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ORIGINAL ARTICLE

Designing, developing and implementing a 2-year, simulation-embedded curriculum for junior surgical residents

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Abstract

Aim: To develop and implement a comprehensive, quality-assured, cost-effective curriculum for junior surgical residents (core surgical trainees) and to assess its face and content validity. **Hypothesis**: A 2-year, hands-on curriculum teaching technical and non-technical skills in an array of surgical specialties (general surgery, trauma and orthopaedics, paediatric surgery, urology and cardiothoracic surgery) is feasible, cost-effective and well received by residents. **Methods**: The population included core surgical trainees in Yorkshire and the Humber region. We designed a comprehensive core surgical training curriculum aiming to teach both technical and non-technical skills. To enhance the didactic impact of the curriculum, we introduced a multimedia channel and made free-style training in fully equipped education centres available to trainees. The implemented changes were evaluated prospectively by means of a questionnaire. **Results**: The curriculum designed included 54 topics from the UK Core Surgical Training syllabus in addition to five sessions with of non-technical skills scenarios. These were supplemented by a multimedia online channel and facilitation of free-style training in state-of-art centres. Trainees rated the curriculum using a 5-point Likert scale questionnaire (response rate, 88%). They found the curriculum to be fit for purpose for acquiring technical and non-technical skills (median, 5/5; interquartile 1st–3rd, 4–5) and viewed curriculum delivery positively (faculty, 5/5, 4–5; equipment, 5/5, 4–5). **Conclusions**: Simulation and technology-enhanced learning was well received by core surgical trainees. This is likely to be associated with the structured curriculum design, the quality assurance process overseen by the School of Surgery and the availability of appropriate faculty and infrastructure.

Keywords: *medical education; simulation; training*

Introduction

Traditional surgical training consists of the clinical apprenticeship paradigm, enhanced by didactic lectures.[1] This learning style was nurtured by the model of health care delivery previously in place (specific clinical teams, absence of working-time restrictions). However, as reported in "To Err Is Human: Building a Safer Health System" by the Institute of Medicine (USA) in 2000,[2] medical error was a frequent occurrence within the apprenticeship model. In Europe, the enforcement of the European Working Time Directive (EWTD)[3] for all workers within the European Union reduced the working hours of doctors and made the continuation of the existing apprenticeship model difficult. Further, public intolerance of medical errors globally,[4] and the inevitable reduction in training opportunities consequent upon EWTD[3] and intensification of service provision due to cost cutting[5] provided the impetus for developing simulation programmes to augment surgical training. Embedded within a curriculum, simulation has proven effective in improving both technical[1,5-7] and non-technical skills.[8,9]

Embracing the new realities in surgical training, the School of Surgery, Health Education Yorkshire and the Humber, incorporated surgical simulation into the teaching curriculum for core surgical trainees and invested heavily in simulation resources for free-style practice. Health Education Yorkshire and the Humber has also launched a surgical simulation online multimedia channel.

This study describes the design and implementation process of this novel curriculum and aims to assess its face and content validity.

Study population

There are approximately 124 core surgical trainees within the Yorkshire and Humber region spread across three sectors (East, South and West Yorkshire). Core surgical training is the equivalent of the first 2 years of surgical residency. Trainees may rotate through almost all surgical specialties (e.g. general surgery, plastics, orthopaedics) before making a decision about further specialization in future years.

During the 2-year curriculum, first-year core trainees were taught different procedures from those taught to second-year trainees. After the completion of year one of the programme, 296 feedback questionnaires from core surgical trainees were obtained (response rate, 88%, 109/124).

Curriculum design

Curriculum design included the following phases: problem identification, content design, establishing availability of infrastructure required and feedback and quality assurance.

Identifying the problem

Initial situational analysis demonstrated that there was inconsistency in the teaching sessions delivered in the three different localities within the Yorkshire and Humber region. This led to trainees undergoing duplicate sessions and not participating in others. Further, because of the discrepancies between regional delivery of teaching, a uniform quality assessment could not be applied. The new curriculum aimed to establish consistency of content across the region, and allow the introduction of a common quality assurance process.

