# A Systematic Review and Cohort Study of Operative Training in General Surgery

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Thesis submitted to the University of Nottingham for the degree of

Doctor of Philosophy

Student number: 4264340

September 2018

**This thesis is dedicated to my children, Katherine and Benjamin,**

**who make me smile every day.**

**Acknowledgements**

To all three of my supervisors; Professor Joe West, Associate Professor David Humes and Mr Gareth Griffiths for their supervision, support and guidance with developing all aspects of my doctoral studies. Without their expertise, I would not have been able to achieve the results of the last three years.

Professor Joe West for his invaluable understanding of epidemiological study, enthusiasm and entertaining and creative commenting style.

Associate Professor David Humes for his coaching, support of my academic pursuits and direct words of advice.

Mr Gareth Griffiths for his knowledge of the UK's training system, kindness and wisdom.

Ms Cristel Santos, and Mr Andrew Lamb for extracting data from the databases and help with understanding the relevant data processes and protocols.

The Intercollegiate Surgical Curriculum Programme Management Committee and Mr Bill Allum for their support of my work.

Dr Fiona Pearce for her support and friendship throughout my doctoral studies.

My friends and family for their unending patience and tolerance over the past three years.

**Abstract**

Surgical training in the UK has seen many changes over recent years with a move towards competency-based curricula requiring trainees to undertake workplace-based assessments and meet operative experience targets. Data from assessments and operative experience are collected routinely but have not been used to understand the outcomes of the UK national General Surgery specialty training programme. The aim of this thesis was to understand the operative experience of General Surgery specialty trainees in the UK.

The first study in this thesis (Chapter 2) explored published data for the operative experience of General Surgery trainees completing training worldwide. With the exception of the USA, very few studies had been published. Of the five countries that had reported relevant data, there was wide variation seen in operative experience with a mean pooled estimate of 1366 procedures (95% CI 1026- 1707) per trainee at completion of training and marked heterogeneity between studies ($I^2$= 99.6%). Whilst the included studies quantified operative experience, none had linked experience to a formal measure of technical competency or provided evidence of competency attainment through training.

The three other studies in the thesis used routinely collected surgical training data from a national cohort of General Surgery trainees in the UK from 2007- 2016. The key data sources for these studies were the Intercollegiate Surgical Curriculum Programme (ISCP) database and the eLogbook database. Both databases are mandatory in UK surgical training and linked by trainee GMC number. Trainees

record placement and assessment information in the ISCP and operative experience data in the eLogbook.

Following work to determine the timeline of training for each trainee, two cohorts were defined; those that had completed training (n=360) and those that remained in training at the time of data extraction (n=994).(Chapter 3).

The first study using ISCP data aimed to evaluate trends in the time taken out of training and the impact on the duration of UK General Surgery specialty training. (Chapter 4) This study found an increasing number of trainees taking time out of training (54.5% of In Training cohort vs 45.9% of Completed Training cohort, p <0.01). The most common reason for time out of training was for research with 35.1% of the In-Training cohort undertaking research out of programme compared to 6.1% of those who had completed training (p <0.01). This trend is increasing the time taken to complete specialty training with those In-Training who had already taken time out of programme predicted to take a median 8.0 (iqr 7.0-9.0) years to complete training compared to a median 6.0 (iqr 6.0-7.0) years in those who had already completed training.

The next study in the thesis explored the use of the procedure-based assessment (PBA) in judging the competency of trainees undertaking General Surgery index procedures. It explored the relationship between increasing operative experience and changing PBA outcomes. (Chapter 5) Differences in this association were identified between index procedures and the results provide further understanding of the validity of the PBA within General Surgery specialty training. This study also evaluated the number of procedures undertaken to award of competency (as judged by the PBA) and found this differed to current UK curricula targets for operative experience.

The final study aimed to determine the autonomy of General Surgery specialty trainees by assessing changing procedural supervision and PBA outcomes through the course of an entire training programme. (Chapter 6) This study found that supervision of trainees varied both by index procedure and by stage of training. The proportion of all index procedures recorded as unsupervised increased through training ($p<0.05$) and varied between index procedures with 91.2% of appendicectomies, 40.6% of emergency laparotomies and 17.4% of segmental colectomies recorded as unsupervised during the final year of training.

This thesis provides evidence of operative experience and competency outcomes in General Surgery specialty training. It suggests that the way in which procedural competency is attained varies between index procedures and that current UK indicative numbers for operative experience do not relate to the operative experience required for competency. This work uses surgical training data to reflect the changing autonomy through training, providing evidence of changing entrustment decisions in keeping with current trends for assessing competency in post-graduate medical education.

**Fellowships/ Grants**

£121,443. Royal College of Surgeons of Edinburgh Research Grant (RB48BL). Two year fellowship. October 2015.

£210,379. National Institute of Health Research Doctoral Research Fellowship. Two year fellowship. October 2016.

**Publications arising from doctoral studies**

1. **Meta-analysis of operative experiences of General Surgery trainees during training. E. Elsey,** G. Griffiths, D. Humes, J. West. Br J Surg, 104: 22–33. doi:10.1002/bjs.10396 (IF 5.596)

2. **The Impact of Out of Programme Periods on Time in General Surgical Training: a UK National Database Study. E Elsey,** G Griffiths, J. West, D. Humes. J Surg Educ. 2018 Aug 6. pii: S1931-7204(18)30137-5. doi: 10.1016/j.jsurg.2018.06.011. [Epub ahead of print] (IF 2.302)

3. **Does the operative experience of UK General Surgery trainees reflect the entrustment model of competency assessment? A retrospective cohort study. E. Elsey,** G Griffiths, J West, D Humes. In press, Annals of Surgery. (IF 9.203)

**Presentations to learned societies arising from doctoral studies**

*International:*

1. **Does the operative experience of UK General Surgery trainees reflect the entrustment model of competency assessment? A retrospective cohort study. E. Elsey,** G Griffiths, J West, D Humes. Oral Presentation. *Top 5 Residency Research Papers Prize Session.* International Conference for Residency Education, ICRE. October 2018.

2. **The Impact of Out of Programme Periods on Time in General Surgical Training: a UK National Database Study. E Elsey,** J West, G Griffiths, D Humes. Oral Presentation. International Conference for Residency Education, ICRE. October 2018.

3. **What is the experience of UK General Surgery trainees in relation to haemorrhoidectomy: operative numbers, procedure-based assessments and the association between these? E Elsey**, G Griffiths, J West, D Humes. Poster presentation. United European Gastroenterology Week, Vienna, October 2016

*National:*

1. **Does the operative experience of UK General Surgery trainees reflect the entrustment model of competency assessment? E. Elsey,** G Griffiths, J

West, D Humes. NIHR Doctoral Training Camp: Applying for Future Research Funding. Poster Presentation. May 2018.

2. **Does the operative experience of UK General Surgery trainees reflect the entrustment model of competency assessment? E. Elsey,** G Griffiths, J West, D Humes. Association of Surgeons of Great Britain and Ireland, (ASGBI). Oral Presentation. May 2018.

3. **The Impact of Out of Programme Periods on Time in General Surgical Training: a UK National Database Study. E.Elsey,** J. West, G. Griffiths, D. Humes. Poster Presentation. Association of Surgeons of Great Britain and Ireland, (ASGBI), May 2018.

4. **The Impact of Out of Programme Periods on Time in General Surgical Training: a UK National Database Study. E.Elsey,** J. West, G. Griffiths, D. Humes. Oral Presentation. Society for Academic and Research Surgery (SARS), January 2017.

5. **Developing evidence-based standards for operative competency in General Surgery in the UK. E.Elsey,** G.Griffiths, D. Humes, J. West. Oral presentation. Moynihan Chirurgical Club, Nottingham, October 2016.

6. **What is the experience of UK General Surgery trainees in relation to haemorrhoidectomy: operative numbers, procedure-based assessments**

**and the association between these? E. Elsey,** G. Griffiths, J. West, D. Humes. Poster presentation. Association of Coloproctology of Great Britain and Ireland (ACPGBI), Edinburgh, July 2016.

**Prizes awarded**

1. University of Nottingham Tricampus Award: The Andrew Hendry Prize. For outstanding achievement during doctoral studies. (£150)

2. Junior Presentation Prize, Nottingham Biomedical Research Centre (Second Place, £75) December 2017.

3. Sue Watson Prize for research presentation, University of Nottingham (First Place, £75) November 2017.

4. Excellence in Education Awards (Health Education East Midlands). Future Educator, March 2016.

**Glossary of Terms**

- ABS: American board of Surgery
- ACGME: Accreditation Council on Graduate Medical Education
- ARCP: Annual Review of Competency Progression
- ASA: American Society of Anaesthesiology
- CanMEDS: Canadian Medical Education Directives for Specialists
- CBD: Case- Based Discussion
- CCT: Certificate of Completion of Training
- CESR-CP: Certificate of Equivalence of Specialty Registration, Combined Programme
- CEX: Clinical Evaluation Exercise
- CiP: Capability in Practice
- COPMeD: Conference of Postgraduate Medical Deans
- DOPS: Direct Observation of Procedural Skills in Surgery
- EPA: Entrustable Professional Activity
- FRCS: Fellowship of Royal College of Surgeons
- GMC: General Medical Council
- HEE: Health Education England
- ISB: Intercollegiate Specialty Board

- ISCP: Intercollegiate Surgical Curriculum Programme
- JCIE: Joint Committee for Intercollegiate Examination
- JCST: Joint Committee for Surgical Training
- JSCFE: Joint Surgical Colleges Fellowship Examination
- LAS: Locum Appointment for Service
- LAT: Locum Appointment for Training
- LETB: Local Education and Training Boards
- LTFT: Less Than Full Time
- MMC: Modernising Medical Careers
- MRCS: Membership of Royal College of Surgeons
- MTAS: Medical Training Application Service
- NHS: National Health Service
- NIHR: National Institute of Health Research
- NTN: National Training Number
- OOPC: Out Of Programme Career break
- OOPE: Out Of Programme Experience
- OOPR: Out Of Programme Research
- OOPT: Out Of Programme Training
- OSATS: Objective Structured Assessment of Technical Skills

- PGMDE: Postgraduate Medical and Dental Education teams
- PBA: Procedure Based Assessment
- RRC-S: Residency Review Committee for Surgery
- SAC: Specialty Advisory Committees
- ST: Specialty Trainee
- TPD: Training Programme Director
- WBA: Work-place Based Assessment

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# Chapter 1 Introduction

## Section 1.1 Background to surgical training

Surgical training around the world has seen vast change over recent years. There has been a global trend towards the standardisation of surgical training with the setting of curricula and the aim of improving the quality and safety of surgical services by ensuring surgeons are trained to specified criteria. This began in the 1990's with the Canadian Medical Education Directives for Specialists (CanMEDS) framework of competencies for training.[1] Since then, other countries have adopted competency-based models for surgical training, rather than time-based, with defined curricula.[2-5] Several surgical curricula include requirements to be met before completion of training with a programme of assessments to be undertaken and minimum operative numbers to be achieved during general surgical training.[6-10] Despite this global trend for curricula, there is no worldwide standardisation of surgical training with expected operative experience varying widely. (Chapter 2)

The UK adopted a competency-based model of post-graduate surgical training in 2007 with the launch of the Intercollegiate Surgical Curriculum Programme (ISCP) and introduction of formal curricula for all surgical specialties.[11] In addition to a syllabus of knowledge, procedural and clinical skills to be met, there is a detailed programme of assessment, including different work-place based assessments (WBAs), designed to evaluate the competency of a trainee to work independently as a Consultant surgeon. Large amounts of data relating to UK surgical training are collected and recorded in online training systems and databases (Section 1.5). Yet, despite this established training system and huge repositories of data, there is little known about the attainment of competency through training nor the outcomes of surgical training in the UK.

### 1.1.1 Assessment in surgical training

The assessment of surgical competence or "skill" is difficult as no single measure reflects the performance of a surgeon. Several studies have attempted to assess surgical competence by either measuring the surgical process (operative time, conversion rates if a laparoscopic procedure, resection margins for cancer surgery) or measuring surgical outcomes (estimated blood loss, length of stay, complication rates and mortality outcomes). The most commonly reported measure is operative time. However, this is only a proxy for surgical performance, its measurement is not standardised and does not always reflect the competence of the surgeon.[12] Having attempted to quantify surgical competence in this way, many reports have then assessed the relationship between operative volume and competence. A systematic review, published in 2015, synthesised the evidence from 57 such studies of operative volume and surgical outcome measures among consultant (i.e. surgeons who had completed their training) surgeons.[13] In 44 of the studies, improved surgical outcomes (including decreased operative time, recurrence rate, intra and peri-operative complications, and estimated blood loss and mortality rates) were associated with increased volumes of cases performed. A plateau in improvement of outcomes was observed in several studies and hence many of the authors referenced a surgical learning curve i.e. that mastery of the procedure had been reached once there was no further improvement in outcomes.[14-17] The numbers reported for a plateau in outcomes to be reached was procedure specific with a very large range (25- 750 procedures) and also differed between the various complications. For example, one study describing outcomes in pancreaticoduodenectomy found that a plateau in morbidity (all major complications including infections, cardiopulmonary and gastrointestinal complications) was reached after 20 procedures but required 40 procedures to reach equivalent operating times. A plateau in mortality rates (defined as death occurring in the hospital or within 30 days of operation) was not reached until 60 procedures.[14]

All of the evidence summarised above relates to consultant surgeons and their practice. In the NHS, once a surgeon has gained their Certificate of Completion of Training (CCT) they are able to be appointed as a Consultant Surgeon and can be considered as independent practitioners. Given this fact it is surprising that there appears to be little evidence in the literature describing the operative numbers completed during UK post-graduate surgical training and few studies analysing the relationship between operative numbers and any measure of competency during training.[18-20]

#### 1.1.1.1 Workplace Based Assessments

Workplace Based Assessments (WBAs) were formally introduced into UK post-graduate medical training in 2005 and formed part of the assessment programme for the Foundation Programme.[21] They were introduced as a tool to assess and measure competency with a focus on formative feedback. WBAs were adopted into post-graduate surgical training in 2007 with the launch of ISCP and the uptake of a competency-based curriculum.[18] There are different tools available for use in post-graduate surgical training including the Case-Based Discussion (CBD)[22], Clinical Evaluation Exercise (CEX)[23], the Direct Observation of Procedural Skills in Surgery (DOPS) [24] and the Procedure-Based Assessment (PBA).[25] These are used to provide evidence of trainee competency and form part of the compulsory assessment process for all surgical trainees.[26]

### 1.1.2 Assessment theory

Innumerable studies, reviews and books have been published relating to assessment in medical education. The broad subjects of assessment referencing, and the psychometric theories of reliability and validity are summarised here.

#### 1.1.2.1 Assessment referencing

Assessments are measured with a trainee judged against a standard. Such standards are either criterion- referenced or norm- referenced. Norm-referenced assessments use judgements relating a trainee's performance against that of their peers at the same stage of training. Criterion referenced assessments judge trainees against a series of statements relating to standards of ability. Criterion- referenced assessments, with trainees judged against a standard expected for independent practice, were recommended as best practice by the Academy of Medical Royal Colleges following a review of the use of WBAs in 2009.[27]

#### 1.1.2.2 Reliability theory

Reliability of an assessment relates to whether the outcomes of the assessment are reproducible.[28] In order to evaluate the reliability of an assessment, variability within assessments and between assessors must be taken into account.[18] Internal consistency is defined by how well different scores within a test correlate with each other. For example, if an assessment had several component scores and an overall judgement level, it would be expected that a trainee receiving good component scores would also have a good overall score.[29] Test-retest reliability relates to a trainee receiving the same scores when tested on multiple occasions in the same circumstances. Inter-assessor reliability relates to consistency of scores given by different assessors when assessing the same trainee in the same circumstance.[29] These themes are brought together by Generalisability Theory which generates statistical estimates of reliability that take into account the degree of variance from each of the described themes.[18]

#### 1.1.2.3 Validity theory

The validity of an assessment tool suggests how well the score reflects the measure one is intending to assess. In the case of the PBA, the intended measure assessed is surgical performance. This can be considered in a number of different ways.[18, 29-31] Face validity is defined as the subjective opinion of an expert as to whether the assessment appears to measure what it intends to measure. Content validity refers to the extent to which an assessment measures all relevant aspects of what it is intending to measure. An assessment of surgical technical skill that only assessed the ability to suture, but not to dissect, would lack content validity. Criterion or concurrent validity is demonstrated if the assessment outcomes agree with other validated, established methods of assessing the same measure. Construct validity is the degree to which the assessment measures what it intends to measure and can only be evaluated by hypothesising likely outcomes. For example, it would be reasonable to expect that increasing technical ability would be seen with increasing caseload experience. Demonstrating that assessment scores increase with increasing operative experience would provide evidence of construct validity. Put simply, it is the assessment's ability to distinguish between a novice and an expert. Outcome or predictive validity is demonstrated by how well the test predicts outcomes. In the case of assessing surgical technical skill, one might expect those demonstrating higher assessment scores to have better clinical outcomes (e.g. lower 30-day mortality scores). This was demonstrated by Birkmeyer *et al* when evaluating bariatric surgeon technique and outcomes using a modified O-SATS test.[32]

Opinions about validity of assessments have continued to evolve and have, to an extent, shifted away from statistical analysis of single assessment tools towards understanding a body evidence supporting the use of a WBA tool.[33, 34]

### 1.1.3 Technical skill assessment

Several WBAs for technical skill have been developed with several studies published evaluating the reliability and validity of such tools.[31, 35-37] The Procedure-Based Assessment (PBA) is the tool used in UK surgery training.[26] Three of the more commonly used tools are the Ottawa Surgical Competency Operating Room Evaluation (O-SCORE)[38, 39](Section 1.1.3.2), the Objective Structured Assessment of Technical Skills (OSATS)[40, 41](Section 1.1.3.3) and the Zwisch scale[42](Section 1.1.3.4).

