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Original Research

Simulation in surgical training: Prospective cohort study of access, attitudes and experiences of surgical trainees in the UK and Ireland

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ABSTRACT

Background: Surgical training is evolving, and simulation is becoming more important as a way to expedite the early learning curve and augment surgical techniques. With novel technology, and innovation, major changes are possible in how surgeons are trained. The integration of these concepts into the surgical curriculum may drive up educational standards and enhance patient safety. This survey sought to determine surgical trainees views on the current place of simulation in surgical training and explore their vision for the future.

Material and methods: This is a prospective, questionnaire-based cross-sectional study by *** and the ***, England. Surgical trainees were surveyed about their experiences of simulation during their training through an electronic questionnaire distributed in the UK and Republic of Ireland through mailing lists of RCS and ***. Quantitative and qualitative research methodology was used.

Results: Of 462 surveys submitted, a total of 323 were fully completed and included in the analysis. Core Surgical Trainees represented 28.4% of respondents. The vast majority of respondents (98.9%) considered that simulation training was important, however 55.0% felt it was delivered inadequately. 86.2% wanted greater access to simulation training: Less than half of respondents had access to simulation training at their current place of work or had simulation incorporated into their formal teaching programme (42.4% and 41.6% respectively).

Conclusion: This study highlights the importance of simulation to trainees. Delivery and accessibility of simulation training varies widely. We highlight areas for improvement and best practice. In a culture of accountability, where patient safety is our highest priority, a "see one, do one, teach one" approach to training is no longer appropriate; instead we must utilise available simulation tools to augment learning.

1. Introduction

The growth of technology for simulation and reduced time for surgical training [1] has thrown simulation into sharp focus. In the context of an NHS looking at rationalising procedures [2] and the limits placed on working hours [3], the question of how we train future surgeons in a cost effective, time effective and safe way is a source of much debate and study. In a culture of accountability, where patient safety is our highest priority, a "see one, do one, teach one" approach to training is no longer acceptable. In order to ensure excellence and promote the highest standards of surgical care, simulation must be utilised, encouraged and embraced in the modern era.

The *** (***) is a professional body and registered charity working to promote excellence in surgical training for the benefit of junior doctors and patients alike. With a membership of over 2000 surgical trainees from all ten surgical specialities, the association provides support at both regional and national levels throughout the United Kingdom and Republic of Ireland. Originally founded in 1976, *** is independent of the National Health Service (NHS), Surgical Royal Colleges, and speciality associations. Governed by an elected Executive and Council, the association is run by trainees for trainees. This study aimed to quantify needs, access, and exposure to simulation in contemporary UK surgical practice. We explore the attitudes of surgical trainees to simulation in their training and highlight areas of excellence or barriers to their utilisation in training.

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1.1. Simulation in surgical training

Simulation within surgical training and practice is defined as any activity that aims to imitate an environment in order to inform, modify or assess skills and behaviours [4]. Simulation-based medical education involves the re-creation of real-world clinical problems. This provides learners with the opportunity to develop and to hone skills through experiential learning, within an environment that promotes reflection and ensures patient safety [5–7]. The effectiveness of simulation training and the transferability of simulated skills to the real-life operating theatre have been verified by a number of systematic reviews [8,9] Surgical simulation encompasses both low- and high-fidelity models, such as dedicated wet or dry simulation labs, simulation within working theatres, simulated-patient role-play, computer-based simulators, box-trainers, and basic suturing models. Cognitive simulation training has also been shown to be beneficial in surgical skill development and maintenance, as well as improving stress levels whilst operating [10]. Over recent years simulation training has gained increasing attention in the literature with over 30 randomised controlled trials studying surgical simulation having been published [11]. Studies have shown it can be effective for the acquisition of both technical and non-technical skills (such as decision-making and team-working) and have shown transferability to real-life operating theatres and ward environments [4,8,9,11,12]. Consistent standards of practice have been shown to improve patient outcomes and therefore simulation has a key role in both ongoing training of healthcare professionals and performance assessment, with the ultimate goal of enhancing quality of care and patient safety (13). The Joint Committee on Surgical Training (JCST) agreed to integrate simulation training into the Intercollegiate Surgical Curriculum Project (ISCP) across all specialties within UK surgical training from 2012. However, due to concerns about equity of access, simulation has not been mandated in surgical curricula [14].

