

ORIGINAL ARTICLE

Teaching teamwork during the Neonatal Resuscitation Program: a randomized trial

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Objective: To add a team training and human error curriculum to the Neonatal Resuscitation Program (NRP) and measure its effect on teamwork. We hypothesized that teams that received the new course would exhibit more teamwork behaviors than those in the standard NRP course.

Study design: Interns were randomized to receive NRP with team training or standard NRP, then video recorded when they performed simulated resuscitations at the end of the day-long course. Outcomes were assessed by observers blinded to study arm allocation and included the frequency or duration of six team behaviors: inquiry, information sharing, assertion, evaluation of plans, workload management and vigilance.

Result: The interns in the NRP with team training group exhibited more frequent team behaviors (number of episodes per minute (95% CI)) than interns in the control group: information sharing 1.06 (0.24, 1.17) vs 0.13 (0.00, 0.43); inquiry 0.35 (0.11, 0.42) vs 0.09 (0.00, 0.10); assertion 1.80 (1.21, 2.25) vs 0.64 (0.26, 0.91); and any team behavior 3.34 (2.26, 4.11) vs 1.03 (0.48, 1.30) (*P*-values <0.008 for all comparisons). Vigilance and workload management were practiced throughout the entire simulated code by nearly all the teams in the NRP with team training group (100% for vigilance and 88% for workload management) vs only 53 and 20% of the teams in the standard NRP. No difference was detected in the frequency of evaluation of plans.

Conclusion: Compared with the standard NRP, NRP with a teamwork and human error curriculum led interns to exhibit more team behaviors during simulated resuscitations.

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Introduction

The Neonatal Resuscitation Program (NRP) is the standard curriculum used to teach caregivers how to treat newborns in the delivery room. Worldwide, the NRP could improve outcomes of thousands of newborns per year.¹ However, approximately 30% of NRP steps are not performed or performed incorrectly,^{2,3} and pediatric residents often fail to intubate infants correctly.⁴

Neonatal resuscitation should be a team activity that involves at least two people who work together to achieve a shared goal.⁵ Breakdowns in teamwork may contribute to the quality problems noted above. For example, team behaviors are correlated with the quality of neonatal resuscitation,³ communication breakdowns are root cause of 72% of perinatal deaths and injuries,⁶ perceptions of effective teamwork are correlated with less burnout and fewer delays in labor and delivery,⁷ and there is broad consensus from expert groups and researchers that measuring and improving teamwork will help improve the quality of health care.^{8–10} However, none of the nine lessons in the NRP textbook¹ includes instruction about teamwork, in part because no studies have shown that team training can improve either teamwork or the quality of health care.^{11,12}

Therefore, we conducted a study with two specific aims: (1) to incorporate teamwork skills and information about human error into the 1-day NRP training program for interns and (2) to randomize interns to this new version of NRP or the standard NRP and measure the effects on teamwork during the simulated resuscitations at the end of the day. We hypothesized that it would be feasible to add the teamwork training to the 1-day NRP course, and that interns who were randomized to the NRP course with team training would exhibit more teamwork behaviors during the simulated resuscitation than would the interns in the standard NRP course.

Materials and methods

All interns in pediatrics, combined internal medicine and pediatrics, family medicine, and obstetrics and gynecology who began training in June 2005 were eligible for the study. The study was approved by the IRB, and consenting subjects were randomly assigned (generated using a random number generator by ALW) to attend the standard NRP course or the NRP course with additional instruction in teamwork skills and human error. The course was conducted during their orientation in June.

