before switching to the next randomized scenario.

Outcome measures

The primary outcome was cumulative time error, which is the number of seconds that actions deviate from the ideal times in the NRP guidelines (Supplement File).[6] This time based outcome was chosen over other performance measures as we anticipated that both interventions would primarily effect timeliness of actions.

Pre-specified secondary outcomes were time to first dose of IV epinephrine, team adherence to the NRP algorithm as assessed by the NRPE total score, and workload assessed by NASA TLX. The modified NRPE tool provides a composite score of both decision points and technical performance points.[6] The NASA TLX gives an overall workload score of 0–100. The NASA TLX is a weighted average of six subscale components: mental demand, physical demand, temporal demand, performance, effort, and frustration.[7]

Sample size

We calculated sample size based on our previous study time error where a 41.6 second time error standard deviation was observed.[6] We expected higher time error and larger effect in this study as the scenarios were more complex and required more interventions. For a two-factorial study design, a sample size of 16 teams per group (64 teams total) would achieve 80% power ($\alpha = 0.05$) to detect a 30 second average difference in time error. Half the teams had 4 participants and half had 5 participants for a total of 288 participants. As this sample size was large, healthcare providers could participate multiple times.

Statistical analysis

Two-factor ANOVA was used to examine the effect of a designated recorder, an additional hands-on HCP, and the interaction between these two factors.

We performed ad-hoc analyses for the outcomes of time to first dose of IV epinephrine and NRPE score. Ad-hoc analysis one: a multiple linear regression model was fit to examine the effects of a recorder and additional hands-on team member, in addition to simulation session number (1–64) to investigate whether a learning effect over time existed. Ad-hoc analysis two: linear models were fit for these two outcomes using the two quantitative predictors total number of people on the team (4, 5, or 6, where the hands-off recorder was counted in total team size) and session number.

Results

Cumulative time error

Teams with a recorder had a significantly lower cumulative time error compared to teams without a recorder ($p < 0.001$, Fig. 3A). There was no difference in cumulative time error between teams with and without an additional hands-on team member ($p = 0.671$, Fig. 3B).

Time to first dose of IV epinephrine

There was no difference in time to first dose of IV epinephrine between teams with and without a recorder ($p = 0.189$, Fig. 4A), nor between teams with and without an additional hands-on team member ($p = 0.083$, Fig. 4B). After controlling for the effects of recorder and additional hands-on team members, the predicted epinephrine time did decrease by 0.035 minutes per session (2.12 seconds per session, $p = 0.005$) in ad-hoc analysis one, suggesting a learning effect over time. After controlling for session number, presence of a recorder was still not significantly associated with faster time to first