2. Methods

2.1. Questionnaire design & distribution

A novel 44-item questionnaire survey was developed by *** with RCS England, consisting of free text, binomial and five-point Likert scale responses. The questionnaire was designed with reference to previously published guidelines on questionnaire-based research. The survey tool was peer reviewed by consultant trainers and senior trainees and piloted by *** council, prior to distribution. Content validity was ensured by this peer review and piloting process. The feedback received was used to refine the question items. Individual question items were compulsory. No individually identifiable information was collected (eg, email address); therefore, non-responders could not be identified for follow-up. No incentives were offered for participation. Data is reported with reference to the STROCSS checklist [15] The study was registered with Open Science Framework [16] and Clinical Trails.gov PRS: Protocol Registration and Results System.

A link to the online survey (SurveyMonkey.com, LLC, Palo Alto, California, USA) was distributed to members of the *** (***) and RCS mailing lists in compliance with GDPR. Data collection took place from January to May 2018. The ethical dimensions of this non-mandatory, anonymous evaluation survey were considered, and no concerns were identified. Completion of the questionnaire was taken as implied consent to participate in this study.

2.2. Data analysis

Only fully completed questionnaires were included in the analysis. Microsoft Excel (Microsoft, 2010, Redmond, Washington, USA) was used to calculate descriptive statistics. Statistical analysis was performed using SPSS (v25.0) and statistical significance was accepted at $p < 0.05$. Significance testing was performed using $\chi 2$ test for non-parametric binary data.

Qualitative analysis was performed on the free text comments using an inductive thematic analysis approach [17]. The survey was imported into Nvivo 11 Pro for Windows (QSR International Pty Ltd., Australia) which was used to organize and support the coding process [18]. An initial coding framework was generated (DN). Using a reflexive approach, researchers collaboratively reviewed and considered initial coding and preliminary themes. Through further reflexive discussion, these themes were refined, defined and named. Illustrative examples were selected for inclusion in this manuscript.

3. Results

3.1. Demographics

Of the 2000 members surveyed, 462 surverys were submitted. A total of 323 were fully completed and included in the analysis. 55.2% of respondents were male and 44.8% were female. Training level of respondents ranged from Medical Student to Post-CCT Fellow, with the largest percentage being Core Surgical Trainees (28.4%). Respondents were from all training regions within the UK and ROI and represented all 10 surgical specialties. Overall, 30.5% of respondents were working in general surgery (30.5%)., however, 76% respondents who fell in the ST6-8 category and 58% of ST3-5 respondents listed General Surgery. Most respondents were non-academic (91.1%), non-military (98.5%), full-time (96.3%) trainees and over half (58.0%) worked in a University Teaching Hospital. Fig. 1 shows respondents by region and training grade.

55.2% of respondents were male and 44.8% were female.

3.2. Simulation: trainees' attitudes & needs

The vast majority of respondents (98.9%) considered that simulation training was important, however 55.0% felt its current form was inadequate. When compared to e-learning, respondents considered simulation substantially more useful (46.7% ranked simulation as "most useful" versus 5.1% ranked E-learning as "most useful"), but not significant through statistical analysis.

Simulation was considered most comparably useful for teaching technical skills (51.12% ranked "most useful"), followed by human factors (29.65%) and procedures (23.49%) and human factors. Simulation was thought to be easier to provide for junior trainees by 42.4% (versus 27.5% who disagreed with this notion), whereas a clear majority (64.2%) agreed that said high fidelity models were needed for more senior trainees (versus 9.74% who disagreed). Looking specifically at those respondents who were in training programs, this is correlated with 41.4% of Higher Surgical Trainees rating simulation as least useful for procedures versus 20.2% of Core Surgical Trainees. It was interesting to note that of only 4 respondents who did not feel that simulation training was important for training, the majority [3] were senior specialty registrars of training grades ST6-8, two of which elaborated on their answers with the following free text responses: *"There is a role for core/early training but I do not believe current options are helpful for senior training"* and *"It is difficult to access and far removed from reality"*.

