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Effectiveness of a centrally designed, large-scale, multisite undergraduate medical simulation programme: student-reported confidence across eight London hospitals in a UK medical school setting

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ABSTRACT

Objectives Simulation is well established in medical education. However, with rising numbers of medical students globally, provision of high-quality, equitable simulation teaching on a large, multisite scale is increasingly challenging. We sought to explore whether a centrally designed, multisite simulation programme could enhance student confidence equitably across multiple clinical sites with differing resources.

Design An evaluative study on the changes in medical student confidence on defined intended learning outcomes (ILOs) in 3 undergraduate year groups across 11 simulation sessions delivered at eight different clinical sites with variable resources and facilitators.

Setting Eight hospitals affiliated with Imperial College School of Medicine.

Outcomes Students' self-reported confidence in achieving the ILOs via a questionnaire at the end of each session. Changes in confidence following each session were analysed and compared across sites.

Results 522 students responded to the survey over 3 academic years. Students' mean confidence in achieving ILOs increased in all sessions. Nine out of 10 sessions showed no statistically significant difference in the confidence increases between sites.

Conclusion Our study suggests it is possible to deliver an equitable, centrally designed, large-scale simulation teaching programme to medical students across multiple clinical sites with different facilitator teams. The programme is sustainable, easily facilitated by new teaching fellows each year and is likely adaptable to other healthcare professions and settings.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study demonstrates the effectiveness of a large, centrally designed simulation programme in achieving equitable gains in confidence across multiple clinical sites with varying facilitators.
⇒ This method of programme design can be generalised for use by other multisite health institutions as well as devolved clinical settings such as general practice or community placements.
⇒ While self-reported confidence is a subjective measure, its use encourages students to focus on session objectives and provides useful data for facilitators as part of the spiral learning programme.
⇒ The number of responses received from students may be impacted by the scheduling of the sessions within the academic year.

INTRODUCTION

Simulation is the artificial representation of a real-world process to achieve educational goals via experiential learning.[1] It is widely used in education across many professions including in military and aviation settings.[2] In medical education and clinical practice, simulation is well established,[3] and in recent years, there has been a rise in the use of simulation methodologies in undergraduate and postgraduate education.[2 4] With limited exposure to patients in a clinical environment and ad hoc educational sessions known to be insufficient to create competent doctors, simulation-based education can assist in education delivery for medical students.[4]

Simulation uses principles of experiential learning[5] and learners have an active experience, usually followed by a debrief to facilitate reflection and learning.[6] Simulation enables learning opportunities for healthcare professionals in realistic, safe environments, without compromising patient safety.[7] The use of simulation in medicine has been identified as important to maintain a culture of safety and foster changes in procedures and systems.[8] There is evidence of simulation being used in medical education to assist learners in the

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acquisition of skills in a broad range of areas including performing practical procedures, management skills, clinical skills and knowledge of basic medical sciences.[9] As a teaching tool, it is also highly valued by undergraduate medical students, particularly where lack of practice can be a common complaint.[10]

The diversity of applications of simulation in medical education has been described by Gaba.[8] Gaba categorises the current and future applications of simulation into 11 dimensions, each of which represents a different attribute of simulation including the aim of the simulation activity, the experience level of participants, the discipline of those participating in the simulation and the technology applicable or required for simulations. They explain some of these are gradients, while others have categorical differences. This results in many (over 48 million) combinations of simulation types that can be achieved depending on where a session sits in each of the dimensions. Introducing simulations that sit in different areas of the range of dimensions will assist in simulation being embedded into the fabric of patient care, thus improving patient safety.[8] The technology used in the simulation is categorised under dimension 8 of Gaba's 11 dimensions, who points out a variety of technologies from role playing and standardised patient actors, to patient simulators.

