Multidisciplinary simulation training for perioperative teams: An integrative review

Supplemental material: Summary of study findings

Author, date, title, country	Partici-pants	Outcome measures / method	Reliability / validity of measures	Findings/conclusions	Limitations
Arriaga et al. (2014)[1], Pilot testing of a model for insurer-driven, large-scale multicentre simulation training for operating room teams, USA	n = 221	Participant perceptions; realism of the scenario, quality of debriefing and scenario relevance to clinical practice. Post-test survey questions scored on a five-point Likert scale and one free-text open-ended question.	Not specified	Participant evaluation of simulation scenarios and debriefing: • 94% found simulation to be realistic • 95% found the simulation challenging • 95% found the simulation appropriate for their level of training • 98.2% of participants felt they could be open and honest during debriefing • 98.1% of participants strongly agreed debriefing was of high quality • 96.3% of participants will use lessons learnt from simulation training in clinical practice • 92.6% felt simulation training would improve patient safety Free text question leading results: improved personal communication and assertiveness.	Unclear if the intervention will demonstrate changes in practice or improved patient outcomes.
Paige et al. (2014)[2], Getting a head start: high-fidelity, simulation-based operating room team training of interprofessional students, USA	n = 66	Feasibility and effectiveness of high-fidelity simulation training for interprofessional operating room students. Pre- and post-training questionnaires including 15-item Likert-type questions. Observers evaluated teams using Operating Room Teamwork Assessment Scales (ORTAS). Open-ended questions analysed using Miles and Huberman qualitative methods.	Paired t-test with Bonferroni adjustment. One-way ANOVA.	Statistically significant increases of $p < 0.001$ were found in 11 of the 15 items compared between scenarios one and two. Observer-rated performance scores showed statistically significant increases from scenarios one and two for all three comparisons $p < 0.001$. Observer-rated role scores showed statistically significant increases between scenarios one and two $p < 0.001$ and $p = 0.001$. Team-based behaviour scores were statistically significant for comparison between observer and participants $p = 0.039$. Themes identified: simulation-based training benefits, debriefing impact, enhanced communication and scenario realism. Themes identified: least beneficial aspects of simulation-based training, lack of time and feeling unprepared.	Small sample size. Multisource ratings were based on roles rather than individual performance. Three scenarios had more participants from one discipline.
Shapiro et al (2014)[3], The use of in-situ simulation to improve safety in the plastic surgery office: A feasibility study, USA	n = 16	In situ simulation used to assess the ability to manage medical emergencies and increase awareness of safety issues. AHRQ Medical Office Survey on Patient Safety administered before and after simulation training. Debriefing with open-ended questions in follow up survey.	McNemar or Stuart-Maxwell test performed. Fisher's exact test. Statistical tests 2-sided with type 1 error of 0.05. $p < 0.05$ considered statistically significant.	Statistical significance was found in three of the 18 categories in the abbreviated AHRQ Medical Office Survey. Debriefing identified crisis resource management principles and system-based issues. Follow-up surveys identified five improvements: BLS/ALS algorithms to be reviewed, algorithms to be placed in the operating room, code cart to be regularly reviewed, simulation exercises to be repeated, team communication to be practiced regularly.	No limitations identified by authors.

