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The effective implementation and assessment of a surgical simulation programme for undergraduate medical students

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Master in Surgery (MCh)

This thesis is submitted to University College Dublin in fulfilment of the requirements for the degree of Master in Surgery (MCh).

This research was conducted in the UCD School of Medicine, specifically the Department of Surgery at Mater Misericordiae University Hospital.

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This thesis is submitted to the University for examination in
September 2021.

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Abstract

Background

COVID-19 has impacted all non-emergent hospital activities, including on-site medical student education. In response, we implemented an on-site simulation programme to supplement our existing curriculum to ensure that our students' clinical learning experience is optimised.

Methods

Over the course of the academic year all students enrolled in the Surgery module received simulation training in the decommissioned original operating theatres of the Mater Misericordiae University Hospital. As this was during reduced the COVID-19 pandemic, ward based learning was limited at this time. This incorporated biweekly surgical tutor-led simulated patient sessions over a twelve week period in semester one and surgical skills simulation throughout both semesters. Best practices in infection prevention were researched prior to implementing our programme. To ensure optimal benefit a systematic review evaluating performance benefits of simulation training was performed. To assess usefulness, independent clinical teams scored student clinical competence (using twelve components of the Surgical Ward Assessment Tool) in representative groups completing surgical rotations who had simulation training versus those completing same duration medicine rotations without. Student feedback was obtained before and after completing simulation training.

Results

3074 articles were initially identified using the search criteria with 92 full-text articles then screened for eligibility. Nineteen articles were selected for review. All articles reported a positive effect of simulation training on performance.

220 students underwent simulation training this semester over 96 hours of scheduled, direct teaching. 66 students (38 females, 29 graduate entry) were formally assessed by clinical staff from ten specialties at two clinical sites. Students who received simulation training (n=35) were significantly better at history taking ($p=0.004$) and appropriate laboratory ($p=0.001$) and radiological investigation ($p=0.01$) ordering.

Conclusion

SMBE, as an adjunct to existing curricula, improves knowledge-based performance medical students. This pilot study shows the rapid implementation and feasibility of a simulation programme for medical students at our clinical site. This will provide a basis for further development of on-site simulation training.

I hereby certify that the submitted work is my own work, was completed while registered as a candidate for the degree of Master of Surgery, and I have not obtained a degree elsewhere on the basis of the research presented in this submitted work.

Collaborators

Mohammad Faraz Khan (MD): assisted in simulation training and systematic review article selection.

Laoise Coady (MB): assisted in simulation training

Jeffrey Dalli (MB): statistical analysis

Chapter 1: Purpose and Significance of the Study

Background

Undergraduate medical education has traditionally been based on the principles of William Osler. The initial pre-clinical years are spent learning foundational biomedical and clinical sciences, with the latter clinical years spent in hospitals applying this knowledge. There is a particular focus on bedside teaching and patient contact at this stage (1,2). Students have learned on-site and been part of the Mater Misericordiae University Hospital campus for many years. As discussed by the British General Medical Council in 2020, there is limited time for ward based teaching (3).

COVID-19 has severely impacted all non-emergent hospital activities, including on-site medical student education. At the onset of the COVID-19 pandemic all student activity at our clinical site ceased. Teaching hospitals must prioritise patient care but cannot forget their student body. Students require clinical experience to progress, however it is not feasible to introduce a large volume of people onto a vulnerable population during an ongoing pandemic (4). In response to COVID-19, we plan to implement a simulation programme to supplement our existing curriculum to ensure that our students have the optimal clinical learning experience.

Basis for Simulation-based Medical Education

Simulation involves a “device that presents a simulated patient (or part of a patient) and interacts appropriately with the actions taken by the simulation participant” (5). Simulation has been studied

extensively in the literature and some of the benefits include greater patient safety, a safer learning environment for students, increased repetition, improved teamwork and enhanced confidence (6–12).

Simulation has long been used as an adjunct to training in various fields such as aviation and the military. Simulation based medical education is increasingly being used to supplement the undergraduate medical curriculum. Several studies have shown the benefits of simulation (1-3). The latter years of medical education have been traditionally based on lectures and ward-based learning. Many institutions have added simulation programmes to complement their existing curriculum (13,14). Greater patient safety and the ability to run a reproducible standardized curriculum have been some of the reasons for this shift. Patient safety and medical errors have come to the forefront of healthcare since the Institute of Medicine released *To Err Is Human: Building a Safer Health System* in 2000 (15). Due to COVID-19, the need for simulation based teaching has been accentuated.

Investigation

Prior to implementing our programme we investigated the factors required for successful simulation in medical education, namely the physical plan, the simulation equipment, the curriculum and the teaching methodology (16). The physical plan and simulation equipment was acquired and set up based on existing clinical facilities at our clinical site. The curriculum was based on our pre-existing ward-based learning curriculum, with clinical scenarios based on common surgical pathologies simulated, and then

discussed. The key aspect of simulation training is post-session debriefing (14,17,18). Feedback should be consistent with the learning objectives of the session, it should focus on the positives and negatives of the session and can be led by either the facilitator or the students themselves.

Implementation plan

Based on other institutions' experience in implementing a simulation programme we divided the process into three steps; planning, implementation and evaluation (14).

The planning phase initially involved developing our simulation facility. Whilst this was taking place we formulated a number of relevant surgical clinical scenarios.

During the running of this programme we troubleshoot and recorded any problems that arose.

The primary goals of our research were to:

1. Evaluate the benefits of a simulation programme as an adjunct to the current curriculum.
2. Assess students' perceptions of a simulation programme.
3. Assess how we can improve our simulation programme in the future.
4. Provide a guide to other institutions on how best to implement a simulation programme.

This study was undertaken over the course of the 2020-2021 academic year, which was split into two modules for students:

Surgery A and Surgery B. The Surgery A simulation module is primarily focused on history taking and clinical knowledge, with an end of semester examination consisting of a multiple-choice paper and short answer question paper. The Surgery B simulation focuses on clinical examinations and the end of semester examination is an OSCE (Objective Structured Clinical Examination).

Planning

Prior to implementing our simulation programme, a systematic review was undertaken according to the PRISMA guidelines using the Ovid, EMBASE and PubMed databases for studies reporting on undergraduate simulation based medical education programmes. Establishing a simulation centre involved assessing various locations across our clinic site. We did this with the aid of experts in the fields of medical education and audio-visual technology. After choosing a suitable site, we had to decide on a number of factors to optimise our location. Audio-visual equipment was researched and sourced. We used a portable set up as it allows for greater flexibility. Light placement and power supply were already present and set up based on a real-life surgical theatre.

Qualitative & quantitative data was collected from students with consent before and after simulation sessions and various other points throughout the year. Students completed a questionnaire before and after simulation training, consisting of 5-point Likert scale questions.

All students in their second last year of medical school who were based in our teaching hospital were included in our study. All students had previously completed a history taking and physical examinations module. As this was exploratory work, all students were included, and the data obtained will be used to inform and power subsequent studies in this area.

This research has been approved for Human Subjects Low Risk Ethical Exemption. This is anonymous data, with students recruited from one school. Permission has been obtained from the head of the school (UCD Surgery) to collect this data.

Chapter 2 – Systematic review

Medical education largely still follows traditional structures (1,2). Students undergo didactic lecture-based learning throughout their studies but especially in their early years. Once on clinical sites, they learn by engaging with clinical teams and real patients. Although proven sufficient over time, the acquisition of medical knowledge and skills in this way has a number of potential pitfalls. Students are expected to learn from and practice recently acquired knowledge and skills on actual patients. This interaction may be complicated both ways— medical students can be nervous and patients, a vulnerable cohort, can be fearful. Furthermore, the clinical experience may be variable between teams and over time and much of the interaction happens without direct observation by academic faculty. The heterogeneity and inconsistency of clinical exposure coupled with lack of assessment-relevant feedback before examinations is suboptimal and may undermine fairness in competitive assessments and standards in future medical practice. Also, the COVID-19 pandemic has greatly challenged medical undergraduate programmes and students by the withdrawal of ward-based placements.

To improve their skills in both history taking and physical examinations, students have long practiced individually and with their peers. This provides a safe, comfortable environment for them to hone their skills and enables iterative improvement by doing, although this again lacks senior supervision and standardisation

and may not challenge. Simulation has long been used in aviation and military training and is fast becoming a formal component of undergraduate and postgraduate medical education (19–21). Simulation training providing a “device that presents a simulated patient (or part of a patient) that interacts appropriately with the actions taken by the simulation participant” allowing users to learn in a safe, controlled and standardised environment, so that skills and knowledge can be applied and practiced (5). Recent technological advances have increased the capability to realistically mimic actual patients and real-life clinical scenarios (22,23).

While postgraduate simulation has been studied extensively in the literature (with some of its proven benefits including greater patient safety, improved teamwork and enhanced confidence (6–12)), there is less evidence detailing the effect of such training on undergraduate medical student performance. Although many previous studies have detailed the self-reported effects of simulation training on medical students (6,24,25), objectively assessed impacts need to be established prior to its broad implementation most particularly to justify the necessary expenditure but also especially if it's to replace other existing curricular components, either by design or necessity (eg due to public health emergencies). The purpose of this review is to synthesise the available evidence on the performance effect of simulation based medical education (SBME) for undergraduate medical students in general medicine and surgery.

Methods

Search database: This systematic review was conducted using the Preferred Reporting Items for Systematic Review & Meta-Analyses (PRISMA) guidelines. The searches were performed independently in duplicate (NM, FK) using OVID, EMBASE and PubMed databases from 2010 to 2020 inclusive.

Search terms: The following Medical Subject Headings terms and keywords were used: medical education OR medical students OR medical student AND simulation training OR high fidelity simulation training OR mannequin OR manikins OR SimMan or simulation. Boolean AND/OR operators were used to combine MeSH and terms and keywords. Following the search, titles and abstracts were screened. Full text of potentially eligible articles were reviewed by two authors (NM, FK) independently and eligible studies selected.

Inclusion/exclusion criteria: Our inclusion criteria required all articles to be in English, to be research-based and to include objective investigation of the efficacy of a simulation-based training programme for undergraduate medical students in general medical and surgical clinical learning stages regarding clinical performance. Studies which assessed history taking, physical examination, and clinical practice either separately or together were included regardless of method of simulation (including whether mannequins or simulated patients were used) and assessment (i.e. whether written, Objective Structured Clinical Examination (OSCE) or tutor

assessment). Studies assessing procedural protocols (including BLS, ACLS and ATLS) and surgical skills were excluded as were those using only subjective assessment methodology. Studies assessing subspecialty domains such as obstetric, paediatric, anaesthetic and psychiatric simulation were excluded.

Data Collection

The following data was extracted from each included publication: first author, publication year, country, study design, number and stage of students, simulation method, assessment method, performance levels pre and post simulation, effects on knowledge retention, students' confidence and authors' conclusion.