#### 1.1.3.1 Procedure-Based Assessment (PBA)

In the UK, the WBA tool used to assess operative competency is the PBA. The PBA model of assessment is designed to assess the "does" element of Miller's clinical competence model.[43] The PBA tool is made up of a series of binary, criterion- referenced ratings for task specific points as well as a global summary ordered categorical assessment (rated 0-4) of the trainee's ability to perform the procedure.

The possible global summary scores for a PBA are:

**Level 0:** Insufficient evidence observed to support a summary judgement

**Level 1:** Unable to perform the procedure, or part observed, under supervision

**Level 2:** Able to perform the procedure, or part observed, under supervision

**Level 3:** Able to perform the procedure with minimum supervision (needed occasional help)

**Level 4:** Competent to perform the procedure unsupervised (could deal with any complications that arose)[18]

Each of these global summary scores were divided into further sub-levels "a" and "b" from 2015 onwards. Each PBA is procedure specific and has task specific criteria written to reflect that particular operation. This element was designed to be used as a guide for formative feedback.  The global rating score is generic to all PBAs. The global summary score is used for both formative and summative purposes, being a contributory factor in the latter. Assessment guidance is published on the ISCP website and suggests that the assessment should be completed immediately after the procedure with both the trainer (assessor) and trainee present for feedback purposes. All surgical trainers are required to be trained in the use of WBAs (either face-to-face, web-based or written guidance.)

The PBA been a formal component of the surgical training assessment programme since 2007 and was assessed by Beard *et al* in an National Institute of Health Research (NIHR) Health Technology Assessment programme in 2011.[18, 26] Beard *et al* evaluated the use of the PBA, along with two other methods of assessment, in a single training region across three hospital sites. The study involved 85 trainees of differing training stages and from mixed surgical specialties including General Surgery, Trauma and Orthopaedics, Vascular Surgery, Cardiothoracic Surgery and Obstetrics and Gynaecology. Procedures assessed were as diverse as Diagnostic Laparoscopy, Coronary Artery Bypass Grafting, Elective Caesarean Section and Segmental

Colectomy. Despite the diversity of these procedures and the backgrounds of the trainees undertaking the assessments, all data were grouped together for the purposes of statistically evaluating the validity of the PBA. Beard *et al* suggested that if the PBA was found to be valid then the hypotheses stated below will be fulfilled:

*Hypothesis testing for the validity of the PBA. Taken from Beard et al,*

1. Scores obtained by each assessment will correlate with the other assessments that set out to measure the same aspect of performance. These correlations will operate within instruments (internal structure) and between instruments.

2. Scores will increase with duration of surgical training and number of similar procedures performed (experience).

3. Higher-scoring operations will result in less operative time and blood loss, fewer perioperative and postoperative complications and a shorter length of hospital stay.

4. Mean scores, and scores for each element, will not be significantly different across the fifteen different index procedures.

5. Assessor designation (clinical supervisor versus independent assessor for PBA and OSATS,anaesthetists and scrub nurses versus independent assessor for NOTSS) will not affect assessment stringency.

6. Assessment (plus or minus video-recording equipment) will not affect the performance of trainees.

*Assessing the surgical skills of trainees in the operating theatre: a prospective observational study of the methodology.*[18]

One of the reported outcome measures in the study was the construct validity of the PBA assessed by the correlation between PBA levels achieved and number of procedures undertaken, the total time in training and the training level of the trainee. (Hypothesis 2) Beard *et al* reported a significant positive correlation between both training stage and operative experience with PBA level outcomes, (r= 0.71 and r= 0.50, respectively. P<0.05). Training stage (ST year) and number of index procedures undertaken were found to be significant predictors of surgical performance as judged by the PBA.

The study group reported a reliability score of G>0.8 for three PBA level scores when a trainee was assessed on the same index procedure by three individual assessors. They interpreted this result to conclude that trainees should be assessed on every index procedure individually to establish competence in that procedure. The authors also concluded that the high reliability demonstrated in their study meant that PBA was suitable for use as part of a summative assessment programme. Subsequently, the UK adopted the PBA into the General Surgery requirements for completion of training in 2013 with trainees expected to achieve three, Level 4 PBAs in each of the General Surgery index procedures.[7]

Beard *et al* concluded their study by calling for further studies, using real-time training data, to evaluate the PBA further, with particular reference to setting requirements for operative competency in the future. However, until now, the hypothesis of increasing PBA level scores with increasing experience (time and number of cases) (i.e. the construct validity of the PBA) has not been assessed using routinely collected national data and studies linking assessment outcomes with operative experience are small and limited to single region data.

#### *1.1.3.1.1 Other research linking operative experience to PBA outcomes*

De Siqueira *et al*, Abdelrahman *et al* and Brown *et al* have all published studies evaluating the association between PBA scores and operative experience.[19, 20, 44] All three studies were of single UK regions and used data available via Training Programme Director ISCP access meaning the authors were unable to undertake detailed analysis of training timelines or exclude time periods not contributing to approved surgical training.

In 2016, De Siqueira *et al* reported an association between higher PBA scores and increasing numbers of procedures undertaken for cholecystectomy ($r = 0.53$, $p < 0.001$) and segmental colectomy ($r = 0.55$, $p < 0.001$) in a cohort of 121 General Surgery specialty trainees from a single UK training region.[19] De Siqueira *et al* also described a mean number of procedures undertaken in specialty training prior to award of a third Level 4 PBA and found these mean averages to be higher than the present UK curriculum requirements. It is not clear whether the authors considered any operative experience prior to surgical training and the number of trainees included (i.e. those that were awarded three Level 4 PBAs) was small (n=8).[19]

Abdelrahman *et al* undertook a similar study using eLogbook and ISCP data from 69 General Surgery specialty trainees from the Wales Deanery in 2016.[20] The study included operative experience recorded prior to specialty training with the assumption that all operative experience contributed to the acquisition of competency. The authors calculated a median number of procedures undertaken prior to award of first and third Level 4 PBA and evaluated this in relation to the present UK requirements for operative experience at completion of training (Section 1.4.4.5.2).[20] Abdelrahman *et al* compared operative experience at award of competency (as defined by the PBA) to UK requirements for operative experience and found disparity between the two. The trainee numbers included were low, ranging from 19 for segmental colectomy to 24 for inguinal hernia repair and appendicectomy, limiting the generalisations that can be drawn from this study.

In 2017, the same study group published a further study of 84 trainees from the Wales Deanery. The authors described median operative experience to award of third Level 4 PBA and calculated learning curve gradients for each of the General Surgery index procedures using both first Level 4 and third level 4 PBA with operative exposure and time in training as exposure variables.[44] Again, trainee numbers were small and limited to a single region. Whilst the authors described learning curve trajectories, they did not propose what operative experience is required for attaining competency.

#### 1.1.3.2 Ottawa Surgical Competency Operating Room Evaluation (O-SCORE)

The O-SCORE was developed in 2010, initially for use in orthopaedic surgical training. It is a criterion-referenced assessment with the competency descriptors centred around trainee readiness for independent, unsupervised practice and is designed to be used for any surgical procedure with generic areas of judgement.[38] A study by Gofton *et al* piloting use of the O-SCORE in both General and Orthopaedic surgery training reported that a reliability G-Score of 0.8 was reached after five individual assessments. The authors combined assessments from both specialties when evaluating validity. Gofton *et al* reported an association between increasing seniority of the trainee and operative experience with O-SCORE levels attained and interpreted this as evidence of assessment validity. There were several limitations of this study including low numbers of trainees (n=37) included from only a single site and an assumption that a single trainer rating the same trainee on multiple occasions for the same procedure represented independent observations for the purposes of statistical analysis. [38]

#### 1.1.3.3 Objective Structured Assessment of Technical Skills (OSATS)

The O-SATS was developed by Richard Reznick in 1996 and was one of the first WBAs for technical skill assessment.[40, 41] The use of O-SATS has been studied widely with several publications relating to the reliability, validity and acceptability of the tool.[31] The Royal College of Obstetricians and Gynaecologists adapted the original O-SATS for use in UK obstetrics and gynaecology training in 2007.[45] Beard *et al* assessed the use of the O-SATS tool in the same NIHR study evaluating use of the PBA.[18] They reported that the O-SATS was less reliable than the PBA and required five assessors to reach a G-Score of 0.8 and reported no evidence of construct validity with no correlation between test scores and trainee experience. However, this study was single centre and the recruited Obstetrics and Gynaecology trainees had a high proportion of senior trainees whose competency had subjectively been described as below expected for stage of training. These factors may have biased the findings in this study.[37] Despite these findings, O-SATS remains the

WBA used by the Royal College of Obstetricians and Gynaecologists for assessing technical skill.

O-SATS is one of the few WBAs to have published evidence of outcome validity. Birkmeyer *et al* studied the association between technical skill of 20 Attending (Consultant) bariatric surgeons and their post-operative outcomes in Michigan, USA.[32] Videos of laparoscopic procedures were rated by 33 Attending bariatric surgeons who were blinded to the identity of the surgeon undertaking the procedure. Surgical outcome data were analysed for 10,343 patients who had been operated on by the operating surgeons over the previous 6 years. The authors reported a range of mean technical assessment scores and an association between poorer technical performance and increased rates of adverse post-operative outcomes. The surgeons in the lowest quartile of skill scores, compared to those in the highest quartile of scores, had increased rates of post-operative complications (14.5% vs 5.2%, $p<0.001$).[32] The authors acknowledged limitations of the study including that each participating surgeon was only rated on one self-selected video and there was no account of the grade or skill of the assisting surgeon. Whilst this study was of independently practicing surgeons, so not directly relatable to the acquisition of competency during surgical training, it does demonstrate evidence of outcome validity of the O-SATS.

#### 1.1.3.4 Zwisch scale

The Zwisch scale was developed by a Cardiothoracic surgeon in the USA.[46] It differs to the aforementioned scales in that it is designed to quantify the autonomy of the trainee rather than descriptors of performance.[46] It is a 4-level scale based on behavioural statements describing the degree of support that the trainer gave to the trainee during the procedure. The first level is described as “Show and tell” and is where the trainer performs the procedure with the trainee watching and assisting. The second level is “Active help”. At this level, the trainee undertakes the procedure but with the trainer actively helping the trainee through the procedure. “Passive help” is the third level and represents a decrease in the amount of guidance provided by the trainer with the trainee undertaking the procedure with the trainer only making teaching points or refining technique. The final and fourth level is “Supervision only”. At this level, the trainee performs the procedure independently with the trainer only present for patient safety purposes.[42] George *et al* undertook a study of the use of the Zwisch scale in 2012/2013 with an electronic data collection system called Procedural Autonomy and Supervision Scale (which has since been renamed SIMPL: System for Improving and Measuring Procedural Learning). [47] The study team undertook a reliability and feasibility study using real-time and procedure video data from a single institute with 31 general surgery trainee participants comparing Zwisch scale ratings with previously validated assessments of competency. The group were able to demonstrate trainee progression through the rating scale with increasing operative year of training and procedural experience. The study also demonstrated evidence of concurrent validity with the previously validated O-SCORE scale and the Operative Performance Rating System (OPRD).[38, 48] The authors concluded that the Zwisch scale was a reliable and valid measure of recording trainee autonomy. The single institution limitations of this study were addressed in a follow up trial of the use of the Zwisch scale in determining trainee autonomy across 14 General Surgery programmes in the USA.[49] The Zwisch scale was adopted into a smart-phone based system; SIMPL.[47] The Zwisch scale was used in addition to a performance rating scale (the OPRS) which rated trainee's operative performance with a 5-point scale:

1. Unprepared/ Critical Deficiency
2. Unfamiliar with Procedure
3. Intermediate Performance
4. Practice Ready
5. Exceptional Performance

This scale was adapted from a previous study that had evaluated the use of the scale to determine performance assessment.[48, 50] The study team evaluated 536 trainees on 10,130 procedures for both autonomy evaluation and performance.[49] George *et al* reported increasing autonomy rating and performance rating through the course of training but expressed concerns that trainees were not universally ready to perform key procedures independently, even at completion of training. Participation in the study was voluntary therefore possibly introducing selection bias with trainees less capable possibly choosing not to participate. Trainees were only rated on a selection of cases and so results presented may not reflect the totality of practice. Furthermore, the data was collected for the purposes of a study period and so inferences about changing autonomy and performance with increasing experience are made by comparing current first year trainees with final year trainees at a single point in time rather than a reflection of each trainee's changing performance over time.[49]

#### 1.1.3.5 Other assessments of technical skill

Motion analysis has been suggested as an alternative to objective, expert opinion for the assessment of technical skill.[51] Various systems designed to evaluate motion analysis have been developed such as the Imperial College Surgical Assessment Device (ICSAD), the Advanced Dundee Endoscopic Psychomotor Tester (ADEPT) and the ProMIS Augmented Reality Simulator.[52-54] None have been adopted into the UK programme of assessment and have not been evaluated as part of any studies within this thesis.

## Section 1.2 The future of assessment in UK surgical training

### 1.2.1 Entrustment decision concept

In the wider context of competency based medical education, there is an international trend towards moving away from a reductionist approach of individual case assessments to broader, more holistic assessments of a trainee's ability to manage defined tasks of work.[1, 55-59] Lockyer *et al* described a need for multiple assessment methods, by multiple assessors and an emphasis on the expert view (i.e. the Consultant assessor) within competency-based medical education.[34] From this paradigm, the concept of "Entrustment" has developed which is defined as the degree of trust conferred by a trainer to a trainee to work independently.[60] An "Entrustable Professional Activity (EPA)" is defined as a unit of activity undertaken which the trainee could be trusted to complete.[61] Ten Cate established a scale to describe the degree to which a trainee could be trusted to perform that unit of activity independently.[62] This scale closely relates to both the way in which the supervision level of an operation is recorded in the UK and PBA levels.[18, 63, 64](Table 1).

*Table 1 Entrustable Professional Activity levels, supervision coding for operative procedures in the UK and Procedure Based Assessment levels*

| Ten Cate Entrustable Professional Activity Supervision Levels[62] | Supervision Coding for Operative Procedures in the UK (adapted)[63] | Procedure Based Assessment levels [18] |
|---|---|---|
| Observation but no execution, even with direct supervision | Assisting: the trainer completes the procedure from start to finish | **Level 1:** Unable to perform the procedure, or part observed, under supervision |
| Execution with direct, proactive supervision | Supervised, trainer scrubbed: the trainee performs key components of the procedure with the trainer scrubbed | **Level 2:** Able to perform the procedure, or part observed, under supervision |
| Execution with reactive supervision, ie, on request and quickly available | Supervised, trainer unscrubbed: the trainee completes the procedure from start to finish. The trainer is unscrubbed and is in the operating theatre throughout or in the operating theatre suite and regularly enters the operating theatre during the procedure. | **Level 3:** Able to perform the procedure with minimum supervision (needed occasional help) |
| Supervision at a distance and/or post hoc | Performed: The trainee completes the procedure from start to finish. The trainer is not present in the operating theatre. | **Level 4:** Competent to perform the procedure unsupervised (could deal with any complications that arose)[18] |
| Supervision provided by the trainee to more junior colleague | Training a more junior trainee: a non-consultant grade surgeon training a junior trainee. | |

Entrustment decisions (a decision by a trainer to allow a trainee to complete a unit of work independently) have been described as either ad hoc or summative decisions.[60] Ad hoc entrustment decisions are characterised as based upon estimated ability of the trainee, potential risk to the patient and contextual issues such as time of day, urgency and staff availability. These decisions typically take place daily in clinical practice. In contrast, summative entrustment decisions are more formal and made deliberately based upon an established relationship between trainee and trainer with sufficient opportunity for trainee capability evaluation.[60]

### 1.2.2 New GMC requirements for curricula

Following a review of fitness to practice referrals and the Shape of Training Review[65], the GMC mandated that all postgraduate curricula should be rewritten to address specific areas of professional practice within a framework that the GMC termed “Generic Professional Capabilities Framework”.[55] This framework describes nine domains of professional practice that all curricula should map to:

1. Professional values and behaviours
2. Professional skills (including areas such as clinical skills, practical skills and communication skills)
3. Professional knowledge
4. Capabilities in health promotion and illness prevention
5. Capabilities in leadership and team working

6. Capabilities in patient safety and quality improvement
7. Capabilities in safeguarding vulnerable groups
8. Capabilities in education and training
9. Capabilities in research and scholarship

The GMC also published curricula and assessment standards for all post-graduate medical curricula in its 2017 document "Excellence by Design: standards for post-graduate curricula".[56] In addition to a requirement for curricula to map to the nine Generic Professional Capability domains, all post-graduate curricula are required to describe high-level outcomes, which are generic to all specialties, with the addition of specialty-specific outcomes. These high-level outcomes should describe the broad capabilities (akin to Entrustable Professional Activities) that trainees are expected to achieve by completion of training. The Excellence by Design document details five themes which must be used when developing a curricula:[56]

**Excellence by Design: standards for postgraduate curricula.**

**Key themes and principles:**

Theme 1: Purpose. Why is the curriculum needed?

Theme 2: Governance and strategic support. What processes were used to develop the curriculum?

Theme 3: Programme of learning. What does a doctor need to experience and achieve to progress or complete training?

Theme 4: Programme of assessment. How will doctors demonstrate attainment of the intended learning outcomes?