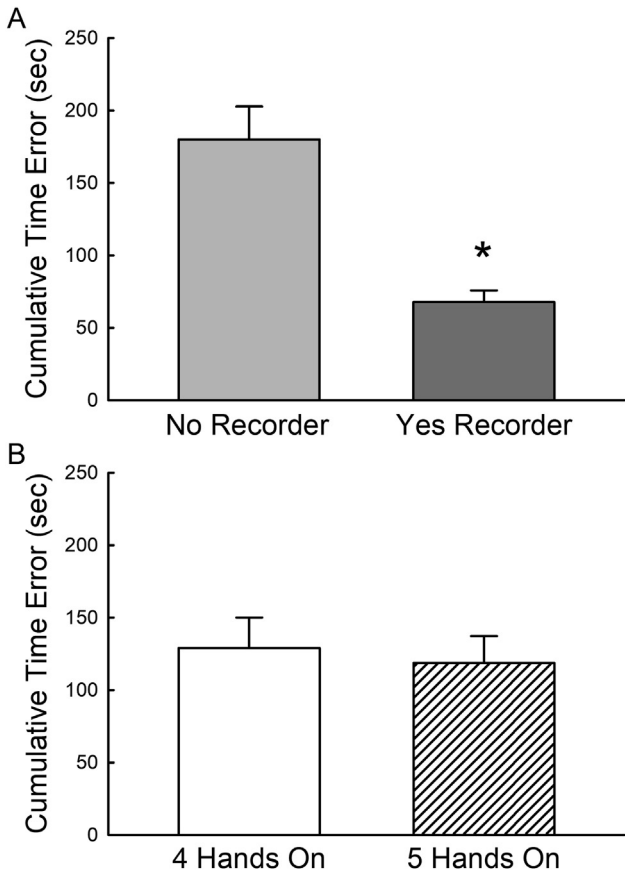

Fig. 3 – The Recorder/Time Coach Reduced Cumulative Time Error. (A)Teams without a hands-off recorder/time coach (light gray bar) had a higher cumulative time error compared to teams with a recorder/time coach (dark gray bar). 180.1 ± 128.3 vs 67.7 ± 45.4 seconds, no recorder vs yes recorder, mean ± SD, *n* = 32 vs 32, **p* < 0.001. (B) There was no difference between 4 (open bar) and 5 (hatched bar) hands-on person teams. 129.1 ± 118.3 vs 118.7 ± 104.8 seconds, 4 hands on vs 5 hands on, mean ± SD, *n* = 32 vs 32, *p* = 0.671. All bars are mean ± SE.

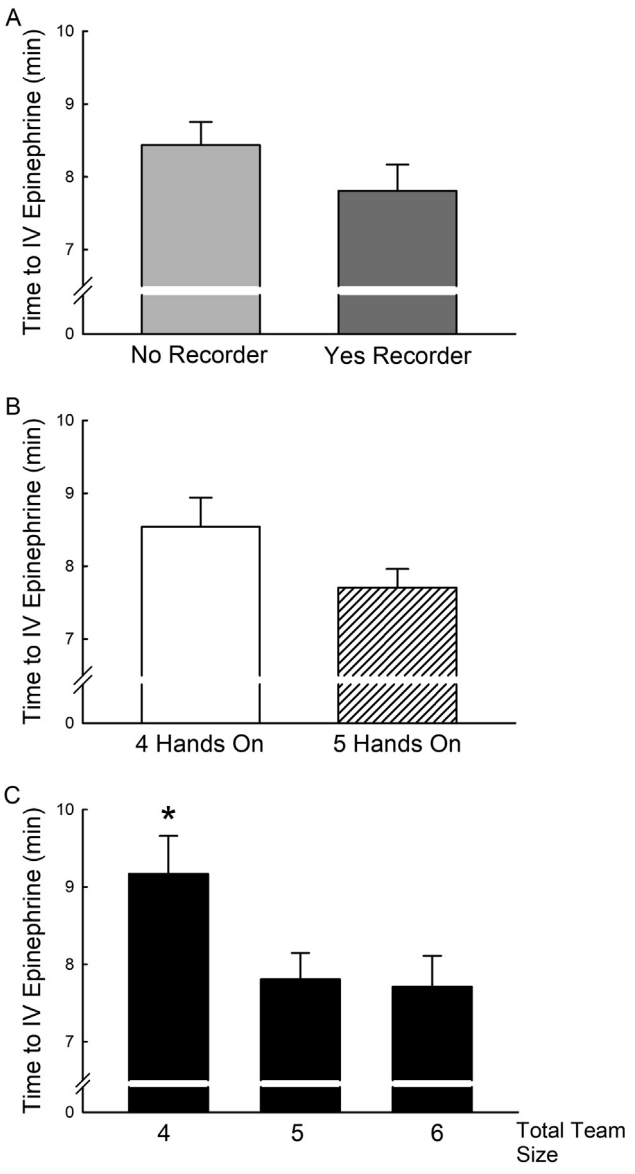

Fig. 4 – Teams of Smallest Size Take Longer to Administer IV Epinephrine. (A) No difference in time to IV epinephrine between teams with and without a recorder. 8.4 ± 1.8 vs 7.8 ± 2.0 minutes, no recorder vs yes recorder, mean ± SD, *n* = 32 vs 32, *p* = 0.189. (B) No difference in time to IV epinephrine between 4 and 5 hands-on person teams. 8.5 ± 2.3 vs 7.7 ± 1.4 minutes, 4 hands on vs 5 hands on, mean ± SD, *n* = 32 vs 32, *p* = 0.083, (C) Teams with the minimum of 4 team members took significantly longer to give IV epinephrine than teams with 5 providers, whether by addition of a hands-off recorder or an additional hands-on team member (9.2 ± 2.0 vs 7.8 ± 1.9 minutes, 4 vs 5 total, *n* = 16 vs 32, **p* = 0.025). The full complement of 6 healthcare providers did not give any additional benefit (7.7 ± 1.6 minutes, mean ± SD, *n* = 16, *p* = 0.866 compared to 5 total providers). All bars are mean ± SE.

