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A review of UK undergraduate surgical curricula and teaching methods with an analysis of the university of Dundee (2011–2021)☆

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ABSTRACT

Introduction: This review discussed the current state of undergraduate surgical education in UK medical schools with focus on changes over the previous decade (2011–2021). An analysis of theatre etiquette and basic surgical skills (BSS) courses from the University of Dundee undergraduate curriculum was also undertaken, with comparison to the literature.

Materials and methods: A PubMed search using the quire "(undergraduate) AND (medicine) AND (Surgical) AND (teaching) AND (UK)" returned 155 publications. These were screened for relevance to yield the 100 publications discussed in this review. Analysis of student feedback (2016 – 2019) was carried out for BSS and theatre etiquette courses.

Results: There exists a lack of consensus around the undergraduate curricula with extreme variation in teaching and clinical exposure by speciality and medical school. These are aided by the widespread adoption of simulation-based learning and non-technical skills teaching. Most teaching is conducted in transitional programmes to prepare students for surgical attachments with skills teaching focused on fourth- and fifth-year students. Scrubbing, gowning, gloving, and suturing are all often taught briefly and inconsistently with little follow up.

A wide variety of novel techniques including near peer assisted, targeted basic surgical skills (BSS) courses and student opportunities, including mentorship and conferences have been found to be effective but are often limited to a single institution.

Conclusions: Consensus amongst the existing literature highlights an urgent need for reform of surgical education to ensure patient safety and graduate competency. The University of Dundee runs a theatre etiquette and BSS courses which produces results which indicate a high degree in confidence subjective outcomes. There is a wealth of subjective and non-specific data with infrequent objective comparison between modern teaching modalities. The deficiency of undergraduate surgical teaching presents an opportunity to re-establish curricula using significantly more effective non-technical, near-peer, and simulation teaching modalities.

Introduction

Within UK medical schools, the undergraduate MBChB course is composed of 2 strands: the Bachelor of Medicine, and Bachelor of Surgery. Most surgical training is completed via intensive postgraduate training programmes over the course of a decade or more. However, initial teaching of core surgical skills, including suturing, aseptic techniques, and supervised assistance, are provided at undergraduate level. Currently the undergraduate surgical training programme is substantially smaller than its medical counterpart in content and practical exposure [1].

The Royal College of Surgeons of England released the "National Undergraduate Curriculum in Surgery" in 2015, focusing on 35 key conditions and skills to form a standard minimum surgical teaching curriculum in line with requirements from the General Medical Council's "Outcomes for Graduates" [2], formerly "Tomorrow's Doctors" [3]. These outcomes fall into 4 broad categories: surgical knowledge, practical skills, non-technical surgical skills, and patient safety. There is little

List of abbreviations: BSS, basic surgical skills; SBL, simulation-based learning; GMC, general medical council; RCSENG/ RCS (England), royal college of surgeons of England; NHS, National Health Service (UK); DOPS, Direct Observation of Practical Skills; OSCE, Objective Structured Clinical Examination.

☆ This work was completed by a student and staff associated with the University of Dundee. No additional financial compensation was awarded for completion of this work. No other conflicts of interests.

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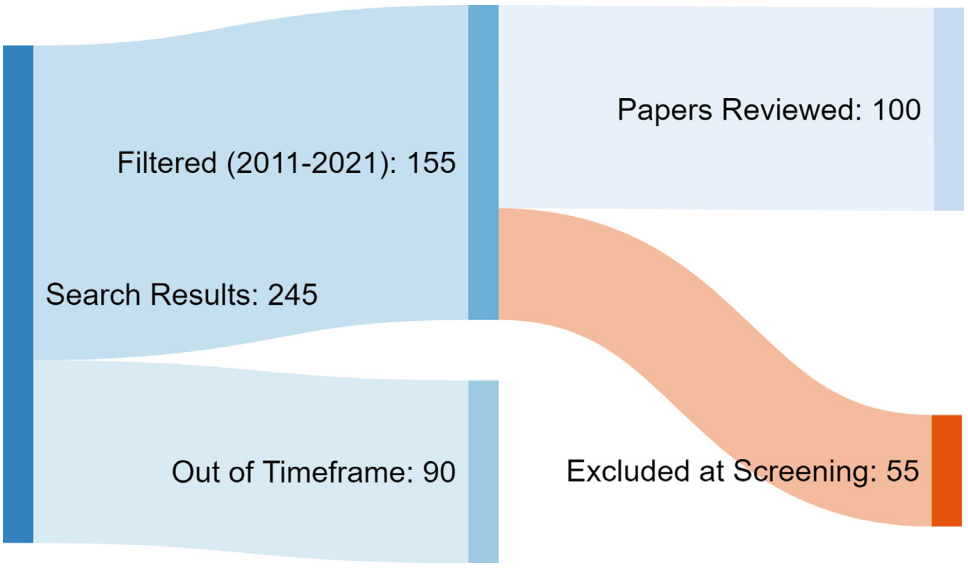

Fig. 1. Flowchart of literature review structure.

disagreement of the need of surgical education; however, a striking lack of consensus on the detail of these topics and their delivery exists.

This review discussed the current state of undergraduate surgical education in UK medical schools with a focus on changes over the previous decade (2011–2021). An analysis of theatre etiquette and basic surgical skills (BSS) courses within the University of Dundee undergraduate curriculum was also undertaken.

Materials and methods

This review collected publications of a variety of study designs and institutions from across the UK completed between 2011 and September 2021. PubMed was searched with the following query: "(undergraduate) AND (medicine) AND (Surgical) AND (teaching) AND (UK)" [appendix A] with filters: From 2011 to 2021. From the 155 resulting publications collected, 55 were excluded at screening due to the lack of relevance or for the use of data collected prior to 2011 (Fig. 2). 100 papers were reviewed to produce this report. Additional publications were included where relevant for supporting discussion or relevance of the collected papers.

Results

Curricular content and teaching methods

Practical surgical skills teaching most frequently centres on preoperative sterilisation protocols (gloving, gowning, and scrubbing) and basic surgical skills (BSS) including suturing, the use of local anaesthesia, and very basic procedures. Non-technical skills, focusing on stress management, communication, and decision making are taught less often. Nationally, of 23 medical schools, 73.8% taught gowning and gloving, 29.4% taught instrument handling, 17.4% taught knot tying, and 24.7% explicitly taught suturing. Only 4.3% taught skills beyond those previously mentioned. The median group size for the typically consultant-led session was 18 [4]. Teaching is predominantly focused within senior years and provided through a mix of self-guided, tutor-guided, lecture, and video methods [5]. Wet and dry labs are often utilised with non-significant differences seen between them [6]; however for suturing, it was most beneficial to have one-to-one tutoring by a tutor of the same handedness [7].

Simulation based learning (SBL) is a frequently used method of training focused on creating a more relevant environment for a skill to be practiced in [8]. Over the past decade, simulation has become more a mainstay of contemporary medical education used in the design of new courses due to its flexibility in group size, setting, and course aims. This new pillar of medical curricula should not be seen as an effective replacement for either traditional lecture or clinical teaching models, but as a tool for bridging the divide between the two and the initial safe development of surgical skills [9]. The SBL design framework highlights the different options available to skills units in course development and can aid in comparison of similar and varied course structures [10]. SBL settings can vary from simulation wards for clinical decision making or wet labs for surgical skills practice.