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Sørensen et al. (2015)[4], Clarifying the learning experiences of healthcare professionals with in situ and off-site simulation-based medical education: a qualitative study, Denmark	n = 25	Influence of setting on the experiences of learning for health care professionals undertaking simulation training. Focus group discussion.	Transcripts coded by two moderators. Principle researcher interpreted the data, three authors validated the data.	Theme 1: The value participants put on in situ simulation training being a priority for their learning decreased during the course of the study. Theme 2: Participants involved in off-site simulation training felt that it challenged them to adapt to changes. Theme 3: Participants felt realistic roles were more important than location. Theme 4: Positive and negative factors were not related to location. Theme 5: Regardless of location, teamwork skills, communication and interprofessional communication improved due to simulation training. Theme 6: Organisational changes were suggested after simulation training at both in situ and off-site simulation training.	Participants were known to each other which may have affected the accuracy of results. Heterogeneity of groups may have influenced results. Composition of focus groups may not have represented clinical working groups.
Sørensen et al. (2015)[5], Simulation-based multiprofessional obstetric anaesthesia training conducted in situ versus off-site leads to similar individual and team outcomes: A randomised educational trial, Denmark	n = 100	Examine the effect of in situ simulations (ISS) versus of-site simulation (OSS) on team performance, participants perceptions of simulation, organisational impact, stress, patient safety attitude, motivation and knowledge. 40-item multiple-choice question (MCQ). 33-item Safety Attitudes Questionnaire (SAQ). Salivary cortisol levels and Stress-Trait Anxiety Inventory (STAI) and cognitive appraisal (CA). 22-item Intrinsic Motivation Inventory (IMI). Evaluation questionnaire. Team Emergency Assessment Measure (TEAM). Open ended questions and debriefing and evaluation.	95% confidence interval calculated with generalised estimating equations. Kruskal-Wallis rank-sum test. P values adjusted using the Benjamini-Hochberg method. Mean outcomes compared with linear ANCOVA model and inferences based on GEE. Linear mixed methods models. Two-sided p values < 0.05 considered significant.	MCQ: no statistical difference between ISS and OSS. SAQ: no statistical difference between ISS and OSS. Salivary Cortisol, STAI and CA: mean change from baseline to the peak was similar in both ISS and OSS for both scenarios. IMI: no statistically significant difference found between ISS and OSS. Evaluation questionnaire: no difference between ISS and OSS for 20 questions. Two questions on the fidelity and authenticity were scored higher for ISS than OSS. TEAM: no statistical difference was found between ISS and OSS. Organisational outcomes: more ideas for organisational change were identified by ISS participants. ISS and OSS groups scored equally concerning simulations inspiring participants to make changes to guidelines and practices.	No follow-up testing of team performance or knowledge or long-term retention. Teams had previous simulation experience.

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Weller et al. (2015)[6], Multidisciplinary operating room simulation-based team training to reduce treatment errors: A feasibility study in New Zealand hospitals, New Zealand	n = 120	Primary objective: development and running of a simulation course, calculating course costs, perceived learning experience by participants, is there evidence of learning. Secondary objective: obtain feedback to guide future development of similar education resources. Post-course evaluation using a 5-point Likert scale and written responses. Behavioural Marker of Risk Index (BMRI) scored for induction and intra-operative phases.	Inter-rater agreement reached. Mazzocco et al. method used to calculate BMRI scores. Braun and Clarke methodology used for thematic analysis of transcribed debriefings. Two authors used to reach consensus on themes.	Cost: set-up costs $50 000, per day $4000. Participant's perceptions: • 80% found simulations and model realistic • 87.7% agreed or strongly agreed simulations were as challenging as an actual case • 93.6% agreed or strongly agreed that their behaviour was the same in the simulation as it would be in a real case. Free text answers indicated that model and scenario realism was very good. Some aspects of the models were shown to be limitations of the realism. Some aspects of the environment added to the limitations of the realism of the scenario training. End of course questionnaire: 98.3% agreed or strongly agreed the course was a useful learning experience. 89.2% of participants indicated that they would change their practice. BMRI scores improved from the first to the last scenario, p= 0.04. Themes identified in qualitative analysis: promoting team orientation, establishing a coordinated team, appreciation of the importance of information sharing.	Long term follow-up data not collected. Potential bias because participants were volunteers.
Hinde et al. (2016)[7], A study to assess the influence of interprofessional point of care simulation training on safety culture in the operating theatre environment of a university teaching hospital, UK	n = 84	Pre- and post-intervention comparison of operating theatre teamwork, climate and safety scores. The Safety Attitude Questionnaire – Operating Room (SAQ-OR) survey instrument Teamwork and Safety Climate survey instrument with language modified for the UK setting.	Scores compared using paired sample t-test. Effect size measured with Cohen's d.	Of the 84 participants, only 72 remained at the trust six months later. Only 46 (64%) of the 72 participants completed the SAQ-OR six months after the intervention. Outcome measures: • Safety Climate – pre/post intervention mean 65.8 vs 73.9 p< 0.001 Cohen's d 0.604. • Teamwork Climate – pre/post intervention mean 73.6 vs 78.9 p= 0.013 Cohen's d 0.382. Participants reports: • 90% had increased awareness • 85% had increased confidence in dealing with critical incidences • 100% felt in situ simulation was a valuable learning experience • 81% supported simulation training being conducted six-monthly.	Modest sample size. Improved patient outcomes cannot be directly shown with study results.