dose of IV epinephrine (p = 0.170), and teams with an additional hands-on team member had a predicted epinephrine time that was 0.82 minutes faster (95% CI: 1.71 minutes faster to 0.07 minutes slower), but did not achieve statistical significance (p = 0.071). Because of the apparent difference in the four person hands-on team without a recorder compared to the other team combinations, we performed ad-hoc analysis two comparing teams by total number of team members (Fig. 4C). When number of team members and session number were both included in a regression model as quantitative predictors, each additional team member was associated with a decrease in time to epinephrine (total decrease of 1.5 minutes, p = 0.025) and each additional session was associated with a decrease in time to epinephrine (p = 0.045).

NRPE score

There was no difference in NRPE score in any of the groups (79.0% ± 8.7 vs 80.8% ± 6.5, no recorder vs yes recorder, mean ± SD, n = 32 vs 32, p = 0.366 and 78.5% ± 6.9 vs 81.3% ± 8.2, 4 hands on vs 5 hands on, mean ± SD, n = 32 vs 32, p = 0.136). In ad-hoc analysis one, recorder (p = 0.370), addi-

tional hands-on team member (p = 0.139), and session number (p = 0.935) were not significantly associated with the NRPE score, nor were number of team members (p = 0.092) or session number (p = 0.934) for this outcome in ad-hoc analysis two.

NASA TLX

Team leader NASA TLX overall workload scores were higher in teams with a recorder compared to teams without a recorder (p = 0.047, Fig. 5A). The higher team leader workload score was primarily due to the temporal demand subscale component (73.5 ± 17.8 vs 80.8 ± 10.4, no recorder vs yes recorder, mean ± SD, n = 31 vs 32, p = 0.055). There was no differences in the other subscale components for team leaders in this comparison. There was no difference in team leader NASA TLX overall scores or subscale components between teams with and without an additional hands-on team member (p = 0.086, Fig. 5B).