Content design

The programme was designed by a National Health Service (NHS) Leadership Fellow (AK) seconded to the School of Surgery and was based on the contents of the Intercollegiate Surgical Curriculum Programme (ISCP) for core and junior higher surgical trainees.[10] All skills included within ISCP were assessed for potential inclusion in the curriculum primarily according to whether they could be replicated in a simulated environment. Overall, 54 topics were considered suitable and were included within the teaching curriculum. Both technical and non-technical skills teaching sessions were introduced.

The teaching curriculum includes an array of surgical skills (Table 1) designed to provide exposure to most of the surgical specialties encountered in core surgical training and assist towards the seamless transition from core to higher surgical training. Cost-effective, validated simulation models were sought for each skill. A combination of commercially available and in-house simulation models were used. The latter were manufactured from both porcine tissue and synthetic materials. The curriculum used a mixture of animal tissue, physical models and virtual reality simulators. The selection process for simulation models is shown in Fig. 1. The skills taught differed according to the level of training (year 1 or year 2).

In addition to technical skills, non-technical skills were introduced in the curriculum. The aim of this was to aid decision-making skills on commonly occurring clinical issues. Asking for help as appropriate, a multi-specialty team approach to treatment, breaking bad news and leadership skills were all effectively embedded in simulated scenarios.

Throughout the year, eight sessions of non-surgical skills are offered to trainees, each including four clinical scenarios based in a simulated ward with video recording and live feed equipment. In each scenario, the trainee assumed the role of the surgical registrar (senior resident) undertaking a ward round that included three simulated patients (two actors and one simulated patient model with a variety of programmable signs). The critical events requiring urgent management were anaphylaxis, sepsis and gastrointestinal and intra-cerebral haemorrhage. A remotely controlled screen displayed the vital signs of the simulated patient. A further communication scenario was used based on prioritizing the management of a patient with a leaking abdominal aortic aneurysm.

The scenarios were observed by a consultant surgeon via a live audio-visual link to assess both initial and subsequent management. Structured feedback, based on a standardized marking sheet, was given to the trainee.

Availability of infrastructure

Clinical skills centres, all of which had permanent administrative and technical staff, in both teaching hospitals and district general hospitals throughout the region were central to implementation of the programme. Sessions were allocated to centres depending to the equipment available.

Delivery was facilitated by three regional training programme directors and Trust-based Royal College of Surgeons of England surgical tutors. Further faculty was obtained on demand for each teaching session, several months in advance. The School of Surgery issued specific recommendations in respect of faculty; at least 50% had to