Theme 5: Quality assurance and improvement. How will the performance and development of the curriculum and programme of assessment be monitored and reviewed?

### 1.2.3 Proposed changes to the UK General Surgery training system

The UK General Surgery curriculum is presently being rewritten in line with the GMC mandatory standards for post-graduate curricula and with the adoption of a new competency-based assessment framework. The high level outcomes described by the GMC are expected to take the form of Capabilities in Practice (CiPs) which are defined units of work akin to Entrustable Professional Activities.

The assessment for CiPs is proposed to be via the use of a Multi-Consultant Report. The Multi-Consultant Report is a formalised way for trainers to record entrustment decisions for CiPs after repeated observation over time, for example, at the end of a placement. The use of WBAs will remain and are expected to support the development of specific competencies where required. Full details of the new curriculum are not presently in the public domain.

## Section 1.3 Global Training Systems

Surgical training programmes differ around the world with several countries using established training systems and curricula. Some curricula identify key procedures to be undertaken during surgical training. In the UK, these include the commonest general surgical procedures undertaken worldwide; appendicectomy, cholecystectomy and inguinal hernia repair. In 2016/17 there were approximately 36,000 emergency appendicectomies, 77, 000 cholecystectomies and 72,000 inguinal hernia repairs performed in England alone.[66]

Those countries which publish data relating to the volume of the aforementioned key procedures undertaken during General Surgery training have been included in the systematic review in Chapter 2. The training systems included in the systematic review are detailed below. Canada and Australia and New Zealand have well developed and established surgical training systems but have not published national data relating to operative experience in training.

### 1.3.1 USA Surgical Training

General surgical training in the USA is a 5-year residency programme, which is undertaken following completion of a single post-graduate “intern” year. Attending surgeons (“consultants” in UK terminology) can be qualified as soon as 6-years after finishing medical school. However, about 80% of surgical trainees continue training into a fellowship period for a minimum of a year post residency graduation.[67]

The Accreditation Council on Graduate Medical Education (ACGME) is the over-seeing group for all graduate medical education in the USA. Within the structure of the ACGME are specialty-specific Residency Review Committees. Each committee sets accreditation standards and provides peer evaluation of residency programs. The American Board of Surgery (ABS) provides board certification to individuals who have met the Residency Review Committee for Surgery (RRC-S) standards of training. The ABS sets out terms of requirements for completion of training in the "Booklet of Information: Surgery".[6] The ABS stipulates minimum operative requirements of 750 major cases in 5 years of residency training including at least 150 cases in Chief Resident year. Major case numbers are exclusive of endoscopy, minor skin procedures and surgical critical care patient procedures (such as invasive line management).[68] These numbers were based on a consensus judgement of directors of the ABS and are unrelated to a measure of competency. [Personal communication, Dr Frank Lewis, Executive Director, ABS]

Surgical trainees in the USA are expected to log their clinical experience using the Resident Case Log System, which is a web-based record of experience, and overseen by the ACGME. The ACGME have published data from these records for trainees completing training for some 16 years.[68]

### 1.3.2 Spanish Surgical Training

General surgical training in Spain is undergoing reform with proposals for a period of core surgical training followed by a 4-year period of "Specific Area Training".[69] Presently there is a 5-year residency programme in existence. This programme was set in 2007 and defined a minimum numbers of procedures to be achieved by completion of training in addition to other criteria such as research requirements and essential courses. The required operative experience during residency includes 200 emergency operations, 15 cholecystectomies, 10 colectomies and 25 inguinal hernia repairs.[70]

### 1.3.3 Netherlands Surgical Training

Surgical training in the Netherlands is a 6-year residency programme split into a 2-year core programme of basic surgical training followed by a 4-year period of higher surgical training. The 4-year higher surgical training period comprises 3-years of General Surgery training and a further 1-year of differentiated training in the surgical specialty of choice (e.g. gastrointestinal, trauma or vascular surgery). Upon completion of the training programme, the programme director proposes the trainee to the Medical Specialists Registration Committee for registration as a surgeon capable of independent practice. Surgical trainees in the Netherlands previously had to provide logbook evidence of their operative experience with minimum experience of 550 procedures as primary surgeon, including 350 “complex” cases. This model of training ended in 2011 and the Netherlands have since adopted a competency-based programme with no minimum operative experience stipulated. Rather, trainees are expected to achieve levels of expertise judged by work-based assessments similar to the Objective Structured Assessment of Technical Skills (OSATS) model. [Personal communication, Professor JF Hamming, President Board of Surgical Training, Netherlands].

### 1.3.4 Thailand Surgical Training

The Royal College of Surgeons of Thailand offers a 4-year residency programme in General Surgery in all major university hospitals. At the end of the training programme, trainees are required to provide logbook evidence of operative experience with standards set as 100 cases performed as primary surgeon and a further 400 cases as an assistant. Procedure specific numbers are also defined including 10 inguinal hernia repairs, 5 laparoscopic cholecystectomies and 2 open cholecystectomies and 3 colectomies.[71]

## Section 1.4 Surgical Training in the UK

### 1.4.1 Role of the governing bodies

There are several bodies for surgical training in the UK, which are all linked, and work together with trainees and surgical trainers. (Figure 1) Responsibility for governance and regulation falls to the General Medical Council (GMC)[72] and the four UK and Ireland Royal Colleges of Surgery.[73-76] Responsibility for the delivery of surgical training lies with the four UK education bodies: Health Education England (HEE),[77] National Health Service Education for Scotland (NES),[78] Health Education and Improvement Wales (HEIW)[79] and the Northern Ireland Medical and Dental Training Agency (NIMDTA).[80]

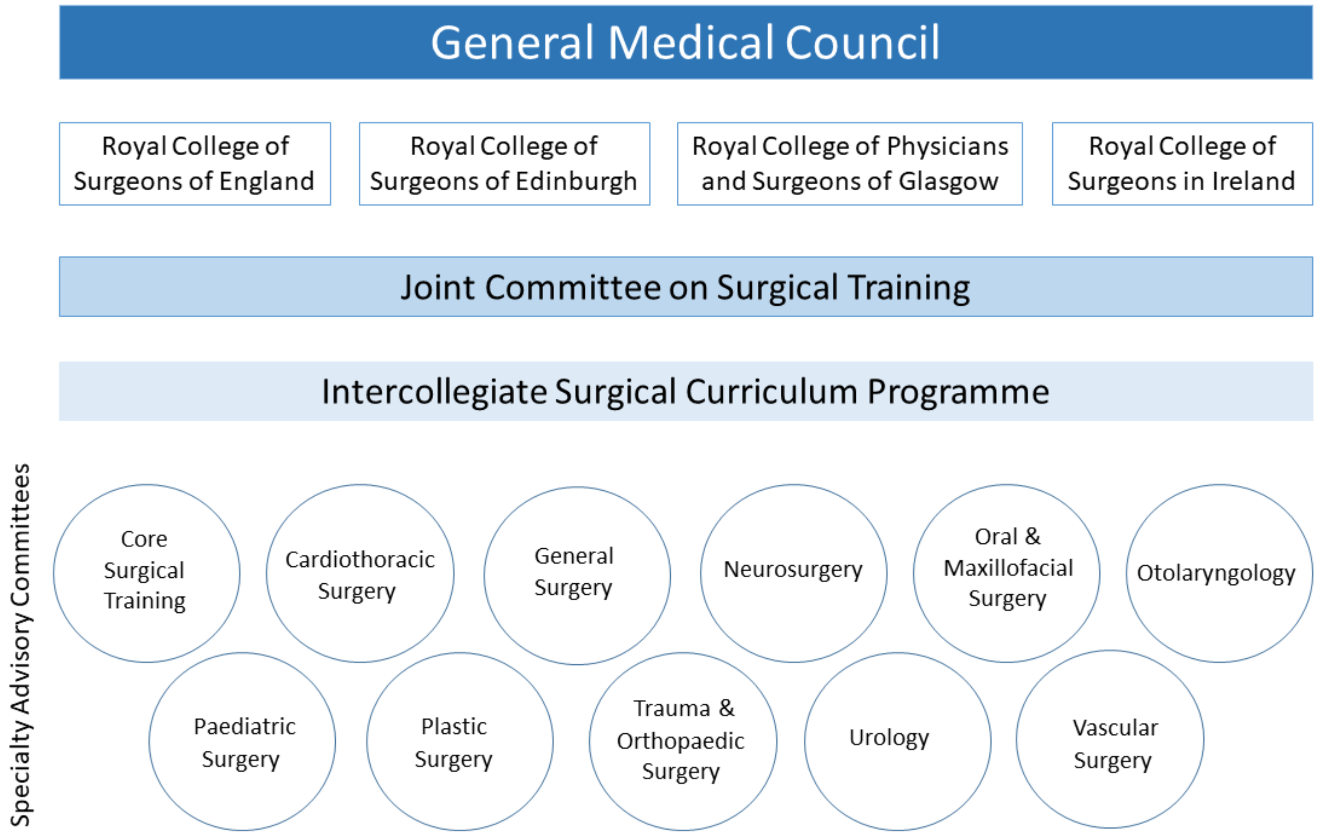



***Figure 1 Governing and regulatory bodies for surgical training in the UK***

### 1.4.1.1 General Medical Council

The General Medical Council (GMC) is the UK regulatory body for all medical education and training. It has five main areas of work which are:

1. Maintaining a medical register of doctors approved to practice in the UK

2. Setting standards for doctors including professional values and behaviours.

3. Overseeing medical education and training including approving curricula and monitoring training centres.

4. Ensuring that revalidation processes and standards are met for senior doctors.

5. Investigating and managing concerns about poor medical practice.[72]

### 1.4.1.2 Royal Colleges of Surgery

There are four Royal Colleges of Surgery:

1. Royal College of Surgeons of England[81]
2. Royal College of Surgeons of Edinburgh[82]
3. Royal College of Physicians and Surgeons of Glasgow[83]
4. Royal College of Surgeons in Ireland[76]

The Colleges are professional membership organisations and provide representation for surgical affiliates, members and fellows in addition to providing education and continuing professional development with the aim of advancing standards in surgical care. The Joint Committee on Intercollegiate

Examinations (JCIE) is responsible to the four Royal Colleges for the compulsory Intercollegiate Specialty Board exams required of surgical specialty trainees.

#### 1.4.1.3 Joint Committee on Surgical Training

The Joint Committee on Surgical Training (JCST) is an intercollegiate advisory body to the four Royal Colleges of Surgery in the UK. The responsibilities of the JCST include the national registry of UK trainees, the recommendation of trainees to the GMC for Certificate of Completion of Training, developing the surgical curriculum and monitoring the quality of surgical training in the UK.[84] It is also responsible for developing and maintaining the Intercollegiate Surgical Curriculum Programme (ISCP) online training management system. The JCST is the parent body for all the Specialty Advisory Committees (SACs) which are responsible for each surgical specialty.

There are ten surgical specialties in the UK, each with their own SAC:

- Cardiothoracic Surgery
- General Surgery
- Neurosurgery
- Oral and Maxillofacial Surgery
- Otolaryngology
- Paediatric Surgery
- Plastic Surgery
- Trauma & Orthopaedic Surgery
- Urology

- Vascular Surgery

Core Surgical Training is represented by the Core Surgical Training Advisory Committee which also falls under the JCST remit.

#### 1.4.1.4 Intercollegiate Surgical Curriculum Programme (ISCP)

The ISCP was launched in August 2007 to coincide with reforms to post-graduate training. It is a web-based training management system that hosts the surgical curriculum for each surgical specialty, including Core Surgical Training, and has become central to the delivery of surgical training in the UK. It includes a syllabus to be covered during training, criteria to be met for completion of training, online work-based assessments and an online portfolio for evidence of achievement.[11] The portfolio includes the electronic logbook of operative experience, supervisory reports, records of the Workplace Based Assessments completed, documents that a trainee has uploaded as evidence of development e.g. conference attendance certification, presentations given to learned societies, letters of thanks from patients and supervisory reports. The evidence in the trainee's portfolio is used for the trainee's Annual Review of Competency Progression. Use of the ISCP is compulsory for all surgery trainees.

The ISCP is overseen by a Surgical Director, who leads the ISCP Management Committee and the Head of the ISCP. The ISCP Management Committee comprises individuals with responsibility for surgical training, for example representatives of the SACs, a surgical educationalist, trainee representatives, representatives from the training bodies and a lay representative. The committee is responsible for overseeing curriculum development, assessment, training process and the ongoing development of the online database.

#### 1.4.1.5 Specialty Advisory Committees

The JCST, through the SACs, has a range of responsibilities including registration of trainees for specialty training, recruitment, logbook development and writing the curriculum to be followed in association with stakeholders. The SACs are also responsible for providing externality to assessment processes e.g. at the trainee's Annual Review of Competency Progression and for recommending a trainee to the GMC for Certification. The externality and advisory function is provided by the presence of an SAC Liaison Member who represents the SAC to a region. The Liaison Member must originate from a geographically separate training region in order to provide externality and is a Consultant surgeon.

### 1.4.2 UK organisation for post-graduate surgical training

#### 1.4.2.1 England

Post-graduate medical and surgical training in England is delivered by Health Education England (HEE) which has responsibility for workforce planning, education commissioning and education provision.[77] There are four Local Education Training Boards (LETBs) overseen by HEE: London and the South East; Midlands and East; North and South. The responsibility for local delivery of post-graduate medical and surgical training falls to 12 post-graduate deans, each with a smaller geographical area of authority, termed Postgraduate Medical and Dental Education (PGMDE) teams:

1. East of England
2. East Midlands
3. Kent, Surrey and Sussex
4. London
5. North East
6. North West
7. South West: Peninsula region
8. South West: Severn region
9. Thames Valley
10. Wessex
11. West Midlands
12. Yorkshire and the Humber

These smaller geographical areas all have a PGMDE team with responsibility for the delivery of surgical post-graduate education, the quality of local post-graduate training, the ARCP process and trainee specific aspects of training such as working less than full time or taking time out of training to complete a period of formal research. The PGMDE teams and local deans took over the functions of the previous Deaneries from 1st April 2013.[77] At this time, some deaneries were merged to a single geographical region. For example, Mersey Deanery and North Western Deanery becameHealth Education North West. Each HEE board area has a Head of School of Surgery and Training Programme Director (TPD) for General Surgery who are local surgeons given responsibility for ensuring the adequacy of surgical training.

#### 1.4.2.2 Devolved Nations

NHS Education for Scotland manages education of the health service workforce in Scotland including post-graduate surgical training through a single deanery. For General Surgery, Scotland is divided into four smaller geographical regions for training, each with their own TPD: North; South East; East; West.[78]

Health Education and Improvement Wales, also known as Wales Deanery, is responsible for post-graduate surgical training across the whole of Wales.[79]

The Northern Ireland Medical and Dental Training Agency is responsible for post-graduate surgical training across the whole of Northern Ireland.[80]

### 1.4.3 Timeline of post-graduate General Surgery training in the UK

Trainees pursuing a career in General Surgery in the UK follow a typical pathway for General Surgical training which has been standardised since 2007.[85] After graduating from medical school, trainees complete two years of Foundation Training and then two years of Core Surgical Training. Following this, trainees apply for specialty surgical training and if successful, are awarded a National Training Number (NTN), which defines the trainee as being appointed to an approved surgical training programme. General Surgery specialty training is an indicative 6 years in duration. A trainee in the first year of Core Surgical Training is referred to as a Core Trainee, year 1 (CT1) with the second year trainees known as CT2 trainees. A trainee in the first year of specialty training is referred to as a Specialty Trainee, year 3 (ST3). Trainees typically finish standard training at the end of their ST8 year.

#### 1.4.3.1 Calman Trainees

Trainees appointed to General Surgery training programmes prior to 2007 were known as Calman trainees, named after Sir Kenneth Calman, the then Chief Medical Officer who led a working group on specialist training in 1992.[86] Calman trainees were transferred flexibly onto the ISCP system depending on seniority, trainee and TPD preference.

#### 1.4.3.2 Run-through training

The recruitment of surgeons in 2007 saw trainees awarded NTNs at ST1 and ST2 levels, known as “run-through training” without the need to reapply for specialty training at ST3 level. These trainees are recorded as commencing specialty training at a date commensurate with their run-through appointment. Recruitment at this time was controversial with the launch of Modernising Medical Careers (MMC) and Medical Training Application Service (MTAS) resulting in delays to recruitment and the MTAS system was abandoned the following year.[87] The delays in recruitment resulted in unclear start dates for many trainees in 2007. Training in General Surgery was “decoupled” in England and Wales in 2008 with trainees subsequently required to reapply for surgical training posts and unable to obtain NTNs until minimum ST3 level. Scotland decoupled core and specialty training for General Surgery in 2011 [Personal Communication. Mr Gareth Griffiths, JCST Chair].

#### 1.4.3.3 Locum Appointment for Training posts

Previously, if trainees were unsuccessful at recruitment to specialty training, they could be appointed to Locum Appointment for Training (LAT) posts. LAT posts were typically one year in duration and within an accredited surgical training scheme but were not full training pathway appointments with no progression beyond the end of the fixed-term post. Once a trainee had secured a NTN training appointment, they could apply for retrospective recognition of the time spent in a LAT appointment towards time required for CCT. No LAT appointments have been made in General Surgery in England since 2014 following a move away from these posts. Instead, trainees who fail to obtain a NTN post may apply for Locum Appointment for Service (LAS) posts. LAS posts cannot be counted towards time in training.

