Resuscitation 82 (2011) 203–206

Contents lists available at ScienceDirect

Resuscitation

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

Simulation and education

The management of a simulated emergency: Better teamwork, better performance☆,☆☆

Dimitrios Siassakos[a,*], Robert Fox[b], Joanna F. Crofts[a], Linda P. Hunt[c], Catherine Winter[a], Timothy J. Draycott[a]

[a] Southmead Hospital, BS10 5NB, Westbury on Trym, Bristol, UK
[b] Taunton and Somerset Hospital, TA1 5DA, Taunton, UK
[c] University of Bristol School of Clinical Sciences, c/o UBHT Education Centre, Upper Maudlin Street, Bristol, BS2 8AE, UK

ARTICLE INFO

Article history:
Received 25 June 2010
Received in revised form 14 October 2010
Accepted 31 October 2010

Keywords:
Teamwork
Leadership
Emergencies
Patient care team
Training
Knowledge, skills and attitudes
Education
Teaching
Simulation
Obstetric labour complications
Eclampsia
Pre-eclampsia
Magnesium sulfate
Team behaviour
Team training
Multiprofessional team

ABSTRACT

Objectives: To determine whether team performance in a simulated emergency is related to generic teamwork skills and behaviours.
Methods: Design – Cross-sectional analysis of data from the Simulation and Fire-drill Evaluation (SaFE) randomised controlled trial. Setting – Six secondary and tertiary Maternity Units in Southwest England. Participants – 140 healthcare professionals, in 24 teams. Assessment – Blinded analysis of recorded simulations. Main outcome measures – Correlation of team performance (efficiency conducting key clinical actions, including the administration of an essential drug, magnesium), and generic teamwork scores (using a validated tool that assesses skills and behaviours, by Weller et al.).
Results: There was significant positive correlation between clinical efficiency and teamwork scores across all three dimensions; skills (Kendall's $tau_b = 0.54$, $p < 0.001$), behaviours ($tau_b = 0.41$, $p = 0.001$), and overall score ($tau_b = 0.51$, $p < 0.001$). Better teams administered the essential drug 2½ min more quickly (Mann–Whitney U, $p < 0.001$).
Conclusions: The clinical conduct of a simulated emergency was strongly linked to generic measures of teamwork. Further studies are needed to elucidate which aspects of team working are critical for team performance, to better inform training programs for multi-professional team working.

1. Introduction

Medical emergencies can have devastating consequences. In maternity, poor team co-ordination during the management of emergencies results in worse outcomes for mothers or their babies,[1–3] patient dissatisfaction, complaints and litigation.[4]

Eclampsia is a potentially catastrophic medical emergency[2,5] where a patient collapses, and its effective management requires medical teams to perform several tasks expeditiously. These include immediate life support including placement in the recovery position, administration of oxygen, and sampling of venous blood, as well as the administration of an essential drug, magnesium sulfate, for seizure control and prevention.[6–8] Magnesium administration in this context is associated with a significant reduction in serious maternal morbidity, perinatal morbidity, and mortality; it is thus an ideal surrogate measure for clinical outcome.[8]

Not all teams are effective or efficient in performing these crucial clinical actions, even after training.[9] We have demonstrated that conventional measures of the knowledge, skills and attitudes of individual team members do not predict the variation in team performance.[10] It seems that other characteristics make some teams more efficient. Difference in teamwork, the way the members of the team interact and put their skills to practice, is one possible explanation.

The aim of this study was to explore the relationship between generic teamwork scores and performance of emergency teams in simulation, using simulated eclampsia as an exemplar medical

☆ A Spanish translated version of the abstract of this article appears as Appendix in the final online version at doi:10.1016/j.resuscitation.2010.10.029.
☆☆ Trial registration ISRCT number: 67906788 (www.isrctn.org).
* Corresponding author. Tel.: +44 7930624894; fax: +44 1179683464.
E-mail address: jsiasakos@googlemail.com (D. Siassakos).

0300-9572/$ – see front matter © 2010 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.resuscitation.2010.10.029

Table 1
Clinical efficiency score.

