Final Evaluation Report – Workforce Innovation Simulation Project

Multidisciplinary Operating Room Simulations (MORSim)

Citation: The University of Auckland. 2015. *Final Evaluation Report – Workforce Innovation Simulation Project: Multidisciplinary operating room simulations (MORSim).* Wellington: Ministry of Health.

Published in September 2015
by the Ministry of Health
PO Box 5013, Wellington 6145, New Zealand

ISBN 978-0-478-44881-8 (online)
HP 6261

This document is available at www.health.govt.nz

Executive Summary

Failures in communication and teamwork in the operating room lead to patient harm. The Multidisciplinary Operating Room Simulation (MORSim) project was designed to be a course for teams of operating room staff to train together to improve teamwork and reduce patient harm.

A course consisting of three simulated acute surgical cases with debriefs and a didactic lecture was created. The cases were based on the experience of the multidisciplinary faculty and designed to be realistic and challenging for the whole team. Faculty members were trained in debriefing and novel surgical models were created for the scenarios.

Feedback from participants on 20 courses was overwhelmingly positive. There was also evidence of improved information sharing over the course day. Measures in the clinical environment showed an improvement in communication that has been associated with a 14% reduction in patient harm. We hope to have a notes review completed in 2015.

In addition to the 20 research course days, we have also run two simulations in a hospital-based simulation centre and have plans to run course modules in real operating theatres in 2015. There are also ongoing discussions with ACC about funding the course for nation-wide implementation.

Ass/Prof Jennifer Weller and Prof Alan Merry

(Principal investigators)

Table of Contents

Project Overview

Background

Failures of teamwork are frequent in healthcare and may result in compromised patient care, inefficiency, and tensions among staff (Lingard et al., 2004; Manser, Harrison, Gaba, & Howard, 2009; Reader, Flin, & Cuthbertson, 2007; Webb et al., 1993). Salas et al (Salas, Sims, & Burke, 2005) propose that three coordinating mechanisms are required for effective teamwork: mutual trust, closed-loop communication, and shared mental models (a shared understanding between members of the team of the situation, goals and plan). These shared mental models have been linked to improved team performance across many industries. Two fundamental requirements for developing a shared mental model are effective communication and sharing of information between team members. In healthcare, the use of checklists that promote the sharing of clinical information and construction of shared mental models has resulted in reduced surgical complications, increased timely antibiotic administration, and improved medical management. Structured handovers also provide benefits that include fewer unexpected deaths and adverse events.

Simulation is often used for training teams in healthcare. However, simulation-based initiatives are often targeted at a single professional discipline (McFetrich, 2006; McLaughlin et al., 2008), and as such, fail to address issues of communication between team-members from different disciplines. While multidisciplinary simulation-based team-training interventions have been reported in obstetrics and emergency medicine, little has been published on such initiatives for whole operating room (OR) teams (Cumin, Boyd, Webster, & Weller, 2013; Tan & Sarker, 2011).

Project objectives

The goal of the project was to develop a multi-disciplinary educational programme for the operating department utilising simulated learning environments. This included creation of the environment and requirements for the simulations, including models, standards, and instructor training materials; run and evaluate at least two courses with developed tools for measuring behaviours with the purpose of improving team process, efficiency and safety; and reporting to HWFNZ on the progress of the project.

Development of the Course

Faculty and participants

In order to create a course for multidisciplinary teams, we brought together a multidisciplinary faculty and governance board. The team was comprised of anaesthetists, surgeons, anaesthetic technicians, nurses, psychologists, and engineers. Preliminary meetings established some ideas about possible scenarios that could be used to engage the whole team based on the experiences of clinical faculty members.

The target participants for the simulations was a complete, general surgical OR team, comprising a consultant surgeon, a surgical trainee, a consultant anesthesiologist or senior trainee, two operating room nurses and an anesthetic technician.

Focus groups

As part of the development process, we conducted 9 focus groups separately with surgeons, anaesthetists, anaesthetic technicians and OR nurses (45 individuals). Using a semi-structured question guide, we enquired about the obstacles to good teamwork in the OR.

Of the 21 themes initially coded from these focus groups, those concerning 'communication' appeared most frequently, followed closely by 'understanding'. Staff felt teamwork breaks down because of a lack of explicitness, poor briefings, or inadequate explanation by surgeons. A lack of knowledge of team members' roles and capabilities was also critical in triggering problems. Similarly, strong demarcations and discipline-based information exchange between anaesthetists/anaesthetic technicians and nurses, and also between medical and non-medical staff evidently hamper communications and teamwork.

We identified certain kinds of situations in the OR where teamwork often fails, such as low team vigilance at induction, no announcement of massive transfusion, and even frequent cell phone interruption. These situations were considered for incorporation into the simulations as part of the programme.

The focus groups also helped shape the learning outcomes for the course as:

- Identify situations where information sharing among the whole team could be improved
- Identify barriers to information sharing among the whole team in the OR
- Create a list of ways in which information sharing can be improved in practice

Information sharing and debriefs

As the focus groups identified "communication" and "understanding" as the primary educational needs, a strong focus of the scenarios was on information sharing. To this end, each participant was given a brief with key details of the case and a piece of clinically-important information that no one else in the team received (information probe). At the end of the scenario, all participants answered a questionnaire to see who knew which pieces of information – therefore, who shared the information successfully.

As well as being a research and evaluation tool (see below), the information probe methodology was also useful in debriefs as a concrete and real-time example of information sharing. The debriefs, therefore, leveraged this tool to help participants reflect on their communication during the scenarios. As there were three debriefs in the programme (one for each scenario), each one focussed on a separate aspect of communication. The first debrief was designed to be generally focussed on information sharing; the second was to highlight "call-outs", a structured way to make sure the whole team understands what is going on – this could include a briefing; and the third debrief sought to help participants reflect on closed-loop-communication, a way of ensuring that important information is communicated effectively.

The debriefs followed the 3D model ("diffusing", "discovering", "deepening") and were facilitated by a surgeon, an anaesthetist, and an anaesthetic technician or nurse who had all completed the course (see below).