Table 1. Topics of sessions included in curriculum

Sessions	Skills
September	
CT 1 – Basic Skills Revision	Scrubbing up, gowning and gloving, WHO checklist, instrument trays, knot tying (on jigs) – 45 minutes Incision and closure of superficial tissues (using porcine skin) – 45 minutes Surgical drains (using porcine abdominal wall) – 45 minutes Diathermy and haemostasis of superficial vessels – 45 minutes
CT2 – Laparoscopic Skills	Laparoscopic dissection (balloon and glove model) – 2 hours (1 hour performing, 1 hour assisting) Laparoscopic appendicectomy model – 2 hours (1 hour performing, 1 hour assisting)
October	
CT 1 – Basics of Laparoscopy	Establishing a pneumoperitoneum and insertion of ports – 1.5 hours Basic laparoscopic skills – 1.5 hours (45 minutes performing, 45 minutes operating the camera)
CT2 – Small Bowel Anastomosis	Side to side – 2 hours (1 hour performing, 1 hour assisting) End to end – 2 hours (1 hour performing, 1 hour assisting)
November	
Trauma & Orthopaedics (CT1 and CT2)	Ankle fracture fixation – 1 hour Dynamic hip screw – 1 hour Manipulation and reduction of a fractured wrist (Colles fracture) – 1 hour
December	
CT 1 – Opening and Closing	Laparotomy: open and close – 2 hours (1 hour performing, 1 hour assisting) Local anaesthetic use, and excision and closure of skin lesions – 2 hours
CT 2 – Vascular Anastomosis	Arteriotomy and closure – 2 hours (1 hour performing, 1 hour assisting) End to end – 2 hours (1 hour performing, 1 hour assisting)
January	
Urology (CT1 and CT2)	Catheterization – 1 hour The acute scrotum (testicular fixation) – 1 hour Circumcision – 1 hour Cystoscopy (where Uro-mentor is available) – 1 hour
February	
CT 1 – Non-technical skills scenarios	Full-day session
CT 1 – Core Procedures	Tracheostomy – 1 hour Central line insertion – 1 hour Chest drain insertion – 1 hour Lumbar puncture – 1 hour
CT2 – Small Bowel Anastomosis	Side to side – 2 hours (1 hour performing, 1 hour assisting) End to end – 2 hours (1 hour performing, 1 hour assisting)
March	
CT 1 – Various	Biopsy techniques and breast lump excision – 2 hours Principles of endoscopy (including an introduction to the GI mentor) – 1 hour Repair of serosal tears – 1 hour
CT 2 – Various	Laparoscopic suturing – 2 hours (1 hour performing, 1 hour operating the camera) Tendon repair – 2 hours (1 hour performing, 1 hour assisting)
April	
Trauma and Orthopaedics (CT1 and CT2)	Ankle fracture fixation – 1 hour Dynamic hip screw – 1 hour Manipulation and reduction of a fractured wrist (Colles fracture) – 1 hour
May	
CT1 – Operating at Depth	Open appendicectomy model – 2 hours (1 hour performing, 1 hour assisting) Closure of enterotomy/Ligation of vessels – 2 hours
CT 2 – Simulated Scenarios (16 trainees maximum)	
CT 2 – Vascular Anastomosis	Patch closure of arteriotomy – 2 hours (1 hour performing, 1 hour assisting) End to side – 2 hours (1 hour performing, 1 hour assisting)
June	
CT 1 – Simulated Scenarios (16 trainees maximum)	Full-day session
CT 1 – Core Procedures	Tracheostomy – 1 hour Central line insertion – 1 hour Chest drain insertion – 1 hour Lumbar puncture
CT2 – Hernia/Skin flaps	Ventral hernia model – 2 hours (1 hour performing, 1 hour assisting) Skin flaps – 2 hours
July	
CT 1 – Stomas	End colostomy – 2 hours Loop ileostomy – 2 hours
CT 2 – Simulated Scenarios (16 trainees maximum)	Full-day session
CT 2 – Vascular Anastomosis	Patch closure of arteriotomy – 2 hours (1 hour performing, 1 hour assisting) End to side – 2 hours (1 hour performing, 1 hour assisting)

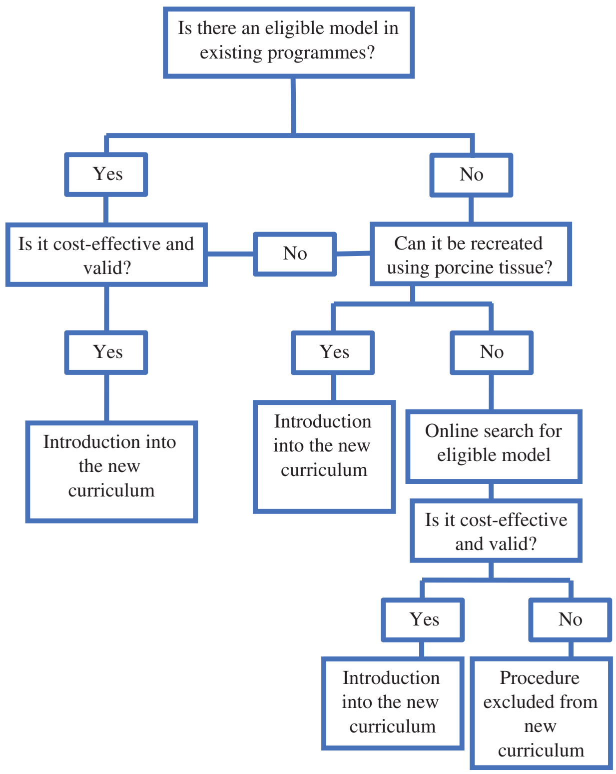

Figure 1. Process of simulation model selection.