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Weller et al. (2016)[8], Can team training make surgery safer? Lessons for national implementation of a simulation-based programme, New Zealand	n = 49	What are the perceived challenges of implementing change? What are the motivators for implementing change? How was the change implemented in the clinical practices following MORSim? Semi-structured interviews.	One researcher conducted, transcribed and analysed the interviews. Crosschecking conducted by a second researcher to refine themes.	Theme: Lessons learnt and changes in clinical practice. • Positive practice changes 73% of participants. • No change in practice 9% of participants. • New knowledge gained from MORSim 94% of participants. Theme: Changes in other's work styles. • No changes observed in other's work practices 65% of participants. Theme: Effect on patient management • Improved processes had improved patient management 25% of participants. Theme: Shared learning with staff members • Positive shared learning 65% of participants. Theme: Barriers to change in clinical practice • Participants perceived one or more barriers existed to prevent change in practice 81%.	Bias may have been introduced by the framing of questions by the interviewer. Interviewees may have reported positively on their communication and teamwork skills. Study limited to two centres.
Weller et al. (2016)[9], Improved scores for observed teamwork in the clinical environment following a multidisciplinary operating room simulation intervention, New Zealand	437 surgical cases observed.	Observing changes to communication behaviours and teamwork in clinical practice following participation in MORSim. Behavioural Marker Risk Index (BMRI) measured at three phases of surgery before and after MORSim participation.	Acceptable inter-rater agreement reached. Calibration session held to maintain inter-rater agreement. Pre- and post-test scores compared using ANOVA. To test for effect, a logistic regression model was used. Significance set at p=<0.05. Bonferroni correction used during secondary analysis.	Extended BMRI decreased by more than 20% following MORSim compared to before MORSim. Statistically significant improvement in extended BMRI for induction p= 0.005 and intra-operative p< 0.001phases. Individual domains of vigilance, information sharing, interdisciplinary information sharing, intra-operative briefing, briefing, information sharing, and interdisciplinary information sharing were more frequently observed after MORSim for all three phases.	Unable to blind raters. Simulation occurring in the clinical setting introducing variables which could not be controlled. No use of a control group. Voluntary participation could have introduced bias.