Environment, models, and scenarios

The course was based at the Simulation Centre for Patient Safety (SCPS), University of Auckland. We created a realistic OR environment using: real drugs and fluids; equipment and instruments similar to those used in our participants' hospitals; patient clinical notes and investigations available online. We designed the scenarios to proceed with minimal input from faculty members or actors. (A faculty nurse assisted the participants when required e.g. by helping them to locate equipment).

The scenarios were developed primarily with anaesthetic, technician, and nursing input. Scenarios were designed to have an acute surgical need for operation and involve an anaesthetic crisis. Two scenarios involved acute abdominal pathology: appendicitis complicated by sepsis and subsequent allergic reaction; and a stab wound with lacerated inferior vena cava (IVC) complicated by cardiovascular collapse. The third scenario involved a traumatic leg amputation and pneumothorax following an explosion. Refinement of the scenarios was iterative and required modifying the time-line of events, all patient details, and necessary equipment. Sponsorship of some equipment was obtained to create a more realistic environment (for example, new drapes and gowns were donated by KimberlyClarke).

Working with a special effects company (Main Reactor Ltd), we created novel models that integrate with our existing manikins for surgeons to work with in a realistic manner. We collaborated to design the models such that they could be used in three scenarios. Our surgical faculty members led this iterative process with the Main Reactor team. The abdominal model had a replaceable skin that could be cleansed with chlorhexidine, incised and retracted. Within the abdominal cavity there were a molded aorta, kidneys and psoas muscles and models of small and large bowel with mesentery and omentum, and IVC. The root of the appendix, the caecum, the IVC, and the skin could all be sutured as necessary. The models could be connected to a blood pump to produce bleeding consistent with an IVC laceration or bleeding from the femoral vessels. Blood could be suctioned and the abdomen washed out.

Technical specifications for the scenarios are detailed in the simulation technician's manual as part of the course. These include checklists for required equipment/props with representative pictures of the equipment, overview of the scenario timeline, scripts for telephone operator and patient, and example patient documentation.

Non-simulation materials

The pedagogical basis for the course was simulation-based learning. Supporting the simulations and debriefs, there was also a didactic lecture that was created to introduce participants to the evidence-based importance of information sharing and some tools that have some evidence for effectively improving teamwork. The tools presented in the lecture were integrated with the debriefs (see above) – call-outs and closed-loop-communication.

A course for debriefers was also created. This involved pre-readings and two two-hour sessions where the basics of debriefing were discussed and practice under the guidance of experienced faculty members.

We also developed a computer program to evaluate the extent to which different team members have the same mental model of the tasks involved in the case they were about to do, and who was responsible for the tasks. This is a novel measurement tool in this context and was created as part of the funded PhD project. The tool was used in 40 simulations we ran and allowed insight into the shared understanding of the teams. Members had some disagreement on the order of critical tasks in the procedures and quite different understandings of who should be primarily responsible for the tasks.

Structure of the Course Day

Familiarization

We began each day with introductions and a 30-minute familiarization exercise to the equipment and environment.

Presentation

We provided an overview of the evidence on communication failures in the OR; outlined the basic elements of effective teamwork and explained two communication tools: closed-loop communication and structured call-out.

Briefing

We provided participants with individualized case briefing notes before each of the three scenarios. All participants received the same description of the basic clinical details for the case, but in order to highlight any deficiencies in information sharing practices, each received a unique item of clinically relevant information, unknown to other participants. This allowed tracking of information through the scenario as it was shared (or not) between participants and provided a stimulus for discussion on information sharing during the scenario debrief.

Scenarios

Each team of six participants attended for one full day and took part in all three scenarios, each of approximately 40 minutes duration. The first and third scenarios (abdominal cases) were presented in random order to account for order effects.

Debriefing

After each scenario, participants took part in a 40-minute debrief, facilitated by trained debriefers from the research group comprising a surgeon, anesthesiologist, and nurse or anesthetic technician. The debrief clarified with participants which unique items of information had been shared. The subsequent discussion focused on barriers to sharing information in their clinical practice and strategies to improve information sharing such as briefing and “time out”, structured communication in a crisis, and closed loop communication.

Course Evaluation

A total of 20 teams (120 professionals comprising 20 surgeons and 20 surgical trainees, 20 anesthesiologists, 20 anesthetic technicians, and 40 nurses) participated in the study between October 15th 2012 and July 1st 2013.

Teams of six participants were recruited from the two study hospitals using a first-come first-enrolled approach following presentations at staff meetings, emails via departmental lists, posters on clinical notice boards, and personal approaches. The six participants in each team were: surgeon, surgical trainee, anesthesiologist, anesthetic technician, circulating nurse, and scrub nurse. Recruiting 20 teams implied recruiting the majority of consultant general surgeons in each institution, but not the majority of the anesthesiologists, nurses, or anesthetic technicians.

Two research days were rescheduled because of surgeon unavailability. We were unable to recruit the full complement of participants from the study hospital on three days, and filled the gaps with participants from other hospitals in the region. The majority of participants were female (62.5%), but this varied by role (Table 1).

Table 1: Demographics of participants by role.

Role	**Gender (% F)**	**Experience in the role in Operating Room (%)**					
		0-12 months	**1-2 years**	**3-7 years**	**8-12 years**	**13-20 years**	**21+ years**
Senior surgeons (n=20)	20	0	0	10	40	35	15
Junior surgeons (n=20)	75	15	15	35	20	0	0
Anesthesiologists (n=20)	65	0	0	25	30	25	20
Nurses (n=40)	80	0	22.5	45	12.5	15	5
Anesthetic Technicians (n=20)	55	0	5	35	40	10	10
Overall	*62.5*	*2.5*	*10.83*	*32.50*	*25.83*	*16.67*	*9.17*

Participant perceptions

Participants completed a questionnaire about the realism of the simulation and the models after each scenario.

In the questionnaires administered after each scenario, when asked if the simulations and models were realistic, over 80% of participants agreed or strongly agreed. Also, 87.7% agreed or strongly agreed that the simulation was as challenging as a real case of similar nature, and 93.6% agreed or strongly agreed that they behaved as they would in real procedures. In free text comments many noted that the model and scenario realism were generally very good:

'The patient was very real and it felt like real scenarios' (nurse); 'Both the surgical models and scenarios were realistic and generated the appropriate stress response' (surgeon); 'Great simulator/manikin, great scenarios' (anesthesiologist).