In clinical education, increasing attention is being focused on delivering 'high-fidelity' simulation.[2] The term 'fidelity' describes the extent to which the simulation matches the system it is aiming to simulate.[11] This can refer to 'physical fidelity', which is the extent to which the environment replicates the physical characteristics of the task, or 'psychological fidelity', which is the degree to which the skills from the real task are present in the simulated task.[12] From an educational perspective, high-fidelity simulation is not necessarily superior to low-fidelity simulation,[4 13] despite high-fidelity simulation having long been a focus in medical education literature with an upward trend in articles from the end of 20th century.[9] Typically, high-fidelity simulation is highly resource-intensive with high number of facilitators needed to teach small groups of students. Furthermore, high-fidelity simulation is often restricted to a limited number of sites due to the high setup and maintenance costs of the simulation environment.[14 15] This is a particularly important consideration in undergraduate medical education as routine availability and the possibility of repeated practice are most valuable for early learners of tasks and skills, which inherently requires lower cost.[8]

Medical student numbers have increased globally since 2000, in part as a response to the COVID-19 pandemic and in response to current or future shortages of doctors.[16] The UK government has recognised this and has implemented a 'Long Term Plan'[17] to double medical student places to 15 000 by 2031. Providing high-quality and equitable simulation experience on a large, multisite scale is likely to become an increasing challenge for medical schools. This is likely to require schools to develop creative ways to deliver simulation teaching to ensure it remains feasible in terms of cost and resources available, so that students are still able to reap the benefits. One possible solution to this is to provide lower fidelity simulations for students, which are often lower in cost, while adapting some of Gaba's dimensions [8] to create an effective learning experience for students.

Imperial College School of Medicine (ICSM) sought to explore whether a centrally designed, large-scale simulation course, the 'Cross-Site Simulation Programme' (CSSP), could achieve equitable student-reported confidence increases across multiple sites despite being taught by different teaching teams. This large-scale, multisession, simulation programme was specifically designed by the medical school to be deliverable to approximately 1000 medical students each academic year across multiple clinical sites with known differences in available resources. The programme was made up of a series of low-fidelity simulations delivered to 3 different year groups of the undergraduate medicine course, building on skills developed in preceding sessions. This programme was evaluated with a self-reported questionnaire, completed by students.

METHODS

Setting and population

The CSSP was designed centrally by the medical school for students in years 2, 3 and 6 of the 6-year undergraduate Bachelor of Medicine, Bachelor of Surgery (MBBS) programme at ICSM, in London, UK. At ICSM, years 1, 2 and 3 provide the foundational and scientific basis of clinical education, while years 5 and 6 focus on preparing students for clinical practice. In year 4, students undertake an intercalated undergraduate degree. Aside from year 4, ICSM provides multiple clinical placements in affiliated teaching hospitals in the city as well as in numerous district general hospitals in the surrounding suburban areas as part of the MBBS programme (table 1).

Each year group contains 307–380 students, who are allocated a rotation of clinical placements based at any of eight National Health Service (NHS) hospitals throughout each academic year (table 1). Students are

Table 1 ICSM-affiliated hospitals delivering the CSSP

Trust site	Hospital type
Hospital 1	Large inner city teaching hospital
Hospital 2	Large inner city teaching hospital
Hospital 3	Small inner city tertiary referral hospital
Hospital 4	Large suburban district general hospital
Hospital 5	Large suburban district general hospital
Hospital 6	Large inner city teaching hospital
Hospital 7	Small suburban district general hospital
Hospital 8	Large suburban district general hospital

CSSP, Cross-Site Simulation Programme; ICSM, Imperial College School of Medicine.

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Table 2 Number of teaching fellows allocated to each site per academic year and available teaching space

Trust site	Number of teaching fellows	Teaching setting
Hospital 1	4	Simulation suite or teaching room (session dependent)
Hospital 2	3	Teaching room with screens to mimic clinical space
Hospital 3	3	Clinical skills lab
Hospital 4	4	Simulation suite or teaching room (session dependent)
Hospital 5	12	Simulation suite or teaching room (session dependent)
Hospital 6	5	Simulation suite
Hospital 7	5	Simulation suite or teaching room (session dependent)
Hospital 8	3	Simulation suite or teaching room (session dependent)

randomly allocated to attend placements between one and three hospitals each year, depending on year of study. The number of students allocated at each hospital varies based on local teaching capacity and clinical services.