The preferred access formats for simulation training were ad hoc sessions within their own hospitals or pre-arranged allocated periods of training, such as regional full day sessions. 39.0% of respondents ranked ad hoc sessions in their current places of work as the "most useful"; and 52.0% of respondents ranked a pre-arranged regional full day simulation session as the "most useful" (Fig. 2) Home-based options were seen as less ideal, with over 61.3% of respondents ranking these the "least useful" format of simulation training deliver. When asked how frequently simulation training should be delivered in a formal teaching programme, more than half thought this should be monthly or more often (58.4%), 33.0% considered that every few months was

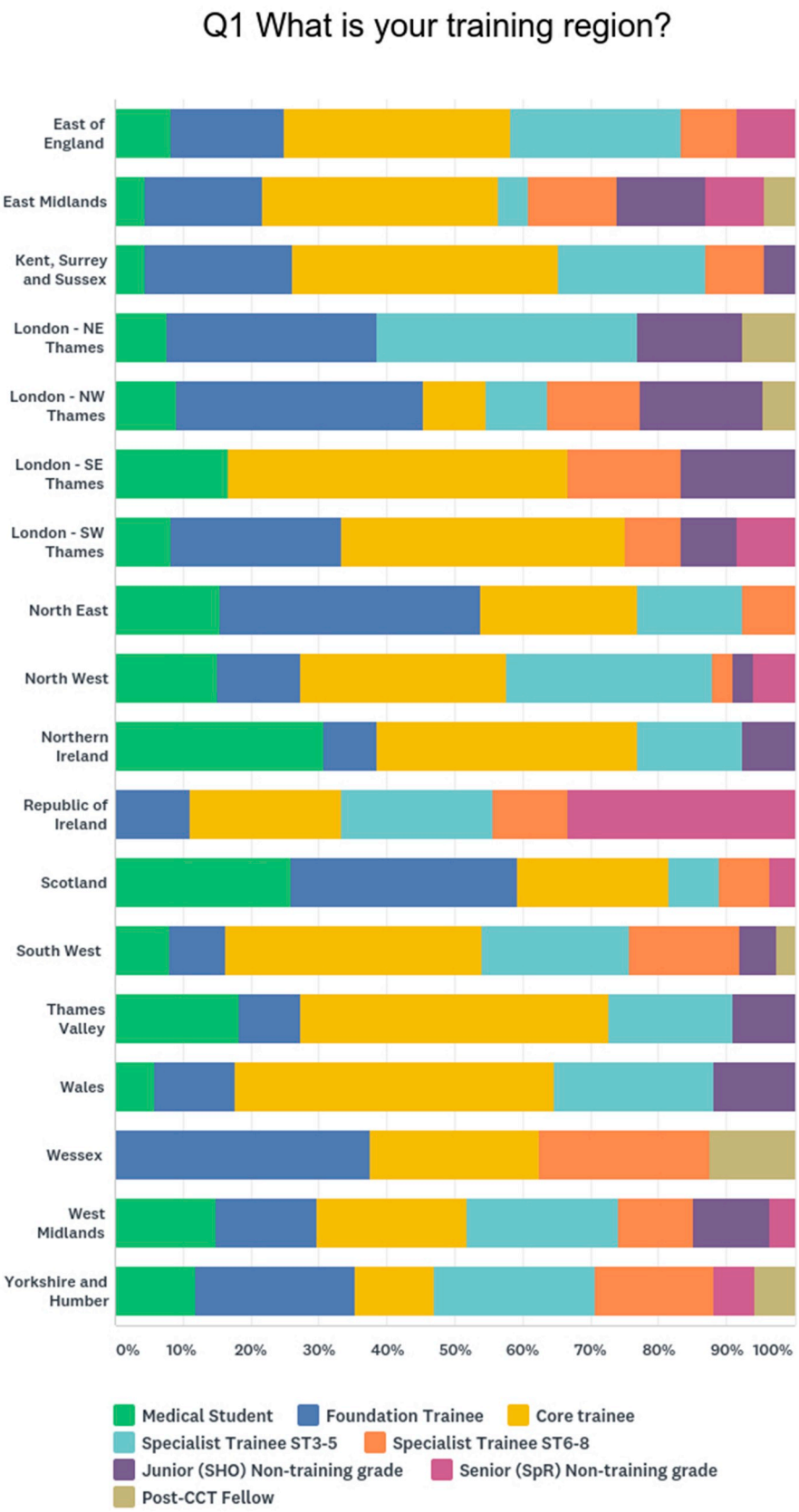

Fig. 1. Showing the geographical distribution and stage of training of respondents.

adequate and only 8.6% thought that less frequent formal simulation training was acceptable.

Overall, the simulation methods considered "most useful" were ex vivo animal tissue (70.8%), box simulators (69.6%) and watching live operating (61.0%). Of note, these three preferred methods correlated with the three methods that respondents had most exposure to (Fig. 3).