PRISMA 2009 Flow Diagram

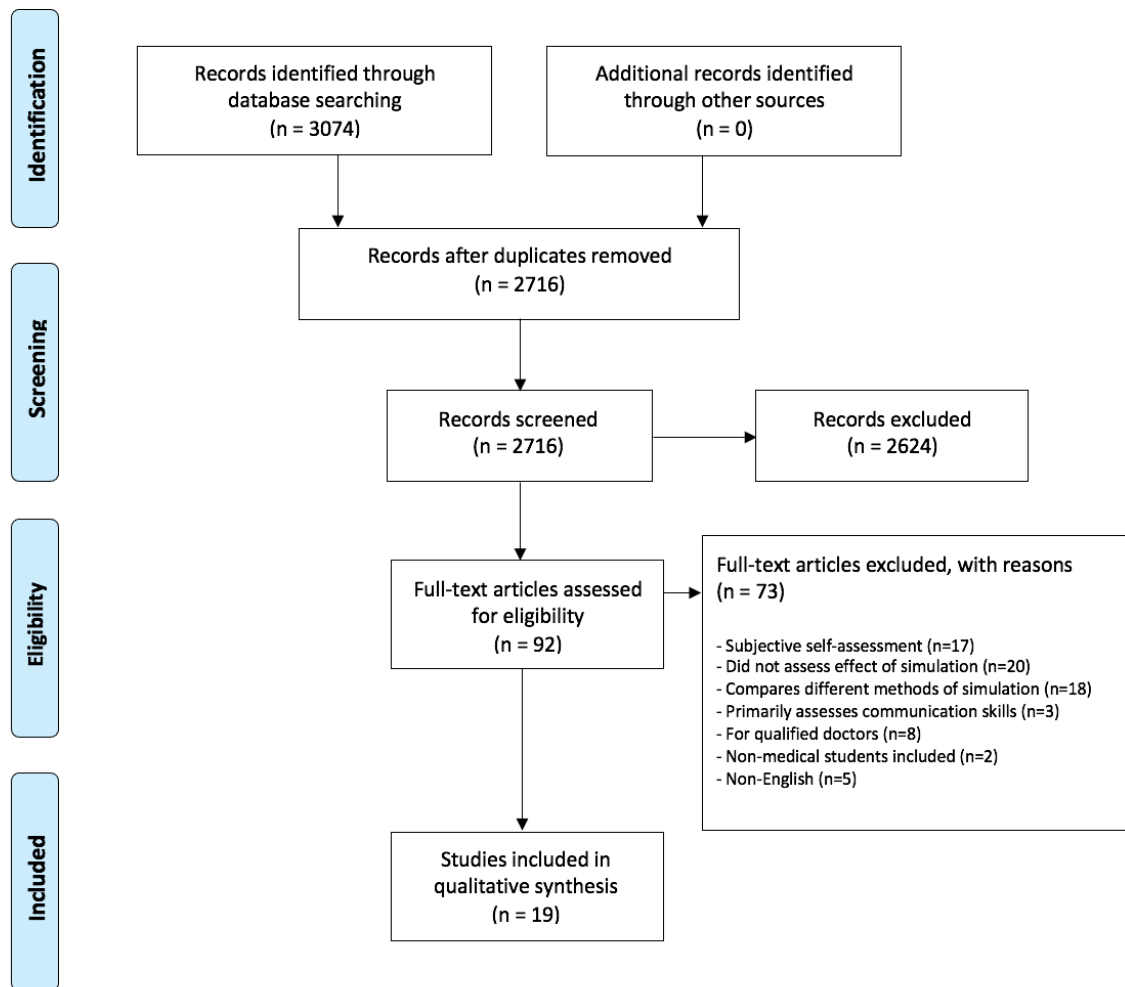


Figure 1: PRISMA flowchart of the search and selection process

Author	Year	Origin	Population	Speciality	Sample Size	Simulation method	Assessment method
Grunewald(26)	2019	Germany	4 th year	Surgery	27	Standardized patients	Checklist
Nassif(27)	2019	Lebanon	3 rd year	Breast surgery	82	Standardized patients and a breast model	OSCE
Bernardi(28)	2019	Italy	5 th year	Cardiology	107	Kyota kagaku simulator	Written
Angarita(29)	2019	Canada	4 th year	Breast surgery	120	Simulated breast model	OSCE and written assessment
Vattanavanit(30)	2016	Thailand	6 th year	Medicine	79	SimMan	Checklist
Giblett(31)	2017	UK	3 rd year	Surgery	104	Standardized patient	Written
Sanchez-Ledesma(32)	2016	Spain	4 th year	Medicine	300	SimMan	Checklist
Pereira(33)	2016	Portugal	3 rd and 4 th years	Cardiology	117	Heart sounds simulator	Written
Alluri(34)	2016	USA	2 nd year	Medicine	20	METI simulator	Written
Zhang(35)	2015	China	5 th year	Medicine and Surgery	203	Standardised patient	OSCE
Williams(36)	2015	UK	5 th year	Cardiology	24	Standardised patient	Written
Solyomos(37)	2015	Ireland	5 th year	Medicine	41	SimMan	Written
Swamy(38)	2014	UK	1 st year	Medicine	79	SimMan	Written
Perlini(39)	2014	Italy	3 rd and 4 th year	Cardiology	615	Harvey simulator	Written
Fisher(40)	2014	UK	3 rd year	Medicine	74	Standardized patient	Written
DeWaay(41)	2014	USA	4 th year	Cardiology	291	Standardized patient	Written
Swamy(42)	2013	UK	1 st year	Medicine	24	SimMan	Written
McCoy(43)	2011	Canada	4 th year	Medicine	28	SimMan	Checklist
Kern(44)	2011	USA	3 rd year	Cardiology	124	Harvey simulator	OSCE

Table 1: Table summary of included publication study characteristics

Results

Study Characteristics: Figure One shows the PRISMA flowchart of search and selection process. Table one summarizes the nineteen included studies comprising 2740 students ranging from first to final year medical students. Studies from eleven countries were included with three focusing on first (n=2) or second year (n=1) students and the remainder concerning those in later years. There were nine randomised control trials (26,27,29,34,35,37,40,41,43), six prospective cohort studies (28,31–33,36,39), two crossover studies (38,42), one retrospective analysis (30), and one case-control study (44). The median number of patients per study was 79 (20-615 patients). Due to heterogeneity of study type including the variety of tools used for assessing multiple skills, meta-analysis was prohibited.

Specialities: Medical scenarios were the most common topics for simulation with fourteen groups (28,30,41–44,32–34,36–40) conducting simulation training based around common medical pathologies. Of these, six groups simulated cardiac scenarios with four of these assessing auscultation skills (20,25,31,36) and two simulating acute cardiac presentation scenarios (36,41). Surgical topics were simulated in two groups (26,31) while one group (35) used both medical and surgical scenarios for their simulation sessions.

Methods of Simulation: Various different methods of patient simulation were used with the majority (n=12) using artificial patient

models in scenarios to mimic the medical setting lasting a median of 17.5 minutes (range 15-30 mins) (28,29,43,44,30,32–34,37–39,42). SimMan™ (Laerdal) was the most commonly used simulator (n=6) (30,32,37,38,42,43). Harvey (n=2)(39,44), METI (n=1)(34) and Kyota kagaku (n=1) along with a heart-sound simulator (n=1) were the other artificial simulators used. SimMan is a wireless, life-sized advanced patient simulator, that can display physiological changes that the 'patient' undergoes in real-time on a monitor, under the control of the simulation facilitator (45). In all six groups who used SimMan, general medical scenarios involved students taking a history and performing a physical examination (30,32,37,38,42,43). In these, the SimMan displayed abnormal cardiovascular and respiratory signs based on the simulated scenario. In two studies (32,43), students were given a short orientation (15-30 minute) to clinical practice using a SimMan.

Standardized patients were used in seven studies (26,27,31,35,36,40,41), three of which (27,31,35) focussed on assisting clinical examination practice. Standardized patients methods ranged from actors (26,30,41) or academic staff mimicking learned symptoms to expert patients and focused on standardised patient histories (40) and ward rounds (26) with supplementary material such as drugs charts, patients' vital parameters and end of bed notes being made available to students in all studies. The median time for simulation with standardized patients was 82.5 minutes (15-180 minutes). Giblett et al (31) cumulatively spent 21 hours over the course of one semester simulating encounters with standardized patients. Giblett (31) and

Nassif (27) used standardized patients in conjunction with breast models to educate students on breast examination.

Methods of Assessment: Various methods of assessments were used to evaluate the performance effect of simulation training.

Written assessment was the most common (n=10)(28,31,42,33,34,36–41), predominantly comprising of an MCQ examination. Four groups (26,30,32,43) used a checklist assessment, which was either completed during or after the simulation scenario. Three groups (27,35,44) assessed their students using OSCE examinations alone. One group (29) used a combination of OSCE and written assessment.

Effect on Performance: All groups reported a performance benefit to students associated with simulation training. Simulation training was shown to have a positive effect when used across a broad range of medical and surgical specialities, in acute and non-acute scenarios.

Auscultation Simulation: Swamy (42) reported improved results on a knowledge based questionnaire following clinical chest examination training with SimMan™ compared to examining their student colleagues, later confirming these results in a further larger cohort (30). There was also improvement noted in the simulation group's self-perceived confidence. In a cross-over trial, at the mid-test point, the group who performed examinations on mannequin performed significantly higher on a knowledge assessment than those who performed peer examinations. Perlini (39) also

demonstrated the impact simulation training has on retention of knowledge, focusing on cardiac auscultation. After three years, a subgroup of his students were reassessed. Without any further exposure to the Harvey simulation over that timeframe, retention of the acquired capability was maintained. Pereira (33) also showed a positive effect of simulation on cardiac auscultation. When comparing pre and post test scores, there was a 16% performance improvement when simulation training is added to the existing curriculum. Equally, Bernardi (28) demonstrated an improvement in cardiac auscultation skills when practiced on a simulator. There was however no improvement in respiratory auscultation between the simulation and control group. Kern et al (44) implemented a cardiac auscultation programme following previous reports of deficiencies in physician's clinical examination skills (46,47). In this, students who received simulation training (using the Harvey simulator) along with the standard curriculum were compared to students who received the standard curriculum alone. To ensure little variation in teaching between the groups, the same three faculty teachers facilitated teaching in the same facility for all students. Students were assessed in a multi-station OSCE five weeks following their respective learning. Students who received simulation training performed significantly better in the respective assessed cardiac skills than the control group. Again, there was no difference in pulmonary examination skills.

Breast Examination Simulation: Nassif (27) used a hybrid simulation model of breast examination where a standardized patient wearing a silicone breast simulator jacket was examined.

This group was compared to students who examined a standardized tabletop breast model. Following this intervention, both groups were assessed in an OSCE. Students who participated in hybrid simulation training were significantly better at lesion reporting, identification of malignant features and accurate location identification compared to the group who received traditional teaching. Angarita (29) also evaluated the effect of simulation training on students' clinical breast examinations. Students were taught using a simulation and multimedia-based curriculum, which was compared to the traditional didactic lecture and clinic based teaching. Both groups were assessed using written and OSCE assessments. The group who completed the simulation based training were significantly better at all aspects of the breast exam (including inspection, position, palpation, pressure, axillary exam and providing justifications for performing a breast exam). Additionally students who underwent simulation training were significantly more confident than their peers who were taught with traditional methods. Alluri (34) used simulation to teach pre-clinical medical students, and assessed the effect in a randomised, controlled cross-over study finding that both simulation and didactic lectures improved student knowledge when assessed on an MCQ. When assessing delayed test scores, thus evaluating retention of knowledge, students who completed simulation training demonstrated improvement while those who were taught didactically did not.

Simulation of Emergency Scenarios: Vattanavanit (30) assessed sixth year medical students knowledge and confidence in septic

shock resuscitation. Students who received simulation training improved significantly in knowledge and resuscitation skills, whilst also improving their confidence at assessing patients in septic shock (Post-simulation 68.1% $\pm$ 12.2% vs pre-simulation 5.64 $\pm$ 13.1, $p<0.001$). Solymos (37) looked at the area of critical medicine, comparing simulation based teaching to traditional didactic teaching. Final year students were evaluated using a multiple choice questionnaire - at baseline, post-teaching and a two week follow up. Although there was a significant improvement following simulation compared to the didactic lecture group, baseline scores were higher in the didactic lecture group. McCoy (43) performed a cross-over study, particularly focusing on assessing critically unwell patients with myocardial infarction or anaphylaxis. Simulation training was compared to traditional didactic lectures. Students' performance was evaluated in real-time during the simulation. 96% of students performed better when trained with simulation. Overall, simulation training resulted in a 22% absolute increase in scores (95% CI 18-26%). History taking (27% absolute increase in score), physical examinations (26%) and patient management (16%) components of the assessment were higher in the simulation group compared to the lecture group. DeWaay (41) investigated fourth year medical student performance in students who received simulation training compared to a control group (who received no intervention) and to a group who received didactic lectures. Simulation significantly improved overall performance. The percentage of correct answers in the simulation group was 53.5 $\pm$ 8.9% compared to 47.9 $\pm$ 9% in the didactic teaching group and 47.9 $\pm$ 9.8% in the control group ($p<0.001$).

Williams (36) also simulated cardiac emergencies, but this time using real patients with a cardiac history taking the simulated patient role. Students were assessed using knowledge based short answer questions. Mean scores increased (25/43 to 34/43) after the intervention. A sustained effect was seen at one week post intervention, with scores of 35/43. Students self-perceived confidence was also improved post intervention. Sanchez-Ledesma (32) focused on the use of simulation training in the management of neurological emergencies. The simulation instructor evaluated students' during the simulation session. Once again, statistically significant difference were found between pre and post-test groups with results improving further following repeated simulation sessions.