Table 2. Procedures included in the multimedia internet channel

Tracheostomy
Subcuticular suturing
Excision of skin lesion
Side to side bowel anastomosis
Opening and closing a midline incision
Mattress suture
Blood vessel ligation
Knot tying
Stoma formation
End to end bowel anastomosis
Open hernia repair
Breast lump excision
Open appendicectomy
Repair of serosal tear

be consultants supported by senior trainees in the relevant specialty. A minimum number of faculty members was also suggested for each training session. Faculty briefing was provided by the School of Surgery.

Where models (manufactured, fresh frozen animal tissue) were required, a detailed guide on their assembly was provided. Appropriate surgical instruments and suture materials were also made available.

In addition to the scheduled sessions, the School of Surgery launched a YouTube channel (San Mateo, California, USA) hosting 14 videos of procedures (Table 2) included in the technical skills programme. This allowed trainees to review the procedures in their free time and learn at their selected pace.

Quality assurance and trainees' feedback

To ensure that simulation training within the region was being delivered to high standards, the programme was quality assessed using the framework developed by the Quality Assurance group of the Joint Committee on Surgical Training. Besides quality assessment, trainees were given the opportunity to provide feedback for the teaching sessions both in the form of scores on a Likert scale and in free-text boxes.

Funding

The funding for the Core Surgical Trainee teaching programme was derived from the curriculum delivery budget.

Quality assurance and feedback

Feedback from trainees and faculty was received through a questionnaire and a series of checklists, a system designed by ISCP and piloted in our region for the first time. Completing the specific feedback forms was compulsory for trainees and was used as proof of their attendance in the specific session. Participation in at least 70% of teaching sessions is required for a successful outcome at their annual review of competence progression required for advancing in their training.

From August 2013 to August 2014, 296 completed feedback forms were received. The response rate was not 100% as one would expect from a feedback tool requiring compulsory completion, because some centres used different feedback tools in error or forms were lost in transport. The overall response rate achieved was 88%. First-year and second-year trainees underwent simultaneous teaching on a different set of skills (identified in the curriculum as year 1 and year 2 skills, respectively). Cumulative feedback results for skills addressed to both year 1 and year 2 trainees are presented here, demonstrating the evaluation of year 1 and year 2 of the curriculum.

The feedback form included questions relevant to the content of the teaching sessions and the faculty, as well as practical aspects, such as the venue and catering. The answers for the latter were not included in this study because they do not reflect face or content validity of the curriculum. A Likert scale ranging from 1 (negative opinion) to 5 (positive opinion) was used to obtain the trainees' opinions about the teaching programme. The median of the responses obtained for all the questions ranged from 4 to 5 (Table 3). The median and first and third interquartile ranges of the Likert scores are shown in Table 3. These data confirm that trainees considered that the programme was organized and delivered appropriately and met their requirements for acquisition of surgical and non-technical skills.

In addition to the feedback forms collected from trainees, the directors and faculty of the clinical skills centres were required to complete a checklist before conducting the teaching sessions, assuring that the necessary infrastructure and faculty were available. This process prompted the resolution of potential issues before the teaching sessions. A similar checklist was completed after the teaching sessions and returned to the School of Surgery, where they were reviewed for the identification of difficulties that should be addressed in future sessions.

Free-text comments were mostly positive, however some issues were raised by the trainees. These were addressed to the degree possible by the School of Surgery. For instance, some of the sessions had to be relocated because of insufficiency of equipment; transportation of small portable box trainers was necessary for a laparoscopic suturing session conducted in a district general hospital. These were found by faculty and trainees to not represent depth perception adequately, which prompted the request to conduct the specific session in a teaching hospital where high-quality laparoscopic stacks were available. Furthermore, as a result of feedback from trainees and faculty, specific sessions take place only at teaching hospitals in order to facilitate faculty recruitment, allow easier access for trainees and ensure the presence of appropriate equipment.