Participants indicated low blood viscosity, insufficient bleeding from lacerated IVC, and breath sounds that were difficult to interpret as limitations to the realism of the models. Limitations to the realism of the environment included lack of clinical help, limited equipment, and differences from usual practice (e.g. diathermy could not be used, the endotracheal tube needed lubrication with silicon and updated laboratory results had to be requested by telephone).

Participant satisfaction

Participant satisfaction was measured by an end of course questionnaire (appendix A). Almost all participants agreed or strongly agreed (98.3%) that the course was a useful learning experience and everyone agreed that it was enjoyable. All but one participant indicated they would recommend the course to colleagues and 89.2% of participants indicated they would change their practice as a result of the course. All participants were generally happy and excited by the course. In free text fields in the end of day questionnaire it was described as: 'perfect' (tech), 'excellent' (anaesthetist), 'outstanding', 'awesome' (nurse), 'incredibly well run' (surgeon), 'invaluable' (surgeon).

Eighty-four participants wrote responses in a free text field on the end of course questionnaire. No participants indicated the course was unsatisfactory, and many participants suggested expanding the scope to other specialties and providing more regular courses:

'please keep doing these as a means of promoting education and awareness' (anesthetic technicians*); 'could make this a course for theatre staff to attend on a yearly basis' (anesthesiologist); 'this course should be compulsory as part of annual update' (nurse); 'can broaden it to include others not taking part' (surgeon); 'every theatre staff should be encouraged to attend' (surgeon).*

Participant reported learning

We recorded, transcribed and analyzed the debriefs that followed the three scenarios. Formal thematic analysis of the transcripts was done according to the methodology of Braun and Clarke. This analysis identified the following four themes: promoting a team orientation; establishing a coordinated team; prompted pauses to achieve a shared mental model; and good communication practices.

Promoting a team orientation

Participants indicated that it was important for team members to set aside professional silos and work toward a common goal. Similarly, participants suggested that greater continuity of teams and debriefing after complex cases could help create an environment where team values of cooperation and mutual support are actively encouraged (below). Some of the comments relating to this theme were prompted by the discovery that not all team members had been given the same information about the case.

Discouraging professional silos and hierarchies	*"Establishing the culture to actually have everybody contribute to the situation and not feel that there is a hierarchal situation where one's information is not necessarily relevant [is important]."* (Surgical Registrar) *"I think it just highlights that we all work our own little areas and we're all very professional: anesthetic, nursing, surgical, and we communicate very well within those little areas, and it is very important that we do the cross-pollination or cross-communication to make sure that we get that overview of the whole picture"* (Consultant Surgeon)
Supporting team continuity	*"I mean I've known [name] since I was a former medical student. So I feel like I could, I might pipe up with something a little bit more than I might with some of these brand new bosses that I've known for two weeks, and don't know how they might respond to me or, you know, a question or a suggestion."* (Surgical Registrar)
Debriefing after complex cases	*"I think you do need to, particularly if there has been an absolute disaster, you know, a clinical disaster… some emotional support and emotional debrief is necessary in those circumstances."* (Anesthesiologist)

Establishing a coordinated team

Participants highlighted the importance of a team that functions well as a unit. They suggested this could be encouraged by clearly defining roles and establishing a team coordinator (below).

Clearly defining job roles	*"I think there's room for having even more defined roles in theatre like, you know, whose job it is to put the TED [thromboembolism-deterrent] stockings on, whose job it is to … get stuff ready for the catheter sort of thing, you know."* (Consultant Surgeon)
Use of team coordinators	*"As long as you all agree that what we need to do is a laparotomy, then getting the steps done to get to a point where you can incise the abdomen, doesn't have to be a surgical, or for that matter, anesthetic, job. It's just an organisational job."* (Anesthesiologist)

Prompted pauses to achieve a shared mental model

Many participants discussed the use of pauses in surgery that could be prompted by any member of the team. Prompted pauses were identified as opportunities to share information, and included team briefings before the start of an operation, formal time-outs immediately before surgical incision, and 'callouts' when the case became confusing or difficult to manage (below). The second scenario (traumatic leg amputation) in particular, with time allocated for a pause and team brief, encouraged discussion of these issues.

Sharing information through briefings and prompted pauses	*"I think it's [the course] pointed out that if the opportunity is there then it is great to have a briefing as a team beforehand, which may be possible in a trauma situation, you know if the patient's gone for an investigation, or you've got ten minutes before they are coming up to theatre from ED or whatever. And I think for big elective cases that's worthwhile too, but then we tend to do that more, more routinely I think. But yeah, I think the team briefing is a good idea."* (Anesthesiologist) *"When we had a bronchospasm… it was a thyroidectomy patient and on induction [she] just went into severe bronchospasm - but it wasn't clear whether she was having anaphylaxis or what was going on. And there were definitely SNAPPIs [structured callout] - trying to go through tick boxes, and also actually think about stating the obvious, like, we're not doing the surgery, which to the anaesthetists everyone rolled their eyes at me as if that was obvious, but the nurses were like, "Oh, okay good. We'll un-scrub and help then."* (Consultant Surgeon) *"Because we do actually often have like, you know, the classic sort of coming from ED [Emergency Department] of three minutes per case… You do actually have a bit of time... Often when the nurses are around, surgeons kind of waiting and anesthetist person and tech... And you get a little bit of time to kind of say, "Hang on a sec, this is what we sort of think is gonna happen here?" I know we often always do our own thing, but there's actually… we probably do have time."* (Consultant Surgeon)
Timing of timeouts	*"But in trauma, when you aren't really sure where it's evolving, having [timeout] before the patient goes to sleep is quite good… You unmask a whole lot of things when you start giving a patient drugs and there isn't a lot of time to stop and think after that, you really have to have thought through your options before that."* (Anesthesiologist) *"You can [have] time out once you get stability though, can't you - you know to start saying do we have the right patient - you know, those sort of checks don't really need to be done. But I think it's important about antibiotics, DVT and those other things being done. But standing around doing that when you have got an unstable patient you can quickly probably fix…"* (Consultant Surgeon) *"It should be, "Is it okay to do timeout?" In which case, "Actually no*

	I'm putting in an arterial line, can you just wait for a minute."” (Consultant Surgeon)

Good communication practices

Participants suggested that all members of an OR team should communicate their relevant thoughts and opinions during an operation to contribute to a successful outcome. A number of recommendations for good communication were identified. These included: putting hierarchy or anxiety aside to articulate uncertainty rather than continuing in silence; being assertive and explicit regardless of your position in the team; and inviting contributions from others. Participants reflected on the importance of closed-loop communication, on avoiding acronyms, and on using a whiteboard as methods for achieving a shared mental model. They also identified directed communication (i.e., directing messages to intended recipients by name) as a potentially effective technique. Visible name tags were therefore considered important. Participants also identified the importance of not communicating unnecessarily as too much communication could distract from important issues (below).