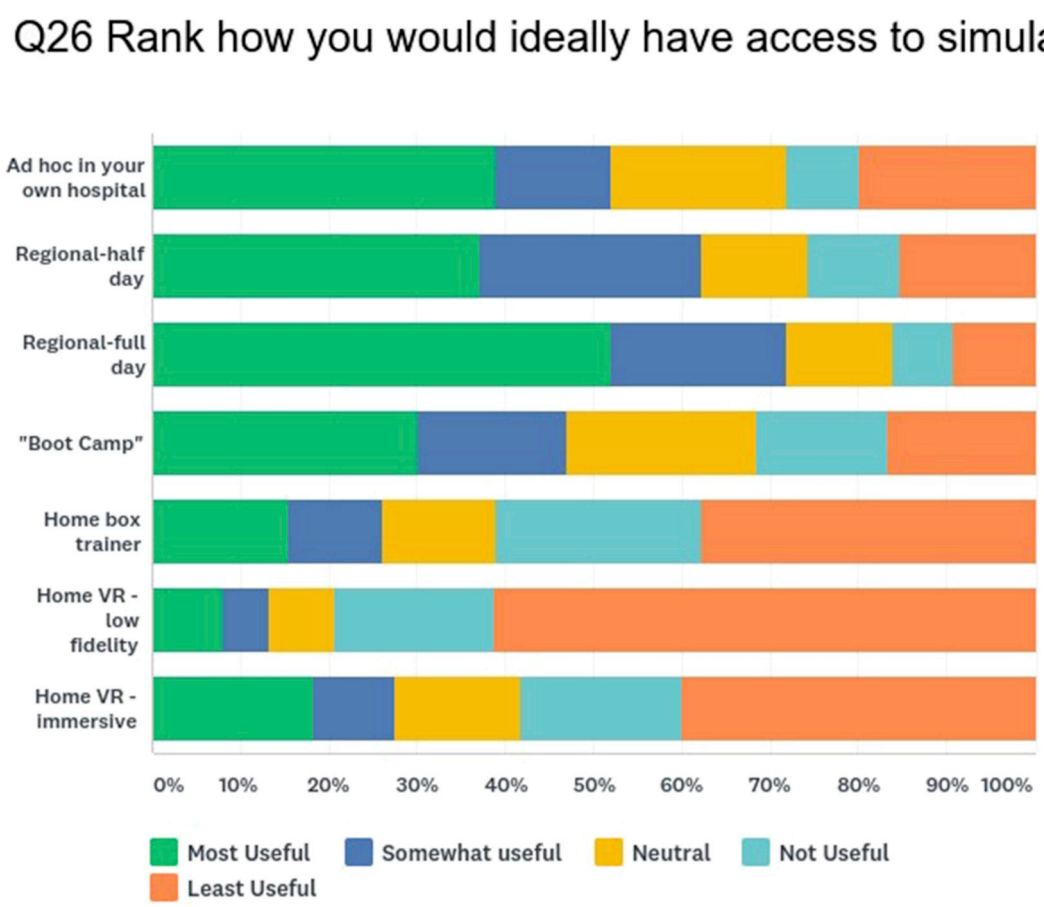

Fig. 2. Showing how often respondents of different levels of training felt simulation training should be delivered.

Trainer feedback was considered an important aspect of simulation training: 99.71% said it was important to receive trainer feedback when undertaking simulation and 64.9% felt it was essential. Face to face was considered the most useful form of feedback (89.1%).

3.3. Simulation access & funding

The majority of trainees wanted greater access to simulation training (86.2%). Fewer than half of the respondents had access to simulation training at the hospital in which they work (42.4%) and only had simulation incorporated into their formal teaching programme (41.6%). More than two thirds of senior trainees (ST6-8) did not have any simulation incorporated into their formal teaching programme (69.7%). Only half of the respondents reported simulation training access within their region (52.9%). In the worst performing region with regards to simulation training access, 27.3% of respondents reported no access to simulation at all. In a better performing region, 84% of respondents had access to simulation at pre-defined times. The gold-standard for simulation training would be considered unlimited access. The best performing region for access managed this 15% of the time. Most trainees did not have access to any form of home simulation training (86.3%) and of the few who did, most incurred a personal expense (64.8%). The most frequent forms of simulation delivered in training regions were box simulator models (50.1%), human factors training (24.9%) and ex vivo animal tissue (20.9%), although 20.2% of respondents reported no access to any form of simulation. Of note, more than half of the respondents had had no experience of Virtual Reality in either high- or low-fidelity forms (56.7% and 55.6% respectively). Those with access to simulation reported that this was funded by the training programme in 58.7% of cases, it was self-funded in 38.1% of cases, funded by industry in 11.2%of cases, and a combination of these sources in 16.3%.