The CSSP was delivered by teaching fellows locally at each site, where the number of fellows employed varied from 3 to 12. While some sites had a dedicated simulation suite for simulation teaching, others had tutorial rooms styled to look like clinical spaces and the remainder just had access to classrooms (table 2). Some sites had access to high-fidelity simulation rooms and mannequins, while others did not (table 3).

Development of the CSSP

Eleven simulation sessions were developed in total across years 2, 3 and 6 of the MBBS programme. Each session was accompanied by its own bespoke set of intended learning outcomes (ILOs). The ILOs were adapted from the General Medical Council's (GMC) student assistantship guidance [18] and designed to help students achieve a broad range of skills identified as important in students' preparedness for practice. Twenty-eight specific ILOs were developed, which were covered across the CSSP programme. As the CSSP ran across 3 of the 6 years of the course, which operates a spiral curriculum, certain ILOs were covered in multiple sessions.

Delivery of the CSSP

Teaching fellows at each site delivered the CSSP programme over the course of one academic year. Teaching fellows attended an induction session, which outlined the CSSP programme and were provided with training on teaching methods and feedback. Teaching fellows were then provided with the comprehensive CSSP handbook, which included detailed lesson plans, learning objectives and printable student resources as well as a cache of videos, presentation slides and other digital and printable resources (such as drug charts and observation charts).

The CSSP sessions are linked to each year groups' clinical placements, and the same session would be delivered regardless of the site students were allocated. Year 2 students received two sessions, year 3 students received four sessions (from a set of six complementary sessions) and year 6 students received three sessions. Each session was designed to build on knowledge gained in previous years. The type of simulation in each session varied, with some involving roleplay and communication skills, and others involving clinical scenarios and practical procedures. Each session was designed to give students the opportunity to practise skills determined in the sessions' ILOs (table 4).

Student evaluation questionnaire

At the end of each session, students were invited to complete an online questionnaire to give their feedback on the session. Students were presented with the ILOs for the session and rated their confidence in each on a 5-point Likert scale from 'not at all more confident' to 'much more confident'. Data were collected over 3 academic years. Students would be expected to complete the questionnaire for each different simulation session attended.

Table 3 Equipment available at each site

Trust site	*Full body sim mannequin*	*Part task trainer*	*Simulated patient (volunteer)*	*Simulated patient (professional)*	*Examination couch*	*TV*	*Computer*	*Projector*
Hospital 1	Y	Y	Y	N	Y	Y	Y	Y
Hospital 2	Y	Y	Y	N	Y	N	Y	Y
Hospital 3	Y	Y	Y	N	Y	Y	Y	Y
Hospital 4	Y	Y	Y	N	Y	N	Y	Y
Hospital 5	Y	Y	Y	N	Y	Y	Y	Y
Hospital 6	Y	Y	Y	N	Y	Y	Y	Y
Hospital 7	Y	Y	Y	Y	Y	Y	Y	Y
Hospital 8	Y	Y	Y	N	Y	N	Y	Y

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Table 4 Breakdown of simulation session and aims

Session	Year group	Simulation session overview and aims	Number of students per facilitator	Session length (hours)
1	2	**Session 1: Handover—Introduction, Situation, Background, Assessment, Recommendation (ISBAR) Simulation** Session aims: ► Effectively use ISBAR for clinical handovers ► Calculate and interpret National Early Warning Score 2 (NEWS2)	6	2
2	2	**Session 2: Airway, Breathing, Circulation, Disability, Exposure (ABCDE) video simulation** Session Aims: ► Use ABCDE approach to clinical management ► Use ISBAR to handover patients	6	2
3 and 4 5 and 6 7 and 8	3	**Session 3*: Presenting Clinical Information (Patient Histories)** **Session 4*: Acute Management (Acute Coronary Syndrome and Abdominal Pain)** **Session 5*: Presenting Clinical Information (Clinical Examinations)** **Session 6*: Acute Management (Head Injury and Sepsis/Pneumonia)** **Session 7*: Presenting Clinical Information (Clerking vs Ward Rounds)** **Session 8*: Acute Management (Heart Failure and Traumatic Injury)** Session aims: ► Presenting clinical information ► Assessment and management of acute conditions *Sessions 3 and 4, 5 and 6, and 7 and 8 are paired, complementary sessions. Each student receives 4 of 6 available sessions.	8	1
9	6	**Session 9: Referrals Simulation** Session aims: ► Making concise, complete and accurate referrals ► Request appropriate information	6	2
10	6	**Session 10: Ward On-Call Simulation** Session aims: ► Prioritising and completing clinical tasks ► Recognising limitations ► Demonstrate effective communication	1–2	2
11	6	**Session 11: Simulated Emergency Department On-Call** Session aims: ► Manage undifferentiated acutely unwell patients ► Demonstrate effective interdisciplinary working ► Demonstrate effective communication	3	1