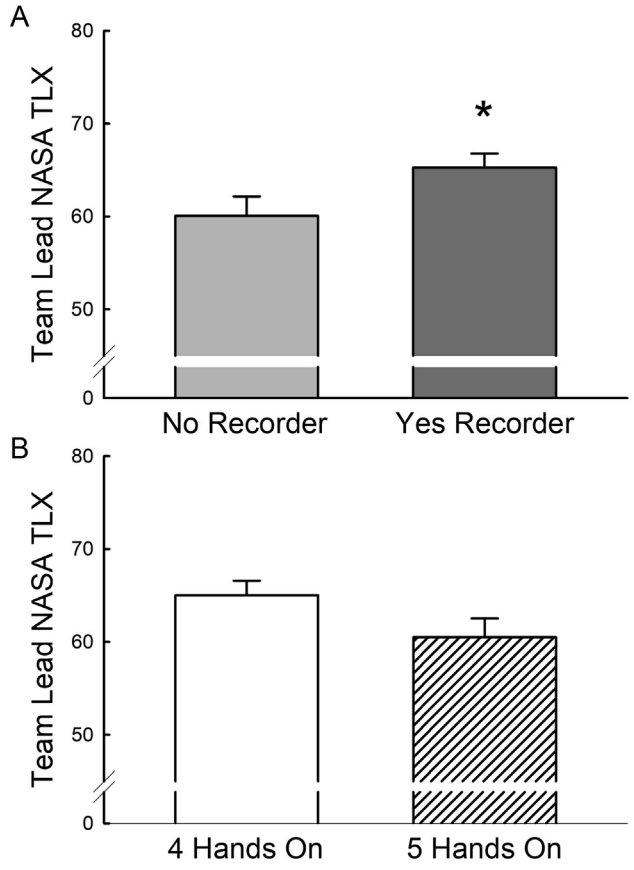

Fig. 5 – Team Leader Workload Increased with Recorder/Time Coach. (A)Team leaders without a hands-off recorder time coach (light gray bar) had a lower overall workload as measured by the NASA TLX compared to team leaders with a recorder (dark gray bar). 60.1 ± 11.6 vs 65.3 ± 8.5, no recorder vs yes recorder, mean ± SD, n = 31 vs 32, *p = 0.047. (B) There was no difference in team leader overall workload between 4 (open bar) and 5 (hatched bar) hands-on person teams. 65.0 ± 8.7 vs 60.5 ± 11.5, 4 hands on vs 5 hands on, mean ± SD, n = 31 vs 32, p = 0.086. All bars are mean ± SE.

There was no difference in nurse NASA TLX overall workload scores in any of the groups (59.0 ± 10.6 vs 58.4 ± 13.1, no recorder vs yes recorder, mean ± SD, n = 47 vs 48, p = 0.706; and 61.8 ± 12.5 vs 57.2 ± 11.3, 4 hands on vs 5 hands on, mean ± SD, n = 31 vs 64, p = 0.081). Nurses had a lower frustration subscale component in teams with five hands-on team members compared to teams with four hands-on team members, but only in teams without a recorder (39.7 ± 20.2 vs 59.9 ± 27.8, 5 hands on, no recorder vs 4 hands on, no recorder, mean ± SD, n = 32 vs 15, p = 0.003) as there was a significant interaction of the two interventions (p = 0.031). There was no difference in the other subscale components for nurses.

There was no significant difference in NASA TLX overall scores or the subscale components for resident or respiratory therapist team members.

Discussion

Recorder vs no recorder

A designated, hands-off recorder/time coach improved compliance to the NRP algorithm by decreasing cumulative time error in teams performing complex simulated neonatal resuscitations. This decrease was almost exclusively from the time error components of heart rate check after chest compressions and heart rate check after IV epinephrine. This is significant as checking a heart rate at the appropriate times is critical in neonatal resuscitation. Coaching is used in many resuscitation environments. A pediatric CPR coach was a preassigned role in 43% of institutions surveyed, and integration of a CPR coach in pediatric resuscitation teams significantly improves CPR quality.[8–10] Kessler et al. found that teams performing simulated pediatric resuscitations with a designated hands-off CPR coach had a shorter pause duration during chest compressions and intubation and improved coordination of tasks during pulse checks whereas an additional hands-on provider did not.[11] There are fewer studies evaluating coaching in neonatal resuscitation, but a pilot study found that ventilation coaching during simulated bag-mask ventilation improved ventilation performance.[12] Our study demonstrates another potential benefit of coaching in neonatal resuscitation, specifically the usefulness of time prompts to keep a team on task.

Although teams with a recorder had a significantly lower cumulative time error, we did not demonstrate a significant difference in time to first dose of IV epinephrine. However, teams of five (whether by addition of a hands-off recorder or an additional hands-on team member) were able to give IV epinephrine 1.4 minutes faster than the minimum four-person team (teams of six were 1.5 minutes faster than the minimum four-person team). Therefore, some team actions may benefit from an additional team member, regardless of their specific role. Our scenarios required only one dose of epinephrine. If the scenarios required multiple doses of IV epinephrine, it is possible that prompts for appropriate timing would have been more beneficial.

The presence of a recorder did not affect the NRPE score. The total NRPE score is a combination of decision making (moving appropriately through the algorithm) and technique (performance of skills) components which the recorder did not provide prompts for or assist with in our study. Therefore, it is not that surprising that the recorder/time coach did not affect cognitive and technical team performance in this study, but might if different prompts were provided such as “perform ventilation correction measures”.