Articulating uncertainty	*"You know, to me it's, it's sort of – [a] quiet revolution in anesthesia because, rightly or wrongly, I got the impression during my anesthetic training [that] your role in a crisis was to lead and to admit any uncertainty or indecision or let anyone else chip in, that was sort of a sign of weakness... and it's really nice to perhaps be given a template whereby you can maintain a leadership role whilst admitting uncertainty, indecisiveness, inviting input without… abdicating leadership."* (Anesthesiologist)
Increasing assertiveness and explicitness	*"When you're a junior, or when you're a nurse, you should always remember that your opinion counts, because when you're a junior, you know, you don't want to talk up, because as you say, you might offend someone." (Anesthesiologist)*
Inviting Contributions	*"It's important to make sure that everybody in the room not only does share what they know but is made to feel like what they know is important. It doesn't matter if you're the porter or the scrub nurse, whoever you are in the room, that you are confident to share what you know."* (Surgical Registrar)
Increasing closed-loop communication	*"She directly spoke to me [about] what she wanted for the operation and I rephrased back. And then I closed looped with [name] and told her [what] [name] wanted for the operation. And, yeah, we understood each other."* (Nurse)
Avoiding acronyms and abbreviations	*"But then I realised when we were doing that debrief on the computer, do people have different ideas of 'triples'? Cause my 'triples' is Amoxicillin, Gentamicin and Metronidazole… And I thought maybe I should have asked exactly what triples are."* (Surgical

	Registrar)
Using a whiteboard	*"On the nursing side of things, a lot of our information we write up on our board. So you know allergies… the patient's name, NHI, any drug allergies, any metal wear, um, group and hold, weight, all that sort of stuff, can be written up there, so that's something which even if you can't, if you haven't actually properly listened to something - then you can flip back and look at the board."* (Nurse)
Directing communication to specific people	*"And it's not like, "Oh, someone get me this and someone get me that" it's "[Name] can you go and get this" and "[Name] can you go and get me that", so your name is said first, so you know that people are talking to you."* (Nurse)
Using visible team names	*"[It's] important for the names to be on the board. Cause then you can't do any closed communication or you can't talk to, oh you know, "You over there", or who are they, unless you got the names there."* (Consultant Surgeon)
Establishing the right amount of communication	*"Noise is as bad, too much noise is bad as, it's as bad as too little information sort of thing, and we should, we should have good default procedures so that you don't have to talk a lot about stuff that we should all absolutely have in play anyway. It should just be routine procedures."* (Consultant Surgeon)

Participant reflections on the course

We interviewed a representative sample of participants (48 in total) 3-5 months after the course to ask their reflections. These were semi-structured interviews. Despite some initial concerns about what the course may entail and worries about being judged, performing poorly and/or working with unfamiliar teams, over 75% of the respondents reported that they were pleased they had participated in the course. Positive reports reflected on the learning opportunities provided, the opportunity to work in good teams with members of other professional groups and to participate in an active learning environment. The majority (58%) of participants suggested that they had learned about the importance of sharing information to achieve a common understanding within their team. Seventeen participants (35%) indicated that they had learned about other team members' roles, competencies or pressures.

Information sharing

We measured information sharing using a modified "information probe" method originally described by Blum et al (Blum, Raemer, Carroll, Dufresne, & Cooper, 2005). After each simulation participants independently answered a set of multiple-choice questions about the case, including questions about the unique item of clinical information each had received as part of a written brief before each simulation. We generated an "information sharing score" out of 30 (presented as a percentage) from their answers, on the basis that there were five people who could potentially learn each item of information from the (sixth) person to whom it had been disclosed.

In the second scenario we assessed information sharing at two additional times: immediately after the first patient encounter when the surgeons and anesthesiologist were in pre-op and the nurses/technician were in the OR, and after the team had five minutes together to brief before they entered the OR.

Sharing of the unique items of clinical information each participant received prior to the scenario (information sharing score) improved from the first to final simulation, but a considerable proportion of this clinically relevant information was never shared. The information sharing scores were highest in the second scenario after participants were given five minutes together to discuss the case.

In the first case of the day teams shared an average of 29.2% of the available information; this increased to 48.6% in the third scenario of the day. In the second scenario, they shared 39.2%, 66.1%, and 62.3% at the first, second and third assessment points respectively (Figure 1).