Data presentation and analysis

Data from the survey were then analysed. For each session, the following steps were taken:

1. Students' Likert scale responses to each ILO were converted into numerical scores between 0 and 4. 'Not at all more confident' was scored as 0, and 'much more confident' was scored as 4.
2. ILO numbers varied across sessions, so for each student responding to the survey, a mean change in confidence score was calculated across ILOs.
3. Using these individual student means, median change scores were then calculated overall and for each site, as individual student means were not normally distributed. To ensure sufficient sample size, only sites with five or more respondents per session were included.
4. This was repeated for each of the sessions.

The median of the individual student mean was used in statistical analysis to investigate whether there was a statistically significant difference between confidence changes at each site. The Kruskal-Wallis H test [19] was used to analyse the differences between sessions. Where only two sites had run a session, the Mann-Whitney U test [20] was used. Statistical analysis was conducted with SPSS (V.23.0; SPSS) with the critical p value calculated using the Bonferroni method.

For sessions where a statistically significant difference was detected between sites, a series of Mann-Whitney U tests [20] were conducted to determine whether there were statistically significant differences between the median ratings of the pairs of sites being compared. The critical p value for these tests was calculated using the Bonferroni method.

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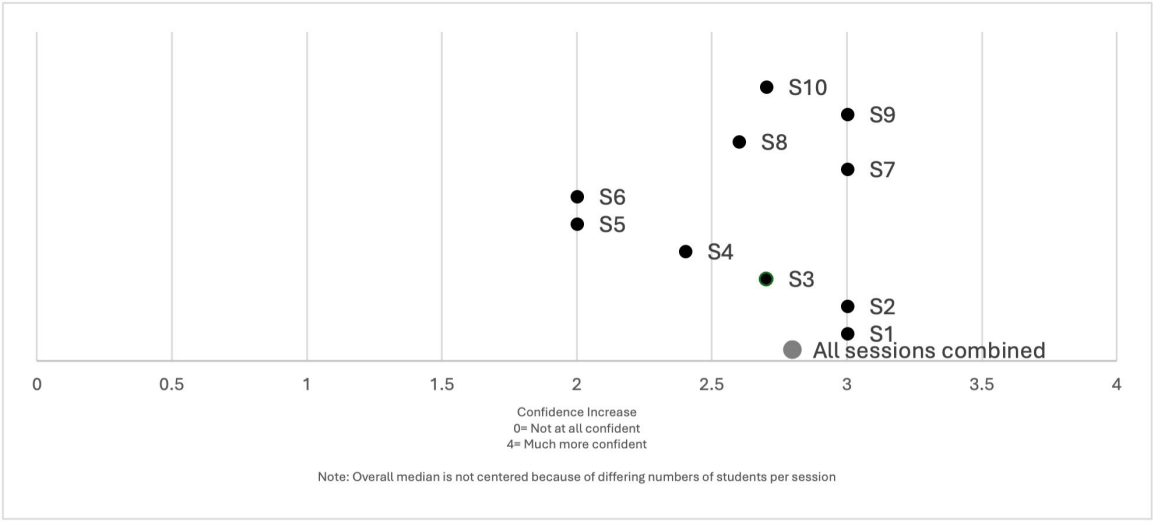


Figure 1 Median confidence increases across all sites, per session. SX = Session X

RESULTS

A total of 522 questionnaire responses were received between August 2021 and January 2024 from a possible 8091 responses. Of the 11 simulation sessions, one was removed from the study (session 11), due to insufficient responses from students (n=4 across two sites). The number of sites receiving sufficient responses for each session varied from 2 to 7 across the programme. The maximum number of respondents at one site for the sessions included in the analysis was 36 (hospital 2, session 2), and the minimum was 5.