Workload, measured by the NASA TLX, is a perception of the amount of work required.[7] Team leaders experience high workload, specifically mental demand.[13–15] Our team leaders experienced higher overall workload in groups with a recorder than in groups without a recorder while no other team members had changes in overall workload. This increase was primarily due to the temporal demand subscale component and indicates that team leaders experienced more time pressure when a recorder was present and providing prompts for the timing of interventions. Studies looking at CPR feedback devices or coaches have found that CPR providers reported higher workloads, specifically effort and physical demand components, when feedback was provided.[14,16] They postulated that CPR feedback increased their exertion and motivated them to improve performance which, like the team leader focusing on timing when a time coach is present, may actually be an advantage. In addition, no trend toward worse performance was observed in teams with the recorder even with this increase in team leaders' perceived overall workload.

4 vs 5 hands-on healthcare providers

NRP suggests that a full neonatal resuscitation will likely require four or more healthcare providers performing both hands-on and hands-off tasks.[2] One multicenter study reported that more than two healthcare providers were present at 91% of deliveries when advanced resuscitation efforts were required.[17] Previously, we demonstrated that an initial response team size of two compared to three healthcare providers had similar neonatal resuscitation performance outcomes.[6] In this study, we further demonstrate that, even in scenarios requiring a high level of resuscitation, additional hands-on team members do not guarantee improved team performance as measured by cumulative time error or NRPE score. However, teams with only four members did have a delay in IV epinephrine administration when compared to teams with more healthcare providers.

An additional hands-on team member ideally would distribute the number of tasks over the larger group, but this did not change the workload perceived by the team leader in our study. This contrasts with our previous study where team leader workload was reduced with the addition of another hands-on provider.[13] In the previous study, the team leader was required to be hands-on in teams with only two members, but the addition of another hands-on provider allowed the team leader to step back and be hands-off and thus led to a decreased perceived workload. In this study, by contrast, our minimum team of four team members generally allowed the team leader to be hands-off throughout the simulation (with the exception of intubation if needed as well as umbilical venous catheter placement). Thus, the addition of another hands-on provider did not reduce the number of tasks performed by team leaders in this study. Other team members' overall workload did not change with the additional hands-on provider and they reported lower overall workload scores than the team leader consistent with other reports.[13–15]

Limitations

The study was conducted in a simulation-based environment which may not be equivalent to clinical situations. To mitigate this, we used high-fidelity simulators in realistic resuscitation environments. Although we cannot represent the entire spectrum of what could be encountered during a neonatal resuscitation, we used four different simulation scenarios and the NRP algorithm (specifically up to the step of administering IV epinephrine) is designed to be followed regardless of the underlying cause necessitating resuscitation.

Providers could participate multiple times, however this is representative of how teams are assembled to attend deliveries. Even though our primary outcome was a team-based assessment and team combinations were unique for all 64 teams studied, there did appear to be a learning effect over time as demonstrated in our ad-hoc analysis. This may have limited some of our ability to detect differences in some of the secondary outcomes.

Our recorder/time coach intervention was a combination of a person (time coach) and a display tablet (NeoCHART+). This study did not address which component of the two was more helpful to the teams.

For consistency, our study had one video reviewer that could not be blinded. However, a previous study evaluated the same outcomes of cumulative time error and total NRPE score and Intraclass Correlation Coefficients indicated excellent inter-rater reliability.[6] In addition, the outcomes that were scored from the videos were objective and questions on how to score a particular item were resolved by use of our scoring guide and by discussion between study personnel.

Conclusions

In complex simulated neonatal resuscitations, the addition of a designated, hands-off recorder/time coach improved NRP algorithm compliance by decreasing cumulative time error while an additional hands-on team member did not. This recorder/time coach role can be expanded to provide prompts for other critical steps in the NRP algorithm with which teams struggle to comply. Individual hospitals and resuscitation teams should first consider adding this role when additional help arrives and the minimum four person team is already performing hands-on roles.

Funding

This work was supported by the American Academy of Pediatrics Neonatal Resuscitation Program Human Factors/Education Grant Award 2019, Itasca, IL, the Evangelina Whitlock Grant 2020, Houston, TX, and Texas Children's Hospital Educational Scholarship Award, 2017, Houston, TX.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We thank our study participants. NeoCHART+™ was developed by Dr. Regine Fortunov at Baylor College of Medicine and is provided for free through institutional agreements. We also thank our education coordinator Delinda Castillo for help with recruitment, Dan Feux with our Simulation Center for simulation support, and Dr. Stephanie Hale for blinding the randomization.