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Doumouras et al. (2017)[10], Non-technical skills of surgeons and anaesthetists in simulated operating theatre crisis, UK	n = 26	Primary outcome measure: time to crisis resolution. Secondary outcome: non-technical skills (NTS) score of anaesthetists and surgeons using Anaesthetist Non-Technical Skill (ANTS) and Non-Technical Skill for Surgeons (NOTSS) rating systems.	Student t-tests. Inter-rating reliability assessed with intraclass correlation absolute mixed-effect statistic. Linear mixed-effects regression models with 95% confidence intervals. Statistical significance was set at p= <0.05.	NOTSS scores higher for haemorrhage scenario than difficult airway scenario 14.34(2.07) vs 12.15(2.07) p<0.001. ANTS scores did not differ between scenarios 13.04(2.62) vs 12.99(2.62) p=0.895. NOTSS and ANTS scores were higher before compared to during the crisis 13.62(2.57) vs 12.78(3.00) p=0.031 and 13.75(2.22) vs 12.28(2.78) p<0.001. Higher NOTSS score before and during was associated with a faster crisis resolution (34.69 seconds p= 0.001). Increased ANTS scores were associated with faster crisis resolution (32.09 seconds p= 0.009). NTS declined during the crisis for both the anaesthetist and surgeons evident by NOTSS scores 0.74 points lower during crisis (p= 0.008) and ANTS scores 1.38 points lower during the crisis (p< 0.001). NOTSS scores were also significantly lower during the difficult airway scenario 2.09 points lower (p< 0.001). NOTSS scores were found to influence ANTS scores during the haemorrhage scenario and vice versa. A 1-point increase in NOTSS scores increased ANTS score by 0.30 (p= 0.005). A 1-point increase in ANTS scores increased NOTTS score by 0.21 (p= 0.0012). ANTS scores had the greatest influenced on the predictor of crisis resolution. 1-point increase decreased crisis duration by 53.50 seconds (p< 0.001).	Interpretation of results was more complex due to the use of a sensitivity analysis using a time-to-event hazard ratio model; therefore, results may be less meaningful. Only two potential scenarios were used during the simulation. The study is based on simulated crisis events. The contributions of scrub technicians and theatre nurses during the scenarios were not analysed.
Wongsirimeteekul et al. (2018)[11], Identifying and managing intraoperative arrhythmia: a multidisciplinary operating room team simulation case, USA	n = 91	The primary goal was for the participants to develop crisis management and clinical practice skills. Post-intervention evaluation using a seven-point Likert scale and free text.	Not specified	Participant evaluation: • 94% agreed or strongly agreed working as an interprofessional team was important • 96% agreed or strongly agreed the simulation exercise was applicable to their own practice • 88% agreed the simulation improved their teamwork skills. Free text answers indicate that participants' practice will change, communication is vital for effective teamwork, and new knowledge was gained, as a result of the simulation training.	Small sample size. Intervention implemented for operating room staff only.

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Leithead et al. (2019)[12], Examining interprofessional learning perceptions among students in a simulation-based operating room team training experience, USA	n = 152	Examine the impact of high-fidelity interprofessional simulation training on students from different professions within the operating room. A 15-item questionnaire using a six-point Likert-type interprofessional teamwork (IPT). Readiness for Interprofessional Learning Scale (RIPLS) using a five-point Likert Teamwork Assessment Scale (TAS) with six-point Likert scale and two three-item subscales.	Student t-test. ANOVA analysis. p-value <0.05 statistically significant. Effect size calculated with Cohen's d. Post-hoc pairwise analysis of pre–post score differences with Tukey's Studentised Range Distribution.	The response rate was over 80%. IPT scores were statistically significant for all professions p< 0.001. RIPLS overall scores were statistically significant p< 0.001. Nurse anaesthetist improvement scores p= 0.003 and medical students p= 0.042. The mean IPT difference between the professions was statistically significant p< 0.001, whereas the mean RIPLS differences were not p= 0.491. Pairwise comparison of the mean differences between professions on the IPT survey showed statistical significance between a nurse anaesthetist and medical students – mean difference 0.62, 95% confidence level 0.34 to 1.01, effect size 0.91 – and undergraduate nursing student and nurse anaesthesia student – mean difference 0.62, 95% confidence level 0.24 to 1.00, effect size 0.79.	Greater number of medical students in some groups. Student differences over four years may have influenced results. General Linear Model analysis may have been a more appropriate statistical technique. Small sample size. Statistical significance for mean RIPLS scores was small and may not reflect the clinical significance. RIPLS was not implemented until 2012–2013.
Rochlen et al. (2019)[13], Pilot one-hour multidisciplinary team training simulation intervention in the operating room improves teams non-technical skills, USA	n = 31	Hypothesis 1: Simulation training will improve non-technical skills. Hypothesis 2: Self-Reflection Survey scores will improve during the intervention and at the 2-week follow up. Non-Technical Skills II (NOTECHS II) tool Self-Reflection Survey (SRS)	Generalised Estimating Equations. Statistical significance set at p= <0.05. Confidence interval set at 95%.	NOTECHS II scores increased from simulation one to simulation two and simulation two to post-intervention. All scores were higher for post-intervention than scenario one. No scores were statistically significant. Changes in scores between scenarios two and one with 95% CI were not statistically significant. All SRS scores compared to pre-intervention increased with statistical significance. Mean SRS scores immediately after intervention 0.57 p = 0.0175, at the end of the day 0.81 p = 0.0150, at the two-week follow up 0.49 p = 0.0426 The type of profession affected SRS scores.	Small sample size. Study conducted at a single centre. False positive correlations due to team familiarity. Raters and participants were not blinded to interventions or control group.
Long et al. (2020)[14], Sustaining multidisciplinary team training in New Zealand hospitals: a qualitative study of a national simulation-based initiative, New Zealand	n = 27	Explore perspectives on the long-term sustainability of the NetworkZ programme. Semi-structured interviews. Codes deductively developed into themes aligned to Roger's Diffusion of Innovation Theory's five main factors.	Coding conducted by author one and reviewed by author two.	Theme 1: Relative advantage – multidisciplinary, delivered in situ, the relevance of communication and teamwork, realism of scenarios and generalisability to another setting. Theme 2: NetworkZ aligned with personal beliefs of the importance of teamwork. Theme 3: Complexity of course delivery – complexity reflected in the reduced time available to set up the program and multiple roles required of the instructors. Theme 4: Observability of programme impact – improved teamwork, improved teamwork behaviour, improved communication, reduced hierarchy, improved confidence to speak, identification of latent safety threats.	Potential bias due to vested interest by researchers. Generalisability is untested.