Impact on ILOs

The median confidence increased for each session, across all sites combined, is shown in figure 1. Across sessions, students reported an increase in confidence, with a minimum increase of 2.0 (sessions 5 and 6) and a maximum confidence increase of 3.0 (sessions 1, 2, 7 and 9), on the 5-point scale from 0 to 4. Across all sessions combined, students reported a median increase in confidence of 2.8 out of 4.

Variation across clinical sites

The median of the mean scores across ILOs for each student and the number of students who completed the questionnaire at each clinical site are shown in online supplemental table 1. Nine out of 10 sessions showed no statistically significant difference in the increase in confidence between students at different sites.

Online supplemental table 1 presents the median of mean increase in confidence and numbers of students responding at each site for each session, test statistic and statistical significance

The Mann-Whitney U significance testing run for session 5, which showed a statistically significant difference, is shown in table 5. The median increase in confidence was lower at Hospital 7 than at any of the other three hospitals running session 5.

DISCUSSION

As the global demand for medical professionals rises,[16] including in the United Kingdom where student numbers are set to increase by thousands over the coming years,[17] providing high-quality, equitable, education will bring new challenges. More students will bring with them a need for educators to be increasingly creative in order to maximise resources when creating more clinical placements. Institutions aiming to ensure students receive equitable training may find meeting this objective more challenging when students are spread out across higher number of clinical sites, which will inevitably have variation in resources available for medical student training. This includes differences in physical space, equipment and number and experience of simulation facilitators.

The CSSP successfully demonstrates an innovative model of a centrally designed simulation teaching programme, which allows for large-scale delivery regardless of site and resources available, including a range of

Table 5 Mann-Whitney U test statistic and p value for the median increase in confidence at each site for session 5 (statistical significance threshold: p<0.0083)

Test statistic (p value)	Hospital 1 (median: 3.00)	Hospital 2 (median: 2.75)	Hospital 4 (median: 2.38)	Hospital 7 (median: 1.25)
Hospital 1 (median: 3.00)		17.0 (1.000)	24.0 (0.315)	8.5 (0.004)
Hospital 2 (median: 2.75)			16.5 (0.310)	2.0 (0.002)
Hospital 4 (median: 2.38)				17.5 (0.006)
Hospital 7 (median: 1.25)				

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simulation equipment and facilitators. The most notable outcome of the study is that in 9 out of 10 of the CSSP sessions, there was no statistically significant difference in students' confidence increase in the relevant ILOs between different clinical sites.

While there are limited differences in space and equipment across the clinical sites, there remains variation in the number of teaching fellows as well as their experience. This suggests that, for most sessions, the site at which the student received their teaching did not affect their ability to achieve the ILOs. For the session that showed statistical significance, it appeared to be isolated to one site (hospital 7) causing this difference. Together with the trend in results in online supplemental file 1, it appears this site had minor challenges with session delivery.

Our results may be explained in the context of Gaba's 11 dimensions of the application of simulation.[8] Despite the inherent variance that would naturally occur across sites, the resources available at the different sites were generally the same, as were the knowledge, skill, attitudes or behaviour addressed in the simulation[6] and the extent of direct participation,[10] therefore the differences are minimised.

The CSSP programme benefited from the initial scoping exercise conducted by the central medical school team to understand the baseline human and equipment resources that each hospital site had at its disposal. This understanding allowed the sessions to be developed accounting for different resources. Achieving this understanding ensured that the resources were developed in such a way that, regardless of the site where the simulation session was taught, the intended ILOs could be fully delivered.