#### 1.4.3.4 Certificate of Eligibility for Specialty Registration via the Combined Programme

In addition to entering specialty surgical training through UK approved Foundation and Core training (with all posts prospectively approved by the GMC), trainees may also obtain an NTN post having completed non-GMC approved posts with demonstration of acquisition of the equivalence of Core training competencies. This is typical for trainees applying for specialty surgery training from overseas. These trainees are awarded a Certificate of

Eligibility for Specialty Registration via the Combined Programme (CESR, CP) rather than a Certificate of Completion of Training.[88] Trainees from overseas who complete UK Core Surgical Training prior to obtaining a NTN training appointment may also be recommended for Certificate of Completion of Training in the usual fashion. In 2011, half of the applicants to General Surgery specialty training were those with a primary medical qualification from overseas and half had primary medical qualifications from the UK. [Personal Communication. Mr Gareth Griffiths, JCST Chair]. The requirements for recommendation for CESR CP are the same as the requirements for recommendation for CCT and both routes allow entry to the GMC Specialty Register enabling independent practice as a Consultant Surgeon in the UK.

Figure 2 shows a typical training pathway with the blue arrow at start of specialty surgical training and the red arrow indicating the point of completion of training.

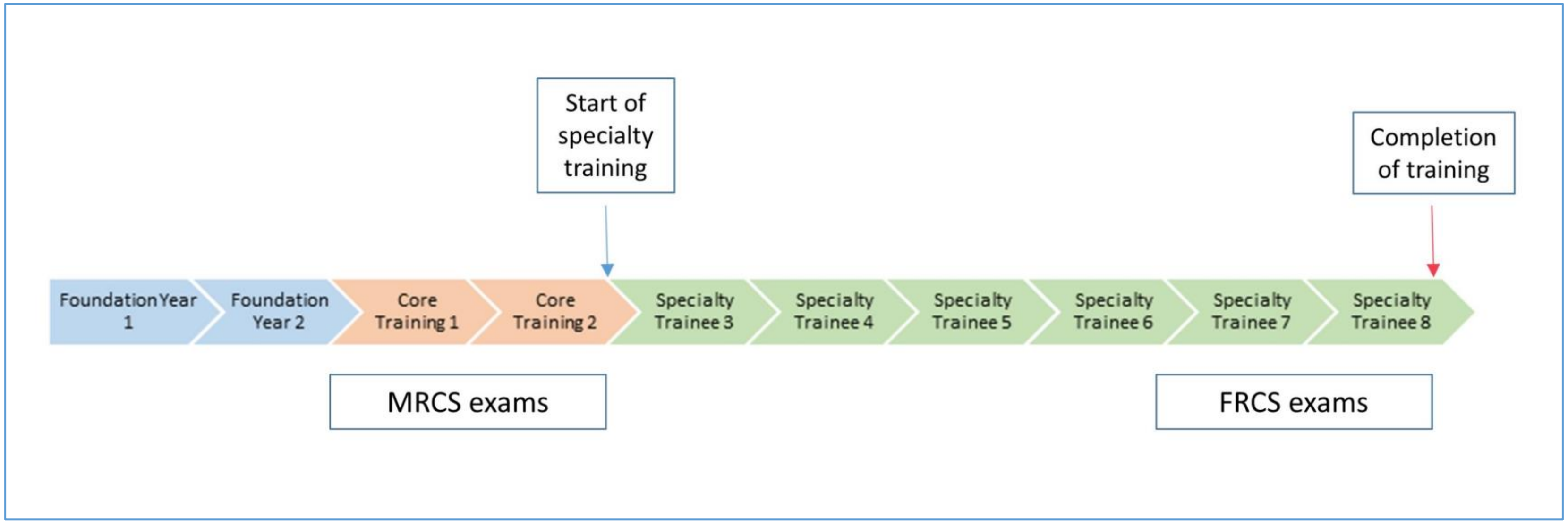



***Figure 2 Timeline of postgraduate surgical training in the UK***

#### 1.4.3.5 Time out of training programme

Trainees may take time out of training for the following reasons:

- sick leave
- maternity leave
- military service leave
- time out of programme for research (OOPR)
- time out of programme for other experience (OOPE)
- time out of programme for career break (OOPC)

Other reasons for prolonged training time include:

- working less than full time
- extension of training for additional training needs

Trainees may also take time out of programme for further training (OOPT) which is training in a different approved programme.

All periods of time out of training except OOPT result in an extension to the trainee's total training time. Time for OOPR is usually for a minimum of two years and the trainee is typically expected to undertake a higher degree.[88]

### 1.4.4 General Surgery

#### 1.4.4.1 Special Interest

General Surgery trainees are trained in the specialty of General Surgery and, if successful, are recommended for Certification in General Surgery. Trainees declare a special interest which reflects the particular area within General Surgery that the trainee has focused upon throughout their training.

Special interests include:

- Colorectal surgery
- Upper Gastrointestinal Intestinal surgery
- Breast surgery
- Endocrine surgery
- Transplant surgery
- Vascular surgery
- General Surgery of childhood
- Advanced Trauma surgery
- Remote and Rural surgery

Vascular surgery became an independent surgical specialty in August 2013. Trainees with NTNs in General Surgery appointed prior to 2013 are still able to declare vascular surgery as a special interest but are unable to transfer their training into the new Vascular Surgery specialty training scheme. General Surgery trainees appointed to NTNs from 2013 are unable to declare vascular surgery as their special interest.[89]

#### 1.4.4.2 General Surgery Curriculum

The curriculum is hosted on the ISCP website.[3] It contains a detailed syllabus with the knowledge, clinical skills and procedural skills expected of trainees by completion of training. It also describes the programme of assessment and the supervision of trainees in the UK alongside details of surgical education, training pathways and quality assurance processes. Trainees are expected to cover the breadth of the curriculum by completing a variety of surgical training placements through the course of the 6-year specialty training. Each training year is typically divided into two 6-month placements. Trainees may remain in the same placement for 12 months but are still required to meet with their named supervisors with the same frequency as those in a 6-month placement. Trainees are placed in General Surgery posts with a variety of special interests (e.g. colorectal, oesophago-gastric, transplant) with emergency General Surgery common to all posts. Placements are at approved regional training centres varying in size from major, tertiary referral centres affiliated with Universities to smaller district general hospitals. All regions have both tertiary referral centres and district general hospitals to ensure a variety of training environments and case-mix.

#### 1.4.4.3 Supervision of surgical trainees

The Reference Guide for Postgraduate Specialty Training in the UK is colloquially known as The Gold Guide. The Gold Guide applies to all postgraduate medical trainees in GMC approved programmes and it details the regulation, delivery and supervision of post-graduate specialty training in the UK.[88] It is maintained by the Conference of Postgraduate Medical Deans (COPMeD). Each trainee in GMC approved programmes should be supervised according to Gold Guide principles which include having named supervisors with specific training responsibilities and appropriate clinical supervision as set out by standards published by the GMC.[88, 90]

#### 1.4.4.3.1 Training Programme Director

Each region has an appointed Training Programme Director (TPD) for General Surgery who is responsible for overseeing the delivery of training regionally. The TPD ensures that training standards set out by the Gold Guide, GMC and JCST are adequately met. Activities include ensuring curriculum delivery and quality of local training, allocating placements, managing trainees in difficulty and overseeing the annual review process. The TPD is a Consultant surgeon from the training region but will not necessarily work clinically with most of the trainees they are responsible for.

#### 1.4.4.3.2 Assigned Educational Supervisor

Each trainee has an Assigned Educational Supervisor (AES) who is responsible for meeting with the trainee at least three times in each 6-month surgical placement. The role of the AES includes setting educational goals with the trainee, engaging in constructive and career developmental dialogue with the trainee and has responsibility for appraisal.[88] The AES reviews the trainee's ISCP portfolio and their progress as evidenced by WBAs, logbook review and reports from the Clinical Supervisor. They write a report based on this information at the end of each placement that contributes to the trainee's portfolio and is reviewed at the ARCP. (See Section 1.4.4.4)

#### 1.4.4.3.3 Clinical Supervisor

The Clinical Supervisor (CS) is a named Consultant responsible for the day-to-day supervision, training and assessment of the trainee. The CS may work in a team of Consultants and share this responsibility with colleagues or may work independently. The CS provides a written report for the trainee's portfolio at the end of each placement with a summary of the trainee's performance and progress. The CS also has access to the trainee's portfolio including summary reports of the logbook and WBAs.

#### 1.4.4.4 Annual Review of Competency Progression

Progression through surgical training is dependent on the trainee's satisfactory assessment at a yearly review, termed the Annual Review of Competency Progression (ARCP). The requirements and purposes of the ARCP process are generic to all post-graduate training in the UK.[88]

Trainees are required to provide evidence of meeting curriculum requirements at ARCP e.g. achievement of learning goals and satisfactory demonstration of stage-appropriate competencies through completion of WBAs. Trainees are awarded an ARCP outcome (Table 2), with ARCP outcomes 1, 6, 7.1 and 8 deemed to be satisfactory outcomes and the other outcomes reflecting non-standard trainee progression. The ARCP panel is made up of at least three members of the regional training committee (regional consultants with CS or AES responsibilities), one of whom is the TPD or more senior member of the regional training board (Head of School of Surgery or Postgraduate Dean). The panel also includes lay representation and an external advisor who is usually the SAC liaison member.[88] The panel makes an independent judgement of the trainee's online portfolio which includes WBA outcomes, the CS and AES reports and evidence of other activities e.g. courses attended, audit and research documentation.

*Table 2 Annual Review of Competency Progression outcomes [88]*

| ARCP Outcome | Definition | Satisfactory/ Unsatisfactory |
|---|---|---|
| 1 | Achieving progress and development of competences at the expected rate | Satisfactory |
| 2 | Development of specific competences required – additional training time not required. | Unsatisfactory |
| 3 | Inadequate progress - additional training time required. | Unsatisfactory |
| 4 | Released from training programme with or without specified competences. | Unsatisfactory |
| 5 | Incomplete evidence presented - additional training time may be required. | Unsatisfactory |
| 6 | Will be recommended as having completed the training programme and for award of a CCT | Satisfactory |
| 7.1 | Satisfactory progress in or completion of the LAT / FTSTA placement. | Satisfactory |
| 7.2 | (Fixed term training) - Development of specific competences required – additional training time not required. | Unsatisfactory |
| 7.3 | (Fixed term training) – Inadequate Progress by the Trainee). | Unsatisfactory |
| 7.4 | (Fixed term training) – Incomplete evidence presented. | Unsatisfactory |
| 8 | Out of programme for research, approved clinical training or a career break (OOPR/OOPT/OOPC). | Satisfactory |

***ARCP: Annual Review of competency and Progression. CCT: Certificate for Completion of Training. LAT: Locum appointment for Training. FTSTA: Fixed Term Specialty Training Appointment. OOPR: Out of Programme Research. OOPT: Out of Programme Training. OOPC: Out of Programme Career break.***

### 1.4.4.5 Requirements for Certificate of Completion of Training in General Surgery

Trainees must meet minimum requirements in the curriculum prior to being recommended for Certification. [7] These include:

- demonstration of knowledge by passing the FRCS exam
- breadth of experience by completion of required placements in various General Surgery specialties
- attainment of specific competencies through WBAs in specified subject areas
- understanding of research evidenced of satisfactory research involvement
- understanding of quality improvement projects evidenced by audit completion
- understanding of medical education principles evidenced by appropriate courses or qualifications
- experience of leadership and management
- trauma care provider certification

Additionally, the curriculum sets out expected indicative operative experience requirements and operative competency requirements.[7]

#### *1.4.4.5.1 Intercollegiate Specialty Board examinations*

Trainees are required to pass the intercollegiate specialty exams prior to being recommended for Certification. These exams are known as the Intercollegiate Specialty Board (ISB) exams. Passing these exams confers eligibility to apply for Fellowship of one of the Royal Colleges of Surgery (FRCS).

The ISB examinations are typically undertaken during the final two years of specialty training. The exams are intercollegiate and overseen by the Joint Committee for Intercollegiate Examinations (JCIE). Trainees must declare a special interest, as defined within the curriculum (Section 1.4.4.1) for the clinical component of the examination.[91] The exam is in two sections. Section 1 is a written examination comprising two papers of single-best answer questions and extended matching item questions. Section 2 is a clinical examination comprising clinical cases and viva examinations with the themes of emergency surgery, trauma and critical care; General Surgery; special interest; academic critique.

##### *1.4.4.5.2 Requirements for operative experience*

All General Surgery trainees are expected to meet indicative numerical operative experience requirements for key index procedures and for total operative experience, regardless of special interest. These numerical requirements were introduced in the 2013 iteration of the General Surgery curriculum following concerns that trainees were nearing completion of training without adequate operative experience enabling a broad understanding of techniques to surgically manage a range of clinical presentations.[92]

The numbers were set following a consensus decision of UK surgical training leads and a study by Allum *et al* of General Surgery trainee logbooks. Allum *et al* reviewed the operative experience of 58 trainees completing training in 2010/2011 with the aim of defining operative experience in a cohort of trainees completing training and setting thresholds for operative experience in future training cohorts.

The study was limited in a number of ways. Firstly, the study group excluded any trainees who had undertaken any time out of training or had been identified as requiring additional time for training. The group calculated total time in training and reported this to be a median of 6 years with a range of 4.8 to 7.3 years. No explanation was given for non-standard training time in General Surgery specialty training. The authors calculated the operative experience of the cohort both in total and for key index procedures and evaluated variation by special interest. The authors inferred trainees' chosen special interest from the volumes of procedures undertaken but did not have special interest data to formally support these assumptions. Defining emergency laparotomy experience was limited as it was not compulsory for trainees to record the urgency of a procedure. One trainee was reported to have only undertaken 18 emergency laparotomy procedures by completion of training, suggesting inaccuracy in the recording of these procedures. The authors suggested a figure of 100 emergency laparotomy procedures to be undertaken by completion of training in the future. This figure was unrelated to the data presented in the study.

Allum *et al* presented the view that thresholds for operative experience for other index procedures should be set at the 25$^{th}$ centile of the calculated trainee operative experience.[92] Subsequently, the following indicative numbers were defined and published as criteria for operative experience in the 2013 iteration of the ISCP curriculum:

- 80 appendicectomy
- 60 inguinal hernia

- 50 cholecystectomy
- 100 emergency laparotomy to include 20 segmental colectomy and 5 Hartmann's procedures[3]

These numbers must relate to the trainee having been the primary surgeon in the case, which is defined as non-assisting supervision codes.[63] Non-assisting supervision codes means all supervision codes except those recorded as the trainee taking an assisting role. The supervision codes for operations in the UK are:[63]

**Supervision Code help guide: eLogbook**

**Assisting:** The trainer completes the procedure from start to finish. The trainee performs the approach and closure of the wound. The trainer performs the key components of the procedure

**Supervised, Trainer Scrubbed:** The trainee performs key components of the procedure (as defined in the relevant PBA) with the trainer scrubbed.

**Supervised, Trainer Unscrubbed:** The trainee completes the procedure from start to finish. The trainer is unscrubbed and is:

- in the operating theatre throughout
- in the operating theatre suite and regularly enters the operating theatre during the procedure (70% of the duration of the procedure)

**Performed:** The trainee completes the procedure from start to finish. The trainer is present for <70% of the duration of the procedure. The trainer is not in the operating theatre and is:

- scrubbed in the adjacent operating theatre
- not in the operating suite but is in the hospital

**Training a more junior trainee:** A non-consultant grade surgeon training a junior trainee.

Additionally, trainees have to perform a total of 1600 procedures through the course of their specialist general surgical training. This total value is inclusive of cases where the trainee had an assisting role.[7] Operations are recorded in an electronic logbook (the eLogbook, Section 1.5.3) by trainees and reviewed at clinical supervision meetings, educational supervision meetings and at ARCP. The eLogbook is a single, secure, standardised, electronic database used for recording operative experience across all of specialty surgery training. It was linked to ISCP portfolios in 2009 with data linked between the two databases by the trainee's GMC number. Use of the eLogbook is compulsory and summaries can be produced indicating the types , quantities and supervision of procedures that trainees have recorded over defined time periods.[93]

*1.4.4.5.3 Requirements for operative competence*

Trainees must complete WBAs and attain assessment levels described in the completion of training certification guidelines in order to demonstrate operative competence.[7] By the end of training, general surgeons are expected to have achieved three PBAs at level 4, judged by three separate assessors, in the same index procedures described for operative experience: appendicectomy, inguinal hernia repair, cholecystectomy, emergency laparotomy, segmental colectomy and Hartmann's procedure.[7]

The indicative numbers and PBA requirement standards were introduced in the 2013 version of the curriculum. These standards were applied flexibly to trainees who were appointed to specialty training prior to 2013 depending on their stage of training and at TPD discretion.

#### *1.4.4.5.4 Process for application for CCT*

When a trainee is within 6 months of their expected Certification date, the JCST specialty teams check that the trainee has met the requirements stipulated by the JCST for CCT.[94] If the JCST specialty team find that the trainee records are in order, they contact the trainee and advise the trainee how to proceed with initiating the process for gaining a CCT. The JCST specialty team then change the trainee's status in training to "Awaiting Certification Documents" in the JCST database.

The GMC are the body responsible for issuing CCT. In order to be recommended for CCT, a trainee has to receive an ARCP outcome 6 (Table 2). The JCST recommend that a trainee does not receive an ARCP outcome 6 more than 4 months before their predicted end of training date.[94] After an ARCP outcome 6 is awarded, an alert is received by the JCST specialty team. The team check that the Specialty Advisory Committee (SAC) Liaison Member has been a part of the ARCP decision and agrees with it. If both confirmation of ARCP outcome 6 and SAC Liaison Member approval have been received, then the JCST specialty team proceed to sending the recommendation for CCT to the GMC. The JCST team then change the trainee's status in training to "Recommended for certification" in the database.