1 Did not obtain magnesium sulfate (Mg)
2 Obtained but did not prepare Mg
3 Prepared but did not administer Mg
4 Administered Mg but ≥ 6 min from start of drill
5 Administered Mg < 6 min from start of drill

emergency.

2. Materials and methods

This is a cross-sectional analysis of data from a large randomised-controlled trial of training for obstetric emergencies (Simulation and Fire-drill Evaluation [SaFE]).[11] The methodology of the main study has been described in detail elsewhere.[9] In brief, participants were recruited to the study in 2004–5, from six Maternity Units in the Southwest of England. Participants were randomly selected from staff lists and then randomly allocated to one of four teams from each unit, to make a total of 24 simulation teams. The individual teams comprised of two doctors and four hospital midwives, except three teams that lacked one team member.

A previous study from our group focussed on the effect of training, with a before–after design.[9] In this study, the cross-sectional design aimed at finding the active ingredients of effective teams, regardless of their training status.

Teams were evaluated for their ability to manage simulated eclampsia with a standardised clinical scenario, before and after team training.[9] The patient–actor was instructed to have a seizure for 1 min, starting 60 s from the end of the handover. The drill was terminated after a period of 10 min from the end of the handover, or earlier if the team began to transfer the patient to the operating room, because there was no facility to continue to record the simulation outside the delivery room. The team members were not aware of which team they would be in, nor of the nature of the simulation before it started.

Using video recordings of the simulations, the teams were assessed, with Likert scales (1 worst, 5 best), for their generic team working using a teamwork analytical tool developed and validated by Weller et al. (Appendix 1).[12] All the evaluations were undertaken by two trained external assessors (a doctor and a midwife), working independently, who viewed the digital recordings in different sequences randomly generated by computer, blind to the timing and type of training. If there had been discordance, a third independent assessor scored the team(s). The final score for each team was an average of the scores, calculated to the nearest integer.[9]

The timing of key events and clinical actions was recorded for each team. After the end of the primary study, an ordinal *clinical efficiency* score, based on the time to administration of magnesium sulfate, was formulated and its face and construct validity was established.[10] The teams were ranked, using the clinical efficiency score, by two different researchers, a clinician (DS) and a statistician (LH) (Table 1).

Given these measures tended to improve with training, we combined before- and after-training assessments together to give a wider range of scores for statistical analysis ($n = 47$). We tested for correlation between the generic teamwork scores (GTSs) and the team magnesium-based clinical efficiency scores. We also tested for correlation between GTS and the time taken to perform three key clinical tasks; turning the woman into the recovery position, administration of O_2, and venous blood sampling. The timings to perform these tasks were the ones shown to discriminate best between efficient and less efficient teams, as well as most sensitive

Table 2
Distribution of number of teams across teamwork (GTS) and clinical efficiency scores (CESs); concentration of observations around the top-left to bottom-right diagonal in each box is indicative of correlation between the two variables.

	Pre-training					Post-training					Pre and post				
	Clinical efficiency score (magnesium)														
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Skill															
1 |	1	2									1	2			
2 |		1		2	1							1		2	1
3 |		2	2	2	2			1	1			2	3	3	2
4 |			1	4	3		1		6	6		1	1	10	9
5 |									1	8				1	8
Behaviour															
1 |		2										2			
2 |	1	1		1	1						1	1		1	1
3 |		1	1	5	3			1				1	2	5	3
4 |		1	2	2	1		1		5	7		2	2	7	8
5 |					1				3	7				3	8
Overall															
1 |	1	3									1	3			
2 |		1	1	2	1							1	1	2	1
3 |	1			6	3		1		1	1		2		7	4
4 |			2		2			1	7	7			3	7	9
5 |										6					6
Comments						A previous study has shown significant improvement in teamwork (GTS) scores after training[9]					What is added by this paper is that teamwork (GTS) scores correlate with teams' clinical efficiency (CES) scores – regardless of training status (pre/post-training)					

Table 3
Comparison of team performance (efficiency in conduct of key clinical actions) between *better* (generic teamwork scores ≥4 out of 5 in all three dimensions) and *worse* teams.