Simulation in Non-emergent Scenarios: Simulation training was not limited to acute medical presentations. Fisher (40) developed and delivered a simulation programme dealing with common geriatric issues, including delirium, falls and elder abuse.

Author	Assessment method	Non-simulation group scores	Simulation group scores	Effect on performance	Self-perceived confidence	Knowledge retention
Grunewald(26)	Checklist	n = 11 Difference in pre and post intervention scores -1.2 +/-11.1	n = 16 Difference in pre and post intervention scores 6.9+/-10.3	Difference of 8 points on SWAT assessment between groups p = 0.061	Confidence at conducting surgical ward round following intervention: Control group: 0.7+/-0.4 (p = 0.088) Intervention group: 4.8+/-0.4 (p<0.001)	
Nassif(27)	OSCE	n = 26 CBE completeness score: 16.83 Visual inspection score: 4.83 Palpation score: 11.67 Lesion identification grade: 1 Reporting a lesion: 0.5 Malignant features of the lesion: 0.00 Accurate location of the lesion: 0.33 Falsely reporting a lesion: 0.00 Detecting lymph nodes: 1.0	n = 56 CBE completeness score: 16.58 Visual inspection score: 5 Palpation score: 11.5 Lesion identification grade: 3 Reporting a lesion: 1 Malignant features of the lesion: 0.67 Accurate location of the lesion: 1.33 Falsely reporting a lesion: 0.00 Detecting lymph nodes: 1.0 Falsely reporting lymph nodes: 0.00	Simulation group were significantly better at lesion identification, identification of malignant features, and accurate location identification (p < 0.001)	11.11% of simulation group feel more prepared for their upcoming examination compared to 3.85% of the control group (p=0.418)	

		Falsely reporting lymph nodes: 0.00				
Bernardi(28)	Written	Cardiac auscultation Aortic stenosis: 77.6% Mitral regurgitation: 71.4% Split heart sounds: 79.6% Respiratory auscultation Wheeze: 91.7% Fine crackles: 58.3% Coarse crackles: 66.7%	Cardiac auscultation Aortic stenosis: 84.5% Mitral regurgitation: 89.7% Split heart sounds: 89.7% Respiratory auscultation Wheeze: 91.4% Fine crackles: 63% Coarse crackles: 70.7%	Training with a patient simulator improved students' cardiac auscultation skills, in particular auscultating for aortic stenosis ($p = 0.36$), mitral regurgitation ($p = 0.02$) and split heart sounds ($p = 0.15$) Training with a patient simulator did not significantly improve students' lung auscultation skills.		Performances of the same experimental students between year three and year five, there were no changes in the heart auscultation results, whereas they significantly improved over time in lung auscultation.
Angarita(29)	OSCE and written assessment	n = 58 Percentage of students who adequately completed all 13 items: 28.2%	n = 62 Percentage of students who adequately completed all 13 items: 88.2%	Students in simulation group adequately completed all 13 items was significantly higher than the control group ($p < 0.00001$)	Students who underwent simulation training were "very confident" more frequently than traditionally trained students (97.1% vs 9.6%, $p = 0.00001$)	
Vattanavanit(30)	Checklist		Pre & post-test analysis		Student confidence in the	

			Mean test score significantly improved following simulation training (66.83% +/-19.7% vs 47.59% +/-19.7%, p<0.001)		management of septic shock significantly better following simulation training (68.10% +/-12.2% vs 51.64 +/-13.1%, p<0.001).	
Giblett(31)	Written	n = 50 Median score = 17 (43%) Range 5-29 (13-74%)	n = 39 Median score = 29 (74%) Range 16-35 (41-90%)	p < 0.001	Confidence improvement in all domains of evaluated (including acute abdomen, assessing breast lumps, assessing peripheral vascular disease. (p < 0.001).	
Sanchez-Ledesma(32)	Checklist		Pre-test scores 2014: 5 2015: 10 Post-test scores 2014: 12 2015: 28	Statistically significant difference found between pre-test and post-test groups (p<0.05)		
Pereira(33)	Written	Pre-test scores Normal: 40.17% Pathology unspecified: 14.02% Mitral regurgitation: 7.18%	Post test scores Normal: 56.92% Pathology unspecified: 31.28% Mitral regurgitation: 10.26% Aortic regurgitation:	Significant improvement (+16%) in the differentiation between normal and pathological cases.		

		Aortic regurgitation: 5.47% Aortic stenosis: 4.1% Pulmonic stenosis: 6.32% VSD: 5.47%	7.52% Aortic stenosis: 4.96% Pulmonic stenosis: 4.27% VSD: 2.05%			
Alluri(34)	Written	n = 20 Pre-intervention: 41.17+/-20.42% Post-test: 66.67+/-19.49% Delayed post-test: 67.71+/-22.33%	n = 20 Pre-intervention: 40.00+/-21.89% Post-test: 55.00+/-18.02% Delayed post-test: 79.17+/-18.76%	Average individual student improvement from post-test to delayed post-test significantly improved in simulation group compared to lecture (p=0.036)		When assessing delayed test scores, thus evaluating retention of knowledge, students who completed simulation training demonstrated improvement, those who were taught didactically did not.
Zhang(35)	OSCE	2013: n = 36 69.91+/-1.24 2014: n = 27 73.58+/-1.34	2013: n=73 80.95 +/- 0.61 2014: n=67 86.12+/- 0.56	p = 0.0114 p = 0.006		
Williams(36)	Written		n = 24 Pre-simulation:25/43 Immediately post-simulation:34/43 >1 week post simulation:35/43 p < 0.001	Improvement in all domains assessed, including management of MI, LV failure, fast AF, medical emergencies and starting as an FY1 doctor. p < 0.001		
Solymos(37)	Written	Baseline MCQ score: 17+/-3	Baseline MCQ score: 14.3+/-2.2	Significant difference in the improvement from baseline and post		2-week follow up MCQ were lower in both groups than

		Post didactic lecture MCQ score: 21.5+/-3.1	Post-simulation MCQ score: 21.1+/-1.8	teaching MCQ in the simulation group compared to lecture 6.8 (21.1 - 14.3) vs. 4.5 (21.5 - 17), p = 0.0387		post teaching results. Smaller margin in the simulation group 1.3 (19.8-21.1) vs. 3.6 (17.9 - 21.5), but not statistically significant (p = 0.167).
Swamy(38)	Written	Pre-test score: 6.5 Mid-test score: 7.2	Pre-test score: 6.7 Mid-test score: 9.3	The group who simulated examinations on a mannikin performed significantly better than the group who performed peer examinations in the mid-test.	Confidence in examining patients improved significantly in the simulation group compared to the control group.	
Perlini(39)	Written	Pre-simulation training percentage of correct diagnoses: 11%	Post-simulation training percentage of correct diagnoses: 72%	Improved capability of correctly recognising cardiac diagnoses (p <0.001)		After three years without any further simulation training, retention remained high (68.4%, p<0.001)
Fisher (40)	Written	Elder abuse management: 20% Falls management: 25% Delirium management: 20%	Elder abuse management: 36% Falls management: 40% Delirium management: 52%	p = 0.002 p = 0.001 p < 0.001	>95% of students felt better equipped to deal with geriatric scenarios	
DeWaay (41)	Written	n = 80 Overall performance score: 47.9+/- 9.8%	n = 147 Overall performance score: 53.5 +/- 8.9%	Overall performance was significantly better with simulation training versus the control group (p <0.001)		

Swamy (42)	Written	n = 12 Mean mid-test score: 5.66	n = 12 Mean mid-test score: 6.75	Mid-test knowledge scores increased significantly between both groups ($p < 0.001$), and the group who performed examinations on SimMan™ performed better than the control group No significant difference in post-test scores after crossing over, which demonstrates equal knowledge improvement after performing examinations on SimMan™	Both groups felt more confident differentiating between normal and abnormal signs after practicing on SimMan™	
McCoy(43)	Checklist	Mean overall score: 71%	Mean overall score: 93%	Significant improvement in student performance for those trained with simulation compared with those trained with traditional didactic lecture ($p < 0.0001$)		
Kern(44)	OSCE	Evaluation of point of maximal impulse: 64% Anterior auscultation of four cardiac areas: 71%	Evaluation of point of maximal impulse: 74% Anterior auscultation of four cardiac areas: 85% Left lateral cardiac auscultation: 52%	Students who trained using cardiopulmonary simulator (SimSPLE) performed significantly better than the controls in all five cardiac exam skills: (a) evaluation of point of maximal impulse ($p = 0.045$), (b) anterior		

		Left lateral cardiac auscultation: 41%	Inspection for lower extremity edema: 71%	auscultation of four cardiac areas (p = 0.003), (c) left lateral cardiac auscultation (p = 0.037), and inspection for (d) lower extremity edema (p ≤ 0.001), and (e) jugular venous distention (p = 0.004). No statistically significant difference in pulmonary examination skills between the groups.		
		Inspection for lower extremity edema: 52%	Inspection for jugular venous Distention: 56%			
		Inspection for jugular venous distention: 41%	Respiratory Chest expansion: 83%			
			Percussion: 82%			
			Auscultation 97%			
		Respiratory Chest expansion: 89%				
		Percussion: 89%				
		Auscultation:99%				

Table 2: Tabulated summary of intervention with method of assessment along with outcome from each included study.

Mannequins and simulated patients were both incorporated into the scenarios. Students were assessed pre, post and one month post-simulation. Test scores were compared to those who underwent traditional didactic teaching with post simulation test scores being better than pre-simulation test scores. For all scenarios, there was a statistically significant difference between the simulation and control group ($p < 0.005$). Students in Zhang et al's (35) study were pre-selected into a simulation and didactic lecture group by virtue of variants in facility across their clinical sites. Students simulated both medical and surgical scenarios. Across two year groups, the mean score for 16 OSCE stations was significantly better in those who had undergone simulation training. The mean score in 2013 for the simulation was 80.95 ± 0.61 versus 69.91 ± 1.24 for the didactic lecture group ($p = 0.0114$), and 86.12 ± 0.56 versus 73.58 ± 1.34 in 2014 ($p = 0.006$).

Simulation in Surgical Education: Two studies specifically examined simulation in surgery. Giblett (31) randomised two groups of medical students in their first year of clinical attachments. In the first semester one group received traditional didactic lecture based education while the other group received simulation training, broadly covering the surgical curriculum. Using independent t-test analysis, a significant performance benefit in a knowledge based assessment was seen amongst the group who received simulation training ($p < 0.001$). Additionally, the simulation group had higher self-reported confidence and understanding of surgical principles. These students also showed substantially improved confidence in acute surgical assessments, particularly in abdominal ($p < 0.001$),

vascular ($p < 0.001$) and breast examinations ($p < 0.001$).

Grunewald (26) used an objective surgical ward round assessment tool to evaluate students' performance. The control group did not receive simulation training. Competence in the intervention group improved from 62.6 to 69.6 points ($p = 0.0169$). In contrast, there was no improvement in the control group (pre: 62.6 vs post 69.6 points ($p = 0.72$)).

Discussion

SBME is of increasing interest for medical undergraduate programmes. This has been especially the case recently with the COVID-19 pandemic pressurising clinical placements with added emphasis on graduating competent doctors in a timely fashion. The primary outcome of this study was to examine for evidence of a performance effect of simulation training on medical student competence through a synthesis of the published literature including summarising the methods used to provide simulation training and the tools used to assess efficacy. As evidenced by this review, simulation training in tandem with the traditional curriculum has been shown to generally improve medical students' performance and knowledge retention alongside confidence over didactic teaching and learning through observation. These benefits can be seen across a number of required skills including core components such as history taking and physical examination (including essential, intimate physical examinations, such as a breast examination which can be otherwise challenging for student to learn) and across various specialities in both emergency and elective general medical and surgical situations. Furthermore, students who experienced simulation training have been found to be more satisfied with their teaching (31). These findings shouldn't perhaps be surprising as students learn best when they are actively involved (48). While medical training has traditionally utilised the adage "see one, do one, teach one", simulation-based education provides the opportunity to 'do one' repeatedly, safely and under supervision.