Intervention

The teamwork and human error component was delivered during the first 2 1/2 h of the day. The curriculum's major topics were as follows: (1) frequency and types of errors during neonatal resuscitation; (2) the nature and causes of human error (limits of human performance, role of systems in causing human error, situational awareness, flawed communication); (3) commercial aviation's approach to team training; (4) role plays and video clips to illustrate concepts and skills; and (5) description of teamwork skills relevant to neonatal resuscitation. Methods used to convey these topics included lecture, low-fidelity simulations (role play), short video clips to illustrate points and a question and answer period. Subsequently, the interns then received the complete standard NRP course lectures. These lectures were delivered in modules that addressed specific skills. After each module, the interns went to skill stations to practice the skill (for example, intubation) on low-fidelity mannequins. During these skills stations, the interns in the intervention arm were prompted by instructors to practice the team behaviors. Otherwise, the curriculum followed the standard NRP course and was identical to the control group curriculum in all aspects other than the teamwork and human error instruction that occurred at the beginning of the day and during the skills stations. All the instructors had experience in teaching NRP and were the usual group of instructors used at the study site. Those who volunteered were taught the teamwork and human error curriculum the day before the study so that they would be prepared to help teach the interns at the skills stations. Instructors who interacted with the control group did not receive the curriculum.

The following team behaviors were taught: inquiry, information sharing, assertion, evaluation of plans, workload management and vigilance (Figure 1). These behaviors were chosen and defined based upon focus groups with neonatal physicians and nurses, observations of actual neonatal resuscitations^{3,13,14} and behaviors found to prevent and manage error in commercial aviation.^{9,15} The behaviors were defined during the lecture, they were illustrated during the role play and video clips, discussed during question and answer sessions, and instructors reminded students to use them during the skills stations.

- a. Inquiry – Interns asked questions of each other about anything related to the resuscitation.
- b. Information sharing- Interns verbalized information to other team members about the infant's status. For example, verbalization of heart rate, color, tone, vocal cord visualization, statements of opinion, advocating of views in *non-critical* moments, and other relevant observations or impressions about the baby's status.
- c. Assertion– An intern asserted an opinion about the resuscitation process (through questions or statements) *during critical times*. Assertion did not include routine statements or questions about a baby's heart rate, tone, color, and respirations.
- d. Evaluation of plans - An explicit and detailed discussion about the status of the baby and the decisions made to get to the current situation.
- e. Workload management – Tasks were prioritized and distributed among the team members.
- f. Vigilance - Interns remained alert and focused on the resuscitation. Lack of vigilance was coded when any of the team members lost focus on the resuscitation for at least 3 seconds.

Figure 1 Definitions of teamwork behaviors.

Data collection

Each intern led a team comprising of one or two other subjects (the other interns) in a mock resuscitation at the end of the day. Each subject took turns being the leader. These were conducted using a low-fidelity mannequin on a table. The intervention and control groups were on different floors. An instructor communicated the clinical situation to the team (for example, the infant's heart rate, color and tone), then asked the team to begin the resuscitation. The resuscitations were video recorded and randomly divided among two trained, blinded observers.

Observer training and reliability testing occurred in three steps over a 5-month period using video recordings from an earlier study.³ First, observers were oriented by an investigator (EJT) and they viewed a training video that demonstrated examples of teamwork behaviors during neonatal resuscitations. Second, the investigator and two observers independently viewed two resuscitations and then met to discuss differences in their observations of teamwork behaviors and to clarify definitions. Third, a total of 28 resuscitations were scored, divided among five phases. At the end of each phase, we calculated a Cohen's κ for each teamwork behavior, and the raters and investigator discussed ways to clarify the definitions of team behaviors and to improve reliability. κ s for the final phase of training ranged from moderate to excellent (workload management ($\kappa = 0.54$), evaluation of plans ($\kappa = 0.57$), vigilance ($\kappa = 0.59$), information sharing ($\kappa = 0.66$), inquiry ($\kappa = 0.82$) and assertion ($\kappa = 0.87$)).

When viewing a video recording, the observers indicated the number of times each behavior was exhibited. Episodes of inquiry,

information sharing, assertion or evaluation of plans were noted based upon verbalizations of team members. Vigilance and workload management were measured as percent time in that particular state. Teams were considered to be non-vigilant when any team member stopped watching the resuscitation for more than 3 s. Workload management assessed the appropriate distribution of tasks during the procedure. Teams were without workload management if any team member did not offer to assist with the resuscitation when the leader was handling two or more tasks simultaneously (for example, if the leader was performing bag-mask ventilation and trying to measure heart rate simultaneously).