Measure of team performance	*Better teams* median time in seconds (IQR)	*Worse teams* median time in seconds (IQR)	*p*-Value (Mann–Whitney *U*-test)
Administering magnesium	331* (272–386)	480.5** (367.5–>508)	$p < 0.001$
Turning the woman into recovery position	24 (13–46)	41.5* (29–58)	0.023
Administering oxygen	28 (24–50)	54* (40–73.5)	0.005
Sampling venous blood	128 (115–150)	159.5* (129.5–197)	0.006
Number of teams	$n = 23$ (3 pre-training, 20 post-training)	$n = 24$ (20 pre-training, 4 post-training)	

* and ** indicate the inclusion of 1 and 10 participants, respectively, who had not performed the action by the end of the drill; for the (non-parametric) group comparisons these were assigned the greatest rank.

to intervention (practical team training).[9]

Non-parametric Kendall rank correlation coefficients were used to assess correlation because of the ordinal nature of the scores. These, however, regarded pairs of results from the same team (before and after training) as being independent. We were not interested in this study in the effect of training, but in what explains variation in team performance, before or after training, as a realistic reflection of everyday practice.

Therefore, we also categorised the individual team assessments with respect to teamwork performance overall; teamwork scores ≥4 out of 5 in all three GTS dimensions were categorised as *better* ($n = 23$; 3 pre-training, 20 post-training) and the remainder categorised as *worse* ($n = 24$; 20 pre-training, 4 post-training).

We then calculated median time to administer magnesium for each group. The time intervals were censored when the drill was stopped, at 600 s (10 min) from handover. Eleven assessments were censored in this way; one of 23 with *better* GTS scores, and ten of 24 with *worse* GTS scores. Time intervals were compared with the Mann–Whitney *U* test.

Statistical analysis used the STATA software v11.0 (STATACorp, College Station, TX, USA). Ethical approval was granted from a Regional Research Ethics Committee (SOUTHWEST DEVON MREC 04/Q2103/68).

3. Results

Twenty-four teams had undertaken the pre-training evaluation; one simulation was not recorded because of a fault in recording equipment. We report results for 23 teams pre-training, and 24 post-training. A flow diagram and descriptive data for the participants have been published.[9,10]

Inter-rater agreement for the GTSs was moderate (kappa = 0.44). Scores by the two reviewers were identical for 27 of 47 assessments and only differed by more than one point on the Likert scale for two assessments in the global teamwork scale.

There was strong, highly significant correlation between *clinical efficiency* score (magnesium administration) and the GTSs for all three dimensions; *team skills* score ($tau_b = 0.54$, $p < 0.001$), *team behaviour* score ($tau_b = 0.41$, $p = 0.001$), and the *overall teamwork* score ($tau_b = 0.51$, $p < 0.001$). Table 2 shows the relevant distribution of scores.

There was a significant negative correlation between the time taken to perform all of the three key clinical actions and *teamwork skills* scores (recovery position: $tau_b = -0.29$, $p = 0.012$; O_2 administration: $tau_b = -0.39$, $p < 0.001$; blood sampling: $tau_b = -0.35$, $p = 0.002$). There were similar correlations with the *overall teamwork score* (recovery position: $tau_b = -0.25$, $p = 0.026$; O_2 administration: $tau_b = -0.41$, $p < 0.001$; blood sampling: $tau_b = -0.35$, $p = 0.002$). For the *teamwork behaviour scores* the correlation was statistically significant for O_2 administration ($tau_b = -0.28$, $p = 0.014$) and blood sampling ($tau_b = -0.35$, $p = 0.002$) but not for recovery position.

Table 3 shows the size of the difference between *better* and *worse* teams in efficiency in the conduct of key clinical actions.

4. Discussion

It has been shown that delayed response to medical emergencies because of poor teamwork is a root cause of a high proportion of adverse outcomes,[1–3,13] often leading to high-cost medical litigation.[4] In this study of simulated eclampsia, we found strong relationships between team performance and generic teamwork scores as defined by the Weller teamwork tool.[12] The results show that the ability to complete crucial clinical interventions in a timely way is strongly linked to the ability to work as a coordinated team, even before training. On average, the *better* teams administered magnesium almost 2½ min more quickly than the *worse* teams (difference of the medians), and were also more efficient in other transferrable resuscitation skills.