SBME requires some investment in terms of teaching personnel, equipment and space meaning objective proof of its usefulness is very important to justify the expenditure. Additionally nuance exists. Hamstra (49) detailed some of the key components to effectively run simulation scenarios. Learner engagement and a suspension of disbelief enhance the learning environment for medical students. By placing them in scenarios and an environment that mimics real life, a superior educational experience can be obtained. Also some studies have suggested that improved student confidence may be a negative finding (50) indicating that further work needs to be done in this specific area. Furthermore, while simulation training has been shown to improve cardiac auscultation skills, it seems to have no effect on respiratory auscultation skills (28,33,39,44). Bernardi (28) hypothesised that this difference is related to the different teaching methods employed for each and that using graphic representation of the lung sounds heard may offset this. Further, additional 'real-world' validity can be added when constructing the scenarios (for example, Williams simulated cardiac emergencies with real patients who had recovered following a previous emergency cardiac presentation including intermittent interruption of the students to simulate a real life "on call scenario" as doctors are often required to multi-task, manage their time efficiently and remain calm under pressure (28)).

As much as simulation training facilitates the standardization of medical education, in allowing all students access similar clinical experiences, it would seem also to provide a useful means of

contributing to student summative assessment in a manner that is reproducible and objective. To date, written examinations in conjunction with observed clinical examination and skills assessment have traditionally been major components of medical students' assessment (51,52). Recently, two studies have indicated that a simulation-based assessment may be appropriate for assessing clinical competence (53,54). In addition, the healthcare educator's primary function is to produce competent and proficient doctors and the physical and mental wellbeing of our students is increasingly recognised as essential given the increasing rates of burnout and mental health issues being reported amongst medical students (55,56). A consensus statement on medical student wellbeing from the Australia and New Zealand (57) recommends "curricula that promote peer support and progressive levels of challenge to students and to employ strategies to promote positive outcomes from stress and to help others in need". These strategies are already components of SBME and further aspects such as resilience training can be readily incorporated. Another area to examine further relates to whether confidence improvement by simulation can help ease the transition from medical student to junior doctor.

In conclusion, this systematic review provides evidence that SBME can improve medical students' performance in a variety of domains and specialities while also identifying areas in need of future address. Alongside performance benefits in history taking and physical examination, there is evidence to show that SBME leads to greater knowledge retention and confidence. Therefore this review validates the use of SBME as an adjunct to the traditional

didactic lecture-based curriculum. For the purposes of ensuring optimal education of medical students, further studies could investigate the best methodologies for SBME by comparison and whether simulation is best employed as an adjunct or replacement to the traditional lecture based curriculum. It is important also to examine cost-effectiveness especially the role of lower cost set-ups versus more expensive systems. Ultimately too it is important to correlate the performance effect of simulation training directly to competence. By building up such an evidence-base we will best evolve the curriculum for the purpose of producing better doctors, and most importantly, better patient outcomes.

Chapter 3 – Methodology / Set up

After performing our systematic review, and investigating other successful implementations of simulation programmes, we initiated the process of actualizing our own simulation space. The final two years of UCD's medical programme are predominantly spent on-site in the Mater Misericordiae University Hospital (MMUH) or St Vincent's University Hospital (SVUH), along with a number of other clinical sites across the greater Dublin area. Our goal was to create a simulation facility on-site at the MMUH. In doing this, our students would have the ability to hone their skills in simulated scenarios, and then employ these skills to deal with real-life patients, often on the same day. Students based at SVUH would also have access to our simulation space.

Facilities

UCD has access to the decommissioned operating theatres at MMUH. Decommissioned eight years previously, these theatres are still used regularly for post-graduate surgical education and maintain an authentic clinical feel. This provided our students with a real-life surgical environment to learn, and also foster their interest in surgical training. One theatre was used to simulate the operative experience, while another was used as an assessment room (emergency department or ward) to simulate common surgical presentations. Two other areas (previously anaesthetic rooms) contained laparoscopic skills training boxes and surgical skills simulation equipment.

Factors in Implementing a Simulation Programme

A number of factors must be considered when setting up a simulation space. Firstly as mentioned, the space must provide a realistic environment for our students. To become fully engaged in the simulated scenario, students must commit wholly to the situation and imagine themselves in a real life scenario.

Portability and ease of movement is important with limited space.

As our simulation space was located at our clinical site, optimisation of available space was paramount. Thus, we required simulation equipment with minimal adjuncts to reduce clutter and also ease of mobility.

The key factor that must be considered when implementing a simulation programme is the availability of personnel. There are two full time surgical tutors in MMUH (myself and one other). We were responsible for the day to day running of the simulation space. There was no technical support available on site. All on site troubleshooting would be performed by the surgical tutors.

Simulation equipment with minimal complexity and maximal efficiency was required.

Along with an education technologist and audio-visual specialist we investigated the optimal set up for our simulation space. Room dimensions, audio-visual requirements and plans were discussed. From these discussions, it was decided that a mobile audio-visual system would serve the highest purpose and provide flexibility in our early developments.

Appropriate equipment was researched and priced. All funding was supplied by the Surgical Department at UCD. We considered using a set up as described by Everett et al (58). Their system consists of multiple, mobile, compact cameras fixed in position with attached external microphones, all connected to a control laptop. However we felt this set up required too many components, and that a single mobile unit would provide the ideal platform for our needs. After extensive research, a smots™ camera system was acquired. It is a cost-effective and effectively “plug and play” solution. Smots™ “is a system of hardware and software that can easily and unobtrusively record video, audio and the vital signs readings of any medical procedure or simulation” (59). It provides two-way communication between the student and the facilitator. A multidirectional camera allows visualisation of the participants and simulated patient throughout the session. This can be controlled by the simulation facilitator. Audio-visual recording is included, which allows easy and prompt debrief following simulation. Meetings with company experts ensured simulation tutors were able to optimally use this system. Prior to undergoing formal teaching, a trial was undertaken with four randomly selected students. Feedback at this time informed us of the appropriate methods to ensure our initial attempts at simulation were fluent. Specific feedback advised us to change the position of the camera system within the room and also to enhance the sound quality provided by the smots™ system. An issue that arose in troubleshooting was the difficulty students had in communicating with both the simulated patient and the simulation facilitator via the single smots™ machine. To mitigate this, tutors spoke clearly and succinctly when communicating via the smots™

machine. This however was only a temporary solution. A second smots™ machine has since been acquired and should allow easy distinction between simulated patient and facilitator during simulation sessions. Additionally, it is envisaged that the portable smots™ machine can be moved throughout our clinical site, so that a variety of simulated and real-life clinical scenarios can be experienced by our students. For example, the smots™ system could be used in the operating theatre to provide a real-time audio-visual learning experience for our students.

Simulated patients (mannequins) and surgical equipment (urinary catheters, intravenous lines, nasogastric tubes, thromboembolic deterrent stockings, suture material and surgical instruments) were available to use.

Attached images (Figures 3-6) detail our clinical assessment room



Figure 3: Decommissioned operating theatre, which is now a simulation space



Figure 4: Simulated operating theatre



Figure 5: Surgical skills simulation facility



Figure 6: Laparoscopic skills simulation facility

Data Protection

The smots™ system has the capability to record simulation sessions. We did not record our students. All feedback was provided in real-time. However, we are aware that other simulation programmes have utilised post simulation debriefing, with video analyses of performance (60). This is something we may seek to implement in the near future, which could be done easily given we have the technical capabilities. One limiting factor is the data protection rights of our students. While most students are eager to receive analysis, it is important to note that they are a vulnerable group and their data protection rights must be rigorously protected.

A number of potential data protection issues were discussed with the university and hospital data protection offices. Firstly, we considered providing a consent form for students to sign prior to participating. However, for a valid consent students must be able to freely opt out, and if they were to do so, we would have to provide an alternative educational opportunity for them. This could be facilitated for our simulation sessions, but if ever required to use or simulation system for an examination, we could not provide an alternative.

After studying the university guidelines, audio-visual recording of simulation sessions belongs to the category of public interest/task (61). Audio-visual recording of simulation sessions to provide a debrief, which is done in our students' best interest allows us to process their data in the exercise of official authority. To ensure students are informed of this, a standard of practice (Fig 7) and

privacy notice (Fig 8) were prepared This should also be included in future module descriptors, so that students can expect simulation training with a potential for audio-visual recording to become a standard practice in the module.

All data stored on the smots™ system is secured, and password protected. Only the simulation tutors and module coordinator have access to the system.

Figure 7: Simulation data protection standard of practice



UCD Centre for Precision Surgery
Mater Misericordiae University Hospital



SOP:
Number:
Version:

SOP Title: Data protection guidelines for video recording of simulated patient encounters

	Name	Title	Date
Author	Dr Niall McInerney	Special Lecturer/Clinic Tutor in Surgery	
Authoriser	Prof Ronan Cahill	Professor of Surgery	

Effective Date	

Purpose: to outline data protection guidelines when recording medical students for educational purposes.

Specific Procedure

Students are recorded visually and audibly when assessing simulated patients (mannequin).

Data will be obtained and processed on the basis of a public task.

A privacy notice with all relevant information will be provided to students.

It will be the responsibility of the tutor to inform the students that their data may be kept for education and research processes.

Verbal information in relation to data usage and storage will be provided by the tutor prior to commencing recording.

All data will be archived securely on an encrypted PC, which will be accessed by authorised personnel only.

This data may be accessed to educate other medical students and may be used for research purposes.

Data will be stored for a maximum time of seven days.

Change History

SOP no.	Effective date	Significant changes	Previous SOP no.

Figure 8: Privacy notice



UCD Centre for Precision Surgery
Mater Misericordiae University Hospital



Who are we?

This privacy notice is for University College Dublin, Belfield, Dublin 4, in particular for the School of Medicine, based at the Mater Misericordiae University Hospital, Eccles St, Dublin 7. You can contact us at niall.mcinerney@ucd.ie.

The University fully respects your right to privacy and actively seeks to preserve the privacy rights of those who share information with the University. Any personal information which you volunteer to the University will be treated in accordance with Irish and European Data Protection legislation.

Why and how we collect and process the information and for how long will it be kept?

We collect your data for the purpose of your education on the bases of public interest. We will collect the following types of personal data: audiovisual recordings. We will keep your data for seven days.

Who has access to the information and who we share it with?

The personal data collected from you will be accessed by authorized academic staff in UCD/Mater Misericordiae University Hospital. There will be no external access to your data. The University will never share your data with any third parties.

What are your rights?

- Right of access
- Right to rectification
- Right to restrict processing

If you have any concerns about your rights as participants/students, you can contact the UCD DPO by email gdp@ucd.ie

If you are not satisfied by UCD's response or believe we are not processing your personal data in accordance with the law, you can complain to the Irish Data Protection Commission. For more detail see: <https://dataprotection.ie/>

Simulation Sessions

Common surgical scenarios, using current best medical practice evidence were formulated (NICE, UptoDate) (62,63). The focus of the Surgery A module is on the skills of history taking and clinical examination. As such, in line with the current curriculum a number of acute and chronic presentations were prepared. All topics would also be covered in a series of didactic lectures throughout the semester. The attached figure (Fig 9) details these scenarios. The scenario used at each simulation session was selected at random by the tutor.

1.	Acute appendicitis
2.	Acute cholecystitis
3.	Acute diverticulitis
4.	Benign prostatic hyperplasia
5.	Biliary colic
6.	Bowel obstruction
7.	Colorectal cancer
8.	Dysphagia
9.	Haematuria
10	Intermittent claudication
11	Nephrolithiasis
12	Pancreatitis

Figure 9: Simulated scenarios

Simulation sessions were conducted by two surgical tutors, who had no prior experience conducting simulation training. As such, the initial phases were an iterative process until the optimal simulation experience could be obtained. To our knowledge, no previous work has been completed detailing the ideal number of students participating in a simulation scenario. We did not conduct formal research in this area, but in our experience, two students working together per session was most productive. This fostered discussion between the students and ensured that the workload was as close to equal as possible. With higher numbers in a session, it would often be the case that some participants could be reluctant to contribute. One student per simulation was also trialled and was effective, predominantly when a student with a higher capability participated. However, some students struggled alone, and a much higher level of tutor prompting was required. It is important to note, that as clinicians we rarely work in isolation. Opinions and advice are often sought from other colleagues and specialities. In this way, simulation can add to the holistic education of our future doctors. Using their clinical knowledge, whilst interacting with a simulated patient, a simulation facilitator and a colleague mimics the complex interactions that occur every day whilst caring for our patients.