Data analysis

Because there were no previous studies addressing this topic, we had no *a priori* sample size calculations. The teamwork behaviors exhibited during the simulated resuscitations were compared for interns who received the standard NRP training and those who received NRP with team training. The data were recorded with Noldus Observer (version 5.0; October 2003; Noldus Information Technology, The Netherlands). Information sharing, inquiry, assertion, intentions shared and evaluation of plans were recorded as rates (number of behaviors per minute). Vigilance and workload management were measured as percentages of the simulation time that interns remained in that state. Teamwork behavior frequencies from the two groups of interns were compared using nonparametric Mann–Whitney rank sum tests in STATA (version 9.0; May 2005; StataCorp., College Station, TX 77845, USA). STATA was also used to calculate CI about the medians using the binomial method.

Results

Of the 51 eligible subjects, 29 were from pediatrics and combined pediatrics-internal medicine, 12 from family medicine and 10 from obstetrics and gynecology. Fifty were asked to participate (one was not in town when consent was obtained) and there were five non-consenters from pediatrics and five from obstetrics and gynecology, so 40 interns were randomized. There were no differences in the distribution of types of interns in the two groups. The intervention group had 11 pediatric interns, 6 family medicine and 2 obstetrics and gynecology; the control group had 12, 6 and 3, respectively.

Seven interns from the control group had an incomplete video recording because the camera ran out of tape or the camera was started after the event began (there was only one person responsible for monitoring six cameras). One intern from the intervention group did not take a turn as a team leader. This left 17 intervention and 15 control interns in the final analysis (Figure 2).

The interns in the NRP with team training group exhibited more frequent information sharing, inquiry and assertion than the interns in the control group (Figure 3). Evaluation of plans was

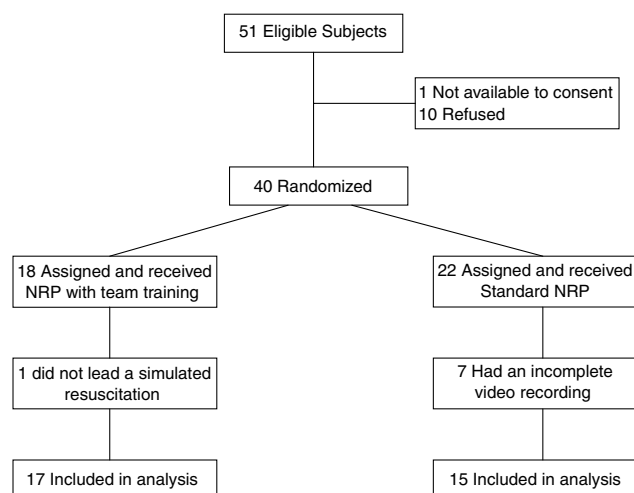


Figure 2 Progress of patients throughout the trial.

observed once in the NRP with team training group. It was not observed in the standard NRP group. Vigilance and workload management were practiced throughout the entire simulated code by nearly all the teams in the NRP with team training group (100% for vigilance and 88% for workload management). In contrast, only 53 and 20% of the teams in the standard NRP group were vigilant and managed their workload throughout the entire simulated code session.

Discussion

Interns who were randomized to an NRP course with a teamwork and human error curriculum exhibited more team behaviors during the simulated resuscitation at the end of the course than interns in the standard NRP course. This is the first study to document that team training for neonatal resuscitation, and perhaps any health-care process, can result in more frequent utilization of team behaviors. Other strengths include random allocation of subjects to the intervention and control groups; use of trained, blinded observers to rate the frequency of team behaviors; teaching and measurement of team behaviors that were developed based upon research in commercial aviation and neonatal resuscitation;^{3,9,13–15} and incorporating the teamwork and human error curriculum into an existing and widely used training program. The latter increases the likelihood that the team training would be widely disseminated if future research confirms and expands our findings. A final strength is that we used low-fidelity instead of high-fidelity simulation. Resuscitation dolls are substantially less expensive and more widely available than computer-driven mannequins in simulated delivery room. However, we have no data to comment on whether low- or high-fidelity simulation is more effective for team training.