Discussion

This prospective study assesses a new, structured programme delivered throughout the region (based on the ISCP curriculum for Core Surgical training) delivering both technical and non-technical skills. Feedback demonstrates good face and content validity of the novel curriculum, demonstrating that the curriculum designed is fit for purpose and has the appropriate content for core surgical trainees, year 1 and 2.

Financial support from the curriculum delivery budget ensured uniformity of training provision in all participating medical education centres (n = 9). Trainees were of the opinion that the training was appropriate to their needs and delivered by an informed faculty. These findings should be robust given the high response rate to the questionnaires (88%).

This study has some limitations. First, it does not assess construct validity with the participation of a control arm, however the purpose of this study was to explore, in the first instance, the appropriateness of the curriculum for core surgical training. Moreover, the clinical transferability of the taught skills has not been assessed in a clinical environment. This, in part, reflects the difficulty of temporally matching taught skills with the clinical opportunities available to trainees working in ten different surgical disciplines.

Furthermore, the curriculum itself has some shortcomings. One could argue that it is not inclusive of some surgical specialties such as ENT or plastic surgery. Although we have tried to make this curriculum as inclusive as possible, the

Table 3. Feedback results

Question	Median	Interquartile range
Was the teaching environment fit for purpose?	5	4–5
Were the joining instructions clear?	4	4–5
Were you adequately briefed about the safety aspects at the start?	4	3–5
Were the programme content, objectives and desired outcomes clear?	5	4–5
Were all faculty members well prepared to deliver the course?	5	4–5
Were the equipment and consumables suitable?	5	4–5
Were the objectives and desired outcomes delivered?	5	4–5
Did the course meet your needs as a trainee?	5	4–5

final design was constrained by cost, the non-availability of simulators for specific procedures and by the small number of trainees working in some specialties. Thus, a pragmatic approach dictated the final choice of procedures to be included in the programme.

There are several challenges in developing a programme like this. These include access to appropriate clinical skills laboratories, identification of suitable models and cost. In our region, comprising 22 NHS Trusts, seven have clinical skills facilities that are equipped with high- and low-fidelity simulation equipment and with dedicated non-technical skills training environments. Nevertheless, the remaining centres do, in most instances, have the facilities to deliver the procedures included in our core programme.

Procurement of appropriate models required an in-depth search of providers in both Europe and North America. Other models were developed using animal tissue.

One benefit of developing a robust simulation programme is the potential reduction in trainee requests for funding to attend external courses where both a course fee and travel/subsistence expenses are requested. Although our programme for core trainees requires annual funding of around £40,000 for 120 trainees, this has been met by our curriculum delivery budget without compromising other areas of expenditure requested by trainees.

There are several studies demonstrating that simulation is effective in enhancing surgical skills.[5-7] Thus, it is likely that this curriculum will have a positive educational impact. Other surveys assessing the perceived benefit of this type of training echo the views of our core trainees. These include a survey by Forster et al.,[13] which reported that almost all UK Urology Training Programme Directors advocated incorporation of a formal competency-based simulation training programme into the urology curriculum. Most importantly, they called for simulation to be made accessible to all trainees. This has been an important tenet of our own programme.

Bhatti et al.[14] conducted a national survey looking into quality indicators for surgical training. They identified faculty development, balanced supervised and independent training, and continuous evaluation and feedback as indicators for quality. Our programme meets these objectives. Similarly, a systematic review by McClusky et al.[15] concluded that a systematic approach to the suitable use of forms of available simulation and a careful design process can produce a successful curriculum.

We are continually increasing the range of the skills programme to cover other specialties. Further, in collaboration with University of Leeds School of Medicine, we are developing programmes for advanced surgical skills using Thiel cadavers.

In conclusion, simulation and technology-enhanced learning was well received by the Yorkshire and Humber core surgical trainees. We believe that this reflects the structured method of curriculum design, the quality assurance process overseen by the School of Surgery and the availability of appropriate faculty and infrastructure.

Conflict of interest

The authors declare no conflict of interest

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