Format of Simulation Sessions

While two students were participating in simulation scenarios, the remainder of the group (typically ten students per group) simulated surgical skills. Laparoscopic skills boxes, suture and knot tying stations were used as “rest stations”. Students were supervised by

a senior surgical lecturer, and practiced basic laparoscopic skills including peg transfer and laparoscopic dissection. All exercises were derived from previous laparoscopic skills training programmes for surgical trainees (64,65). Students also acquired basic surgical skill such as suturing and hand tying. These were evaluated at a later stage of the surgical module, and formed part of the final module assessment.

Over the course of a twelve week module 221 students participated in biweekly simulation sessions, with each session lasting 250 minutes. A ten minute break was given after 120 minutes. Attendance was compulsory and recorded. Students from both MMUH and SVUH participated in simulation training at MMUH. Three surgical tutors from both MMUH and SVUH facilitated simulation sessions over the course of the module. Each simulation session consisted of ten students who were randomly selected into two groups. Figure 10 documents the timetable.

Time	Group 1	Group 2
09:00-09:10	Introduction	Introduction
09:10-10:00	Simulated ward round	Suturing & Knot tying
10:00-11:00	Simulated scenarios	Suturing & Knot tying
11:00-11:10	Break	Break
11:10-12:00	Suturing & Knot tying	Simulated ward round
12:00-13:00	Suturing & Knot tying	Simulated scenarios
13:00-13:10	Debrief	Debrief

Figure 10: Timetable

All students completed a pre-simulation survey prior to commencing. This is discussed further in chapter 6. The introduction discussed the learning goals for the simulation session. The primary goal was to ensure students were more competent when assessing patients in clinical scenarios. Secondary goals were that students were more comfortable and confidence when encountering real patients. We also hoped that students enjoyed the experience of the simulation session and it fostered an interest in pursuing a career in surgery. We did not record this, but verbal feedback following each session was positive.

Session Components

Group one started by participating in a simulated surgical ward. Typically two patients were assessed – one having undergone a major operation (e.g. laparoscopic or open bowel resection) and the other being a day case (e.g. laparoscopic cholecystectomy, appendicectomy, inguinal hernia). Primarily students assessed the post-operative status of the patient, including pain, nutritional status, urinary and bowel habits and mobility. Objective assessments such as outputs (nasogastric tubes, urinary catheters, stomas and drains) and blood results were analysed. A thorough drug chart review was performed, focusing on post-operative analgesia and venous-thromboembolic disease prophylaxis. Analgesia was prescribed according to the WHO analgesia ladder (66). Common general post-operative management and potential complications were discussed.

Following this, two students from group one simulated common emergency presentations. Concurrently the other students in the group participated in simulated laparoscopic skills training.

Students interchanged following completion of one simulated scenario. Potential scenarios are listed above in Fig 9.

As discussed previously, students were in a separate room to the tutor and communication occurred via smots™. All students were provided with the same information at the beginning of the scenario. They were given the patient's name, age, presenting complaint and vital signs. Additional information was provided as requested. Students then proceeded to take a history as they saw fit. Generally, minimal prompting was given, unless the students were struggling to progress. At any stage of the scenario students

could request blood results or radiological investigations. Students were encouraged to explore the patient's symptoms prior to receiving radiological results. A physical examination including a cardiorespiratory, abdominal examination and any other examination required were performed.

Once students had formed appropriate differential diagnoses, the tutor joined the students in the clinical room, thus ceasing communication via smots™. Post-simulation facilitator-guided debriefing took place which is discussed in further detail below (13,14,60). The immediate and long term management plans were discussed. Tutors discussed both positive and negative aspects of the students' performance.

Debriefing

From an extensive literature search prior to commencing our simulation programme it was clear that the debrief is one of, if not the most important components of simulation training (60).

Debriefing can broadly be split into two different types – post event or in-simulation debriefing. Evidence suggests that post event debriefing is the most effective method. In-simulation debriefing does have benefits, such as immediate feedback and novices can be guided efficiently when straying from the topic. We conducted simulation training with only facilitator who was located in a separate room, and we felt that post-event debriefing would be more efficient and lead to less disruptions. In-simulation debriefing has been shown to be more effective when conducting skill based training. Our tutors used informal in-simulation debriefing when students practiced laparoscopic skills.

Post-event debriefing was facilitator led but we did endeavour to empower our students so that they could contribute feedback to their peers. To do this tutors tried to create a non-judgmental environment, where students felt comfortable discussing their own performance and that of their peers. Tutors asked open ended questions and utilised silence and limited responses (thus avoiding a didactic tutorial). After asking a question, tutors were silent so that students could think critically and formulate their own response. Collaboration and discussion between students was encouraged. Students' answers were probed in an inquisitive and non-confrontational manner.

Educational Methods Employed

Tutors utilised the “one-minute preceptor” teaching method to encourage students to actively contribute to patient care (67).

This consists of five principles:

1. Get a commitment from the student
2. Probe for supporting evidence
3. Teach a brief, general principle
4. Reinforce what was done well
5. Correct errors

The one-minute preceptor method is traditionally used by busy clinical staff as a way to quickly educate students with minimal disruption to their clinical commitments. In our simulation sessions more time was allocated to education provision by our clinical tutors than would be provided on ward based tutorials. We still used the one-minute preceptor method, but allowed more time for each of the five components to be developed and explored.

Concluding Simulation Sessions

Students also provided feedback to the tutor at the conclusion of the debrief.

After debriefing, students in group one swapped between the laparoscopic skills training and simulated scenarios.

Concurrently, students in the second group were introduced to basic surgical skills. Initially students were taught the basic principles of wound healing. Students were shown common surgical instruments and the correct way to use them. Once students were comfortable with these concepts, they were taught how to suture. Following this they practiced one-handed knot ties. When basic competence was attained students progressed to horizontal and vertical mattress sutures.

After 120 minutes, both groups were given a ten minute break and then swapped over so that they completed the remaining stations.

At the conclusion of the simulation session, the entire group were debriefed. Students were encouraged to apply knowledge and experience gained in simulation training promptly with actual patients on our clinical site. Our simulation space is directly adjacent to our student hub (library and recreational area), and students were welcome to seek feedback or further simulate surgical skills if the simulation space was not in use, and academic staff were available to supervise.

Chapter 4 – Airflow Assessment

The COVID-19 pandemic has focused attention on the importance of social distancing, cough etiquette, and face mask wearing (68). During clinical examination, physicians and patients come close together. Body heat and movement also induce convection that influences local air currents and airspace particle behaviour (69). The first introduction to clinical medicine and physical examination is daunting for medical students. Although they have a broad theoretical knowledge of medical principles, this needs to be applied in the practical performance of an examination in a correct manner (70). The COVID-19 pandemic has added further complexity both owing to interruption of the usual preclinical preparation for learning in clinical settings and, in particular, by adding a direct potential hazard to close encounters that undermine confidence and induce a risk of infection (4). Using sensitive optical imaging, this study investigated the airflow dynamics inherent in clinical examination to illustrate the impact of masks and visors on both the subject being examined and the examiner during common clinical manoeuvres during physical examination.

Through brainstorming, clinical tutors and medical students together selected common clinical examination scenarios of greatest risk including those with forced expiratory effort (respiratory examination, deep abdominal examination, and hernia assessment) and where one party is directly in the breath line of the other (such as respiratory examination where the patient

breathes on the examiner, and neck examination where the examiner stands behind the patient). Examinations were planned both with and without protective face masks and visors worn by either one or both people. High-speed Schlieren imaging was used to illustrate airflow (both body heat convection and breath) by changes in optical density (71). Schlieren imaging shows how CO₂ is directly channelled between our patient and examiner (CO₂ is optically distinct from room air by its density and so is dynamically detectable by this assessment modality). Clinically, a specific thermographic camera (the FLIR GF 343, FLIR Systems Ltd, West Malling, UK) confirms this mechanism of CO₂ effluvium by its sensitive visualization of CO₂ gas via its specific near-infrared absorption characteristic. This imaging modality also allows imaging with two subjects spatially distinct by horizontal separation while still being within the imaging line of the parabolic mirrors. Therefore, clinical examination can be imaged without in-line exposure of each individual to the other's breath/cough trajectory. Participants were screened for any symptoms or signs of infection in line with local infection control protocols.

Clinical examination can be seen to have a substantial impact on local airspace dynamics (*Fig. 11*). Respiratory manoeuvres to elicit clinical signs invoke considerable turbulence owing to breath trajectory and velocity in the space between subject and examiner. Coughing during a hernia examination, especially with the patient reclined but not fully flat, channels a large volume of gas towards the examiner. Instruction and looking at the patient's face while examining risks breath impacting on the subject as does the

examiner standing above the patient to perform an examination. Airflow can be attenuated bidirectionally by wearing masks that redirect some airflow cranially (in the presence of a good fit around the chin), and both cleans and slows droplets in the breath moving through the material. During neck examination with the examiner behind a reclining patient, however, a surgical mask worn by the patient directs some breath towards the examiner. Visors allow substantial amounts of unfiltered breath to escape vertically up and down.

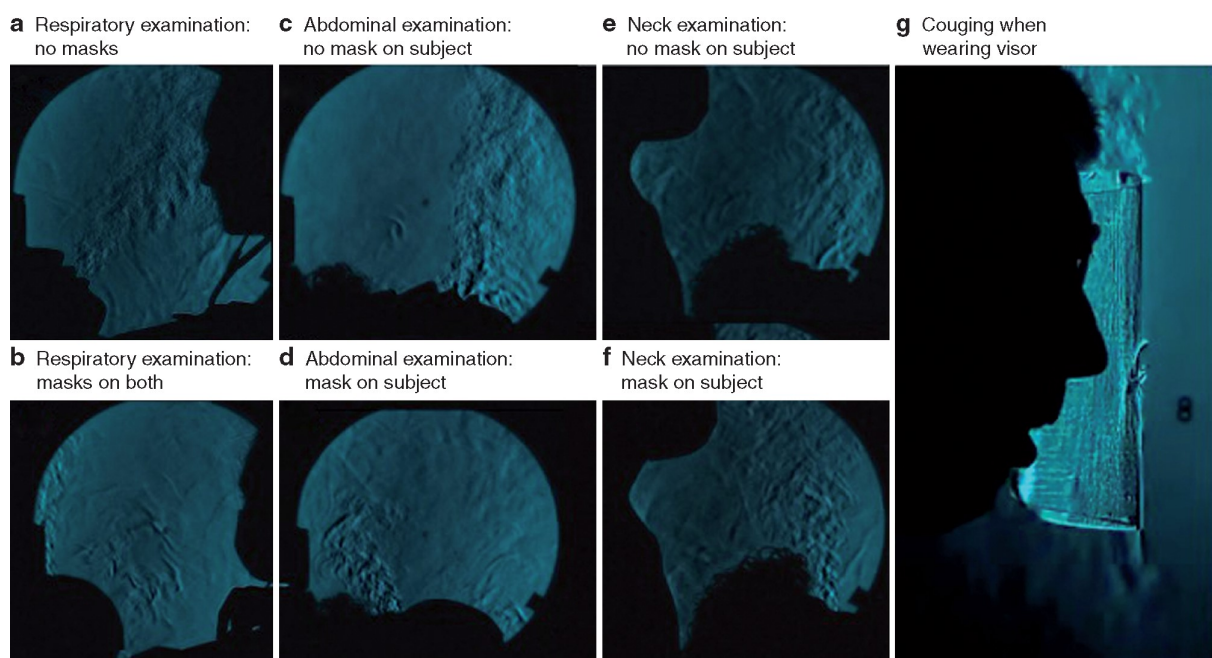


Fig. 11 Frames taken from high-speed Schlieren imaging during clinical examination scenarios Respiratory examination with deep breathing a without and b with masks on both examiner and subject; abdominal examination with coughing, for hernia examination, c without and d with a mask on the subject; neck examination with the examiner standing behind a subject e without and f with a mask. Note considerable redirection of unfiltered airflow towards the examiner as a result. g Airflow while coughing when wearing a visor. Participants were screened by hospital protocol regarding infectious potential

and with spatial distance during imaging by separated positioning while being visible within the imaging set-up

Clinical examinations confer the hazards of aerosols. By making explicit the physics of airflow during clinical examination, this information can help ensure a clear understanding of the rationale and mechanisms of using face masks during close patient–physician encounters for the reassurance of all. Although this study does not show droplet behaviour, it does fully illustrate the airstreams that carry such particles. Facemasks markedly mitigate the airflow disturbances, and understanding their function in this particular use allows optimal practice guidelines. Constant mindfulness is required while muscle memory builds through repeated practice, adding cognitive burden to new practitioners. Visors act quite differently, allowing unfiltered air to be breathed in and breath to escape out.