Limitations included having only physicians (interns) as subjects, so our results may not generalize to more experienced

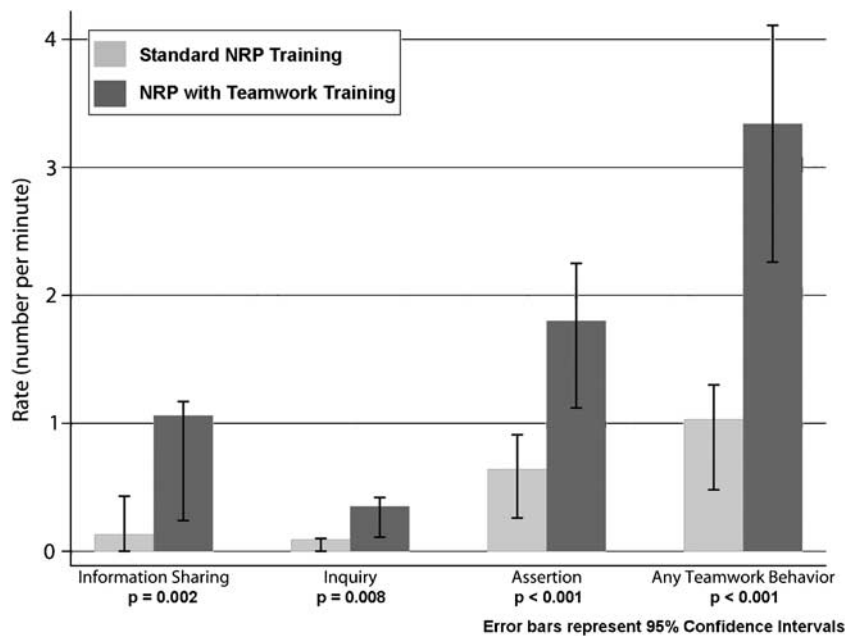


Figure 3 Rates of teamwork behaviors in the standard NRP and NRP with team training groups. Evaluation of plans was observed once in the NRP with team training group. It was not observed in the standard NRP group.

physicians. Seven resuscitations in the control arm (vs only one in the intervention arm) were excluded owing to technical issues with the recordings. We believe that the technical difficulties were random occurrences, but if the excluded subjects exhibited high frequencies of team behaviors, then we might have found a smaller effect size for this intervention. It is also notable that neither the intervention nor the control group used the behavior called evaluation of plans. This may indicate a weakness in the training program, or perhaps that novices are not comfortable using this behavior which conceptually and empirically tends to be a leadership behavior.³ We have not studied how long the team behaviors persist after training and we did not assess whether the intervention improved teamwork or quality during actual patient care.

There is a rapidly growing interest in improving teamwork and using simulation in health care. This is due in part to expert groups such as the Institute of Medicine and regulators like the Joint Commission for Accreditation of Health-care Organizations who advocate some type of team training. In addition, research suggests the need for improved teamwork and communication in neonatal intensive care,^{2,3,16} emergency departments,¹⁰ the operating room,^{17,18} trauma resuscitation^{19–21} and among residents of all disciplines.²² Despite this interest and research, two recent reviews concluded that no studies have shown that team training can improve teamwork and the quality of care,^{11,12} and a cluster randomized trial of team training for labor and delivery teams did not find significant changes in the process of care or outcome measures.²³ Thus, knowledge about how to improve team behavior appears to be in its infancy.