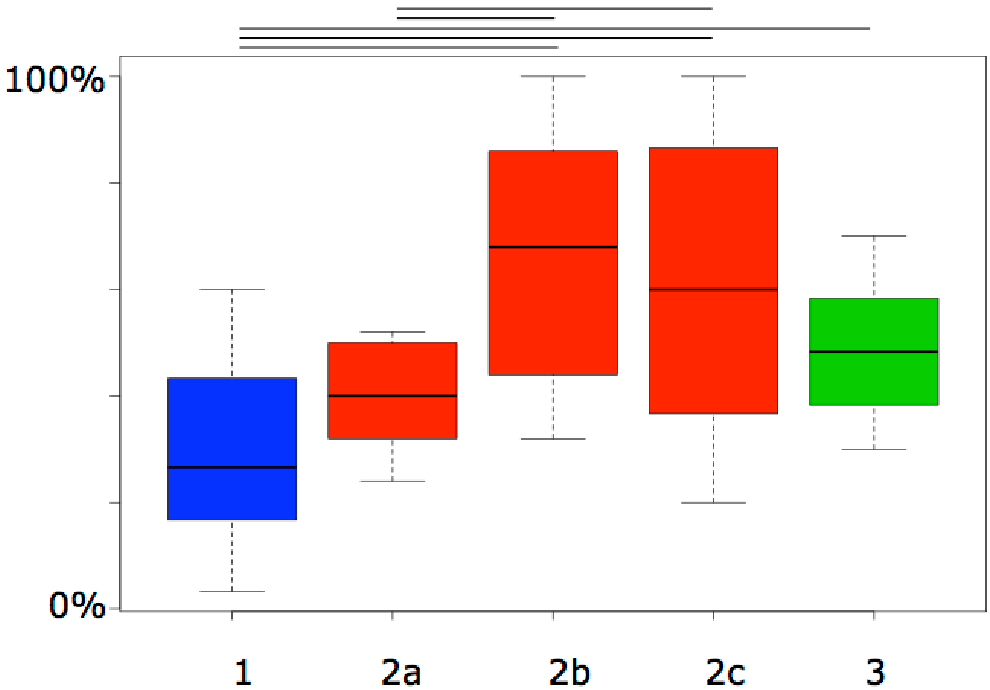

Figure 1: Boxplot of information sharing scores over the course day. The first and third scenarios were the abdominal cases and the second scenario involved questionnaires administered after the first part of the scenario, after the brief, and at the end of the scenario. Bars above the graph represent a significant difference (Tukey HSD $p<0.05$).

Attitudinal changes in the clinical environment

The SAQ is a widely used, psychometrically validated tool to measure and benchmark staff attitudes to important safety topics (Sexton et al., 2006). We used the Teamwork and Safety Climate version of the Safety Attitudes Questionnaire. Although only 60 staff from each hospital attended MORSim, the

SAQ was administered to the entire surgical department at the two participating hospitals 3 to 5 months before and 3 to 5 months after the intervention. This was modified slightly for the local context and consists of 28 items in two sections, 'Teamwork' and 'Safety' (see Appendix B). The tool was distributed to staff at both hospitals in paper form and available online through an email link to the survey URL.

A total of 260 staff from the general surgical departments at the two hospitals responded to the questionnaire before the MORSim course and 132 responded after the course days. Table 2 shows the number of respondents by professional group and hospital.

Table 2: Number of respondents (% total staff)

	Pre-MORSim		Post-MORSim	
	Hospital 1	Hospital 2	Hospital 1	Hospital 2
Anaesthetists	37 (41.6)	31 (36.5)	21 (23.6)	25 (29.4)
Surgeons	19 (33.9)	9 (47.4)	1 (1.8)	11 (57.9)
Nurses	74 (77.9)	47 (31.3)	18 (18.9)	34 (22.7)
Technicians	25 (80.6)	18 (56.3)	6 (19.3)	16 (50.0)
Total	**155 (100)**	**105 (100)**	**46 (100)**	**86 (100)**

Scores for both the Teamwork and the Safety domains of the SAQ did not significantly change over time at either hospital.

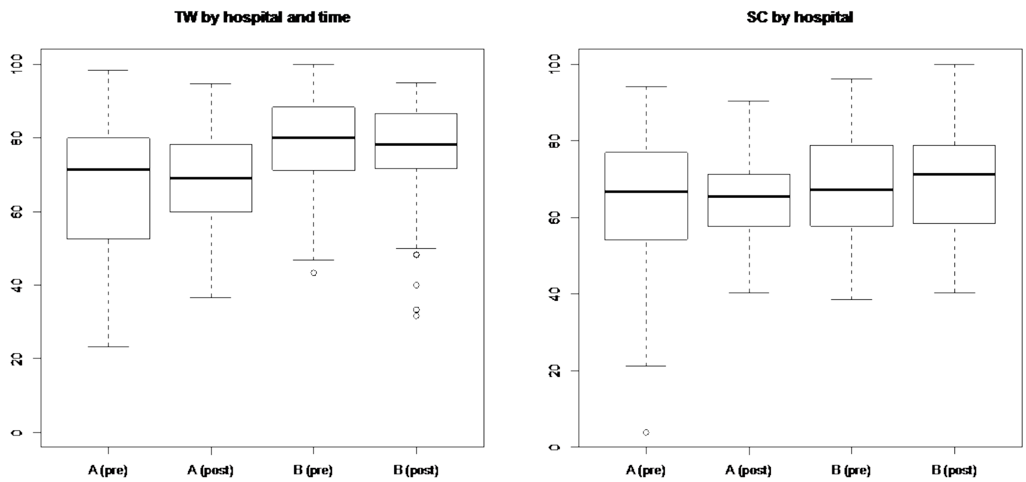

Figure 2: Teamwork scores and Safety Climate scores before and after MORSim for each hospital.

Communication changes in the clinical environment

The Behavioural Marker of Risk Index (BMRI) tool is a validated instrument for measuring teamwork in surgical teams, and shown to be linked to patient outcomes (Mazzocco et al., 2009). The tool measures six domains of behaviour in three phases of surgery. The domains are: briefing, information sharing, inquiry, contingency management, assertion, and vigilance (Table 3). As we were interested in improving inter-disciplinary information sharing, we added a seventh domain, inter-sub-team information sharing. Four sub-teams were identified as: (a) the surgical sub-team, which consisted of all the staff who were scrubbed in for the case; (b) the anaesthetic sub-team, which consisted of the anaesthetist(s) and the anaesthetic technician(s); (c) the nurse sub-team, which consisted of the nurses circulating in the room; and (d) any other person(s) in the room, for example a radiologist. Information that was shared across any of the sub-teams was considered for the inter-sub-team item score.

Each of the seven items were scored during three phases: induction (from patient enters until the incision), intraoperative (from incision until wound closed), and handoff (from wound closed until handover complete). Each item was scored on a scale from 0-4 according to how frequently they were observed in each of three phases. These scores are then converted to a total BMRI score range from 0 to 1 where 0 indicates all behaviours were observed frequently and 1 indicates all behaviours were observed infrequently. In addition to the scores, start and end time of the procedure, the American Society of Anaesthesiologists (ASA) score assigned by the anaesthetist, the duration and type of operation as defined in the patient notes, and the number of people in the room (in each sub-team) were recorded as part of the observations.