The Surgery A module commenced in September 2020. At this time, there was ongoing uncertainty about the risks of transmission and health implications of COVID-19. This work informed us of the potential aerosolization hazard associated with clinical examinations to our students and patients. We were acutely aware that to further their education it is essential that our student's experienced actual patients, and performed clinical examinations on patients with physical findings on examination. To reduce the risk of on-site viral transmission, our simulation programme acted as an adjunct to the existing curriculum of didactic lectures and

bedside tutorials. This work provided hard evidence of the bidirectional airflow dynamics associated with clinical examinations. Following this we encouraged our patients to also wear a face mask during clinical examinations where possible. The local hospital policy prior to completing this experimental work was for all staff to wear a face mask during patient encounters.

Chapter 5: Competence Assessment

Introduction

The provision of medical education whilst not universally standardised has maintained a core structure by tradition for many years, primarily based on Flexnerian principles (1,2,72). Students spend their initial years learning from a predominantly didactic curriculum. They then apply their theoretical knowledge in a clinical setting while also learning practical skills (73) in their final years. This structure has been employed successfully in our university and clinical partner sites for a long period of time. Due to the COVID-19 pandemic, and a national public health directive, all on-site clinical medical education at our health-care institutions ceased in March 2020, greatly disrupting student education. All face to face student-patient contact was halted to mitigate the risk of infection spread and instead students participated in on-line and self-directed learning, as at that time those on-site had completed sufficient clinical experiences to progress. While some on-site attendance was re-permitted by the time of our next student rotations in August 2020, hospital and public restrictions continued to greatly restrict clinical access for students. As experiential learning is a fundamental component of educating competent physicians (74–76), we moved to implement an on-site simulation programme to help the next tranche of clinical students who had missed out on all clinical learning opportunities due to the preceding ban.

Crucial to any education innovation, most especially those occurring near qualification, is assurance of benefit. Competence (defined as “the quality or state of having sufficient knowledge, judgment or skill” (77)) is a key requirement of new doctors as assessing acquisition of knowledge alone ignores the varied skills required by clinicians. The goal of competence-based medical education is to produce “health professionals who practice at a defined level of proficiency, in accord with local conditions to meet local needs” (78). After gaining key competencies, students can of course progress onto proficiency and ultimately even excel in their chosen field but the key qualification standard is competence.

Simple establishment of a simulation programme alone of course is not a guarantee of useful education or new programme efficacy. Nor indeed is self-reported student satisfaction or confidence. While important at any time, maintenance of medical student standards is especially critical at a time when such students face commencing work during a healthcare crisis. Therefore alongside implementation, here we detail the independently-assessed competency assessment of our rapidly established simulation programme. Importantly the competency assessment was performed on actual hospital in-patients. While student curricula need to be equitable for all, the disruption of the pandemic and the structure of our curriculum in terms of summative assessment provided a unique opportunity to implement and assess the new educational component while also allowing all students complete the simulation programme prior to sitting their formal in-module university examinations.

Methods

Study Participants: The focus of this study was to assess attitudes and usefulness of a new simulation programme for senior undergraduate students commencing their clinical learning in general medicine and surgery following two or three years of preclinical education for graduate entry and direct undergraduate medicine students respectively. Students at this stage are divided into groups balanced for gender, nationality, and educational experience (graduate entry vs. undergraduate entry) and assigned to clinical attachments in Surgery or Medicine in equal proportions for six weeks with groups then swapping over for the next six weeks. No academic parameters such as grade point average or prior examination results are taken into account for group assignment. Surgical attachments are each one week long with all students rotating through a different surgical specialty each week in groups of five or six, with those in Medicine also being attached to a clinical team each day. All students share a common lecture series in both Medicine and Surgery and all have completed general clinical skills training including history taking and examination prior to commencement of such attachments. Over all the Surgery and Medicine modules together account for 40 credits that contribute to the students graduating grade point average (GPA) and the attachments in both medicine and surgery takes place in five clinical locations, including two major university teaching hospitals (which host approximately half the class at any one time). Due to COVID-19 restrictions, this year, clinical accessibility was greatly reduced with only one student being

allowed on each ward round. Outpatient experience was also greatly curtailed over the duration of the study, with most patients being seen virtually rather than in-person without student attendance.

Simulation Facility and Programme: The university's Section of Surgery and Surgical Specialities has access to decommissioned operating theatres within one of our clinical sites. With support of the hospital CEO and university section leadership, a simulation space was enabled including the installation of some dedicated equipment. Basic mannikins were used as simulated patients with appropriate vital signs and medications listed in end-of-bed notes. Adjuncts (urinary catheters, nasogastric tubes and venous-thromboembolic disease prophylaxis) were available to the students as required. A Smots™ (Scotia Medical Observation and Training System, Scotia UK plc, Edinburgh, United Kingdom) system was sourced to provide a remote observation audio-visual system that allowed communication with students by a simulation facilitator from an adjacent room.

The simulation programme focussed on surgical history taking and synthesis as well as care plan formulation for an acutely presented patient in five clinical scenarios (see Table 3) as well elective ward rounding. Students were allotted to a four hour surgical tutor-led simulated patient session, run biweekly, in small groups respecting hospital and public health protocols. In session, students within each group were randomly paired and worked collaboratively to perform a history and examination, formulate a differential

diagnosis, order appropriate laboratory and radiological investigations and resuscitate/stabilise the patient. Following this, they composed a short and intermediate term management plan. When all students completed the simulation, the simulation facilitator debriefed the students on the positive and negative aspects of their performance.

Study Design: To assess the usefulness of these simulation sessions, we both assessed student attitudes by questionnaire to both clinical placements at this time (at term start) as well as to simulation (at term end) and designed a prospective study regarding competency assessments of students who had and who had not undergone simulation teaching.

Our study design is innovative because we used practicing clinicians to objectively evaluate medical students' performance with real life patients (as opposed to mannikins). Our students were split into balanced, but somewhat randomised groups by our administrative staff, which we felt was a sufficient method to split our students into different arms of the study, without us interfering with student timetables. Alternatively we could have attempted to truly randomise the students ourselves but this would have meant the study would have to be performed outside of the normal curriculum and timetable.

Attitude Questionnaire: All students were invited to complete an anonymous questionnaire surveying their attitudes to clinical placements as well as to simulation after their simulation sessions on a voluntary basis. The first surveyed their self-perceived anxiety

and preparedness for assessing patients both by history taking and physical examination and the second whether they found simulation training beneficial. Students were informed that feedback provided would guide future iterations of this curriculum and also be used to enhance their own learning opportunities over the remainder of their undergraduate education.

Competency Assessment: Representative groups who completed simulation were compared against students who partook in a similar duration medical rotation without simulation (see Figure One) over the course of one week across the two university teaching hospitals after completion of the simulation sessions for the first 120 students. Students who were rotating through our other clinical sites at the time of assessment (approximately 50% of the class) were not included. Both groups of students had been attached to clinical teams for six weeks on a restricted basis as above and all shared common medicine and surgery e-learning and web-based resources but only the intervention group received simulation-based teaching. For the assessment, students were directly observed assessing real consenting patients with the objective of performing a global assessment and management plan formulation. Objective competency assessment was performed by non-academic clinical staff. The twelve component Surgical Ward Assessment Tool – SWAT) (79) (Table 4) was used by the clinical observers who were blinded to whether the students had undergone simulation training or not. Student participants were informed that they were taking part in formative assessment which would have no impact on the grade and were not informed of the

components of the SWAT before assessment. All data was prospective to ensure further teaching throughout the semester did not impact results.

Verbal patient consent was obtained for all assessments.

Statistical analysis: The collected data was interrogated for normality (Shapiro-Wilk test $p < 0.05$) and confirmed to be non-parametric in nature. The difference between simulation and control groups was thus subsequently evaluated using Mann-Whitney U test ($p < 0.05$), with each component of the SWAT being compared separately. Analysis was carried out using IBM SPSS, version 26 (NY, USA).

Results

220 students underwent simulation training this semester comprising over 96 hours of scheduled, direct teaching. 191 students (111 females, 90 graduate entry) were surveyed prior to commencing simulation training. 22 students (10%) had prior experience of simulation training, mainly from student surgical and emergency medicine society extra-curricular events. 15 students (7%) were anxious about upcoming ward based learning, predominantly due to a lack of clinical experience. Only two students (1%) were anxious due to the risk of spreading/contracting COVID whilst on-site.

66 students (38 females, 29 graduate entry) were formally assessed by non-academic clinical staff from ten specialties at two

clinical sites. 35 students had received simulation versus 31 who had not. Wound and drain site inspection and nutritional status were not applicable to all patients, and as such were removed from final analysis. Competency assessment scores for each component of the SWAT can be seen in Table 5. Students who received simulation training (n=35) were significantly better at history taking (p=0.004) and appropriate laboratory (p=0.001) and radiological investigation (p=0.01) ordering. There was no significant difference between the groups otherwise including clinical examination, assessing the patient's drug chart and differential diagnosis formulation.

Discussion

Medical simulation allows students to interact with a “device that presents a simulated patient (or part of a patient) that interacts appropriately with the actions taken by the simulation participant”, thus the interaction mimics that occurring with actual patients but in a safe and controlled environment (5). During the pandemic, simulation allows students to apply and practice their skills under close supervision without the same risks of infection to themselves and others as would occur in the hospital setting. Simulation programmes require careful planning on a number of fronts (14,80). Adequate facilities and equipment must be sourced. Clinical scenarios must be planned, education goals must be discussed and, most importantly, capable faculty must be available (6,81). Whilst our institution had already commenced such planning as part of ongoing curriculum modernisation, the immediate requirement for supplementing education during the pandemic meant the implementation of our simulation programme had to be expedited.

This study shows that such rapid implementation of a simulation programme can augment an existing although disrupted curriculum. Despite our simulation programme being low fidelity (due to limited budget), it appears effective. While it can be difficult to define and objectively appraise clinical competence (82), non-academic clinical staff provide an excellent objective assessment of the skills required to be a competent doctor. Inclusion so of actual patients (all of whom were screened negative for COVID-19 as part of their

admission protocol) in the observation study, ensures a real-world test-of-usefulness for the competency assessment. The benefits of such a single simulation session was confined in our experience to history taking and radiological and laboratory investigation but not interestingly in other areas such as venous thromboembolism prophylaxis which was a definite component of the simulation session. Generally, other than this, scores tended to be higher for each component in those receiving simulation versus those who didn't, suggesting perhaps a type 2 error is present and larger numbers could have detected a difference.

By simulating common surgical scenarios, the majority of students also felt more confident and capable when dealing with real-life patients on day one of their careers and recommended continuing development of the programme. Interestingly, some students however reported negative effects of the initiative although the reasons are unclear, although we have previously found a minority of students opposed to other evolutions in the curriculum or assessment programmes previously. Interestingly, too, only two students (1%) were anxious about spreading and/or contracting COVID-19. While this may be a reflection of generational attitudes to the pandemic or alternatively student eagerness for a return to clinical education superseding their concerns, their increased awareness of infection prevention and control measures in our institutions may simply have the students feeling safeguarded against infection. Notably, of the twelve components on our competence assessment, students in both groups scored highest

on infection prevention and control measures reflecting their increased awareness and compliance.

Despite the increasing interest in simulation including due to the pandemic, there is still rather limited evidence for the objective performance benefits of simulation training for medical students, most particularly in the surgical curriculum. While two other studies have shown that simulation training improves competence and performance when assessing simulated surgical patients (26,31), our study shows that performance benefits gained from simulation training can be translated to interactions with real-life patients. The majority of studies done have instead focussed on subjective self-perceived parameters such as confidence and enjoyment (7,24,25) which also seem to have generally been achieved by students in this study. Whilst these are valuable metrics, and important to our students, ultimately medical students must become competent doctors. The transition from medical student to junior doctor can be daunting. Although they often have vast knowledge, this must be synthesised and applied to clinical scenarios whilst also acquiring and implementing newly acquired clinical skills. By improving medical students' competence, this transition should be eased, enabling competent medical students to flourish and become proficient doctors.