The CSSP teaching resources were specifically designed to ensure easy reproduction and delivery by teaching fellows. Teaching fellows were provided with a comprehensive handbook, which included the objectives and content for each session, while allowing flexibility for the exact setting and equipment resources, which could be included in the delivery. The 155-page handbook, associated presentation slides and standardised resources for every session, provided structure to the teaching without being prescriptive in its exact delivery. The use of the centrally designed handbook enabled sites to deliver the same teaching content and experience across different sites. The exact dates and times the sessions were taught varied between sites and according to local teaching timetables. Therefore, the accessibility of the handbook allowed teaching fellows at each site to prepare for teaching each session at a time that best suited them.

The design of the programme by the medical school centrally also lends itself to sustainable teaching practices allowing it to run year-on-year due to its relatively minimal resource requirement at each site and relative adaptability. This has meant that even with annual changes to the number of teaching fellows and staff at hospital sites, lack of overlap between outgoing and incoming teaching fellows, and the known challenges around lack of formal handover for organising teaching sessions,[21] delivery of the programme has remained resilient. Furthermore, as conditions at sites can change throughout the academic year, such as procuring new equipment or unavailability of usual teaching rooms, teaching fellows are able to adapt teaching accordingly, maintaining consistency without relying on input from the central CSSP development team at the medical school. In addition to streamlining teaching across the sites, the CSSP has also reduced time required by teaching fellows to create their own simulation sessions, which can be time-consuming at the start of each year[21] as well as likely introducing substantial unwanted variation in student experience between clinical sites.

Our findings suggest that, with the provision of an appropriate, centrally designed simulation programme, such as the CSSP, it is possible for students to achieve equitable learning across clinical sites, even with their inherent differences. This is in contrast to before the introduction of the CSSP when student simulation experience would be entirely dependent on the hospital site to which they were allocated, leading to variable learning opportunities. By unifying the programme into one longitudinal course, all students now receive equitable experience regardless of placement location.

These findings have wide-ranging implications for the practice of simulations across all stages of education and health professions. Simulation is currently used across clinical specialties including surgery,[22] internal medicine,[23] palliative care[24] and anaesthetics.[25] Our findings suggest that standardised simulation programmes can be developed and shared across clinical sites or venues, which are part of larger educational institutions, such as medical schools and postgraduate colleges, with similar outcomes for learners. Furthermore, there is likely scope to extend this methodology to other devolved clinical settings such as general practice or community placements. As simulation is also used across health professions education,[26] this type of programme can be applied across disciplines, such as nursing or allied health professionals, where student numbers are also increasing.[27] The use of shared resources also saves educator time in developing simulation and reducing duplication of work between sites within a single institution.

Limitations

This study primarily evaluated the subjective measure of students' self-reported changes in confidence. While the longer term impact on clinical practice or assessment was not reviewed, the use of improvement in student confidence is well established in the literature and has been adopted by the GMC in their National Training Survey as a measure of preparedness for working in the clinical environment after graduation.[28] While students can misconceive their actual abilities following a simulation, leading to overinflated self-confidence,[13] the use of self-assessment within the context of spiral learning in the CSSP allows students to focus and reflect on key objectives, while also flagging potential educational needs to the facilitator for future sessions.

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One session was excluded due to insufficient feedback. It is noted that this session was scheduled just prior to summative examinations, which may have led to lower prioritisation for completing feedback or poorer attendance to the session. Where sites received lower than expected student responses, this may be due to a lack of time at the end of teaching sessions or facilitators or students forgetting to provide or complete the feedback survey, respectively. Some sites did not register responses for all sessions, which could be attributed to students not providing consent or teaching fellows or students not prioritising feedback. Feedback is an aspect of the programme we plan to provide more training for in the teaching fellow induction programme. Further research is needed to investigate the views of facilitators teaching the session as well as evaluating the data as students move through the programme, to see if sessions build on each other in the way they are designed.

CONCLUSION

Our research shows that it is possible to deliver equitable teaching to medical students from a large, single institution placed across multiple clinical sites with varying resources. The centrally designed simulation programme is also sustainable and able to be easily facilitated by new teaching fellows each year if necessary. This method is likely adaptable to other healthcare professions and clinical settings such as general practice, community placements and postgraduate colleges. With global medical student numbers expected to increase over coming years, there is likely to be more need for students and postgraduate learners to be equitably taught across disparate and varied clinical sites to achieve the same learning outcomes.

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