Table 3: Items used in scoring BMRI. Note inter-sub-team information sharing was not in the original tool.

Item	Description
Briefing	Situation/relevant background shared; patient, procedure, site/side identified; plans are stated; questions asked; ongoing monitoring and communication encouraged
Information sharing	Information is shared; intentions are stated; mutual respect is evident; social conversations are appropriate
Inquiry	Asks for input and other relevant information
Contingency management	Relevant risks are identified; backup plans are made and executed
Assertion	The members of the team speak up with their observations and recommendations during critical times
Vigilance	Tasks are prioritized; attention is focused; patient/equipment Monitoring is maintained; tunnel vision is avoided; red

	flags are identified
Inter-sub-team information sharing	Information is shared between the nursing, surgical, and anaesthetic sub-teams

A total of 453 cases in the OR were observed. However, at one calibration session, agreement was below the threshold (RWC of 0.8) and 16 observations were discarded. This left 437 total observations for analysis (224 pre-MORSim, 213 post-MORSim; below) distributed evenly between the two hospitals.

Table 4: The number (and percent) of scores that were above 2 in each phase and domain.

Phase	**Induction**		**Intraoperative**		**Handoff**	
Domain	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Briefing	132 (58.9)	175 (82.2)	6 (2.7)	60 (28.2)	135 (60.3)	164 (77.0)
Info. sharing	212 (94.6)	179 (84.0)	153 (68.3)	169 (79.3)	178 (79.5)	114 (53.5)
Inquiry	144 (64.3)	123 (57.7)	64 (28.6)	86 (40.4)	74 (33.0)	63 (29.6)
Vigilance	210 (93.8)	191 (89.7)	191 (85.3)	188 (88.3)	169 (75.4)	179 (84.0)
Contingency Mx	6 (2.7)	15 (7.0)	1 (0.5)	2 (0.9)	1 (0.4)	7 (3.3)
Assertion	2 (0.1)	2 (0.1)	4 (1.8)	5 (2.3)	0 (0)	1 (0.5)
ID info-sharing	136 (60.7)	180 (84.5)	45 (20.1)	119 (55.9)	138 (61.6)	144 (67.6)

Info =information; Mx=management; ID=interdisciplinary

The domains 'contingency management' and 'assertion' were observed on only 56 occasions in the 1,311 observation periods (437 cases, three phases) and were thus excluded from further analysis as was the case in the Mazzocco et al. study (Mazzocco et al., 2009). When considering potential cofounders, our analysis suggested that BMRI was significantly related to the time of day the case started ($p<0.001$), the duration of the case ($p<0.001$), the number of staff in the OR ($p<0.001$), and patient ASA score ($p<0.001$).

Table 5: Summary data. Values are given as mean (sd) of staff present in observed cases, and as count (%) of start time, duration and ASA status all cases observed.

Measure	**Pre**	**Post**	**Overall**
	mean (sd)	**mean (sd)**	**mean (sd)**
Observations	224	213	437
Total staff	8.3 (1.6)	10.0 (2.2)	9.1 (2.1)
Surgeons	1.7 (0.7)	2.0 (0.7)	1.8 (0.7)
Anaesthetists	1.3 (0.5)	1.7 (0.6)	1.6 (0.6)
Nurses	3.2 (0.6)	3.5 (0.9)	3.4 (0.8)

Techs	1.1 (0.3)	1.3 (0.5)	1.2 (0.4)
Other	0.9 (1.0)	1.4 (1.1)	1.2 (1.1)
Start Hour	**count (%)**	**count (%)**	**count (%)**
0700-1000	101 (45.1%)	99 (46.5%)	200 (45.8%)
1000-1300	75 (33.5%)	79 (37.1%)	154 (35.2%)
1300-1500	34 (15.2%)	33 (15.5%)	67 (15.3%)
1500-2000	14 (6.3%)	2 (0.9%)	16 (3.7%)
Case duration (minutes)	95.6 (61.9)	110.7 (67.6)	103.0 (65.1)
Patient ASA			
I	61 (27.2%)	57 (26.9%)	118 (27.0%)
II	111 (49.6%)	80 (37.7%)	191 (43.7%)
III	46 (20.5%)	70 (33.0%)	116 (26.5%)
IV	6 (2.7%)	5 (2.3%)	11 (2.5%)

*ASA = American Society of Anesthesiologists classification of patient risk factors.

The final model found that overall BMRI decreased (improved) pre- to post-MORSim by more than 20%, (0.41 v 0.32, $p<0.001$). There was significant improvement in BMRI for each phase pre-post in a repeated measures ANOVA (BMRI scores for Induction, 0.255 v 0.005 $p=0.005$; Intraoperative, 0.590 v 0.413 $p<0.001$ and Handover 0.380 v 0.346 $p=0.22$).

Individual domains that were more likely to be frequently observed post-MORSim in each of the three operative phase were: Induction – ‘briefing’, ‘interdisciplinary information sharing’, ‘information sharing’; Intraoperative – ‘briefing’, ‘interdisciplinary information sharing’; Handoff – ‘information sharing’, ‘vigilance’. However, we found ‘information sharing’ at the induction and handoff phases were scored as less frequent following the MORSim course with an odds ratio of less than 1. (Table 4).

Table 6: Odds ratios (95% confidence levels) for pre-post effect on individual domains rating highly (3 or 4) in the BMRI tool, after controlling for confounders. Significant changes are denoted with * at 0.05, ** at 0.01, * at 0.001 level after a Bonferroni correction.**

Domain	Induction	Intra-operative	Handoff
Briefing	4.0 (2.4-6.9)***	12.0 (5.2-32.9)***	2.1 (1.3-3.4)*
Info sharing	0.3 (0.1-0.6)**	1.5 (0.9-2.6)	0.3 (0.2-0.5)***
Inquiry	0.7 (0.4-1.0)	1.5 (1.1-2.9)	0.8 (0.5-1.2)
Vigilance	0.4 (0.2-1.0)	1.3 (0.7-2.5)	2.9 (1.6-5.7)**
Inter-team	5.1 (2.9-9.4)***	7.3 (4.4-12.4)***	1.2 (0.8-2.0)

Overall BMRI scores in the clinical environment improved by almost 20% from pre to post intervention (0.41 v 0.32, $p<0.001$). On the basis of previous research (Mazzocco et al., 2009), this could be expected to translate into a 14% reduction in 30-day complications and mortality in surgical patients, with an associated reduction in the costs of treatment injuries.