Surgically relevant anatomy teaching is crucial to the safe understanding of procedures. More broadly, a strong radiology [11] and embryology understanding can give context to pathophysiology and surgical landmarks [12]. The use of 3D-prints of cadaveric specimens can aid procedure specific anatomy in settings outside of wet labs [13]. Since 2006, surgery on cadavers has been legal and seen use in postgraduate education (fresh-frozen cadavers) and further expansion of surgical skills to undergraduates may be beneficial [14]. However, the use of cadavers is most effective in teaching of surgical skills to postgraduates, due to a comparative wealth of prior knowledge [15].

The improvement in technology over the past decade has seen the adoption of high-fidelity virtual reality (VR) surgical simulation training modalities. An app-based interactive simulator for cardiac surgical procedures was found to be a significantly more effective method for undergraduate learning compared with traditional reading [16]. Additionally, this improved VR fidelity allows surgical videos for trainee or undergraduate education which could provide an immersive remote additional teaching method [17]. Though SBL techniques often improve student performance, due to their variety it can be difficult to determine significant differences compared to standard practice depending on their implementation [18]. SBL may be able to enhance opportunities for students to repeat tasks independently, which is also a cost-effective teaching tool [19].

Table 1
Distribution of selected papers by year.

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Papers	6	5	7	5	11	13	9	10	4	18	12

Table 2
Areas of focus, methods and findings of various workshops and short courses.

No.	Area of Focus	Methods	Findings
1	Suturing	A 1-day suturing course followed by low-cost kits to take home allowed further practice, technique development, and skills retention.	Short term benefits were seen but not beyond current practices. Study of the long-term effects of practice is still to be completed [29]
2	Acute Management	A workshop for recognition and management of the acutely unwell surgical patient.	Increased confidence in assessment (from 2.5/5 to 4.4/5) and beginning initial management protocols (from 2.7/5 to 4.1/5). MCQ scores improved. Improvements were also retained over 8 weeks. (Both $p<0.001$) [30].
3	Non-Technical Skills	simulation-based workshops with student assessment via the individual teamwork observation and feedback.	tool improved performance in trauma cases by 0.81/3 and by 0.88/3 in ward round scenarios. [31].
4	Basic Surgical Skills	KCL integrated a BSS SBL course into their undergraduate curriculum as 96% of students agreed pre-rotational work was essential.	There were significant improvements to knowledge and performance ($p<0.01$) and as such was recommended for wider adoption by other schools [32].
5	Basic Surgical Skills	KCL also integrated a separate laryngeal airway masque SBL workshop	The workshop was useful; however, extending the duration did not correlate with further improvement of outcomes [33] with recommendations for staggered revision workshops to be used instead.
6	Basic Surgical Skills	Introduction of an additional 3-day mixed SBL surgical skills course.	Increases all objective outcome measures in students [34].

Additionally, improved knowledge of non-technical skills has informed the design of some new workshops and courses to train students on the 3 main factors of non-technical skills of the surgeon: social skills like teamwork and leadership; cognitive skills relating to situational awareness and decision making; personal skills in managing stress and fatigue which is least frequently taught [20]. This recently established area of research has been integrated into national curricula and is often considered in the design of new courses; however local adoption remains limited.

A successful model example of simulation and non-technical skills implementation can be seen in the integrated generation 4 (iG4) course development framework composed of 4 key factors: core learning, case-based learning, basic sciences education, and soft skills workshops. This has been found to improve both technical and non-technical surgical skills outcomes through the systematic application of various modalities of SBL [21]. iG4 is rated 4.73/5 on the Likert scale with 92.7% of students wanting it as an essential part of the curricula [22]. In a separate use, MCQ scores increased by 2.33/32 ($p<0.005$) and DOPS were improved ($p<0.005$) [23], showing the efficacy of this new design over existing educational standard practices. Adoption of the iG4 framework nationally would allow creation of a reproducible and standardised portfolio of surgical skills for continual assessment of students [24]. Furthermore, iG4 is a validated method and recommended for teaching of holistic skills, dataset development and improving the motivation of students towards surgical careers [25].

In microsurgery, SBL with automated analysis is highly effective at generating personalised feedback with the ability to accurately differentiate skill level from undergraduate to expert [26]. Studies revealed the predominant negative performance factor in undergraduate microsurgery skills is self-perceived anxiety rather than physiological tremor [27] and performance is not impacted significantly by choice of speciality at undergraduate level [28]. This supports increasing focus on emotional management as a crucial non-technical surgical skill alongside SBL rather than continued practice alone. Microsurgery is rarely taught due to difficulty of technical skills required and a steep learning curve; however, SBL is typically used when this is attempted [29].

A variety of short courses focused on specific skills have been trialled across the UK with an incomplete list described in Table 2. These courses can provide focused training on a specific topic witha typically very successful, but varied effect. However, they are limited in scope and training volume by practical limitations. These courses cannot replace the integration and commitment to a bolstered surgical strand within the undergraduate medical curriculum.

Peer-assisted learning (PAL), where students are taught by senior students or junior doctors closer in career progression, enhances surgical skills competence with a less stressful environment [35]. 87% of students surveyed found it increased desire in a surgical career and mean no. of sutures completed in a session increased ($p<0.001$) and inter-suture distance halved (+/- 4.7 mm to +/- 2.6 mm) [36]. This training is cheap, not staff intensive and could be used more frequently following its effective utilisation within surgical societies. Final year surgical assistantships can benefit from near peer teaching with improved preparedness for surgical FY roles [37]. A survey found PAL is an effective and feasible method that improves student confidence in technical skills by between +2.99 and +6.53 out of 10 on Likert scales [38]. The University of Keele used informal PAL in teaching of BSS with positive feedback from all involved [39]. Sessions like these can be facilitated either by the medical school or student surgical societies, however review of peer tutors should be undertaken to assure teaching quality.

Teaching of specialist knowledge

Each speciality is best suited to being taught differently, focusing on different relevant anatomical challenges and techniques. Orthopaedics was one of the most taught areas with an average of 3 weeks of teaching, yet still relatively underrepresented in undergraduate curricula compared to frequency of complaints in primary care. The keystone procedure of open rotation and internal fixation is rarely taught in sufficient detail for students to advise patients [40]. Visualisation is important in orthopaedics, hence the use of VR is a particularly useful adjunct for teaching beyond physical models [40], showing significant improvements over traditional methods for intramedullary nailing teaching [41]. Cognitive task analysis aided development of a multimedia tool for the same procedure more effectively than standard manuals in a randomised double-blind trial [42].

In neurosurgery, traditional teaching is supplemented by SBL practical workshops with a focus on wet labs which have been positively received and uniformly increased motivation towards careers in neurosurgery [43]. Neurosurgical Student selected components (SSCs) increased likelihood of a successful speciality application [44]. Additionally, exposure to neurosurgery conferences shifted the focus of student opinion from perceived poor work life balance to the rewarding nature of the work [45]. Another speciality which sees similar benefit from SBL is vascular surgery which often has no basic techniques taught, with students showing poor related practical skills [46]. An intensive 3-day lower leg arterial duplex scanning SBL course allowed senior undergraduates to gain practical results not significantly different from MSc graduates with 3 months of additional training with evidence of real-world skills transferred into continued practice [47].