The requirements for recommendation for CESR, CP are the same as the requirements for recommendation for CCT.

## Section 1.5 Data sources

The studies presented in Chapters 3, 4, 5 and 6 used linked data from the ISCP [11], eLogbook [93] and JCIE databases. The databases are linked by trainee GMC number. A data specification for each database was agreed between the ISCP Data Manager, ISCP Surgical director and the study team.

Following work to define the data fields and tables within the ISCP dataset (see Appendix 1: ISCP Data Fields and Tables for a full description), a data specification was written and agreed with the relevant data managers. The data specification is detailed in Appendix 2: ISCP Data Specification April 2016.

The data managers for each database extracted the relevant data. The ISCP Data Manager removed the trainee GMC numbers and replaced them with a unique identifier prior to secure data transfer to the study team. The unique identifier is consistent for each trainee across each of the data tables included in the data specification. The data were merged using the trainee unique identifier.

Initial data extraction was made in June 2016 with further updates in December 2016 and February 2017.

Data permissions were granted from the ISCP Data Management Committee and ethics approval for the research was granted by the University of Nottingham Medical Ethics Board (Reference: J08122015 SoM EPH).

### 1.5.1 ISCP

Data contained within the ISCP can broadly be divided into trainee related information (e.g. personal identifier, gender, age, training start dates, predicted or actual end of training date, assigned area of training (deanery), assessment related information (e.g. type of assessment, date of assessment, level achieved) and ARCP information (e.g. date of ARCP, trainee stage, ARCP outcome). Data tables and fields are described in Appendix 1: ISCP Data Fields and Tables.

Demographic information relating to both the trainee and their placements for training are inputted by trainees and validated by the trainee's TPD.

Either the trainee or assessor may complete work-based assessment fields. All assessments have to be validated by the assessor completing the assessment.

### 1.5.2 JCST Surgeons Information Management System (SIMS) database

The JCST holds records for trainees which include a start of training date, any type of absence from training with start and end date of the absence period, a categorised reason for absence (e.g. research, parental leave) and a predicted completion of training date. Upon entry to the training programme a predicted completion of training date is created based on a standard 6 years of training and is updated if a trainee has a period of absence from training or trains less than full time.

### 1.5.3 eLogbook

The eLogbook is a single, unified, secure online database for the recording of all surgical procedures in training.[93] The eLogbook is a function of the Royal College of

Surgeons of Edinburgh and was originally provided by the Faculty of Health Informatics. It was initially developed for use in Trauma and Orthopaedics in 2000[64] and subsequently developed to include all surgical specialties. It has since been adopted for use by all four UK and Ireland Royal Surgical Colleges and was linked to ISCP portfolios in 2009. The ISCP and eLogbook trainee data are linked using trainee GMC number. Between the launch of the ISCP in 2007 and the inclusion of eLogbook in trainee portfolios in 2009, trainees recorded operations in a logbook hosted by ISCP. Any operations recorded in the pre-existing ISCP logbook were transferred and included in the eLogbook in 2011. Educational supervisors and TPDs are able to access operative experience summary reports for assessing trainees at ARCP and educational reviews throughout the year. Use of the eLogbook for recording operative experience is a compulsory requirement of UK surgical training.

Data from the eLogbook includes stage of training, the type of operation, urgency of the operation and date of operation. Patient related information includes hospital identifier, date of birth, American Society of Anaesthesiology (ASA) grade (a reflection of the patient's fitness[95]) and any post-operative complications that occurred. Trainees also record the involvement they had in the case. The JCST publish clear descriptions of how a trainee should define their involvement in the case.[63] The supervision codes that may be used by a surgical trainee are detailed in Section 1.4.4.5.2. Trainees have personal responsibility for maintaining accurate records of their operative experience. Surgical trainers are encouraged to validate trainee logbook data on a case-by-case basis but this is not compulsory.

### 1.5.4 Joint Committee for Intercollegiate Examination

The JCIE hold records for trainees sitting the Intercollegiate Specialty Board exam. (Section 1.4.4.5.1) This data was included in the study as a source of information relating to the trainee's declared special interest. Data from the dataset includes date of the exam, special interest and pass/ fail outcome. General Surgery could be declared as a special interest up to 2013 only. After 2013, it was removed in order to match the new curriculum.

## Section 1.6 Rationale for thesis

It is clear that surgical training systems differ worldwide with variation in curricula and expected operative experience at completion of training. However, this variation remains unquantified and furthermore, it is not clear how the UK relates to these other countries, particularly in terms of expected and actual operative experience at completion of training.

Despite a formal surgical training programme and defined curricula, it is not known how long UK surgeons are taking to complete training, nor is it known how many procedures are undertaken during training. Furthermore, it is not understood how general surgical trainees are trained in terms of changing complexity of procedures undertaken or the autonomy of trainees in procedural skill training.

Requirements for competency assessments (as judged by the PBA) and minimum indicative numbers were incorporated into the 2013 curriculum for General Surgery. The current indicative numbers that UK General Surgery trainees are expected to meet were based on consensus decisions by groups of experts guided by a small, selected, study of 58 trainee surgeons and are unrelated to any measure of competency.[92] Beard *et al*, who studied the use of the PBA within surgical training, called for future research to use real-time, operative experience data to describe the numbers of procedures carried out by surgical trainees and the relationship to competency acquisition judged using standardised tools – i.e. the PBA.

Over 2.6 million procedures have been recorded in the eLogbook and every year, over 200 new General Surgery trainees commence general surgical training. [96] Yet there has been no large-scale research to understand the operative experience or competency outcomes of General Surgery trainees. Previous research assessing operative experience or competency outcomes in UK General Surgery training has either been limited to selected cohorts of trainees completing training or single regions, limiting the power of these studies and the generalisability of the results.[19, 20, 44, 92, 97]

In summary, there is a defined General Surgery training programme in the UK with a set curriculum and standards to be met by completion of training. However, these standards are not evidence-based and it is not known how they relate to other countries around the world or what the actual competency outcomes or operative experiences of general surgical trainees in the UK are.

### 1.6.1 Aims of thesis

1. To describe the operative experience of General Surgery trainees globally.
2. To assess the timeline of surgical training in the UK with respect to total time in training and out of programme periods.
3. To accurately describe the operative experiences and procedural assessments undertaken by contemporary General Surgery trainees in the UK.

### 1.6.2 Chapter outline

Chapter 2 “Systematic Review of Operative Experience in General Surgery Training”: This systematic review and meta-analysis aimed to determine the reported operative experience of General Surgery trainees worldwide.

Chapter 3 “Cohort Definition”: The aim of this work was to assess the data for accuracy of training dates and define a cohort of trainees within the dataset for analysis in subsequent studies.

Chapter 4 “Time Out of General Surgery Specialty Training in the UK”: The aim of this study was to quantify the number of trainees taking time out of General Surgery specialty training and the impact on time taken to complete General Surgery specialty training in the UK.

Chapter 5 “The Procedure Based Assessment and its Correlation with Operative Experience”: The aim of this study was to assess the construct validity of the PBA and determine operative experience at PBA levels awarded in General Surgery index procedures.

Chapter 6 “Changing Autonomy in Operative Experience Through UK General Surgery Training”: This study aimed to determine how many operations (both in total and for General Surgery index procedures) trainees undertake during General Surgery specialty training and how the supervision of these changes over the course of training. A secondary aim was to assess whether this data could be used as a reflection of entrustment decisions through the course of a training scheme.

# Chapter 2 Systematic Review of Operative Experience in General Surgery Training

## Section 2.1 Introduction

It is important that surgeons are trained adequately and are able to deliver high-quality care to patients. Globally, surgical curricula are becoming more formalised with the use of competency-based models for training and the adoption of requirements to be met by completion of training. Several surgical curricula around the world set minimum numbers of operations to be achieved during general surgical training [6-10], presumably in light of the reported association between high surgeon operative volume and improved patient outcomes.[98-100]

However, there is no worldwide standardization of expected operative experience in general surgical training, and surgical curricula requirements differ. For example, the UK demands 1600 procedures by completion of training and the USA requires 750, although both programmes have the intention of training surgeons to a standard for independent practice.[6, 7] There appears to be little evidence for the setting of minimum numbers, with the threshold setting for numbers of procedures in the UK based on limited evidence from just 58 trainees who had completed training over a 2-year period.[92] Some curricula, such as those in the UK, define types of procedure required, with minimum numbers to be met for index procedures such as hernia repair, cholecystectomy and emergency laparotomy.[7] The length of surgical training also varies around the world, and trainee working weeks differ, ranging from 48 hours in Europe[101] to 80 hours in the USA.[102] These combined aspects are likely to influence the opportunities for gaining experience in general surgical training, with the potential for wide variation in the operative experience of newly qualified surgeons around the world.

### 2.1.1 Aims

To date there has been no comprehensive review of the operative experience at completion of general surgical training worldwide and its variation between countries. This review aimed to identify and summarise the available literature relating to operative experience at completion of general surgical training worldwide.

## Section 2.2 Methods

### 2.2.1 Search strategy

A concept table was developed and a search strategy built with a medical librarian to identify articles reporting operative experience in general surgical training. Three concepts were developed: graduate education, operative surgical procedures and General Surgery. Exploded medical subject heading (MeSH) terms were combined with text word searching using the Boolean operator 'OR' for each concept. Each concept was combined with 'AND'.

Synonyms for surgical trainees, such as resident, chief resident and registrar, were used in addition to alternative names for training programmes (for example surgical training, residency training and specialty training). Terminologies for specifically named surgical curricula were included with both full terms and acronyms (such as Intercollegiate Surgical Curriculum Programme, ISCP) along with logbook names for the regions that use a single, compulsory logbook (for example eLogbook). A term was deleted from the search strategy if it yielded no results (such as morbidity audit and logbook tool).

No search limits were applied and all languages were included. Five databases were searched (Ovid MEDLINE R, 1996 to present, Ovid MEDLINE In-Process, Educational Resources Information Centre (ERIC), Psycinfo, British Education Index) and the search strategy was adapted to each database. The final search was performed in November 2015. Reference lists of included articles were also searched and further articles included if appropriate. The search strategy used is summarised in Table 3 .

*Table 3 Ovid MEDLINE search strategy*

| | | |
|---|---|---|
| 1 | graduate education.mp. or exp Education, Graduate/ | 22694 |
| 2 | specialty train*.mp. | 631 |
| 3 | residen*.mp. | 138435 |
| 4 | specialty registrar.mp. | 5 |
| 5 | surgical training program*.mp. | 246 |
| 6 | surgical train*.mp. | 2787 |
| 7 | 1 or 2 or 3 or 4 or 5 or 6 | 157166 |
| 8 | technical skills.mp. | 1775 |
| 9 | (operative adj (volume or numbers or experience)).mp. | 571 |
| 10 | ISCP.mp. | 23 |
| 11 | intercollegiate surgical curriculum program*.mp. | 14 |
| 12 | SET2.mp. | 183 |
| 13 | ACGME.mp. | 922 |
| 14 | accreditation council for graduate medical education.mp. | 1348 |
| 15 | resident case log system.mp. | 4 |
| 16 | (elogbook or logbook).mp. | 316 |
| 17 | operative surgical procedures.mp. or exp Surgical Procedures, Operative/ | 1500215 |
| 18 | 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 | 1503332 |
| 19 | General Surgery.mp. or exp General Surgery/ | 19684 |
| 20 | 7 and 18 and 19 | 1730 |

National bodies for surgical training with online contact details and established curricula standards were also contacted by e-mail with a request for any unpublished data (Royal Australasian College of Surgeons, Royal College of Physicians and Surgeons of Canada, The College of Surgeons of Hong Kong, French Association of Surgery).

### 2.2.2 Exclusion criteria

Studies were excluded if the article did not report a number of operations performed in training, was based on simulation or was not related to surgery. Any studies reporting data from medical students or junior trainees (foundation or core training in the UK, intern year in the USA) were excluded. Studies were included only if they reported operative experience data for trainees at completion of an entire higher surgical training programme.

### 2.2.3 Selection of articles

Study titles and abstracts were independently assessed by two assessors (Elizabeth Elsey and David Humes) for inclusion. Differences in title selection were discussed and resolved. A third assessor (Joe West) independently reconciled any differences in abstract selection. Authors were contacted directly to provide articles that were not available online or through library services. Google Translate and multilingual colleagues were used to aid assessment of non-English language articles.

### 2.2.4 Data extraction

Information was extracted from the studies and recorded using a standardised spreadsheet. Data extracted included study year, study design and purpose, numerical data for total operations and procedure-specific operations. Procedures included were inguinal hernia repair, appendicectomy, cholecystectomy and segmental colectomy, with both open and laparoscopic approaches recorded where given. These procedures were chosen as they comprise key 'index' procedures that form essential competency requirements in several general surgical training systems [7, 70, 71]. Total procedure-specific data were calculated by summing open and laparoscopic totals in articles that presented open and laparoscopic data separately. Where only laparoscopic data were presented for cholecystectomy, this was taken as a proxy for total operating, given the high frequency of the laparoscopic approach for cholecystectomy in recent surgical practice [71, 103-106]. Total number of operations per graduating trainee was calculated from the published data if a paper presented total numbers of operations performed by graduating trainees and the total number of graduating trainees.

### 2.2.5 Study selection for meta-analysis

The outcome for the meta-analysis was total number of operations completed in training. Studies were included if they reported data from a national single logbook, mean total number of operations per trainee at completion of training, sample size and a measure of variance. Both the UK and USA surgical curricula specify minimum total numbers of operative procedures to be completed throughout training, which must be exclusive of endoscopic procedures [3, 107]. Therefore, endoscopy numbers were excluded from the data in the meta-analysis. The data from 1999 published by Eckert and colleagues were not included in the meta-analysis to keep included studies contemporaneous.

Study authors were contacted to provide further data where necessary. Allum and colleagues[92] and Thomas *et al* [97] provided raw data for further analysis. Aphinives[71] provided further statistical parameters on request. The authors of one study did not respond to a request for additional statistics. A rate of total number of operations per trainee per year of training was calculated by using total operation data and length of respective training programme for studies included in the meta-analysis.

### 2.2.6 Statistical analysis

Raw data from Allum *et al* [92] and Thomas and co-workers[97] were used to calculate mean total number of operations (excluding endoscopy) and standard deviation. Standard errors were calculated from the standard deviation and sample size reported by each included study. A random-effects meta-analysis of the included studies was undertaken. A random-effects model was chosen as there were obvious differences in total operations between the included studies. Heterogeneity of the studies was assessed using $I^2$ test. All data management and analysis were performed using Stata® version 14 (StataCorp, College Station, Texas, USA).

## Section 2.3 Results

### 2.3.1 Search results

Some 1979 titles were identified which, following screening, resulted in 24 full articles for inclusion in the study. Five studies were included in the meta-analysis from four countries (Figure 3). None of the national bodies for surgery that were contacted provided further data relating to operative experience.

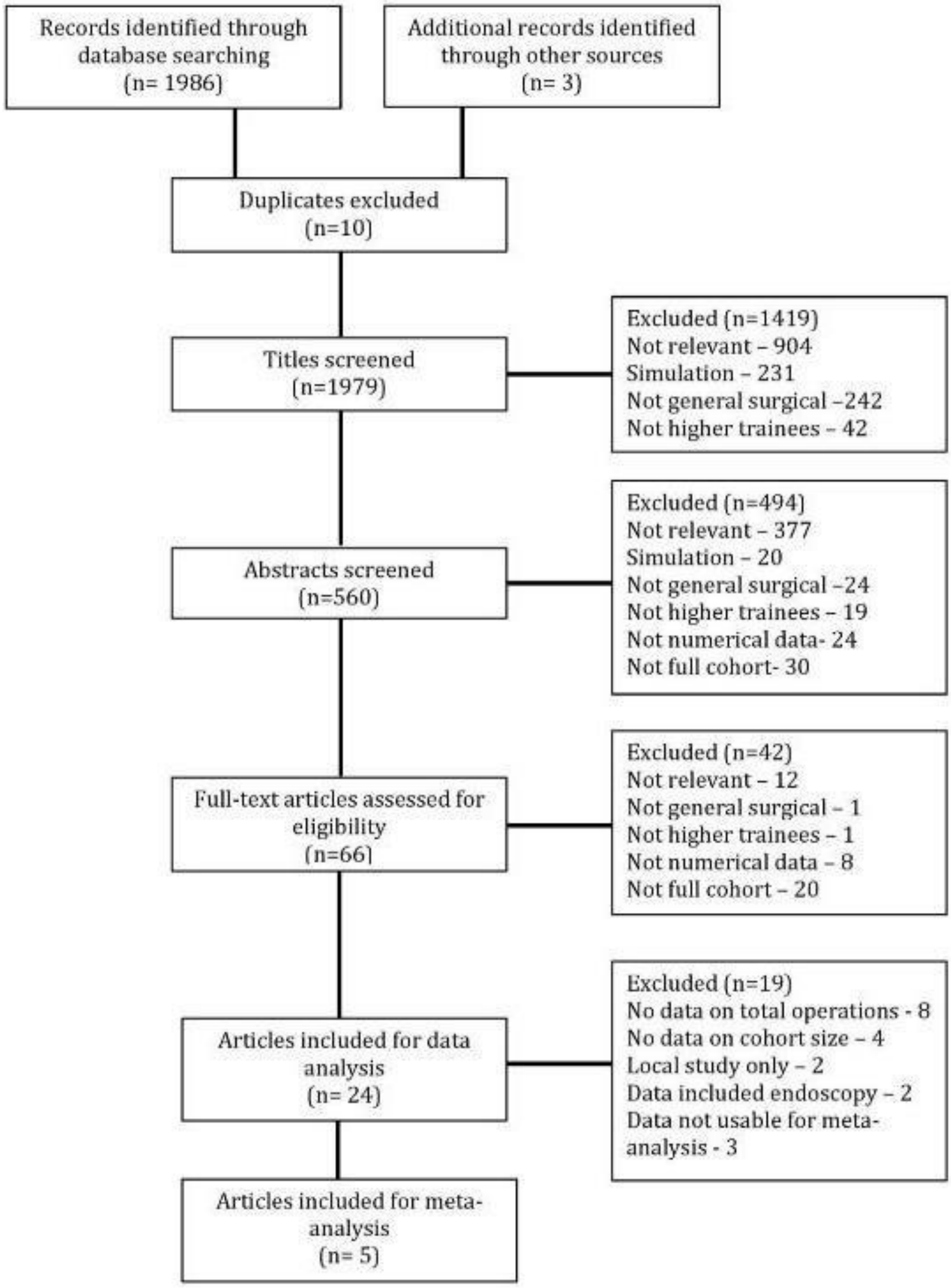



***Figure 3 Prisma diagram***

### 2.3.2 Demographics of included studies

Of the 24 included studies, 19 [103-106, 108-122] were from the USA, one [123] from the Netherlands, one [71] from Thailand, one [124] from Spain and two [92, 97] from the UK (Table 4).