Other changes in the clinical environment

In the same 48 interviews as discussed above, over 75% of the respondents reported that they were pleased they had participated in the course. Reasons these respondents offered included the opportunity to practice as a team with members of other professional groups and to actively participate.

"At the end of the day I tell people it was the best study day ever … You actually get to … participate. It's a lot better than just sitting down in the tutorial to talk about communication skills and teamwork." (Nurse)

Seventeen interviewees (35%) raised concerns about the course and these centred on its realism. In particular, participants identified limitations with the equipment (broken, old, unfamiliar, scarcity) that hindered their immersion in the simulation.

The majority (58%) of participants suggested that they had learned about the importance of sharing information to achieve a common understanding within their team. Seventeen participants (35%) indicated that they had learned about other team members' roles, competencies or pressures.

"I think I understood better how different members of the team can have a different understanding of what's going on."(Surgeon)

Thirty interviewees (63%) reported one or more positive changes in clinical practice subsequent to the course, and a total of 51 positive changes were reported. Twelve interviewees reported there was no change. Of the 30 interviewees reporting change, there were nine (of 11) anaesthetists, two (of 7) surgeons, eight (of 10) technicians, and fifteen (of 20) nurses. Reported changes included improved communication practices, more assertiveness, and increased awareness of others or of the environment.

"In terms of the checklist, I've changed my attitude in terms of that… saying or highlighting things that are important or that might go wrong or change… and definitely paying more attention… it's an important time to discuss things" (Anaesthetist)

"I'm able to communicate more. Like if I feel like the patient is at risk in theatre, I'll be able to say… 'Oh, he might get a pressure area there'" (Nurse)

Dissemination of information about the project

The project has been presented at various meetings throughout the three years. There were multiple presentations to the various DHBs involved at the department and executive levels. There were also presentations at University of Auckland department meetings within the Faculty of Medical and Health

Sciences. There were also presentations of the work at conferences and meetings, as below:

- Boyd, M., D. Cumin, D. Madell, O. Albert, A. F. Merry and J. Weller (2014). Scoring case management in multidisciplinary operating room simulations. *SimHealth*. Adelaide, Australia.
- Boyd, M., D. Cumin, J. Torrie, B. Knowles, A. Gundesen, T. Lee, M. Crossan, S. Garden, W. L. Ng, N. Gurusinghe, D. Marshall, E. Davies, A. F. Merry and J. Weller (2013). Evaluating a Multidisciplinary Operating Room Simulation Course (MORSim): Preliminary Results. *SimHealth* Brisbane.
- Boyd, M., D. Cumin and J. Weller (2012). Whole team OR simulations: what are the educational needs? *SimHealth*. Sydney.
- Cumin, D., M. Boyd, N. Gurusinghe, A. F. Merry and J. Weller (2013). Creating a multidisciplinary operating room simulation (MORSim) for training and research: overcoming barriers. *SimHealth* 2013, Brisbane, Australia.
- Cumin, D., M. Boyd and J. Weller (2012). Whole team OR simulations: why aren't there more courses? *SimHealth*. Sydney.
- Torrie, J. and N. Gurusinghe (2014). *Assessing The Workplace Effects Of A Non-Technical Skills Course For OR Teams.* ANZCA / RACS Combined meeting. Singapore.
- Weller, J., D. Madell, N. Gurusinghe, J. Torrie, A. F. Merry, M. Boyd and D. Cumin (2014). Improving teamwork: a thematic analysis of debriefs following multidisciplinary simulation. *SimHealth*. Adelaide, Australia.
- Weller, J., A. F. Merry, I. D. S. Civil, W. M. Guthrie, C. S. Webster, J. J. Torrie, A. D. MacCormick, K. M. Henderson, W. Ng, M. Gers and D. Cumin (2012). A proposed simulation-based training and research programme for multi-disciplinary operating room teams: work to date. New Zealand Association for Simulation in Healthcare Conference, Auckland, NZ.
- Westli, H., B. Johnsen, J. Eid, I. Rasten and G. Brattebo (2010). Teamwork skills, shared mental models, and performance in simulated trauma teams: an independent group design. *Scandinavian Journal of Trauma, Resuscitation, and Emergency Medicine* **18**: 47.

The work was also featured in a TVNZ news item (http://bit.ly/MORSimTVNZ). Additionally, we have published a journal article relating to the project (below) and have other manuscripts in various stages of draft.

- Cumin, D., M. J. Boyd, C. S. Webster and J. Weller (2013). A systematic review of simulation for multidisciplinary team training in operating rooms. *Simulation in Healthcare*.

Implementation

Given the success of the 20 research days, we see the potential for implementation around New Zealand. We have created materials to enable the course to be run as three separate modules, allowing flexibility in time-tabling staff to attend. We have also run two scenarios in a hospital simulation centre to better understand the logistics of undertaking the course outside of our centre. The feedback from participants on the day was very encouraging. We are now planning to run scenarios in real operating rooms in 2015 and we are engaged with potential funders looking towards a nationwide roll-out of the course.

Financial report

Below is an account of how the money was spent in total over the three years:

Project officer and research assistant	$430,317.00
PhD student	$105,000.00
Consumables and models	$16,289.00
Simulation consumables (gases, drugs etc)	$9,834.00
Simulation centre facility	$32,560.00
Total HWFNZ	**$594,000.00**

The grant has been administered through the University of Auckland Finance Office and all expenditure has been in accordance with standard University policies.

Additional funding for research was obtained from the Auckland Medical Research Foundation, the University of Auckland School of Medicine Foundation, and the Joint Anaesthesia Faculty Auckland. Donations of consumable items from Kimberly-Clark, Smith & Nephew, NZ Blood, Covidien, and Baxter, and equipment loans from DSTC, OBEX and Zimmer helped create a more realistic environment.