Appendix A. Supplementary material

Supplementary material to this article can be found online at https://doi.org/10.1016/j.resplu.2023.100411.

Author details

Division of Neonatology, Department of Pediatrics, Baylor College of Medicine, One Baylor Dr., Houston, TX 77030, United StatesDivision of Neonatology, Department of Pediatrics, Texas Children's Hospital, 6621 Fannin St, Suite WT6104, Houston, TX 77030, United States

REFERENCES

1. Yamada NK, Yaeger KA, Halamek LP. Analysis and classification of errors made by teams during neonatal resuscitation. Resuscitation 2015;96:109–13.
2. Weiner GM. Textbook of neonatal resuscitation. 8th Edition. Itasca, IL: American Academy of Pediatrics; 2021.
3. Carbine DN, Finer NN, Knodel E, Rich W. Video recording as a means of evaluating neonatal resuscitation performance. Pediatrics 2000;106:654–8.
4. Buyck M, Shayan Y, Gravel J, et al. CPR coaching during cardiac arrest improves adherence to PALS guidelines: a prospective, simulation-based trial. Resusc Plus 2020;5 100058.
5. Yamada NK, Fuerch JH, Halamek LP. Ergonomic challenges inherent in neonatal resuscitation. Children 2019;6:74.
6. Roitsch CM, Patricia KE, Hagan JL, Arnold JL, Sundgren NC. Tablet-based decision support tool improves performance of neonatal resuscitation: a randomized trial in simulation. Simul Healthc 2020;15:243–50.
7. Hart SG. Nasa-task load index (NASA-TLX); 20 years later. Proc Hum Factors Ergon Soc Annu Meet 2006;50:904–8.
8. Cheng A, Duff JP, Kessler D, et al. Optimizing CPR performance with CPR coaching for pediatric cardiac arrest: a randomized simulation-based clinical trial. Resuscitation 2018;132:33–40.
9. Hunt EA, Jeffers J, McNamara L, et al. Improved cardiopulmonary resuscitation performance with CODE ACES(2): a resuscitation quality bundle. J Am Heart Assoc 2018;7:e009860.
10. Pfeiffer S, Laundsen KG, Wenger J, et al. Code team structure and training in the pediatric resuscitation quality international collaborative. Pediatric Emerg Care 2021;37:e431.
11. Kessler DO, Grabinski Z, Shepard LN, et al. Influence of cardiopulmonary resuscitation coaching on interruptions in chest compressions during simulated pediatric cardiac arrest. Pediatric Crit Care Med 2021;22:345–53.
12. Sawyer T, Motz P, Schooley N, Umoren R. Positive pressure ventilation coaching during neonatal bag-mask ventilation: a simulation-based pilot study. J Neonatal Perinatal Med 2019;12:243–8.
13. Roitsch CM, Hagan JL, Patricia KE, et al. Effects of team size and a decision support tool on healthcare providers' workloads in simulated neonatal resuscitation: a randomized trial. Simul Healthc 2021;16:254–60.
14. Brown LL, Lin Y, Tofil NM, et al. Impact of a CPR feedback device on healthcare provider workload during simulated cardiac arrest. Resuscitation 2018;130:111–7.
15. Tofil NM, Lin Y, Zhong J, et al. Workload of team leaders and team members during a simulated sepsis scenario. Pediatr Crit Care Med 2017;18:e423–7.
16. Tofil NM, Cheng A, Lin Y, et al. Effect of a cardiopulmonary resuscitation coach on workload during pediatric cardiopulmonary arrest: a multicentre. Simulation-based study. Pediatr Crit Care Med 2020;21:e274–81.
17. Berazategui JP, Aguilar A, Escobedo M, et al. Risk factors for advanced resuscitation in term and near-term infants: a case-control study. Arch Dis Child Fetal Neonatal Ed 2017;102:F44–50.