***Table 4 Study demographics***

| Reference | Country | Years included* | Data geography | Data source | Total no. of trainees† | Exclusions | Aims | Data presented (for full cohort) | Data descriptions |
|---|---|---|---|---|---|---|---|---|---|
| Thomas *et al.*[97] | UK | 2012–2013 | National | eLogbook | 155 | n.s. | Comparison with curriculum requirements | Total and procedure-specific | Median, i.q.r., range |
| Allum *et al.*[92] | UK | 2010–2011 | National | eLogbook | 58 | LTFT, OOPP | Description of operative experience | Procedure-specific | Mean, median, range |
| Hopmans *et al.*[123] | Netherlands | 2005–2012 | Regional | Hospital records | 64 | LTFT, OOPP, area transfer | Analysis of impact of hours restrictions | Total operations | Mean, range, s.d. |
| Serra-Aracil *et al.*[124] | Spain | 2009 | National | Online logbook | 64 | n.s. | Description of operative experience | Total operations | Mean |
| Aphinives[71] | Thailand | 2011–2012 | National | Online logbook | 162 | LTFT, area transfer, non-completers | Description of operative experience | Total and procedure-specific | Mean, median, range |
| Malangoni *et al.*[108] | USA | 2005, 2010–2011 | National | ACGME | 2945 | n.s. | Analysis of impact of curriculum introduction | Total and procedure-specific | Median |
| McCoy *et al.*[109] | USA | 2000–2011 | National | ACGME | - | n.s. | Analysis of MIS operative experience | Procedure-specific | Mean |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Hanks *et al.*[103] | USA | 2009 | National | ACGME | 976 | n.s. | Analysis of impact of fellowship trainee | Procedure-specific | Mean |
| Eckert *et al.*[110] | USA | 2002–2008 | Local | Hospital records | 17 | n.s. | Description of operative experience | Total and procedure-specific | Mean, range, s.d. |
| | | 1999, 2008 | National | ACGME | 2005 | n.s. | | | |
| Sachs and Pawlik[111] | USA | 1999–2012 | National | ACGME | - | n.s. | Description of operative experience | Total operations | Median |
| Neville *et al.*[112] | USA | 2002–2011 | Local | ACGME | 47 | n.s. | Analysis of MIS operative experience | Procedure-specific | Mean |
| | | 2000–2011 | National | ACGME | - | n.s. | | | |
| Unawane *et al.*[113] | USA | 1997, 2010 | National | ACGME | - | n.s. | Analysis of MIS operative experience | Procedure-specific | Mean |
| Fryer *et al.*[104] | USA | 2007–2009 | Local | ACGME | 15 | n.s. | Comparison with curriculum requirements | Total and procedure-specific | Mean, s.d. |
| Carson *et al.*[114] | USA | 2000–2008 | National | ACGME | 9067 | n.s. | Analysis of MIS operative experience | Total and procedure-specific | Mean |
| Alkhoury *et al.*[115] | USA | 1999–2008 | National | ACGME | - | n.s. | Analysis of MIS operative experience | Procedure-specific | Mean |
| Simien *et al.*[116] | USA | 1998–2008 | National | ACGME | 6049 | n.s. | Analysis of impact of | Total operations | Mean |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | hours restrictions | | |
| Kairys *et al.*[117] | USA | 1992–2006 | National | ACGME | - | n.s. | Analysis of impact of hours restrictions | Total operations | Mean |
| Bell *et al.*[105] | USA | 2005<br>2006 | National | ACGME | 1022<br>805 | n.s. | Description of operative experience | Total and procedure-specific | Mean, range, s.d. |
| Damadi *et al.*[118] | USA | 2001–2005 | Local | ACGME | 17 | n.s. | Analysis of impact of hours restrictions | Total operations | Mean |
| Bland *et al.*[119] | USA | 1998–2004 | National | ACGME | - | n.s. | Analysis of impact of hours restrictions | Total operations | Mean |
| Chung *et al.*[106] | USA | 1994–2001 | National | ACGME | 4968 | n.s. | Analysis of MIS operative experience | Total and procedure-specific | Mean |
| Parsa *et al.*[120] | USA | 1991–1997 | National | ACGME | 7036 | n.s. | Description of operative experience | Procedure-specific | Mean |
| Libermanand Greason[121] | USA | 1992–1996 | Local | Hospital records | - | n.s. | Analysis of MIS operative experience | Total and procedure-specific | Mean |
| Schoetz[122] | USA | 1991–1996 | National | ACGME | 6020 | n.s. | Description of operative experience | Procedure-specific | Mean |

***Range of years with data or individual years. †Sum of all trainees with data presented in the study. n.s., Not stated; LTFT, Less than full time training; OOPP, Out of Programme Period; ACGME, Accreditation Council for Graduate Medical Education MIS, minimally invasive surgery.***

Sixteen studies [103, 105, 106, 108-117, 119, 120, 122] from the USA used Accreditation Council for Graduate Medical Education (ACGME) logbook data to assess a national cohort of graduating trainees in a series of cross-sectional analyses. The other US studies used ACGME logbook data from local training cohorts[104, 118] or hospital registry data[121]. Non-US studies used national [71, 92, 97, 124] or regional [123] cohorts, hospital registry [123] and electronic logbook [71, 92, 97, 124] data. Half of the studies had a focus on the impact of working hour regulations on operative experiences in training [116-119, 123], or the impact of minimally invasive surgery on operative experience [106, 109, 112-115, 121]. The 24 studies span nearly two decades of surgical training, with the earliest studies reporting data from 1991[120, 122] and the most recent data reported from 2013[97]. Overlapping data reporting was seen among the 16 studies [103, 105, 106, 108-117, 119, 120, 122] that used ACGME logbook data, with several studies reporting the same data periods. The number of trainees included in the studies varied from 15[104] to more than 9000[114]. Eight [109, 111-113, 115, 117, 119, 121] studies did not report the size of the cohort investigated. Seventeen studies[71, 92, 97, 104-106, 108, 110, 111, 114, 116-119, 121, 123, 124] reported total operative experience, with ten [71, 97, 103, 108, 109, 112-115, 120] reporting appendicectomy data, 12[71, 92, 97, 104, 105, 108-110, 113-115, 120] hernia data, 12[71, 92, 97, 103-106, 108, 109, 113, 120, 121] cholecystectomy data and 13 studies[71, 92, 97, 103-105, 108-110, 113, 115, 120, 122] documenting colectomy data. Of the 12 studies reporting data relating to cholecystectomy, five [71, 103-106] reported data only for laparoscopic procedures rather than open or combined data. Inclusion and exclusion criteria varied, with only three studies [71, 92, 123] stating exclusion of trainees who worked less than full time, had not completed training or completed training periods for research out of programme. Quality of data reporting varied widely among studies, with both mean and medians reported; several studies did not report ranges, measures of variance or sample sizes.

### 2.3.3 Total operating experience

Of the 17 studies reporting total operative experience, three [92, 105, 108] included endoscopy numbers. Data for total operative experience is shown in Table 5.

*Table 5 Total operations per graduating trainee*

| Reference | Country | Years included | Endoscopy | Total no. of trainees* | Total no. of operations† |
|---|---|---|---|---|---|
| Thomas *et al.*[97] | UK | 2012–2013 | Excluded | 155 | 1802‡,1844¶ |
| Allum *et al.*[92] | UK | 2010–2011 | Excluded | 58 | 1876‡¶, 1915¶ |
| Hopmans *et al.*[123] | The Netherlands | 2005–2012 | Excluded | 64 | 1291–1490 |
| Serra-Aracil *et al.*[124] | Spain | 2009 | Unknown | 64 | 1325‡ |
| Aphinives[71] | Thailand | 2011–2012 | Excluded | 162 | 783# |
| Sachs and Pawlik[111] | USA | 1999–2012 | Excluded | – | 903–976‡ |
| Malangoni *et al.*[108] | USA | 2005, 2010–2011 | Included | 2945 | 1023–1238‡ |
| Fryer *et al.*[104] | USA | 2007–2009 | Excluded | 15 | 882–1103 |
| Eckert *et al.*[110] | USA | 1999, 2008 | Excluded | 2005 | 914–966 |
| Carson *et al.*[114] | USA | 2000–2008 | Excluded | 9067 | 879–942 |
| Bell *et al.*[105] | USA | 2006 | Included | 805 | 1264 |
| Simien *et al.*[116] | USA | 1998–2008 | Excluded | 6049 | 900–967 |
| Kairys *et al.*[117] | USA | 1992–2006 | Excluded | – | 900–967 |
| Damadi *et al.*[118] | USA | 2001–2005 | Excluded | 17 | 925–1412 |
| Bland *et al.*[119] | USA | 1998–2004 | Excluded | – | 930–966 |
| Chung *et al.*[106] | USA | 1994–2001 | Excluded | 4968 | 924–962 |
| Liberman and Greason[121] | USA | 1992–1996 | Excluded | – | 1197–1233§ |

***Sum of all trainees with data presented in the study. †Range of averages, rounded to nearest whole procedure for the years included in the study; values are mean, except ‡median and §not stated. ¶Calculated from raw data; #provided by author.***

Six of the US studies reported mean total procedures completed in training for national cohorts of graduating trainees, with endoscopy excluded. These studies reported a range of means of between 879 and 967 procedures.[106, 110, 114, 116, 117, 119] Sachs *et al* reported median total procedures completed in training for a national cohort of graduating trainees, excluding endoscopy, with a range of medians between 903 and 976 procedures.[111] Two studies from the USA included endoscopy in total procedures and reported a range of total procedures between a median 1023 procedures and mean 1264 procedures.[105, 108] In the UK, Thomas and colleagues[97] reported a median total number of procedures per trainee at completion of training of 1802. Analysis of the additional raw data from Allum and co-workers[92] found a median of 1876 procedures (mean 1915) and a range of 1102–2931 operations per UK completing trainee. From a study of trainees in the Netherlands, Hopmans *et al*.[123] reported a range of 1291–1490 for mean number of procedures per graduating trainee. Data from Spain reported by Serra-Aracil and colleagues[124] describe similar numbers, with a mean of 1325 operations per completing trainee. In Thailand, Aphinives[71] reported a mean of 783 procedures per completing trainee.

### 2.3.4 Procedure-specific operating experience

Seventeen studies [71, 92, 97, 103-106, 108-110, 112-115, 120-122] reported data for appendicectomy, cholecystectomy, colectomy or hernia repair. All but three [71, 92, 97] of the studies were from the USA (Table 6)

*Table 6 Procedure-specific data*

| Reference | Country | Years included | Total no. of trainees* | Total no. of procedures† | | | |
|---|---|---|---|---|---|---|---|
| | | | | Appendicectomy | Hernia repair | Cholecystectomy | Colectomy |
| Thomas *et al.*[97] | UK | 2012–2013 | 155 | 121‡ | 92‡ | 103‡ | 42‡ |
| Allum *et al.*[92] | UK | 2010–2011 | 58 | – | 90 | 96 | 33 |
| Aphinives[71] | Thailand | 2011–2012 | 162 | 73 | 18 | 6¶ | 5 |
| Malangoni *et al.*[108] | USA | 2005, 2010 - 2011 | 2945 | 46–60 | 60–70 | 103–118 | 52–59 |
| McCoy *et al.*[109] | USA | 2000–2011 | – | 40–62 | 59–71 | 100–116 | 46–60 |
| Unawane *et al.*[113] | USA | 1997, 2010 | – | 32–59 | 59–67 | 91–118 | 40–60 |
| Hanks *et al.*[103] | USA | 2009 | 976 | 63 | – | 106¶ | 58 |
| Fryer *et al.*[104] | USA | 2007–2009 | 15 | – | 113 | 94¶ | 42 |
| Eckert *et al.*[110] | USA | 1999, 2008 | 2005 | – | 59–60 | – | 57–69 |
| Neville *et al.*[112] | USA | 2000–2011 | – | 39–62 | – | – | – |
| Carson *et al.*[114] | USA | 2000–2008 | 9067 | 39–54 | 59–61 | – | – |
| Alkhoury *et al.*[115] | USA | 1999–2008 | – | 39–54 | 59–61 | – | 50–57 |
| Bell *et al.*[105] | USA | 2005 | 1022 | – | 59 | 88¶ | 52 |
| Chung *et al.*[106] | USA | 1994–2001 | 4968 | – | – | 66§¶ | – |
| Parsa *et al.*[120] | USA | 1991–1997 | 7036 | 31 | 53–54 | 59–91 | 34–39 |
| Liberman and Greason[121] | USA | 1992–1996 | – | – | – | 86–113§ | – |
| Schoetz[122] | USA | 1991–1996 | 6020 | – | – | – | 34–37§ |

***Sum of all trainees with data presented in the study. †Range of averages, rounded to nearest whole procedure for years included in the study; values are mean, except ‡median and §not stated. ¶Laparoscopic cholecystectomy data only.***

#### 2.3.4.1 Appendicectomy

Ten studies [71, 97, 103, 108, 109, 112-115, 120] reported appendicectomy-specific data. Total appendicectomy experience in training in the USA ranged from a mean of 31 procedures[120] to a mean of 63 operations[103]. Seven [103, 108, 109, 113-115, 120] of the studies from the USA reported ACGME data for a national cohort of graduating trainees with the same data reported in multiple studies. The only study[97] from the UK to describe appendicectomy experience in training reported that trainees performed a median of 121 appendicectomies during the course of their training, with a range of 21 to 316 procedures. Data from Thailand reported that trainees performed a mean of 73 procedures per graduating trainee. [71]

#### 2.3.4.2 Inguinal hernia

Twelve studies [71, 92, 97, 104, 105, 108-110, 113-115, 120] reported procedure-specific data for inguinal hernia surgery. Studies from the USA reported a range from 53[120] to 71[109] mean hernia repairs per trainee. An outlying US study [104] reported a mean of 113 hernia repairs per trainee. UK studies[92, 97] reported that trainees performed a mean of 90 and median of 92 inguinal hernia repairs per completing trainee. Aphinives[71] reported substantially fewer hernia repairs per trainee with a mean of 18 procedures.

#### 2.3.4.3 Cholecystectomy

Twelve studies[71, 92, 97, 103-106, 108, 109, 113, 120, 121] reported procedure-specific data for cholecystectomy experience. Studies published from the USA from the year 2000 onwards[103-105, 108, 109, 113], reporting both open and/or laparoscopic cholecystectomy data, reported mean total experience ranging from 88[105] to 118[108, 113] procedures. The USA trainee experience in cholecystectomy was similar to the UK experience, with Allum *et al.* [92] reporting a mean of 96 procedures and Thomas and colleagues [97] a median of 103 operations. Aphinives[71] reported a mean of 6 laparoscopic cholecystectomies per trainee at completion of training.