3.4. Simulation qualitative findings

Analysis of the free text comments provided to this survey revealed three major themes: Feedback, integrating simulation into training and new technology.

- **Feedback:** Trainees were asked specifically for comments regarding feedback after simulation training. Feedback was considered crucial to the learning experience. The advantages of face to face and remote feedback were evaluated. Personalised feedback which facilitated questioning and prompted reflection was appreciated. Real time trainer feedback was considered very important for improved performance. Remote feedback using metrics allowed tracking of personal performance and peer ranking. Competition was considered both motivational and detrimental.
- **Integrating simulation into training:** This theme represents the attitudes of trainees as to the importance, timing and availability of simulation training, as well as its position in the surgical syllabus. One trainee commented on its increasing importance *"given the relative decrease in actual operative opportunities"*. Another identified preparing for theatre through simulation as a method of *"generating the maximum potential for learning from the operating theatre experience"*. Adequate or protected time for simulation was a concern of many respondents. On-site availability was considered highly desirable, other options included deanery based simulation centres and simulation laboratories.
- **New technology. New roles:** Trainees were keen that new technologies including robotics, artificial intelligence and Virtual Reality were adapted and adopted for simulation in surgical training. The

Fig. 3. Showing how different levels of trainees rated different methods of delivering simulation training.

need for and potential of simulation in human factor training was highlighted.

"The true value of simulation has been missed in surgery … Developing leadership, situational awareness, decision making and communication skills, particularly in emergency and difficult situations has far more to do with positive patient outcomes and allows trainees to develop technically far more easily. Simulation could be a cornerstone of this type of training".

4. Discussion

4.1. The important role of simulation in training

Simulation training was highly regarded and sought after by trainees in this study, who desired greater access and exposure to it, and found it considerably more useful than E-learning. The literature demonstrates that simulation has a key role in both ongoing training of health professionals and performance assessment [13]. Simulation was regarded by trainees as valuable for learning individual technical skills, procedures, and non-technical skills. The literature supports this, showing simulation can be used to demonstrate and evaluate technical and non-technical skills, such as decision-making, communication skills and team-working. Operative skills can be learnt using a wide variety of simulated high- and low-fidelity models, including dedicated wet or dry simulation labs, simulation within working theatres, computer-based simulators, box-trainers, and basic suturing models. Most respondents in this study reported exposure to a range of simulation modalities, however the most common forms trainees had access to were box simulators, human factors training and ex vivo animal tissue. The least experience was in low- and high-fidelity Virtual Reality simulations, however qualitative analysis revealed that there was a significant appetite among trainees for integration of new technologies in order to improve simulation in surgical training. Regarding forms of simulation training, the literature suggests that low-fidelity training models can be particularly cost-effective and enable technical skill, but the mastery required for higher surgical trainees requires high fidelity simulation [19]. This was supported by our findings: Most trainees agreed that higher fidelity simulation models were necessary for more senior trainees and one senior trainee specifically commented that although they felt that there was a role for simulation in early training, current simulation models available were not helpful for senior training. Since simulation eliminates the need to expose real patients to learners, it is low-risk. Skills can be gained in a safe environment that promotes reflection without the risk to the patient of an inexperienced trainee in a highly pressurised or emergency situation [20].

4.2. The lack of access to simulation in training

Insufficient access to simulation training was a key finding. Since consistent standards of practice have been shown to improve patient outcomes [21], a lack of access to simulation training or integration into formal teaching programmes is concerning: Nearly half of respondents either had no access to, or were unsure of their access to simulation in their region, and a fifth of respondents reported no access to any form of simulation at present. Universally trainees were noted to have limited experience of Virtual Reality (VR). VR has barriers including initial setup cost and cost of consumables and maintenance is high, and it is not possible to simulate each and every learning task and many complex clinical scenarios, which we postulate as reasons for the limited experience [22] Of those who did have access, over a third were self-funding access. A sixth of respondents had no experience of one or more simulation modalities. Although the preferred access formats for simulation training were based in trainees' places of work, fewer than half had access to simulation at their current hospital. In light of the fact that the JCST incorporated simulation into the intercollegiate curriculum across all specialties within UK surgical training from 2012, the deficiency of universal consistent access to simulation training is worrying. It was particularly concerning, to find that the most senior trainee respondents (ST6-8) did not have any simulation incorporated into their formal teaching programme [14]. This is not for lack of

appetite: Respondents expressed a clear desire for frequent formal simulation training delivery, with over half wanting this to be monthly or more frequently. Lack of time for and access to simulation were also highlighted through qualitative analysis.