A severe lack of education in, or frank omission of, certain surgical specialties is also seen. Cardiothoracic surgery was not explicitly included in most curricula and only 10% of students received placements [48]. This omission may be responsible for a worrying progressive decline in specialisation interests [49]. However, after a 1-day undergraduate course, self-reported understanding of cardiothoracic surgery

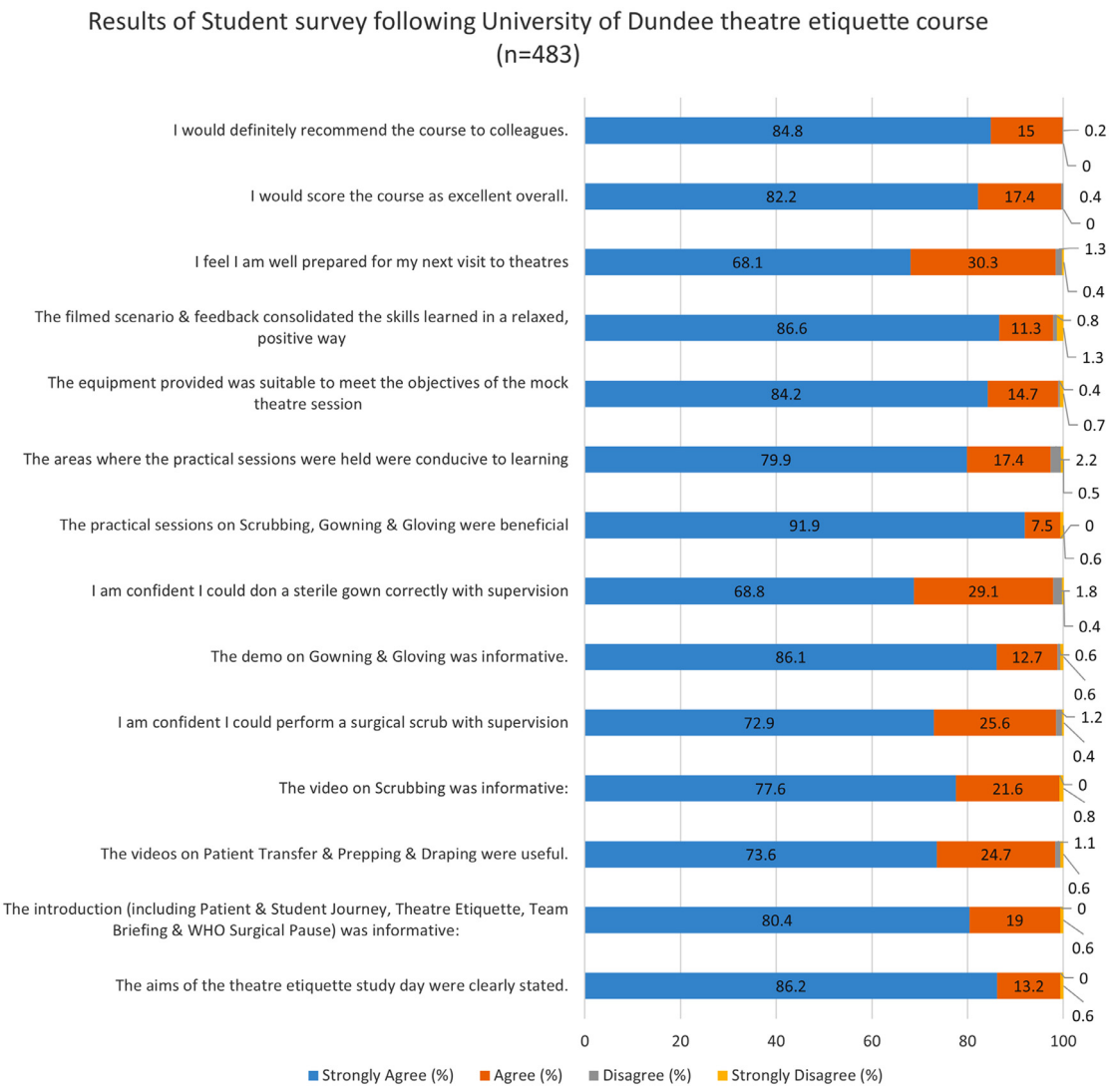

Fig. 2. Results of Student survey following theatre etiquette course (n = 483).

increased from 20% to 80% (p<0.001) [50]. Ear, nose, and throat (ENT) education composes only 1% of MBChB courses yet constitutes 25% of adult and 50% of paediatric primary care consultations. Only a minority of medical schools teach basic techniques like nasal packing and cautery [51]. 15.8% of students had no ENT departmental clinical experiences on graduation leaving 65.8% wanting further teaching [52]. As with cardiothoracic surgery, a 1-day ENT course improved perception of the speciality by up to 80% and interest in an ENT career by 77% [53]. Additionally oral and maxillofacial surgery suffers as severely with 73–75% of students having no exposure to the speciality [54], (55) and only 27% could identify key entry requirements (ex. dual-qualification); from this 76.7% wanted more exposure to this speciality [56].

In plastic surgery, only 47% of students received dedicated teaching. Increasing teaching frequency or the mandate of clinical attachments in plastic surgery have been suggested [57]. The University of Glasgow had no plastic surgery content before 2019, though the introduction of a 90-minute workshop increased perceptions of the speciality and interest of a plastics career by 2% (39–41%) [58], a further 1-day course improved student perception and confidence in the speciality [59]. Additionally, interventional radiology and its techniques were often underrepresented in medical schools compared to use in practice with 70% of undergraduates wanting further teaching in the subject. It is recommended to learn basic procedures in the final year [60].

Training is vastly inconsistent between surgical specialties in the UK, yet universally underrepresented within teaching, with standardisation efforts being uptaken only slowly. The association of surgeons in training (ASiT) consensus report 2019 [61] states that neurological, vascular, and ENT surgery are supplementary to core needs and should be taught as context only in addition to assessment of RCS mandated skills. However this standardisation must be conscious of health service pressures and their effective management [62]. It should be noted that for all surgical specialties there is no direct link between the time spent on a specific discipline and likelihood of the student specialising in it at CT1/ST1 level [63]. From this, a greater volume of effective teaching and personal mentoring throughout all specialties is the recommended method for resolving recruitment shortfalls. Supplementing this with an increased focus on individualised or student-directed learning opportunities via SSCs may allow surgically motivated students to further their education and experiences in specific fields in which they may later consider seeking a career.

Assessment of skills and other outcome measures

Many methods of assessments are currently utilised in UK medical skills teaching, the most prominent being the objective structured clinical examination (OSCE), are rarely utilised for surgical skills in end of year exams, often relegated to providing feedback on clinical skills

workshops. The direct observation of practical skills (DOPS) is an alternative assessment method to the OSCE optimised for practical skills and frequently used in workshops [64]. More specific to surgical skills is the objective assessment of surgical and technical skills (OSATS) [5] which can provide alternative metrics to measure compliance with safe and effective clinical outcomes (SECOs). These may be used as the objectives by which competence in specific skills is assessed [65]. Additionally, combining objective and standardised outcomes allow workshops that mix theory and SBL to be run more effectively, for example in mock pre-op breast clinic consultation assessments [65].