At the outset, one issue was the predetermined sample size (set by the original SaFE trial) and so the lack of a power calculation. Another limitation is that the teams included obstetricians and hospital midwives but not other health care professionals. However, it should be acknowledged that the initial management of most obstetric emergencies tends to involve obstetricians and midwives alone; other professionals are usually summoned afterwards.

The main strength of the study is the use of validated assessment tools. The study also benefited from blinding of the assessors (to each other's scores, to the type of training the teams received, and to whether the videos had been recorded before or after training). We did not rely on self-assessment, which is inaccurate, particularly for human factor skills and behaviours.[14–18] Instead we chose a combination of event-based and behaviour-anchored team performance metrics, which are considered more accurate and more reliable.[15,19] The strength of the study is underpinned by the inclusion of clinical teams from across a health region, and by the choice of magnesium administration as a clinical end point with high validity; an effective intervention that is supported by the safety literature.[20] The three other clinical measures are an important part of management for many emergencies in obstetrics as well as other disciplines, so their inclusion as endpoints adds external validity.

Intuitively, multi-professional training for specific obstetric emergencies seems logical and there is evidence to show it can be translated into reduced errors and improved patient safety.[21] We have shown that embedded practical clinical training is associated with better team performance in simulation[9] and better clinical outcomes.[22–24] It is not known precisely how those improvements are achieved, however, nor why some teams do not improve as much as others.[9] Moreover, other researchers have found that team rehearsals have not always been successful in improving team performance or outcomes in maternity care.[25]

Our new findings are perhaps unsurprising, but following on from our previous finding of the lack of a clear relationship between team performance and measures of knowledge, skills and attitudes,[10] this study shows that generic teamwork skills are prob-

ably the major determinant of variation in team performance of maternity emergency teams. Taken together, our two studies suggest that traditional teaching of individual clinicians is of itself unlikely to optimise team performance, and they raise the possibility that generic teamwork training might provide a means of further enhancing team performance and improving the outcome of emergencies that rely on multi-professional care. To do that, generic team working has to be both understood in context and amenable to teaching.

We need now to uncover the specific behavioural characteristics of clinical teams that are more effective in simulated and real-life emergencies, rather than simply adopting models from other disciplines such as the aerospace industry.[26] Perhaps then we can hope to coach individual clinicians to work better within teams in the heat of emergencies. Future studies should focus on critical teamwork competencies such as effective handover, communication, task management, situational awareness and leadership[27]; how to measure them reliably, and ultimately, how to inculcate them into practice.

Conflicts of interest statement

Mr. Draycott and Mrs. Winter are members of the steering committee of PROMPT, a UK-based charity running training courses and have no financial interest from this association.

Funding

This study is an extension to the SaFE ('Simulation and Fire Drill Evaluation') study, funded by The North Bristol Research and Development Small Grant Scheme. The SaFE study was funded by the UK Department of Health Patient Safety Programme. None of the sponsors have been involved in the study design; the collection, analysis, and interpretation of data; the writing of this manuscript; or the decision to submit for publication.

Acknowledgements

The authors thank the following people for their contributions to the SaFE Study: Valentine Akande, Mark James, Christine Bartlett, Karen Cloud, Joanne Crocker, Anne McCrum, Fiona Donald, Denise Ellis, Sarah Fitzpatrick, Simon Grant, Maureen Harris, Katie Harrison, Neil Liversedge, Imogen Montague, Sarah Read, Melanie Robson, Heather Smart, Bryony Strachan, Derek Tuffnell, Penny Watson, and Stephanie Withers.