The most progress has been made in the emergency room setting where studies have been carried out to evaluate the effectiveness of team training on actual patient care.^{10,24} Morey reported improved measures of teamwork, but their participants were not randomized and their observers were not blinded. Shapiro did not find statistically significant improvements in team behavior. An important difference between both of these studies and ours is that we measured the frequency and duration of specific behaviors whereas they used five seven-point behaviorally anchored rating scales to rate the quality of certain dimensions of teamwork (maintain team structure and climate, apply problem-solving strategies, support team with information, execute plans and manage workload, and improve team skills). It is possible that our more focused frequency and duration-based team outcome measures are more sensitive. Our teamwork measures may also be more sensitive because they were developed and defined based upon observations of actual neonatal resuscitations. Similarly, our training curriculum was firmly grounded in the context and processes of neonatal resuscitation. It included data on the types and causes of errors during neonatal resuscitation and used examples of good and bad teamwork from neonatal resuscitation. Our results support the belief that generic team training principles and skills will only be effective if grounded in specific health-care processes.^{25,26} Another important difference is that we observed video recordings of simulated patient care instead of direct observation of actual patient care. The latter method is much more challenging for observers.

The current NRP student textbook does not mention teamwork, but the leader guide lists 10 behavioral skills for effective

resuscitation teams, and has half a page of accompanying text. The behaviors we measured and those in the NRP leader guide are similar, but our behaviors are more explicit and discreet. This should make them easier to measure and teach. For example, the leader guide suggests communicate clearly, efficiently and directly with other team members. In previous research, we found that two specific behaviors, information sharing and inquiry, group together in a domain we called communication (the other domains were leadership and management, each composed of specific, observable behaviors).³ Thus, future editions of the NRP might note that information sharing and inquiry, as we defined them, are examples of communicating clearly, efficiently and directly. Our study may also have implications for the content of the NRP student textbook, lectures and practicing team behaviors during the skills stations.

A relatively brief teamwork and human error curriculum can affect the team behavior of pediatric, family medicine and obstetrics/gynecology interns. Our study should encourage more research on incorporating similar curricula into the NRP and perhaps other resuscitation programs such as Advanced Cardiac Life Support. It will be important to assess whether the training effects persist and how they affect quality of care and patient outcomes. Clinicians are not provided teamwork training in medical and nursing schools, so future research can expand on our study to provide caregivers the care coordination skills that are increasingly important for modern medicine.