Current quality

There is a clear need to reform surgical undergraduate education to potentially improve patient safety [66]. Medical students are not currently prepared to handle ward-based distractions which can induce dangerous errors. Simulation ward training should be used in this instance, which has been shown to reduce distractive errors by 76.4% compared to a control group ($p<0.0001$) [67]. UK patient safety is also compromised by lack of undergraduate training in establishing emergency control of venous access [68]. It is evident that the current surgical education system with a focus on practical skills must be reformed to improve patient safety.

In a study of suturing, all measured competency markers were below GMC standards ($p<0.001$) with 86.5% of undergraduates ($n = 607$) reporting inadequate training and 21% paying for additional training. The students paying for additional training were more confident ($p<0.001$) [69]. This highlights a severe deficiency in the volume and quality of surgical education in the UK. On average 13.5% of undergraduates who completed curricula suture courses had confidence to suture unsupervised and only 45% of final year students were prepared to suture unsupervised due to a lack of in-vivo training and patient interaction on the topic. The median suture training time in the UK is 2 h over 5 years but surgical society membership significantly improves surgical skills due to provision of at home practice equipment and advice [19]. There is support for additional suturing and local anaesthetic training following a national survey of the percentage of final year students able to pass FY1 using DOPS as a measure of national teaching quality [70]. Separately, the use of delayed measurements should be considered as a useful tool in measuring skills retained.

Analysis of the university of Dundee

The University of Dundee, School of Medicine teaches undergraduate surgical skills from the Dundee Institute of Healthcare Simulation and

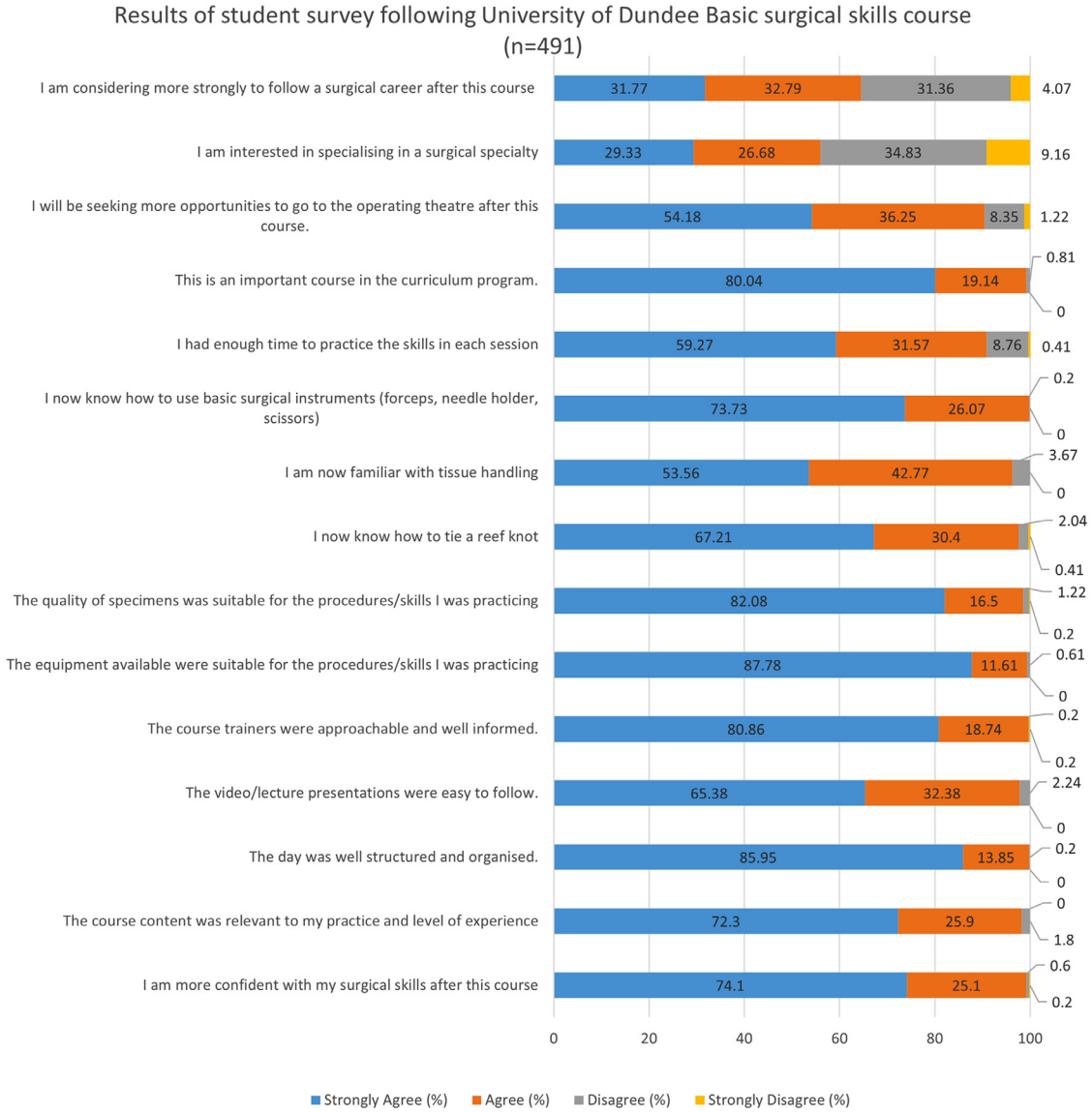

Fig. 3. Results of student survey following basic surgical skills course (=491).