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Multidisciplinary simulation training for perioperative teams: An integrative review

Supplemental material: Application of Joanna Briggs Institute (JBI) Critical appraisal checklist for quasi-experimental studies to the ten quantitative studies

Checklist item	Study									
	Paige et al. (2014)	Arriaga et al. (2014)	Shapiro et al. (2014)	Sørensen et al. (2015)	Weller et al. (2015)	Hinde et al. (2016)	Weller et al. (2016)	Doumouras et al. (2017)	Leithead et al. (2019)	Rochlen et al. (2019)
Is it clear in the study, what is the cause and what is the effect?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Were the participants included in any comparisons similar?	✓	✓	✓	✓	✓	✗	✗	✓	✗	✗
Were the participants included in any comparisons receiving similar treatment/care, other than the exposure of intervention of interest?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Was there a control group?	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Were there multiple measurements of the outcome, both before and after the intervention/exposure?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analysed?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Were the outcomes of participants included in any comparisons measured in the same way?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Were outcomes measured in a reliable way?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Was appropriate statistical analysis used?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Percentage	89%	89%	89%	89%	89%	78%	78%	89%	78%	78%

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Supplemental material: Application of Joanna Briggs Institute (JBI) Critical appraisal checklist for qualitative research to the four qualitative studies

Checklist item	Study			
	Sørensen et al. (2015)	Weller et al. (2016)	Wongsirimeteekul et al. (2018)	Long et al. (2020)
Is there congruity between the stated philosophical perspective and the research methodology?	✓	✓	✓	✓
Is there congruity between the research methodology and the research question or objectives?	✓	✓	✓	✓
Is there congruity between the research methodology and the methods used to collect data?	✓	✓	✓	✓
Is there congruity between the research methodology and the representation and analysis of data?	✓	✓	✓	✓
Is there congruity between the research methodology and the interpretation of results?	✓	✓	✓	✓
Is there a statement locating the researcher culturally or theoretically?	✓	✓	✓	✓
Is the influence of the researcher on the research, and vice versa, addressed?	✓	✓	✓	✓
Are participants and their voices, adequately represented?	✓	✓	✗	✓
Is the research ethical according to current criteria or, for recent studies, is there evidence of ethical approval by an appropriate body?	✓	✓	✓	✓
Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?	✓	✓	✓	✓
Percentage	100%	100%	90%	100%