References

1. Joint Commission on Accreditation of Healthcare Organizations. Preventing infant death and injury during delivery. Sentinel Alert 2004:1–3.
2. Lewis G, editor. The Confidential Enquiry into Maternal and Child Health (CEMACH). Saving mothers' lives: reviewing maternal deaths to make motherhood safer – 2003–2005. The Seventh Report of the Confidential Enquiries into Maternal Deaths in the United Kingdom. London: CEMACH; 2007.
3. CESDI. Confidential enquiries into stillbirths and deaths in infancy. 7th Annual Report. London: Maternal and Child Health Consortium; 2000.
4. Hanscom R. Medical simulation from an insurer's perspective. Acad Emerg Med 2008;15:984–7.
5. Knight M. Eclampsia in the United Kingdom 2005. BJOG 2007;114:1072–8.
6. Royal College of Obstetricians and Gynaecologists. The management of severe pre-eclampsia/eclampsia. Guideline No. 10(A). London: RCOG Press; 2006.
7. ACOG practice bulletin. Diagnosis and management of preeclampsia and eclampsia. Number 33. Obstet Gynecol 2002;99:159–67.
8. Duley L, Henderson-Smart D. Magnesium sulphate versus phenytoin for eclampsia. Cochrane Database Syst Rev 2003.
9. Ellis D, Crofts JF, Hunt LP, Read M, Fox R, James M. Hospital, simulation center, and teamwork training for eclampsia management: a randomized controlled trial. Obstet Gynecol 2008;111:723–31.
10. Siassakos D, Draycott TJ, Crofts JF, Hunt LP, Winter C, Fox R. More to teamwork than knowledge, skill and attitude. BJOG 2010;117:1262–9.
11. Strachan B, Crofts J, James M, et al. Proof of principle study of the effect of individual and team drill on the ability of labour ward staff to manage acute obstetric emergencies: PSRP. Edgbaston, Birmingham: Department of Health, Public Health, Epidemiology & Biostatistics, University of Birmingham; 2008.
12. Weller JM, Bloch M, Young S, et al. Evaluation of high fidelity patient simulator in assessment of performance of anaesthetists. Br J Anaesth 2003;90:43–7.
13. Health Committee, House of Commons. Patient safety, Sixth Report of Session 2008–09. The Stationery Office Limited; 2009.
14. Weller JM, Robinson BJ, Jolly B, et al. Psychometric characteristics of simulation-based assessment in anaesthesia and accuracy of self-assessed scores. Anaesthesia 2005;60:245–50.
15. Shapiro MJ, Gardner R, Godwin SA, et al. Defining team performance for simulation-based training: methodology, metrics, and opportunities for emergency medicine. Acad Emerg Med 2008;15:1088–97.
16. Paige JT, Aaron DL, Yang T, et al. Implementation of a preoperative briefing protocol improves accuracy of teamwork assessment in the operating room. Am Surg 2008;74:817–23.
17. Moorthy K, Munz Y, Adams S, et al. Self-assessment of performance among surgical trainees during simulated procedures in a simulated operating theater. Am J Surg 2006;192:114–8.
18. Morgan PJ, Pittini R, Regehr G, Marrs C, Haley MF. Evaluating teamwork in a simulated obstetric environment. Anesthesiology 2007;106:907–15.
19. Cooper S, Cant R, Porter J, et al. Rating medical emergency teamwork performance: development of the Team Emergency Assessment Measure (TEAM). Resuscitation 2010;81:446–52.
20. Brown C, Hofer T, Johal A, et al. An epistemology of patient safety research: a framework for study design and interpretation. Part 3. End points and measurement. Qual Saf Health Care 2008;17:170–7.
21. Merien AE, van de Ven J, Mol BW, Houterman S, Oei SG. Multidisciplinary team training in a simulation setting for acute obstetric emergencies: a systematic review. Obstet Gynecol 2010;115:1021–31.
22. Siassakos D, Hasafa Z, Sibanda T, et al. Retrospective cohort study of diagnosis-delivery interval with umbilical cord prolapse: the effect of team training. BJOG 2009;116:1089–96.
23. Draycott T, Crofts JF, Ash JP, et al. Improving neonatal outcome through practical shoulder dystocia training. Obstet Gynecol 2008;112:14–20.
24. Draycott T, Sibanda T, Owen L, et al. Does training in obstetric emergencies improve neonatal outcome? BJOG 2006;113:177–82.
25. Nielsen PE, Goldman MB, Mann S, 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.
26. Siassakos D, Crofts JF, Winter C, Weiner CP, Draycott TJ. The active components of effective training in obstetric emergencies. BJOG 2009;116:1028–32.
27. Clay-Williams R, Braithwaite J. Determination of health-care teamwork training competencies: a Delphi study. Int J Qual Health Care 2009;21:433–40.