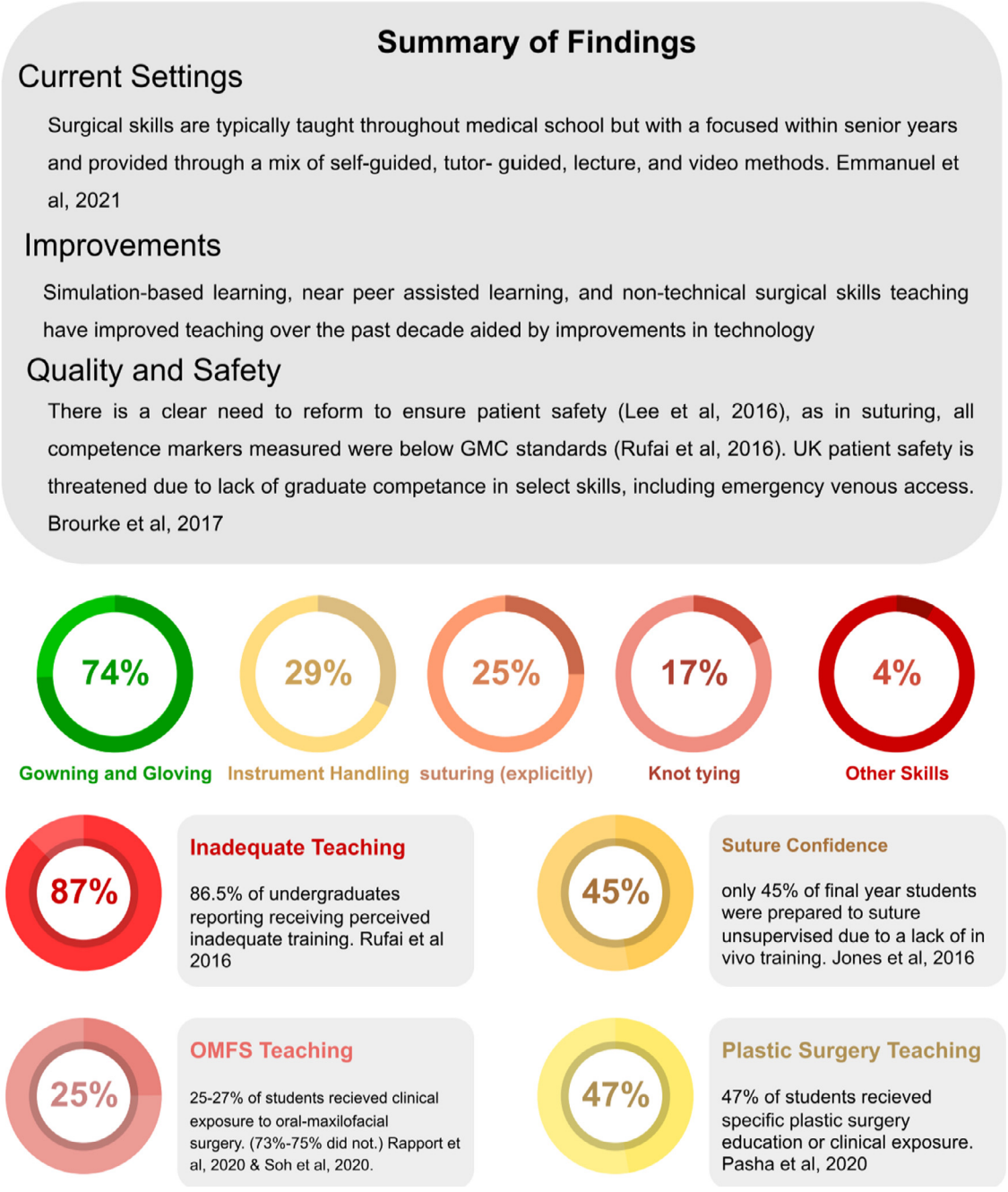

Fig. 4. Summary of Literature review findings.

the clinical skills centre, Ninewells Hospital. The majority of technical and non-technical surgical skills are taught within the pre-clinical to clinical transition block in 4th year, including theatre etiquette and basic surgical skills courses. First implemented in 2009, the theatre etiquette course aims to provide students with sufficient skills for safe observation and limited supervised assistance following concern regarding surgical infection risk carried by observing medical students. The course includes an introduction to theatre etiquette at the beginning of a case, focusing on the patient journey, team brief, and WHO pause [71]. Videos are shown to introduce students to scrubbing before demonstrations and student completion of scrubbing, gowning, and gloving. A mock theatre scenario with feedback is designed to ensure students understand and are competent in the principles of safe practice.

The one-day basic surgical skills course is structured to introduce all students to the safe handling of surgical instruments and basic surgical skills using animal tissue. It uses techniques in line with Royal College of Surgeons of Edinburgh Basic Surgical Skills Course. The course is delivered prior to clinical attachments and is funded by the 'Additional Cost of Teaching' (ACT) fund, provided by the Scottish Government to cover the additional costs of teaching medical undergraduate students within the NHS.

Following the theatre etiquette course, 483 students provided feedback between 2016 and 2019. Students indicated their agreement with statements relating to their confidence in key skills and satisfaction with the materials and content of the course (Table 3). All students surveyed were in their fourth year of studies. Similar responses were also collected from 491 students on the BSS course over the same timeframe. (Table 4).

These results indicate a high degree in confidence in scrubbing and gowning under supervision, with 98.5% and 97.8% responding that they

either agree or strongly agree they are confident to do so respectively, following the theatre etiquette course. Students also indicated strong satisfaction with the course overall as well as its content, materials, and facilities. Most frequently students believed that the theatre etiquette course would be best placed in the second pre-clinical year (49.9%) followed by fourth year – where it is currently located (37.3%). Prior to completing the course, 80.2% of students had at least one theatre experience and of those who did, 55.1% had scrubbed in and 86.3% had subsequently assisted at least once. Following the 1-day basic surgical skills course students indicated a high degree of confidence in tissue handling, instrument handling, and reef knot tying (96.33%, 99.8%, and 97.56% net positive respectfully). 64.56% of students were also more likely to pursue a surgical career.

Discussion

Though significant improvements have been made, most UK medical schools do not currently include all techniques included in national curricula produced by the GMC and RCS. As such, most students are not provided with sufficient technical and non-technical skills teaching and learning opportunities required to achieve the competence required for future safe practice upon graduation. These shortfalls are seen commonly in speciality rotations but most severely in oral and maxillofacial, ENT and vascular surgery, with basic techniques core to these specialties rarely taught.

The adoption of simulation-based learning, near peer assisted learning and expansion of non-technical surgical skills teaching has improved performance outcomes where it has been utilised and its further integration is critical to the success of undergraduate surgical education. These techniques are greatly enhanced by technologies developed over the past decade to facilitate immersive and remote learning.

A direct comparison of teaching methods between institutions is not possible due to numerous factors including differences in teaching structure, student populations, and a lack of transparency in teaching methods. Additionally, no standardised set of outcome measures exists and often institutions collect non-specific data which is rarely followed up. Many institutions collect subjective feedback on student confidence in the topic or enjoyment of the session, which may be difficult to directly correlate to objective outcome measures of practical or non-technical skills performance. Conflicting data in the literature on various topics, due to the high degree of variability of subjective outcomes, institution size and teaching focus, funding, or student preference, results in most comparative studies of educational methods having non-significant outcomes. Furthermore, most studies are not controlled or repeated, with their one-off courses of limited usefulness for national improvement. However, the student experience and objective measures of competency of final year students can provide an indication of the overall quality of education, which may be useful in the comparison of institutions.

The standardisation of surgical curricula is proposed as the key reform measure to allow comparison and improvement of teaching nationally. These efforts are not optimally supported by literature, which predominantly focuses on specific teaching modalities compared to “traditional methods”. Further trials comparing modern teaching modalities is required to determine optimal delivery of teaching. A separate key barrier to standardisation relates to the degree of independence of medical schools from governing bodies. Though assessments of schools take place throughout the year, schools are responsible for planning the volume and delivery of mandated undergraduate curricula [2]. A mandate of a short list of core simulation courses for basic surgical and procedural skills from national bodies with detailed advice on delivery that schools are required to follow may present a limited but effective standard teaching baseline for safer practice. The mandate of teaching should be used sparingly and reserved for the most essential skills only, to conserve schools capacity to further develop their curricula and conduct research.

Marked variation between undergraduates is seen in their interest, skills, and preferred learning styles. In simulation training, varied student performance complicates comparison of students holding different surgical career interests and any innate differences in practical ability therein. Similarly, the cut-off to assess a student as competent may be difficult to set. Variation between learning styles should also be considered in planning effective surgical teaching sessions and the teaching modality used. Simulation should be used as an introduction into postgraduate training in additional to further surgical teaching to bridge into practice from the lacking undergraduate in vivo surgical experiences.