A limitation of this study is the fact that the two groups differ with regard to clinical attachment. Exceptionally, the difference was minimised by the restrictions on clinical site education imposed by the pandemic meaning that students on surgical rotations had less

opportunity to gain surgical patient experience than usual. Also there was a lack of a baseline assessment of each student prior to simulation training which could have been used to gauge individual improvement following such training. Again due to pandemic restrictions, we were unable to perform a baseline assessment prior to module commencement. However, this was our students first clinical attachment and so baseline was likely to be similar most especially with respect to clinical competence. Finally, not every student was assessed, again due to the constraints of the pandemic and the difficulties of moving students between clinical sites for non-essential purposes.

Table 3: Clinical scenarios used during simulation teaching sessions.

Scenario number	Scenario description
1.	Acute cholecystitis
2.	Acute appendicitis in a 30-year-old female
3.	Perforated diverticulitis with peritonitis
4.	Acute pancreatitis
5.	Small bowel obstruction secondary to adhesions

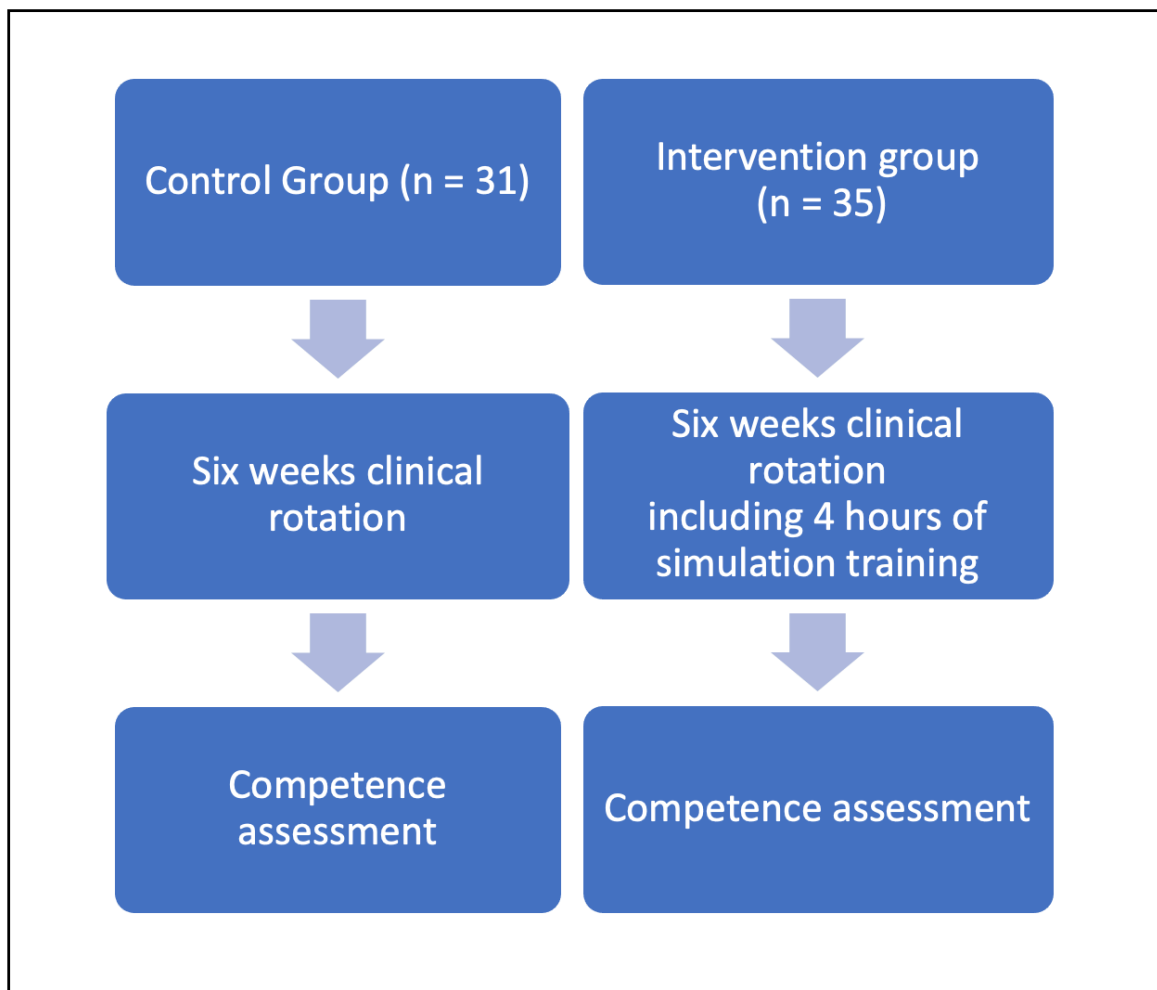
Table 4: Surgical Ward Round Assessment Tool (SWAT) components and Grading System

Tasks				
Takes history from the patient.		Reviews drug chart.		
Examines the patient.		Checks nutrition status.		
Checks patient is wearing appropriate thromboembolic deterrent stockings.		Discusses differential diagnosis.		
Checks vital signs and fluid charts.		Checks wound (if applicable).		
Checks blood investigation results.		Checks drain (if applicable).		
Checks imaging investigation results.		Follows infection control protocols.		
Grading System				
Well below expectations	Below Expectations	Meets Expectations	Above Expectations	Well above expectations
1	2	3	4	5
Fails to complete task	Task completed with prompting	Task completed consistent with level	Task completed better then level	Task completed to junior doctor standard

Table 5: SWAT Competence assessment scores and their statistical analysis of intervention (simulation) versus control (no simulation) student groups by blinded, independent clinicians.

Task	Simulation group (n=35)	Control group (n=31)	p value
Take history from the patient.	3.69±0.76	3.19±0.70	0.004
Examine the patient.	3.37±0.77	3.06±0.85	0.120
Check patient is wearing appropriate thromboembolic deterrent stockings.	2.86±1.00	3.10±1.30	0.557
Check vital signs and fluid charts.	3.43±0.88	3.23±0.80	0.329
Check blood investigation results.	3.51±0.70	2.84±0.78	<0.001
Check imaging investigation results.	3.11±0.72	2.68±0.70	0.010
Review drug chart.	3.40±0.91	3.00±0.58	0.065
Discuss differential diagnosis.	3.40±0.91	3.16±0.73	0.074
Follow infection control protocols.	3.97±0.82	3.39±1.28	0.067

Figure 12: Study Design



Chapter 6: Student Feedback

Introduction

Student feedback is a central tenet of third-level education. It is thought that student feedback benefits both the educator and the student. The educator receives anonymous, honest assessments of their own performance and guidance on how to improve it.

Students, by reflecting on their previous experiences, are empowered to self-regulate their learning. Those who become effective self-regulators are more comfortable receiving feedback and using that feedback to refine their performance.(83)

Potential Biases

It has to be noted, that when surveying medical students there are a number of biases to be taken into account. When surveying students there is a risk of non-response bias, meaning there is a difference between the cohort who respond and the cohort who don't respond. Thus, the responses received may not be representative of the entire class. It is thought that students who respond to teaching evaluation surveys are either quite engaged in their own learning or else they have an issue to report. However, Nowell et al reported that "data collected from a non-random sample of does appear to be representative of the class as a whole" (84).

When responding to their clinical tutors students may be at risk of response bias, thus being overly positive about the findings (85).

Also, there may a degree of social desirability bias – students may

feel that they should answer the questions so that they are seen in a positive light by the tutors.

Students were not required to use their name or student identification number when completing the survey. By anonymizing our survey, these biases are mitigated.

Methods of Data Collection

Anonymized student feedback was sought immediately following completion of the module. Google forms was used to survey students. Participation was voluntary. The survey was purposely made as short as possible, with all questions providing a Likert scale to encourage students to participate. The survey was emailed to the students on two separate occasions. On both occasions it was emphasized that the survey would take less than five minutes. It has been reported that the longer and more difficult a survey is to complete, the more likely only those with grievances will reply (86). All required data was obtained from this survey. The optional comments section at the end of the survey allowed students to communicate their opinions about all components of our simulation curriculum. It also provided them with a platform to outline any potential additions required to enhance our simulation programme.

Results

Of the 221 students who completed the module 75 students provided feedback. 22 males and 53 females responded. There were 37 undergraduate and 38 graduate entry students. Questionnaire items are listed in table 6. Students were informed that feedback provided would guide future iterations of this

curriculum and also be used to enhance their own learning opportunities over the remainder of their undergraduate education. The students were asked to complete the survey in the days following the conclusion of the module to ensure accurate representation of their experience. Unfortunately, this coincided with an examination period and then a term break, which likely contributed to a less than 50% response rate.

Following simulation training, the majority of surveyed students felt more prepared assessing surgical patients (Figs 12 and 13). 84% of surveyed students felt more prepared seeing patients on the ward round, 79% in clinic and 48% in the emergency department. Our simulation work primarily focused on acute scenarios, most of which would be seen in the emergency department. At this stage of their clinical placement, students had not yet completed their emergency medicine rotation. Perhaps after having done this rotation, their self-perceived preparedness to deal with patients in the emergency department will have improved.

62.7% of surveyed students reported that simulation training had a positive impact on their history taking ability (Fig 14 and 15). 4% of surveyed students said that simulation training had a negative impact on their history taking ability. No explanations were provided by the negatively affected students.

In 60% of surveyed students simulation training had a positive impact on their ability to perform a physical examination (Fig 16 and 17). 9.3% of surveyed students said simulation training had a

negative impact on their ability to perform a physical examination. A hypothesized reason for the high proportion of students negatively affected may be the fidelity of our mannequins. We used low fidelity mannequins which did not provide any information to the students. Student feedback has requested more responsive mannequins which would provide actual physical signs (e.g. heart murmurs, lung sounds, tenderness on abdominal examination). Higher fidelity simulators which can provide the aforementioned signs are available, but costly (81).

88% of surveyed students found simulation training beneficial (Fig 19). Students reported that simulation training improved their understanding of surgical physiology and pathology, both of which were not directly covered in the curriculum

82.7% of surveyed students would like more simulation training added to the curriculum (Fig 20).

Additional comments were welcome, and will be used in the future planning of our simulation programme.

Some students requested simulation training immediately prior to commencing clinical placement to improve their preparedness for clinical learning. Others suggested simulation training throughout the year so that material learned on clinical placement could be applied in a simulated environment.

The laparoscopic skills training boxes were added to our simulation programme as a rest station and so that students could get a flavour of the skills required for laparoscopic surgery. Students

found laparoscopic skills a welcome addition, reporting that it was “fun and engaging”.

Table 6: questionnaire items used for data collection

Questionnaire items used for data collection
After your simulation session how prepared did you feel to see surgical patients in the emergency department?
After your simulation session did you feel more prepared to see surgical patients?
After your simulation session how would you rate your ability to take a history?
Did the simulation week have any impact on your ability to take a history?
After the simulation session how would you rate your ability to perform a clinical examination?
Did the simulation session have any impact on your ability to perform a physical exam?
Were you more or less anxious about seeing patients after your simulation session?
Did you find simulation training beneficial?
Would you like more or less simulation training next semester

The graphs below illustrate our results:

Figure 12: Preparedness for assessing surgical patients in clinical environments post simulation

After your Simulation session how prepared did you feel to see surgical patients in the Emergency Dept? Please rank 1-3.

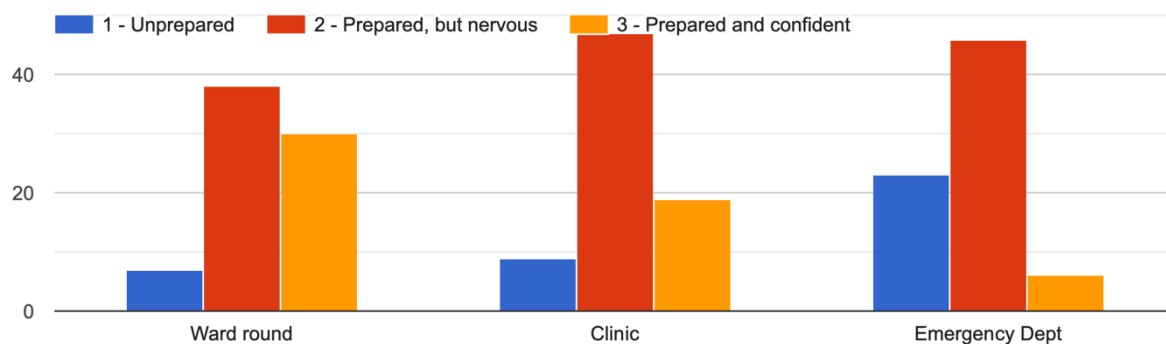


Figure 13: Preparedness for assessing surgical patients post simulation

After your simulation session did you feel more prepared to see surgical patients? Yes, No or Neutral.