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References

- 1 Kattwinkel J (Ed.) *Textbook of Neonatal Resuscitation*. American Academy of Pediatrics and American Heart Association, 2006.
- 2 Carbine DN, Finer NN, Knodel E, Rich W. Video recording as a means of evaluating neonatal resuscitation performance. *Pediatrics* 2000; **106**: 654–658.
- 3 Thomas EJ, Sexton JB, Lasky RE, Helmreich RL, Crandell S, Tyson J. Teamwork and quality during neonatal care in the delivery room. *J Perinatol* 2006; **26**: 163–169.
- 4 Falck AJ, Escobedo MB, Baillargeon JG, Villard LG, Gunkel JH. Proficiency of pediatric residents in performing neonatal endotracheal intubation. *Pediatrics* 2003; **112**: 1242–1247.
- 5 Brannick MT, Prince C. An overview of team performance measurement. In: Brannick MT, Salas E, Prince C (eds). *Team Performance Assessment and Measurement. Theory, Methods, and Applications*. Lawrence Erlbaum: Mahwah, NJ, 1997.
- 6 Joint Commission. Sentinel Event Alert. Issue 30, July 21, 2004 http://www.jointcommission.org/SentinelEvents/SentinelEventAlert/sea_30.htm accessed September 2006.
- 7 Sexton JB, Holzmueller CG, Pronovost PJ, Thomas EJ, McFerran S, Nunes J *et al*. Variation in caregiver perceptions of teamwork climate in labor and delivery units. *J Perinatol* 2006; **26**(8): 463–470.
- 8 Kohn LT, Corrigan JM, Donaldson MS (Eds). To Err is Human. *Building a Safer Health System*. National Academy Press: Washington, DC, 1999.
- 9 Helmreich RL, Schaefer HG. Team performance in the operating room. In: Bogner MS (Ed.), *Human Error in Medicine*. Erlbaum: Hillsdale, NJ, 1994, pp 225–253.
- 10 Morey JC, Simon R, Jay GD *et al*. Error reduction and performance improvement in the emergency department through formal teamwork training: evaluation results of the MedTeams project. *Health Services Res* 2002; **37**: 1553–1581.
- 11 Baker DP, Gustafson S, Beaubien JM, Salas E, Barach P. Medical team Training Programs in Health Care. In: Henriksen K, Battles JB, Marks ES, Lewin DI (eds). *Advances in Patient Safety: from Research to Implementation*. Vol 4. AHRQ: Rockville MD Feb 2005. Programs, tools and concepts. AHRQ Publication No. 05-0021-2.
- 12 Salas E, Wilson KA, Burke CS, Wightman DC. Does crew resource management training work? An update, an extension, and some critical needs. *Hum Factors* 2006; **48**: 392–412.
- 13 Thomas EJ, Sherwood GD, Mulhollem JL, Sexton JB, Helmreich RL. Working together in the neonatal intensive care unit: provider perspectives. *J Perinatol* 2004; **24**(9): 552–559.
- 14 Thomas EJ, Sexton JB, Helmreich RL. Translating teamwork behaviors from aviation to healthcare: development of behavioral markers for neonatal resuscitation. *Qual Saf Healthcare* 2004; **13**(Suppl 1): i57–i64.
- 15 Helmreich RL, Foushee HC. Why crew resource management: empirical and theoretical bases of human factors training in aviation. In: Wiener EL, Kanki BG, Helmreich RL (eds). *Cockpit Resource Management*. Academic Press: San Diego, CA, 1993.
- 16 Halamek LP, Kaegi DM, Gaba DM, Sowb YA, Smith BC, Smith BE *et al*. Time for a new paradigm in pediatric medical education: teaching neonatal resuscitation in a simulated delivery room environment. *Pediatrics* 2000; **106**: E45.
- 17 Makary MA, Sexton JB, Freischlag JA, Holzmueller CG, Millman EA, Rowen L *et al*. Operating room teamwork among physicians and nurses: teamwork in the eye of the beholder. *J Am Coll Surg* 2006; **202**(5): 746–752.
- 18 Carthey J, de Leval MR, Wright DJ, Farewell VT, Reason JT. Behavioural markers of surgical excellence. *Safety Sci* 2003; **41**: 409–425.
- 19 Santora TA, Trooskin SZ, Blank CA, Clarke JR, Schinco MA. Video assessment of trauma response: adherence to ATLS protocols. *Am J Emerg Med* 1996; **14**(6): 564–569.
- 20 Sugrue M, Seger M, Kerridge R, Sloane D, Deane S. A prospective study of the performance of the trauma team leader. *J Trauma* 1995; **38**(1): 79–82.
- 21 Xiao Y, Hunter WA, Mackenzie CF, Jefferies NJ, Horst RL. Task complexity in emergency medical care and its implications for team coordination. LOTAS Group. Level one trauma anesthesia simulation. *Hum Factors* 1996; **38**(4): 636–645.
- 22 Sutcliffe KM, Lewton E, Rosenthal MM. Communication failures: an insidious contributor to medical mishaps. *Acad Med* 2004; **79**: 186–194.
- 23 Nielsen PE, Goldman MB, Mann S, Shapiro DE, Marcus RG, Pratt SD *et al*. Effects of teamwork training on adverse outcomes and process of care in labor and delivery: a randomized controlled trial. *Obstet Gynecol* 2007; **109**: 48–55.

- 24 Shapiro MJ, Morey JC, Small SD, Langford V, Kaylor CJ, Jagminas L *et al*. Simulation based teamwork training for emergency department staff: does it improve clinical team performance when added to an existing didactic teamwork curriculum? *Qual Saf Health Care* 2004; **13**: 417–421.
- 25 Healy AN, Undre S, Vincent CA. Defining the technical skills of teamwork in surgery. *Qual Saf Health Care* 2006; **15**: 231–234.
- 26 Yule S, Flin R, Paterson-Brown S, Maran N, Rowley D. Development of a rating system for surgeons' non-technical skills. *Med Edu* 2006; **40**(11): 1098–1104.