Over the last 10 years, the understanding of the factors affecting surgical performance and training has seen a significant shift. The deficiency of undergraduate surgical teaching has created an opportunity to re-establish how medical students are taught surgery using the evidence-based and significantly more effective non-technical, near-peer, and simulation teaching modalities.

Declarations

Ethics approval and consent to participate:
Not relevant – no participants were involved in this paper.
Consent for publication:
Consent from all authors for submission to this journal of this final version was collected prior to submission.

Availability of data and materials

All data used in this paper has been published and was accessed via licences for journal access under the University of Dundee. Some data may be behind a paywall for individuals not associated with an institution that holds medical journal licences.

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Authors’ contributions

1 – AK Lead Author: Conducted the background research, authored the first draft, and implemented suggested shifts in direction with refinements and finalisation of the submitted version.
2 – KHI Editor: Reviewed drafts and commented on research quality and overarching aims and suitability of the paper relating to current research trends.
3 – NH Editor: Reviewed drafts and provided specific recommended additions and focus points to refine the drafts to be suitable for publication with experience of medical education research.
4 – RM Editor: Runs University of Dundee theatre etiquette course, provided raw data, and reviewed the manuscript.
5 – GH Editor: Runs University of Dundee basic surgical skills course within the surgical skills centre, provided raw data, and reviewed the manuscript.

Authors’ information

AK is studying for MBChB at the School of Medicine, University of Dundee, Ninewells Hospital, Dundee.

Declaration of Competing Interests

The University of Dundee supports the further adoption of practical, non-technical and simulation-based teaching in line with current research. The analysis of the practices of the University of Dundee was completed by a student and staff of the university of Dundee, including

the co-director of the Dundee Institute for Healthcare Simulation (DIHS) and undergraduate surgical teaching lead.

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None to be made.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.hsr.2022.100048.

Appendix

Appendix A. - Full query used to initial publications from PubMed

(undergraduate) AND (medicine) AND (Surgical) AND (teaching) AND (UK) Filters: from 2011 - 2021

(("undergraduate"[All Fields] OR "undergraduate s"[All Fields] OR "undergraduated"[All Fields] OR "undergraduates"[*All Fields*]) AND ("medicin"[All Fields] OR "medicinal"[All Fields] OR "medicinally"[All Fields] OR "medicinals"[All Fields] OR "medicine"[MeSH Terms] OR "medicine"[All Fields] OR "medicine s"[All Fields] OR "medicines"[*All Fields*]) AND ("surgical procedures, operative"[MeSH Terms] OR ("surgical"[All Fields] AND "procedures"[All Fields] AND "operative"[*All Fields*]) OR "operative surgical procedures"[All Fields] OR "surgical"[All Fields] OR "surgically"[All Fields] OR "surgicals"[*All Fields*]) AND ("education"[MeSH Subheading] OR "education"[All Fields] OR "teaching"[All Fields] OR "teaching"[MeSH Terms] OR "teaches"[All Fields] OR "teach"[All Fields] OR "teachings"[All Fields] OR "teaching s"[*All Fields*]) AND "UK"[*All Fields*]) AND (2011:2021[*pdat*])

Translations: undergraduate:

"undergraduate"[All Fields] OR "undergraduate's"[All Fields] OR "undergraduated"[All Fields] OR "undergraduates"[*All Fields*] medicine:

"medicine"[All Fields] OR "medicinal"[All Fields] OR "medicinally"[All Fields] OR "medicinals"[All Fields] OR "medicine"[MeSH Terms] OR "medicine"[All Fields] OR "medicine's"[All Fields] OR "medicines"[*All Fields*]

Surgical:

"surgical procedures, operative"[MeSH Terms] OR ("surgical"[All Fields] AND "procedures"[All Fields] AND "operative"[*All Fields*]) OR "operative surgical procedures"[All Fields] OR "surgical"[All Fields] OR "surgically"[All Fields] OR "surgicals"[*All Fields*] teaching:

"education"[Subheading] OR "education"[All Fields] OR "teaching"[All Fields] OR "teaching"[MeSH Terms] OR "teaches"[All Fields] OR "teach"[All Fields] OR "teachings"[All Fields] OR "teaching's"[*All Fields*]