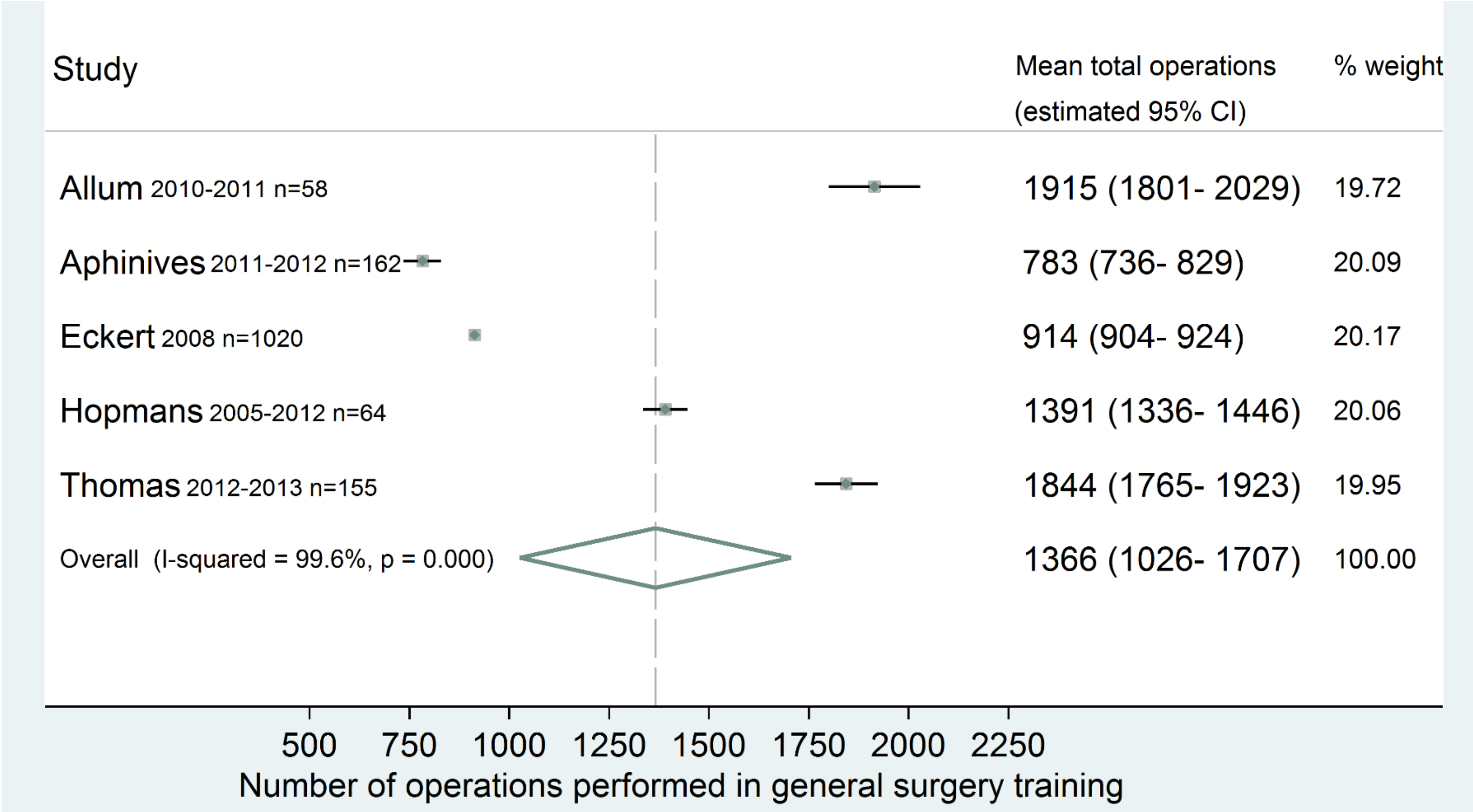
#### 2.3.4.4 Colectomy

Thirteen studies [71, 92, 97, 103-105, 108-110, 113, 115, 120] reported procedure-specific data for colectomy. In the UK, Thomas *et al* [97] noted a median of 42 colectomies per trainee, whereas Allum *et al.*[92] documented a mean of 33 procedures per trainee.[92, 97] Studies from the USA reported a varied colectomy experience of between a mean of 34[120, 122] and 69 [110] procedures per graduating trainee. Aphinives[71] reported a mean of 5 segmental colectomies per completing trainee in Thailand.

### 2.3.5 Meta-analysis

A meta-analysis of data from five studies[71, 92, 97, 110, 123] produced a mean pooled estimate of 1366 (95 per cent c.i. 1026 to 1707) procedures per trainee at completion of training. The $I^2$ value of 99.6 per cent confirms the significant heterogeneity between the studies (Figure 4).

*Figure 4 Meta-analysis forest plot of number of operations performed in* General Surgery *training*



For the studies included in the meta-analysis, mean total operating per trainee per year of training varied from 183 procedures in the USA[110] to 319 operations in the UK[92]. Trainees in Thailand performed a mean of 196 procedures per trainee per year[71] and those in the Netherlands a mean 232 of procedures per trainee per year[123]. Trainees in the UK performed a mean of 307 and 319 procedures per trainee per year.[92, 97] (Table 7)

***Table 7 Estimated total operations per trainee per year in training***

| Country | Study dates | Total no of trainees* | Total no. of operations per trainee† | Length of training (years) | Total no. of operations per trainee per year‡ |
|---|---|---|---|---|---|
| UK[97] | 2012–2013 | 155 | 1844 | 6 | 307 |
| UK[92] | 2010–2011 | 58 | 1915 | 6 | 319 |
| The Netherlands[123] | 2005–2012 | 64 | 1391 | 6 | 232 |
| USA[110] | 2008 | 1020 | 914 | 5 | 183 |
| Thailand[71] | 2011–2012 | 162 | 783 | 4 | 196 |

****Sum of all trainees with data presented in study. †Means, rounded to nearest whole procedure. ‡Total no. of operations/length of training.***

## Section 2.4 Discussion

### 2.4.1 Main findings

This systematic review has three key findings. First, there is limited literature available relating to the operative experiences of surgeons in training, particularly outside of the USA. Second, there is wide variation in the total number of procedures undertaken by a trainee general surgeon, both within training systems and between countries. For example, Bell and colleagues[105] reported a range of 600–2785 procedures per trainee in the USA and Thomas *et al.*[97] documented a range of 783–3764 procedures per trainee in the UK; both studies highlighted the differing operative experiences of trainees, despite training within the same period and curriculum. Global variation in total operations per qualifying trainee is apparent, with a difference between a mean of 783 procedures in Thailand[71] and 1915 in the UK[97], suggesting widely differing procedural experience of newly qualified surgeons around the world. Third, this study has demonstrated variation in the number of key 'index' procedures performed by surgical trainees worldwide.

### 2.4.2 Strengths and limitations

This review was performed according to the methodology for systematic review set out in the PRISMA checklist[125]. Careful planning of search criteria in association with an experienced medical librarian, inclusion of all languages, independent duplicate reviewing of the titles and abstracts, and standardized data extraction contribute to the credibility and strength of this study.

Obtaining original data and parameters relating to the papers included in the meta-analysis allowed these papers to be included.

This systematic review is limited by potential biases within the included studies. The accuracy of the logbook data is reliant upon trainees inputting their operative experiences precisely. However, as several of the studies originate from training systems that set minimum number requirements for completion of training, trainees are likely to be motivated to keep exact records of their operative experiences. Publication bias also affects this study; suitable data for meta-analysis were available from just five studies [71, 92, 97, 110, 123], representing four countries. This limits the generalizability of the meta-analysis results when considering global operative experience. The purpose of performing the meta-analysis was to explicitly quantify the study heterogeneity and variation in total operative experience. That there is statistically significant heterogeneity is shown in the $I^2$ value of 99.6 per cent. The mean pooled estimate of 1306 operations per trainee at completion should be interpreted with caution. Given the disparity between training systems, expected outcomes at completion of training and variation in training years, a pooled estimate of total operations at completion of training worldwide is perhaps irrelevant when considering how many operations are undertaken by general surgery trainees. Rather, it confirms the wide variation between systems, as seen in the wide 95% confidence interval of 1026- 1707 procedures.

### 2.4.3 Other literature

This literature reported numerical operative experience in General Surgery training from only five countries (USA, UK, the Netherlands, Spain and Thailand), which highlights the lack of evidence underpinning the curricula that require minimum operative experience thresholds. Several of the included studies were limited by the absence of reporting of sample size, standard deviation or interquartile range. The adoption of a single electronic logbook by a training system would enable the reporting of the operative experience of trainees, as demonstrated by the higher volume of research published using national ACGME data [103, 105, 106, 108-117, 119, 120, 122].

This review and meta-analysis has described variation in the total numbers of procedures achieved during general surgical training around the world. Differences in data reporting partly account for the variation, with some studies [71, 92, 97, 104, 106, 110, 111, 114, 116-119, 121, 123] documenting only total major procedures and others [105, 108] reporting all procedures including endoscopy.

Differing curricula and varying requirements for minimum operative experience at completion of training are likely explanations for the variation in total operative experience. The ISCP sets the curriculum for UK general surgical trainees with operative experience requirements detailed in Section 1.4.4.5.2.

The American Board of Surgery (ABS) provides board certification to individuals who have met the Residency Review Committee for Surgery (RRC-S) standards of training. In contrast to the UK, the ABS sets out terms of requirements for completion of training in the *Booklet of Information: Surgery*, and stipulates minimum operative experience of 750 major procedures to be completed by the end of residency training (including at least 150 major operations in the chief resident year)[6]. The ABS states that trainees must have 'personally performed either the entire operative procedure or the critical parts thereof' in order that the trainee may count the operation as a major procedure[6]. This description of trainee involvement is akin to the non-assisting codes that UK trainees abide by for counting operations towards index procedure requirements[63]. The difference in the qualification of procedures towards total operating experience will explain some of the difference between the UK and USA total procedure numbers, but does not affect procedure-specific data. Allum and colleagues[92] reported that 66 per cent of total operative experience was recorded as the trainee performing the operation, either supervised or unsupervised. Two-thirds of the mean total experience reported by Allum *et al.* represents some 1264 procedures and remains in excess of reported USA trainee total operative experience. As in the UK, total major procedures in the USA must be exclusive of endoscopy, critical care procedures and very minor procedures such as banding of haemorrhoids[107].

Trainees in Thailand are expected to perform 500 operations during training, and meet procedure-specific requirements for inguinal hernia (10), cholecystectomy (7) and colectomy (3)[71]. General Surgery trainees in Spain[70] and the Netherlands do not presently have to attain minimum total procedural requirements (J. Hamming, Programme Director for Surgical

Training, The Netherlands; personal communication). However, the Spanish curriculum sets procedure-specific requirements including inguinal hernia (25) cholecystectomy (15) and colectomy (10)[70].

Where there are data available for comparison with national curricula, trainees generally exceed minimum training requirements. Thomas and colleagues[97] and Allum *et al.*[92] Both described UK mean total operative experience in excess of the minimum requirement. All of the studies from the USA[103-106, 108-122] reported total operative experience in excess of the minimum requirement, as did Aphinives [71] in Thailand. However, given the wide ranges of experience, it is likely that a small proportion of trainees do not meet the national minimum standards for operating experience at completion of training. The difference in standard setting between countries is also striking, with the UK specifying minimum numbers far higher than those in the other systems.

The smaller number of index procedures completed by trainees in the USA, compared with the UK, probably reflects that total operative experience is less than that in the UK despite the differences described in the criteria for minimum total number of operations. In the case of cholecystectomy, some of the variation between studies might be explained by the reporting of laparoscopic cholecystectomy alone. This may under-represent total cholecystectomy numbers in training for these studies [71, 103-106]. There is an outlying study[104] from the USA describing hernia surgery experience vastly in excess of that in other US studies. This was a local study of only 15 trainees and is perhaps not reflective of national hernia surgery experience. Aphinives[71] reported that trainees perform a relatively large number of appendicectomies in training in Thailand. This may reflect differences in types of surgical procedures performed in Thailand or perhaps a different expectation of the role of trainees.

Other surgical training systems do not set minimum operative experience targets for completion of training. For example, in Australia and New Zealand, trainees are expected to achieve 100 major procedures per 6-month placement, but no minimum numbers are required of trainees and no data describing the trainee operative experience have been assessed.

Canada has adopted a competency-based system of education. The Royal College of Physicians and Surgeons of Canada have clear recommendations for the future of surgical training and assessment in Canada, with no minimum operative experience requirements[126]. Szasz and colleagues[127] recently conducted a Delphi consensus process among Canadian General Surgery programme directors, and developed a list of procedures that could be considered as essential for competency as a general surgeon. No reference was given to the volume of operative experience expected in these procedures; rather that competency should be assessed using work-based assessments.

Variation in training programme duration is a further likely explanation for the variation between operative experiences of trainees between countries. Working hours also differ between the systems, with US residents working to an 80-h working week[102] and European trainees limited to a 48-h working week[101]. However, even when accounting for differences in length of training, European trainees still appear to complete more operations per year of training than their USA counterparts despite working fewer hours per week. (Table 7) Additionally, although each of the training systems described aspires to train surgeons to a standard for competent, independent practice, concerns have been expressed that US trainees are inadequately prepared for independent surgical practice at the end of residency training.[105] Furthermore, up to 80 per cent of graduating US residents seek further training through a period of fellowship training[67, 128] and less than 1 per cent of graduating residents plan to commence immediately with a career as an attending general surgeon.[129] However, nearly 80 per cent of UK trainees also complete some form of post-Certificate of Completion of Training (CCT) training period.[130]

How much operating a General Surgery trainee needs to complete in training is neither well defined nor evidenced-based. The Joint Committee for Surgical Training (JCST) set minimum total and index procedure operating experience requirements for the 2013 UK curriculum[7] based on the study by Allum and colleagues[92] of 58 trainees awarded CCT in 2010–2011. This relatively arbitrary setting of operative experience targets followed concerns that trainees were being deemed competent to perform a procedure (as judged by the procedure-based assessment, the tool adopted by the UK for skill assessment) without the necessary volume of procedures to experience a range of operative complexities[92]. However, the use of trainee logbooks alone (without an associated assessment of competency) to set minimum operative experience requirements is probably more representative of the numbers the small sample of trainees were able to achieve within the confines of the training system rather than an evidence-based reflection of competency.

The ABS specified a minimum of 750 total major procedures for US General Surgery trainees in 2008, an increase from the previous criteria of 500 operations.[131] These numbers were based on a consensus judgement by directors of the ABS and are also unrelated to a measure of competency (F. Lewis, Executive Director, American Board of Surgery; personal communication).

In 2009, Bell and co-workers[105] expressed concerns that trainees completing General Surgery training in the USA had inadequate operative experience in specific operations that programme directors identified as procedures a completing trainee should be able to perform independently. They suggested that inadequate operative experience was unlikely to confer competency in these essential procedures. Allum *et al.*[92] acknowledged the unknown number of procedures required to achieve competency and suggested that further analysis of competency assessment data and operative experience data may help to determine this.

The relationship between procedural experience and competency attainment is not well understood in postgraduate surgical training, but has been investigated in the field of endoscopy. Ward and colleagues[132] studied the learning curve of doctors training to perform colonoscopy in the UK, with reference to standards for minimum numbers in training programmes. The authors analysed the numbers needed to reach competency as defined by a standardized measure (90 per cent caecal intubation rate), and were able to show that current minimum colonoscopy experience targets are appropriate[132]. Wani and co-workers[133] assessed learning curves in trainees undertaking endoscopic retrograde cholangiopancreatography (ERCP) training in the USA. They concluded that specific levels of procedural experience do not ensure competence in ERCP.

De Siqueria and Gough[19] have studied the association between operative experience in General Surgery and the attainment of competency in the UK. They found that trainees performed more operations than current UK requirements for CCT before achieving competency, and concluded that minimum procedural experience did not accurately reflect competence. This study was of a small cohort from a single training region, but provides a potential model for future studies to repeat a similar analysis using national training data sets. Similarly, Abdelrahman *et al.*[134] have examined the relationship between volume of operative experience and level of competence achieved in a small cohort from a different, single geographical area of training, reporting that curriculum requirements do not accurately reflect the numbers of operations required for competency. Such further studies examining the relationship between operative experience and competency will help to inform the future setting of minimum operative experience requirements.

### 2.4.4 Conclusion

This systematic review and meta-analysis has identified a lack of studies describing the operative experience of General Surgery trainees, particularly outside of the USA. It has highlighted the variation in the operative experience of newly qualified general surgeons worldwide, and described the differences in surgical training systems in countries with published General Surgery trainee operative experience data. Setting of UK curriculum operative experience requirements could be informed by future studies of the relationship between operative experience and competency assessments.

# Chapter 3 Cohort Definition

This chapter describes the timeline of general surgical training and the set-up of the two main cohorts for the study; trainees remaining still in training and trainees who have completed training.

## Section 3.1 Introduction

A cohort study is a longitudinal study that follows change in a population through a defined period of time. It is important that the start and end dates for each individual within the overall study period are clearly defined in order to accurately reflect total person time in the study and examine change or events within the study period precisely. The study population was General Surgery trainees registered for specialty training since 1st August 2007. The study period was the duration of specialty training in approved training posts.

The ISCP database is described in Section 1.5. In summary, it is an online surgical training database that was launched in 2007 in the UK as a personal record for surgeons in training to record information such as training placement information, educational goals and work-based assessments. It was not designed to be a database for epidemiological study and hence is likely to contain variability and error for example, the recording of dates relating to training.

### 3.1.1 Start date of Specialty Surgical Training

Timelines of surgical training are described in section 1.4.3. The date that a trainee commences in post as a specialty surgical trainee with a NTN is recorded as the Start of Training Date (SoTD) in the JCST SIMS database. Dates relating to the start date of training and expected completion of training are recorded within the JCST SIMS database by the JCST administrative staff and based on information provided by the trainee and host PGMDE team.

Given that the SoTD is intended to reflect the date that a trainee commenced in specialty surgical training it should, therefore, be commensurate with the date that a trainee commenced in a placement at ST3 level. This is indicated by the blue arrow in Figure 2 (page 39).

#### 3.1.1.1 Placement start and finish dates

Trainee placement start/finish dates with an associated recorded level of training (ST3/ ST4/ ST5 etc) are recorded in the ISCP data. Placement dates are inputted by a trainee when adding training placements to their ISCP training records. Deanery and JCST staff do not validate placement dates, only the start of training date.

Doctors at Foundation and Core stages usually commence in post in the first week in August. Specialty trainees in some regions also commence in post in August whereas other regions do not commence specialty training appointments until October. Specialty trainees typically undertake 6 or 12-month placements meaning that changeover dates between placements usually occur in August, October, February or April.

After inspecting the data, it was apparent that trainees had more than one start of ST3 placement date recorded.