4.3. Importance of feedback in simulation training

Feedback is well-recognised within the medical education literature as playing a crucial role in the experiential learning cycle [7,23]. The value of feedback in maximising the learning opportunities offered by simulation is an important factor highlighted in our findings. Almost universally, trainees considered trainer feedback as important and two-thirds thought it essential. This is an important consideration when planning simulation training delivery, as it may not be sufficient to simply "set up" a simulation lab for self-directed access: The fact that face-to-face feedback was considered most useful and real-time trainer feedback considered important for improving performance has substantial implications for resources in terms of trainer availability and time.

4.4. Study limitations

This study has limitations which must be considered when interpreting the results. Whilst the survey is largely representative of the *** membership and respondents represent the breadth of all 10 surgical specialties and all grades of training, as only a quarter were higher surgical trainees. Therefore, results should be set in context of the majority of respondents representing junior grades of training (Core Trainees, Foundation Doctors and Medical Students). We have highlighted the results from those who are in surgical training programs, comparing core trainees and specialist trainees. Only 323 surveys were completed and used as a representative sample of over 4000 surgical trainees in the UK [24]. It should also be noted that over 30% of respondents were not currently enrolled in an official surgical training programme. Positionality of the researchers must be acknowledged in qualitative analysis. Our individual training experiences and involvement with *** Council and RCS lead to personal and intellectual biases which may influence our engagement with and interpretation of the qualitative data [25]. Collaboration and reflexivity during the process was used to maintain the rigour of the process. Full disclosure and description of our affiliations maximise the credibility of this manuscript.

5. Conclusion

Surgical education is evolving: Time for training has reduced; technology is advancing; and demands for the highest standards of patient safety and accountability are increasing. The traditional "see one, do one, teach one" approach to surgical training is no longer sufficient nor acceptable. In this modern era, simulation has a vital role to play, both in expediting training and ensuring patient safety.

Previous studies have demonstrated the efficacy of simulation in surgical training, and the JCST has embraced the concept, integrating it into UK surgical curricula. This study demonstrates that there is high demand for simulation among UK surgical trainees, who consider it valuable for the acquisition and honing of technical and non-technical skills. However, this study has also demonstrated that significant barriers to its access persist.

Training programmes across the UK still have some way to go towards integration of simulation into all aspects of surgical curriculum delivery. To improve access to simulation training, frequent integration of simulation into formal training programmes throughout the UK is needed. Wherever possible, simulation training opportunities should be made available to trainees in their own hospitals and should be accompanied by face-to-face trainer feedback to maximise potential for improving trainee performance.

There is a growing appetite among trainees for integration of new technologies into their surgical training to improve simulation opportunities and quality. Further study into the application of innovation and novel technologies to enhance the utility and fidelity of simulation training is recommended in the pursuit of the highest standards of surgical training, and ultimately, to improve the delivery of safe, effective patient care.

Ethical approval

Nil required.

Sources of funding

None.

Author contribution

R. Nicholas: Survey reviewing and editing, formal analysis, original draft, reviewing and editing.
G Humm: Conceptualisation, Data curation, Methodology.
K MacLeod: original draft, formal analysis reviewing and editing.
J Glasbey: reviewing and editing.
C Fleming: reviewing and editing of survey and of paper.
A Horgan: Supervision, Visualisation and Validation, Conceptualisation, Methodology.
JM Clements: reviewing and editing.
S Bathla: reviewing and editing.
D Nally: Qualitative methodology and data analysis.
HM Mohan: Supervision, Conceptualisation and Validation, Methodology, reviewing and editing.

Conflicts of interest

None.

Research registration number

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Provenance and peer review

Not commissioned, externally peer-reviewed.

Data statement

The individual responses are not available in order to preserve survey responder anonymity and confidentiality.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijsu.2019.04.004.

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