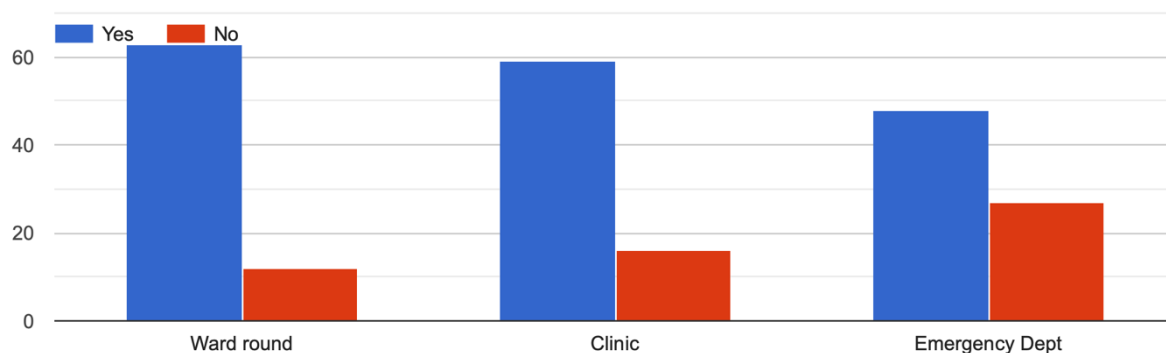


Figure 14: Self-perceived history taking ability post simulation

After the Simulation session how would you rate your ability to a take a history?

75 responses

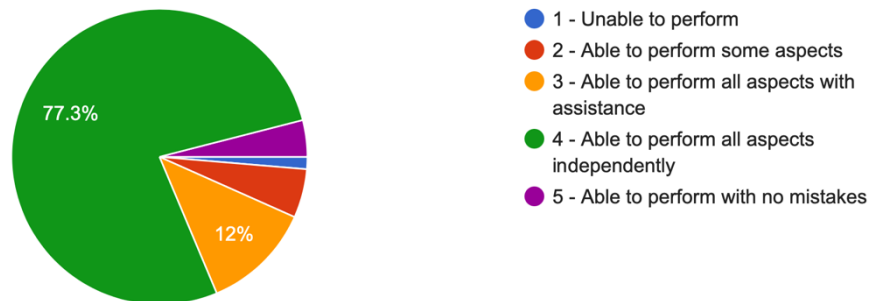


Figure 15: Self-perceived history taking ability post simulation

Did the simulation week have any impact on your ability to take a history?

75 responses

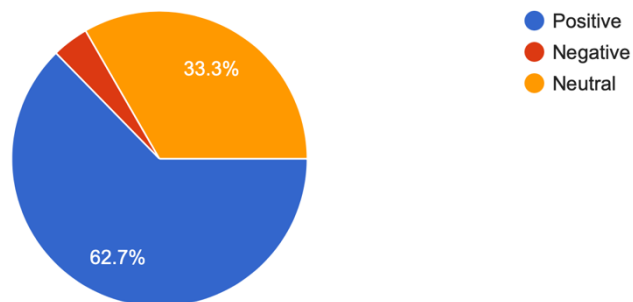


Figure 16: Self-perceived clinical examination ability post simulation

After the Simulation session how would you rate your ability to perform a clinical examination?

74 responses

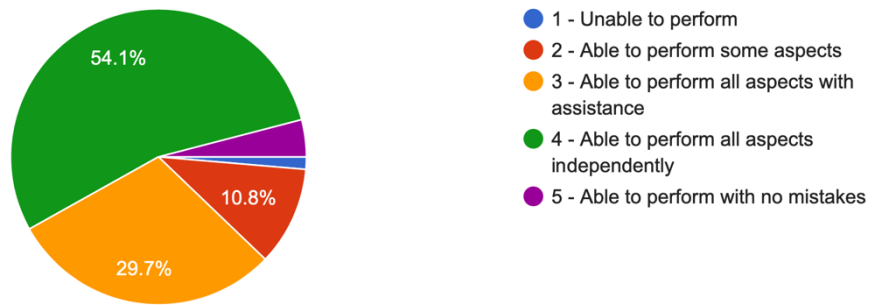


Figure 17: Self-perceived clinical examination ability post simulation

Did the simulation session have any impact on your ability to perform a physical exam?

75 responses

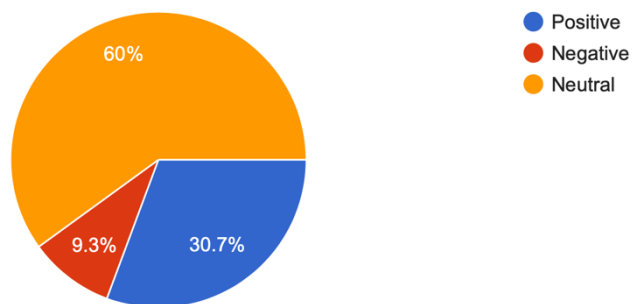


Figure 18: Anxiety levels post simulation training

Were you more or less anxious about seeing patients after your simulation session?

75 responses

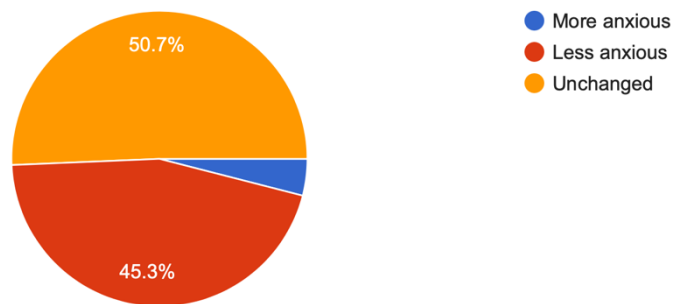


Figure 19: student perception of simulation training

Did you find simulation training at the Mater beneficial?

75 responses

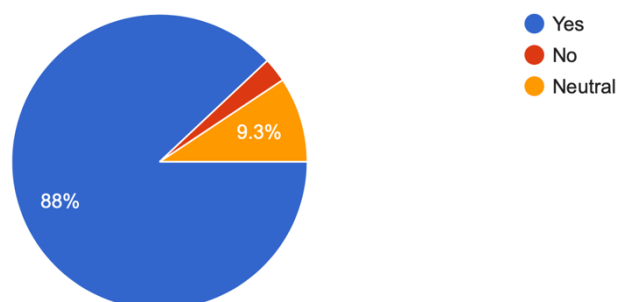
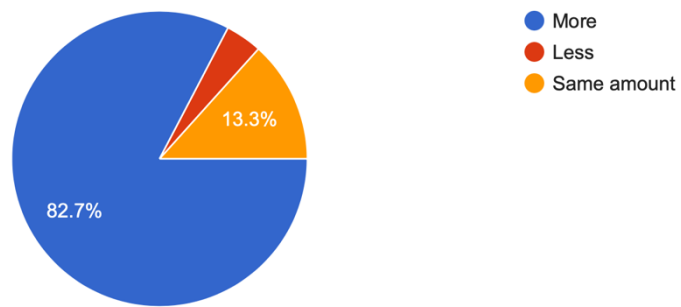


Figure 20: students survey for quantity of simulation for the next semester

Would you like more or less simulation training next semester?

75 responses



Analysis of Results

Following analysis of our results, it is planned to implement more simulation training in the coming year's surgical curriculum. Our work acted as an experimental model to provide evidence for this. Our provisional results and student feedback have encouraged us to implement more regular and longer simulation sessions. A surgical tutor with a specific interest in simulation training will be added to the university staff.

Students will be assigned more time on the laparoscopic skills training in the next iteration of this curriculum. While not relevant to the curriculum, students reported this one of the most enjoyable aspects of the simulation training. In conjunction with the university surgical society, we have run a number of surgical skills (including laparoscopic skills) workshops as an extra-curricular activity. Further workshops outside of working hours are planned.

To enhance our simulation programme, as requested by our students, more lifelike mannequins should be acquired, however this is dependent on funding. A mannequin with actual physical signs should further enhance our students physical examination skills and enjoyment of their simulation sessions. After extensive reading on different simulation programmes from our systematic review, SimMan is the most popular commercially available simulation mannequin. More qualitative work needs to be carried out to ensure it is the optimal system for our simulation programme.

Chapter 7 - Conclusion

Introduction

This pilot study details the effective implementation of a simulation programme to meet our students' needs and also as a rapid response to evolving pandemic restrictions. Simulation programmes require extensive planning, both in implementing and executing. Facilities and equipment must be sourced, administration and scheduling must be planned in advance and trained faculty must be available. While our institution was in the early stages of such planning, the global pandemic necessitated a shift in our teaching strategy and as such a decision was made to expedite our planned simulation programme. All steps in the implementation of our programme are detailed in this study, and can be used as a guide for other institutions planning to implement their own simulation programme. We have shown that the implementation of a simulation programme can be achieved at low costs but can be highly effective. By showing that simulation training can directly improve medical students' competence levels, we hope to reinforce and encourage other institutions to initiate simulation programmes. It is important to recognise the student perception of their own education experience. In our case, the majority of students enjoyed participating in simulated scenarios, and importantly they found it beneficial. Student feedback obtained will encourage expansion and guide future iterations of our simulation programme.

Systematic review of the literature

With pandemic restrictions easing, a return to traditional medical education can be facilitated. With both research-based evidence and practical experience of the performance benefits of simulation training detailed in this study, a combination of the traditional curriculum and simulation training will form the core components of the upcoming intake of students undergraduate surgical training. Our systematic review validates the use of simulation based medical education as an adjunct to the traditional didactic lecture-based curriculum.

Airflow assessment for clinical examinations

Clinical examinations are an essential component of medical education. Using optical imaging techniques, the potential infection risks associated with clinical examinations are discussed in this study. While simulation training can certainly be used an adjunct to this, students must have experience examining real patients prior to graduation. Thus, even during the pandemic we felt it was necessary that our students continued on-site clinical practice in addition to simulation training. By assessing the airflow dynamics associated with clinical examinations, students were guided on appropriate masking wearing and social distancing precaution whilst performing clinical examinations.

Limitations

A primary limitation of our study is that students' baseline level was not assessed prior to commencing simulation training, which may have given an indication of the degree of improvement which can be obtained with simulation training.

Unfortunately we were constrained by the traditional scheduling of our clinical module, so groups differed with regard to their clinical attachments. Again due to the logistical constraints imposed by the pandemic, it was not possible to assess all students in our tertiary sites at the one time, which limited the powering of our study. The systematic review studies heterogeneous groups consisting of various methods of simulation and assessment. As such meta-analysis was prohibited.

Recommendations for future work

This pilot study shows the rapid implementation and feasibility of a simulation programme for medical students at our clinical site. This will provide a basis for further development of on-site simulation training. In terms of the future for our clinical site, this work has provided evidence of benefit, which can be used in the application for greater funding for our simulation programme. A surgical tutor with a special interest in simulation will now be sought to further our programme. In addition, funding has been obtained for another smots™ camera which will allow simultaneous simulation sessions.

For the purposes of ensuring optimal education of medical students, further studies could investigate the best methodologies for simulation-based medical education by comparison and whether simulation is best employed as an adjunct or replacement to the traditional lecture-based curriculum. It is important also to examine cost-effectiveness especially the role of lower cost set-ups versus more expensive systems. Ultimately, too, it is important to correlate

the performance effect of simulation training directly to competence. By building up such an evidence-base we will best evolve the curriculum for the purpose of producing better doctors, and most importantly, better patient outcomes.

Conclusion

Therefore, in summary, this early investigative study has shown that simulation training can be effectively implemented into a disrupted curriculum and its results will encourage and guide future iterations of our surgical curriculum as well as, hopefully, interesting others. While considerable tutor and student enthusiasm is required, it has proven to be a generally welcome addition to the curriculum by both staff and students. Most importantly it has helped student performance at a very challenging time in their studies as well as for healthcare and medical education institutions in Ireland and globally.

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