Appendix A – Participant evaluation form

Course Evaluation

1. Overall, I found the course enjoyable

- ☐ Disagree strongly
- ☐ Disagree slightly
- ☐ Neutral
- ☐ Agree slightly
- ☐ Agree Strongly

2. Overall, I found the course a useful learning experience

- ☐ Disagree strongly
- ☐ Disagree slightly
- ☐ Neutral
- ☐ Agree slightly
- ☐ Agree Strongly

3. Overall, the course was well organised

- ☐ Disagree strongly
- ☐ Disagree slightly
- ☐ Neutral
- ☐ Agree slightly
- ☐ Agree Strongly

4. I would recommend this course to my colleagues

- ☐ Disagree strongly
- ☐ Disagree slightly
- ☐ Neutral
- ☐ Agree slightly
- ☐ Agree Strongly

5. I am likely to change my practice as a result of this course

- ☐ Disagree strongly
- ☐ Disagree slightly
- ☐ Neutral
- ☐ Agree slightly
- ☐ Agree Strongly

6. What suggestions do you have for future courses?

Thank you for completing this questionnaire

Appendix B - The SAQ

Teamwork Climate	Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly	Not Applicable
1.Input from Nurses and other non-medical staff is well received in the ORs						
2.In the OR, it is difficult to speak up if I perceive a problem with patient care						
3.Decision-making in the OR utilizes input from relevant personnel						
4.The medical and non-medical staff on Level 8 work together as a well-coordinated team						
5.Disagreements in the OR are resolved appropriately (i.e. not *who* is right but *what* is best for the patient)						
6.I am frequently unable to express disagreement with the surgical/anaesthetic consultants in the OR						
7.It is easy for personnel in the OR to ask questions when there is something that they do not understand						
8.I have the support I need from other personnel to care for patients						
9.I know the first and last names of all the personnel I worked with during my last shift						
10.Important issues are well communicated at shift changes						
11.Briefing personnel before the start of a shift (i.e., to plan for possible contingencies) is important for patient safety						
12.Briefings are common in OR						
13.I am satisfied with the quality of collaboration that I experience with medical staff in the ORs						
14.I am satisfied with the quality of collaboration that I experience with non-medical staff (including nurses, anaesthetic techs and HCAs) in the ORs						
15.Communication in the OR helps us avoid wasting time during operating lists						

SAQ: Safety Climate	Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly	Not Applicable
16.The levels of staffing in the OR are sufficient to handle the number of patients						
17.I would feel safe being treated in the OR as a patient						
18.I am encouraged by my colleagues to report any patient safety concerns I may have						
19.Personnel frequently disregard rules or guidelines (e.g. hand-washing, treatment protocols/clinical pathways, sterile field, etc.) that are established in the OR						

20.The culture in the OR makes it easy to learn from the errors of others						
21.I receive appropriate feedback about my performance						
22.Medical errors are handled appropriately here						
23.I know the proper channels to direct questions regarding patient safety in the Level 8 OR						
24.In the OR it is difficult to discuss errors						
25.Hospital management does not knowingly compromise the safety of patients						
26.The OR is doing more for patient safety now, than it did one year ago						
27.Leadership is driving us to be a safety-centred institution						
28.My suggestions about safety would be acted upon if I expressed them to management						

References

Blum, R. H., Raemer, D. B., Carroll, J. S., Dufresne, R. L., & Cooper, J. B. (2005). A method for measuring the effectiveness of simulation-based team training for improving communication skills. *Anesthesia & Analgesia, 100*(5), 1375-1380.

Cumin, D., Boyd, M. J., Webster, C. S., & Weller, J. (2013). A Systematic Review of Simulation for Multidisciplinary Team Training in Operating Rooms *Simulation in Healthcare, 8*(3), 171-179. doi: doi: 10.1097/SIH.0b013e31827e2f4c

Lingard, L., Espin, S., Whyte, S., Regehr, G., Baker, G. R., Reznick, R., . . . Grober, E. (2004). Communication failures in the operating room: an observational classification of recurrent types and effects. *Quality and Safety in Health Care, 13*, 330-334.

Manser, T., Harrison, T. K., Gaba, D. M., & Howard, S. K. (2009). Coordination patterns related to high clinical performance in a simulated anesthetic crisis. *Anesthesia & Analgesia, 108*(5), 1606-1615.

Mazzocco, K., Petitti, D. B., Fong, K. T., Bonacum, D., Brookey, J., Graham, S., . . . Thomas, E. J. (2009). Surgical team behaviors and patient outcomes. *The American Journal of Surgery, 197*(5), 678-685.

McFetrich, J. (2006). A structured literature review on the use of high fidelity patient simulators for teaching in emergency medicine. *Emergency Medicine Journal, 23*, 509-511.

McLaughlin, S., Fitch, M. T., Goyal, D. G., Hayden, E., Yang Kauh, C., Laack, T. A., . . . Gordon, J. A. (2008). Simulation in graduate medical education 2008: A review for emergency medicine. *Academic Emergency Medicine, 15*(11), 1117-1129.

Reader, T. W., Flin, R., & Cuthbertson, B. H. (2007). Communication skills and error in the intensive care unit. *Current Opinion in Critical Care, 13*(6), 732-736.

Salas, E., Sims, D., & Burke, C. (2005). Is there a 'Big Five' in teamwork? *Small Group Research, 36*, 555-599.

Sexton, J. B., Helmreich, R. L., Neilands, T. B., Rowan, K., Vella, K., Boyden, J., . . . Thomas, E. J. (2006). The Safety Attitudes Questionnaire: psychometric properties, benchmarking data, and emerging research. *BMC Health Services Research, 6*(44), 1-10.

Tan, S. S. Y., & Sarker, S. K. (2011). Simulation in surgery: a review. *Scottish Medical Journal, 56*(2), 104-109.

Webb, R. K., Currie, M., Morgan, C. A., Williamson, J. A., Mackay, P., Russell, W. J., & Runciman, W. B. (1993). The Australian Incident Monitoring Study: an analysis of 2000 incident reports. *Anaesthesia & Intensive Care, 21*(5), 520-528.