References

[1] Royal College of Surgeons of England, *Surgery Career Paths 2021*[Available from: https://www.rcseng.ac.uk/careers-in-surgery/trainees/foundation-and-core-trainees/surgery-career-paths/.
[2] General Medical Council, Outcomes for graduates. https://www.gmc-uk.org/education/standards-guidance-and-curricula/standards-and-outcomes/outcomes-for-graduates; 2018.
[3] General Medical Council, Tomorrow's Doctors. 2009.
[4] C.R. Davis, E.C. Toll, A.S. Bates, M.D. Cole, F.C. Smith, Surgical and procedural skills training at medical school - a national review, Int. J. Surg. 12 (8) (2014) 877–882.
[5] T. Emmanuel, M. Nicolaides, I. Theodoulou, W. Yoong, N. Lymperopoulos, M. Sideris, Suturing skills for medical students: a systematic review, In Vivo (Brooklyn) 35 (1) (2021) 1–12.
[6] M. Sideris, A. Papalois, K. Theodoraki, G. Paparoidamis, N. Staikoglou, I. Tsagkaraki, et al., Introducing in vivo dissection modules for undergraduate level trainees: what is the actual benefit and how could we make it more efficient? Indian J. Surg. 80 (1) (2018) 68–76.
[7] L.F. Soriano, V. Jolliffe, A. Sahota, Hand concordance and positional preference of students when learning suturing, Clin. Exp. Dermatol. 45 (4) (2020) 456–457.
[8] M. Sideris, M. Nicolaides, J. Jagiello, K.S. Rallis, E. Emin, E. Theodorou, et al., In vivo simulation-based learning for undergraduate medical students: teaching and assessment, Adv. Med. Educ. Pract. 12 (2021) 995–1002.
[9] N. Giblett, R. Rathore, D. Carruthers, Simulating the surgical patient pathway for undergraduates, J. Surg. Educ. 74 (2) (2017) 271–276.
[10] I. Theodoulou, M. Nicolaides, T. Athanasiou, A. Papalois, M. Sideris, Simulation-based learning strategies to teach undergraduate students basic surgical skills: a systematic review, J. Surg. Educ. 75 (5) (2018) 1374–1388.
[11] K. Ahmed, S. Rowland, V.M. Patel, H. Ashrafian, D.C. Davies, A. Darzi, et al., Specialist anatomy: is the structure of teaching adequate? Surgeon 9 (6) (2011) 312–317.
[12] J. Hamilton, R. Carachi, Clinical embryology: is there still a place in medical schools today? Scott Med J 59 (4) (2014) 188–192.
[13] J.W. Adams, L. Paxton, K. Dawes, K. Burlak, M. Quayle, P.G. McMenamin, 3D printed reproductions of orbital dissections: a novel mode of visualising anatomy for trainees in ophthalmology or optometry, Br. J. Ophthalmol. 99 (9) (2015) 1162–1167.
[14] J. Nutt, R. Mehdian, I. Parkin, J. Dent, C. Kellett, Cadaveric surgery: a novel approach to teaching clinical anatomy, Clin. Teach. 9 (3) (2012) 148–151.
[15] C. Schulz, The value of clinical practice in cadaveric dissection: lessons learned from a course in eye and orbital anatomy, J Surg Educ 74 (2) (2017) 333–340.
[16] Z.E. Brewer, W.D. Ogden, J.I. Fann, T.A. Burdon, A.Y. Sheikh, Creation and global deployment of a mobile, application-based cognitive simulator for cardiac surgical procedures, Semin. Thorac. Cardiovasc. Surg. 28 (1) (2016) 1–9.
[17] K. Gallagher, S. Jain, N. Okhravi, Making and viewing stereoscopic surgical videos with smartphones and virtual reality headset, Eye (Lond) 30 (4) (2016) 503–504.
[18] A. Schertel, T. Geiser, W.E. Hautz, Man or machine? Impact of tutor-guided versus simulator-guided short-time bronchoscopy training on students learning outcomes, BMC Med Educ 21 (1) (2021) 123.
[19] C. Jones, R. Mole, M. Jones, Undergraduate suture and local anesthetic training in the United Kingdom, J. Surg. Educ. 73 (6) (2016) e169–ee70.
[20] L. Hull, N. Sevdalis, Advances in teaching and assessing nontechnical skills, Surg. Clin. North Am. 95 (4) (2015) 869–884.
[21] M. Sideris, A. Papalois, K. Theodoraki, I. Dimitropoulos, E.O. Johnson, E.M. Georgopoulou, et al., Promoting undergraduate surgical education: current evidence and students' views on ESMSC international wet lab course, J. Invest. Surg. 30 (2) (2017) 71–77.
[22] M. Sideris, M. Nicolaides, I. Theodoulou, E.I. Emin, J.G. Hanrahan, A. Dedeilia, et al., Student views on a novel holistic surgical education curriculum (iG4): a multi-national survey in a changing landscape, In Vivo (Brooklyn) 34 (3) (2020) 1063–1069.
[23] M. Sideris, A. Papalois, G. Tsoulfas, S. Majumder, K. Toutouzas, E. Koletsis, et al., Developing an international combined applied surgical science and wet lab simulation course as an undergraduate teaching model, Biomed. Res. Int. 2015 (2015) 463987.
[24] M. Sideris, V. Papalois, T. Athanasiou, S. Papagrigoriadis, M. Pierides, G. Velmahos, et al., A novel multi-faceted course blueprint to support outcome-based holistic surgical education: the integrated generation 4 model (iG4), In Vivo (Brooklyn) 34 (2) (2020) 503–509.
[25] I. Theodoulou, M. Sideris, K. Lawal, M. Nicolaides, A. Dedeilia, E.I. Emin, et al., Retrospective qualitative study evaluating the application of IG4 curriculum: an adaptable concept for holistic surgical education, BMJ Open 10 (2) (2020) e033181.
[26] E. Kim, I.C.F. Norman, S. Myers, M. Singh, A. Ghanem, The end game - A quantitative assessment tool for anastomosis in simulated microsurgery, J. Plast. Reconstr. Aesthet. Surg. 73 (6) (2020) 1116–1121.
[27] J. Hanrahan, M. Sideris, T. Pasha, P.P. Tsitsopoulos, I. Theodoulou, M. Nicolaides, et al., Hands train the brain-what is the role of hand tremor and anxiety in undergraduate microsurgical skills? Acta Neurochir (Wien) 160 (9) (2018) 1673–1679.
[28] S.N. Gillan, N. Okhravi, F. O'Sullivan, P. Sullivan, A. Viswanathan, G.M Saleh, Influence of medical student career aims on ophthalmic surgical simulator performance (part of the international forum for ophthalmic simulation studies), Br. J. Ophthalmol. 100 (3) (2016) 411–414.
[29] K.A. Mason, E. Theodorakopoulou, G. Pafitanis, A.M. Ghanem, S.R. Myers, Twelve tips for postgraduate or undergraduate medics building a basic microsurgery simulation training course, Med. Teach. 38 (9) (2016) 872–878.
[30] Z. Mughal, J.D. Isherwood, T.D. Boam, S.R. Knight, J.M. Yeung, Development, evaluation, and delivery of an innovative national undergraduate surgical workshop: recognition and management of the acutely unwell surgical patient, Teach Learn. Med 27 (1) (2015) 85–90.
[31] M. Nicolaides, E. Theodorou, J.G. Hanrahan, I. Theodoulou, E.I. Emin, A. Papalois, et al., Advancing medical students' non-technical skills in a group-based setting, J. Invest. Surg. 34 (1) (2021) 39–43.
[32] K. Hamaoui, H. Sadideen, M. Saadeddin, S. Onida, A.W. Hoey, J Rees, Is it time for integration of surgical skills simulation into the United Kingdom undergraduate medical curriculum? A perspective from King's College London School of Medicine, J. Educ. Eval. Health Prof 10 (2013) 10.
[33] E. Laiou, T.H. Clutton-Brock, R.J. Lilford, C.A. Taylor, The effects of laryngeal mask airway passage simulation training on the acquisition of undergraduate clinical skills: a randomised controlled trial, BMC Med. Educ. 11 (2011) 57.
[34] M. Sideris, J. Hanrahan, G. Tsoulfas, I. Theodoulou, F. Dhaif, V. Papalois, et al., Developing a novel international undergraduate surgical masterclass during a financial crisis: our 4-year experience, Postgrad Med. J. 94 (1111) (2018) 263–269.
[35] Gracie DJ, G. Winter, M.C.C. Clarke, Improving undergraduate education in surgical paediatrics using near-peer assisted learning tutorials, Scott Med. J. 66 (2) (2021) 84–88.
[36] R. Preece, E.C. Dickinson, M. Sherif, Y. Ibrahim, A.S. Ninan, L. Aildasani, et al., Peer-assisted teaching of basic surgical skills, Med. Educ. Online 20 (2015) 27579.
[37] A. Fullbrook, M. Ross, E. Mellanby, K. Wylde, A. Jaap, H. Cameron, Initial experiences of a student assistantship, Clin. Teach. 12 (5) (2015) 310–314.
[38] S.R. Bennett, S.R. Morris, S. Mirza, Medical students teaching medical students surgical skills: the benefits of peer-assisted learning, J. Surg. Educ. 75 (6) (2018) 1471–1474.
[39] M. Saleh, Y. Sinha, D. Weinberg, Using peer-assisted learning to teach basic surgical skills: medical students' experiences, Med. Educ. Online 18 (2013) 21065.

[40] G. Wilson, A. Zargaran, I. Kokotkin, J. Bhaskar, D. Zargaran, A. Trompeter, Virtual reality and physical models in undergraduate orthopaedic education: a modified randomised crossover trial, Orthop. Res. Rev. 12 (2020) 97–104.
[41] K. Sugand, M. Mawkin, C. Gupte, Training effect of using Touch surgery for intramedullary femoral nailing, Injury 47 (2) (2016) 448–452.
[42] R. Bhattacharyya, K. Sugand, B. Al-Obaidi, I. Sinha, R. Bhattacharya, C.M. Gupte, Trauma simulation training: a randomized controlled trial -evaluating the effectiveness of the imperial femoral intramedullary nailing cognitive task analysis (IFINCTA) tool, Acta Orthop. 89 (6) (2018) 689–695.
[43] K.S. Lee, M. Teo, Letter to the editor regarding "factors influencing medical student interest in a career in neurosurgery", World Neurosurg. 139 (2020) 655.
[44] D.J. Clark, A.G. Kolias, M.R. Garnett, R.A. Trivedi, S.J. Price, P.J. Hutchinson, Student-selected components in neurosurgery, Br. J. Neurosurg. 30 (1) (2016) 4–6.
[45] C. Burford, J. Hanrahan, A. Ansaripour, B. Smith, K. Sysum, K. Rajwani, et al., Factors influencing medical student interest in a career in neurosurgery, World Neurosurg. 122 (2019) e367–ee74.
[46] J.J. Ng, K.S. Lee, Call to improve vascular surgery education in medical schools, Br. J. Surg. 108 (3) (2021) e123–e1e4.
[47] U. Jaffer, P. Normahani, N. Matyushev, M. Aslam, N.J. Standfield, Intensive simulation training in lower limb arterial duplex scanning leads to skills transfer in real-world scenario, J. Surg. Educ. 73 (3) (2016) 453–460.
[48] J. Chan, P. Sidhu, How much cardiothoracic surgery is taught in UK medical schools? Ulster Med. J. 88 (2) (2019) 128.
[49] R. Preece, E. Ben-David, S. Rasul, S Yatham, Are we losing future talent? A national survey of UK medical student interest and perceptions of cardiothoracic surgery, Interact Cardiovasc. Thorac. Surg. 27 (4) (2018) 525–529.
[50] A. Bridgeman, R. Findlay, A. Devnani, D. Lim, K. Loganathan, P. McElnay, et al., Inspiring the next generation of Cardiothoracic Surgeons: an easily reproducible, sustainable event increases UK undergraduate interest in the specialty, Interact. Cardiovasc. Thorac. Surg. 22 (1) (2016) 106–108.
[51] A.W. Mayer, K.A. Smith, S. Carrie, A survey of ENT undergraduate teaching in the UK, J. Laryngol. Otol. 134 (6) (2020) 553–557.
[52] J. Powell, F.A. Cooles, S. Carrie, V Paleri, Is undergraduate medical education working for ENT surgery? A survey of UK medical school graduates, J. Laryngol. Otol. 125 (9) (2011) 896–905.
[53] H. Spiers, H. Enayati, R. Moussa, A. Zargaran, A. Thomas, A. Murtaza, et al., Augmenting ENT surgery outside the medical school curriculum: the role of a 1-day otolaryngology course, J. Laryngol. Otol. 133 (4) (2019) 269–274.
[54] B.H.J. Rapaport, K. Gill, J. Douglas, T. Ali, J.S. Brown, Training in oral and maxillofacial surgery: a medicine-first perspective, Br. J. Oral. Maxillofac Surg. 58 (10) (2020) 1333–1334.
[55] T.C.F. Soh, Z.Z. Lim, H.M. Yip, Does the UK undergraduate medical curriculum prepare students in Oral and Maxillofacial Surgery? A scoping review, Br. J. Oral. Maxillofac. Surg. 58 (10) (2020) 1229–1234.
[56] A.M. Goodson, K.F. Payne, A. Tahim, L. Cabot, K. Fan, Awareness of oral and maxillofacial surgery as a specialty and potential career pathway amongst UK medical undergraduates, Surgeon 11 (2) (2013) 92–95.
[57] T. Pasha, E.S. Lumley, L. Dwyer-Hemmings, M. Fell, Undergraduate plastic surgery in the United Kingdom: the students' perspective, J. Plast. Reconstr. Aesthet. Surg. 73 (11) (2020) 2086–2102.
[58] G. Higgins, S.E. Thomson, The introduction of plastic and reconstructive surgery to the University of Glasgow undergraduate medical core curriculum, Postgrad Med J 96 (1132) (2020) 64–66.
[59] H.V.M. Spiers, A. Zargaran, A.N. Murtaza, A. Thomas, M.A.A. Turki, F. Ali, Enhancing medical curricula: the role of a 1-day plastic surgery course as an educational adjunct for medical students, J. Surg. Educ. 75 (1) (2018) 116–121.
[60] Z. Alsafi, V. Bhrugubanda, S. Ramachandran, A. Alsafi, M. Hamady, Is it time for a specific undergraduate interventional radiology curriculum? Cardiovasc. Intervent. Radiol. 40 (7) (2017) 1062–1069.
[61] Core content of the medical school surgical curriculum: consensus report from the association of surgeons in training (ASIT), Int. J. Surg. 84 (2020) 186–193.
[62] O.M. Fayanju, R. Aggarwal, R.B. Baucom, C.R. Ferrone, D. Massaro, K.P. Terhune, Surgical education and health care reform: defining the role and value of trainees in an evolving medical landscape, Ann. Surg. 265 (3) (2017) 459–460.
[63] H.J. Vaidya, A.W. Emery, E.C. Alexander, A.J. McDonnell, C. Burford, M.K. Bulsara, Clinical specialty training in UK undergraduate medical schools: a retrospective observational study, BMJ Open 9 (7) (2019) e025403.
[64] K. Ravi, U.A. Anyamele, M. Korch, N. Badwi, H.A. Daoud, S. Shah, Undergraduate surgical education: a global perspective, Indian J. Surg. (2021) 1–9.
[65] A. Lee, D. Abdulhussein, M. Fallaha, O. Buckeldee, R. Morrice, K. Leedham-Green, Whole consultation simulation in undergraduate surgical education: a breast clinic case study, BMC Med. Educ. 21 (1) (2021) 305.
[66] M.J. Lee, T.M. Drake, T.A. Malik, T. O'Connor, R. Chebbout, A. Daoub, et al., Has the bachelor of surgery left medical school?-A national undergraduate assessment, J. Surg. Educ. 73 (4) (2016) 655–659.
[67] I. Thomas, L. Nicol, L. Regan, J. Cleland, D. Maliepaard, L. Clark, et al., Driven to distraction: a prospective controlled study of a simulated ward round experience to improve patient safety teaching for medical students, BMJ Qual. Saf. 24 (2) (2015) 154–161.
[68] B. Bourke, Central lines and the general medical register - time for a change in the curriculum? Clin. Med. (Lond) 17 (3) (2017) 287.
[69] S.R. Rufai, L.C. Holland, E.O. Dimovska, C. Bing Chuo, S. Tilley, H Ellis, A national survey of undergraduate suture and local anesthetic training in the United Kingdom, J. Surg. Educ. 73 (2) (2016) 181–184.
[70] S.R. Rufai, Commentary to "undergraduate suture and local anaesthetic training in the United Kingdom", J. Surg. Educ. 73 (6) (2016) e171.
[71] World Health O*WHO Guidelines For Safe Surgery* 2009*: Safe Surgery Saves Lives*, World Health Organization, Geneva, 2009.