The following reasons explain why a trainee may have more than one start of ST3 placement date listed in the dataset:

1. The trainee has more than one placement listed at ST3 level, within one year of training. (Figure 5)


***Figure 5 Trainee timeline with more than one ST3 placement. Blue arrows indicate start of ST3 placements***

2. The trainee has undertaken more than one year of work at ST3 level by completing a post without a national training number (LAT or LAS) and a further ST3 post once the trainee has secured their national training number. Any time recorded as a LAT is automatically recorded as contributing towards training unless a trainee requests otherwise. (Figure 6)

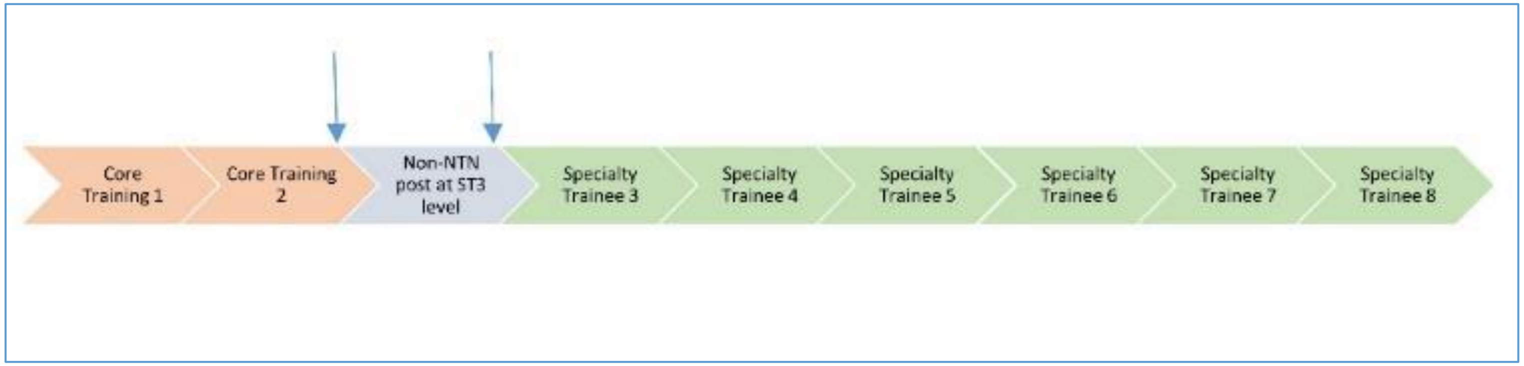



*Figure 6 Trainee timeline with a non-NTN post before specialty training. Blue arrows indicate the start of ST3 placements; non-NTN and NTN posts.*

3. The trainee has worked less than full time and has multiple ST3 placements listed due to their extended time-period as an ST3 level trainee. (Figure 7)

In each of these circumstances, the trainee has more than one start of ST3 placement generated in the dataset.

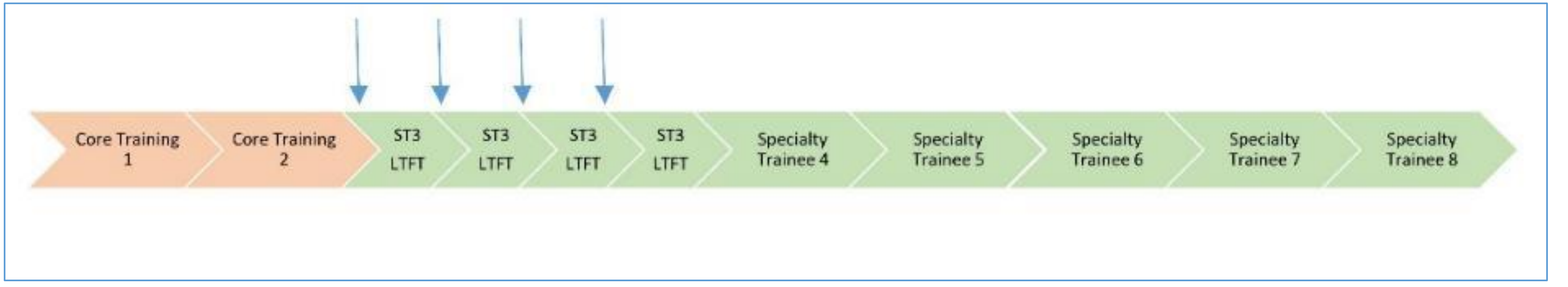



***Figure 7 Trainee timeline working less than full time at ST3 level. Blue arrows indicate the start of ST3 placements.***

### 3.1.2 Anticipated error within start of training dates

There is therefore potential for error with the SoTD as outlined in3.1.1. Other reasons for error within the SoTD are listed in Table 8.

*Table 8 Possible reasons for error within start of training date variable*

| **Possible reasons for error within start of training date variable** | **Explanatory text/ figure** |
|---|---|
| Multiple ST 3 start dates | Section 3.1.1.1,<br>Figure 5, Figure 6, Figure 7 |
| Error between appointment date and placement start dates (Aug/ Oct, Feb/April) | Section 3.1.1.1 |
| Administrative error/ data entry discrepancy | Section 3.1.1 |
| Start date matches ST1 start date | Section 1.4.3.2 |
| Start date matches ST2 start date | Section 1.4.3.2 |
| Start date matches ST4 start date | Section 1.4.3.3 |
| Preceding additional year of training unaccounted | Section 1.4.3.3, Figure 6 |

### 3.1.3 Certificate for Completion of Training date

Trainees have an expected Certification date created and recorded in the ISCP database when they commence in surgical training. This is set for a standard 6 years after the trainee's ST3 training start date. If a trainee commences in post at a more senior level, (having counted a preceding LAT post towards time for Certification) then the expected Certification date is set for the equivalent of a total of 6 years of training. For example, if a trainee commences in an NTN specialty training post at ST4 level, the expected Certification date would be set for 5 years hence.

The expected Certification date is recalculated and updated in the JCST SIMS database by the JCST specialty team if the trainee has an extended time in training e.g. working less than full time or time out of programme.

Trainees have a "status in training" recorded by the JCST specialty team. The status in training can be recorded as: in training; awaiting CCT documentation; pending SAC recommendation; recommended for CCT; left training. The "left training" status is used for trainees who leave the training programme prematurely (rather than those who have completed training).

The process for applying for CCT/ CESR CP is described in Section 1.4.4.5.4.

### 3.1.4 Aims

It was anticipated that there would be inaccuracies within the data relating to trainee timelines (Table 8) and that trainees would be need to be excluded from the dataset as a result. In order to minimise the number of trainees excluded from the study and therefore retain as much data within the dataset as possible, it was important to explore  trainee timeline data with particular attention to the accuracy of start of specialty training dates, stage of training dates and completion of training dates.

The aim of the work described in this chapter was to:

- Assess the variability in the recording of dates in surgical training.
- Create a date for each trainee that accurately reflected the date that the trainee entered specialty surgical training; a corrected start of training date.
- Define two cohorts for analysis based on whether the trainee had completed training or remained in training.
- Define an end of cohort date for each trainee.
- Group trainees into appropriate geographical regions based on updated regional training boundaries (Section 1.4.2).

The rationale for setting up two cohorts was to distinguish between trainees who have been recommended for Certification (and thus represent satisfactory completion of General Surgery training in the UK) and those trainees who are still in training (at the time of data extraction) and so do not have training records that reflect the totality of achievements in training.

The trainees remaining in training have stage specific data that can be used to assess the acquisition of skill through General Surgery training, increasing the statistical power of future analysis when combined with stage specific data from trainees recommended for Certification.

## Section 3.2 Methods

### 3.2.1 Data sources

The data sources used in this study were the ISCP and JCST SIMS datasets. These are described in 1.5.1 and 1.5.2. The data from the two databases were linked using the unique identifier GMC number and then anonymised by the ISCP data manager. All data management and analysis were performed using Stata 14 (Statacorp, Texas 77845 USA).

### 3.2.2 Relationship between start of training date and placement start dates

In order to assess the accuracy of the recorded SoTD, the relation of SoTD to any listed ST3 placement start dates was explored. Corrected start dates were created where necessary to reflect the date that a trainee commenced in specialty surgical training. This was created differently based on the relationship between the recorded SoTD and level start dates as is described below.

#### 3.2.2.1 Strategy for date matches

Windows of date error around the start of training date were assessed to allow for date inaccuracies described in Section 3.1.2 with the aim of retaining as much reasonably accurate data as possible. Exact date match, +/- 90-day and +/- 180-day error strategies were assessed. A window of +/- 90 days was explored to allow for the minor data entry inaccuracies between JCST data entry and trainee’s self-input of placement start dates and to take account of the difference in regional changeover dates (for example, appointment in

August and placement start date of October). A window of +/- 180 days was explored to evaluate whether the number of trainees needing to be excluded from dataset (i.e. those who did not have date matches in the narrower time windows) could be decreased.

The start of training date was assessed for its relationship to other level start dates (ST1, ST2 and ST4) using the same error strategies (+/- 90 and +/- 180 days) and trainees were identified accordingly.

The data was checked at each stage of the data management process for trainees falling into more than one classification group using both +/- 90-day and +/- 180-day error strategies. Trainees falling into more than one classification group were then assessed using individual trainee data to inform which classification group they were most appropriate to.

#### 3.2.2.2 Trainees with a SoTD that matched ST3 placement start date

The SoTD recorded in the data was taken as a true reflection of the date the trainee started specialty surgical training if a trainee had a SoTD that matched an ST3 placement (within a +/- 90 day window). This assumption meant preceding years spent in non-NTN posts were excluded and any subsequent placements listed at ST3 level were included in the trainee timeline.

#### 3.2.2.3 Trainees with a SoTD matching ST1 and ST2 level start dates

Trainees with SoTD that matched the start of ST1 or ST2 levels were assessed further to ascertain progression from ST1 and ST2 placements to specialty surgical training. The time spent in ST1 and ST2 placements and breaks in time between placements were assessed.

Trainees who had not commenced in specialty surgical training (i.e. trainees who had a SoTD matching ST1 or ST2 level start dates but had no recorded progression to a ST3 post) were identified and excluded from the cohort. Trainees with SoTD that matched the start of a recorded ST1 or ST2 placement (with a +/- 90 day window) had a corrected start date created to reflect the start date of the first ST3 placement recorded for each trainee. This group level assumption was made following analysis of group timelines and individual data investigations in the case of discrepancies.

#### 3.2.2.4 Trainees with a SoTD matching ST4 level start dates

Trainees with SoTD that matched the start of an ST4 level were divided according to whether they had an ST3 placement recorded in the one year prior to commencing ST4 placements or not. An error window was used in order to include trainees with slight date errors and differences in changeover dates. The effect of varying the error window used to match from the start of an ST4 placement retrospectively to the beginning of the trainee's most recent ST3 placement start date was assessed. The differing error windows used are shown in Figure 8.

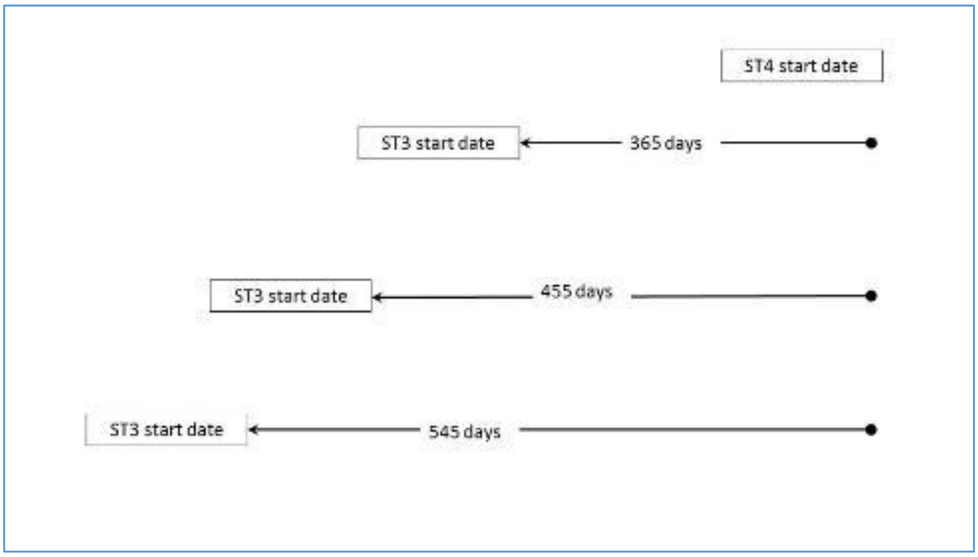



*Figure 8 Error windows for exploring ST4 equivalent SoTD and previous ST3 placements*

Trainees with ST3 placements recorded within one year prior to commencing ST4 level training were assessed further for the number of preceding years spent in additional ST3 and ST4 level posts, the time spent in the most recently recorded ST3 post and the amount of time between commencing ST3 training and the recorded SoTD.

Trainees with a SoTD that matched ST4 placement start dates but did not have an ST3 post recorded within the one preceding year were excluded from the cohort as it was not possible to accurately predict when these trainees commenced specialty surgical training.

Trainees with a SoTD that matched the start of a ST4 placement start date and an ST3 placement recorded in the preceding one year had a corrected start date created 365 days prior to the ST4 placement start date. This assumption was made following group timeline analysis as a best fit for the group, reflecting one prior year of standard surgical training.

#### 3.2.2.5 Trainees with a SoTD unmatched to start of ST1/ST2/ST3 or ST4 levels

Trainees with a SoTD that did not match the start date of any placement recorded as ST1, ST2, ST3 or ST4 were investigated further for their progression through surgical training. It was assumed that a trainee had spent a single standard year at ST3 level if they had recorded a total of less than 455 days at ST3 level. These trainees (unmatched SoTD but with a single year (<455 days) at ST3 level and subsequent continued progression through training) had a corrected start date created equal to the first recorded ST3 placement start date.

Those trainees with an unmatched SoTD and more than a single year at ST3 level were excluded as it was not possible to accurately predict when the trainee started specialty training.

### 3.2.3 Status in Training

Trainees were divided into two cohorts classified as In Training or Completed Training based on the “status in training” variable in the dataset. Those trainees recorded as having been “recommended for certification” were coded to reflect this. All other trainees (status in training recorded as “in training”, “awaiting certification documentation” and “pending SAC recommendation”) were coded as remaining In Training.

The ISCP data manager provided an updated status in training for trainees coded as “awaiting certification documents” 6 months after the data was initially extracted (December 2016). Any trainees who subsequently had their status in training changed to “recommended for certification” and the CCT date recorded as prior to 1st June 2016 were included in the Completed Training cohort. This allowed for trainees to be included in the Completed Training cohort who had been recommended for certification but had not had the online JCST administrative process updated by the point of initial data extraction.

#### 3.2.3.1 Certification date and time in training

An end date of training was defined using the CCT date in those trainees who had been recommended for certification.

Trainees who had been recommended for certification but had less than 5.5 years total training time recorded were examined using individual level data. If trainees had additional LAT appointments prior to commencing specialty training, it was assumed these appointments had been included in total training time and corrected SoTD were created for each individual to include the additional training periods.

Any trainees recommended for certification with less than the minimum expected training time and no explanation for this within the data were excluded from the cohort.

#### 3.2.3.2 End dates for trainees remaining in training

It was necessary to set an end date for the cohort analysis for those trainees remaining in training. It was important to set the end of cohort date for each trainee at the point of their most recently completed stage of training in order to be able to analyse whole stage specific data and retain as much data for analysis as possible.

##### *3.2.3.2.1 No recent placements*

Trainees who were classified as In Training but did not have a start or finish date recorded for a placement since 1st January 2014 were identified. It was assumed that these trainees had left training (either as a result of resigning their position or due to failure to meet the training programme requirements) and were therefore excluded from the cohort.

#### 3.2.3.3 Exploring and setting cohort end date

Any trainees who had completed less than 0.9 years of training (i.e. had not completed a single full stage of training) were excluded from the cohort.

For the remaining In Training cohort, the duration of the most recent listed training stage was assessed. If the duration of the stage was more than 270 days then it was assumed this reflected an entire training stage and an end of cohort date was set to equal the end date of the last listed placement.

Trainees with a last listed placement of less than 270 days were allocated a cohort end date consistent with the end date for the penultimate stage of training in order to capture the entirety of the last completed stage of training.

### 3.2.4 Trainee region adjustment

Trainees registered for specialist surgical training prior to the creation of the Local Education and Training Boards (LETBs) in 2013 had their training region reclassified appropriately according to the Health Education England geographical allocation of deaneries. For example, trainees registered for surgical training in the East Midlands prior to LETB introduction were listed as "East Midlands Education Healthcare Workforce Deanery". They were reclassified as "Health Education East Midlands" and combined with the trainees registered with Health Education East Midlands since 2013. The previous single London deanery and all present London deaneries were reclassified as Health Education London (combined).

### 3.2.5 Cohort analysis

Basic demographics and time spent in training were quantified using summary statistics following the definition of the two cohorts (trainees in training and trainees with a CCT). Comparisons between the two cohorts were made using appropriate non-parametric tests (chi-squared and Mann-Whitney U).

## Section 3.3 Results

There were 1603 trainees in the original dataset.

### 3.3.1 Relationship between start of training date and placement start date

#### 3.3.1.1 Date match strategy exploration

When assessing the relationship of the SoTD to start of ST3 placement dates, 1040 trainees (64.9%) had a SoTD that exactly matched a start of ST3 placement date. This increased to 1203 (75.0%) when a +/- 90 day error window was used. Increasing the error window to +/- 180 days had little effect on increasing the number of trainees with SoTD matched to placement start dates. The classification of trainees into groups according to the relationship between the SoTD and the start of placement dates, and the effect of varying the date match strategy from +/- 90-days to +/- 180-days is shown in Table 9.

***Table 9 Impact of varying the error strategy in assessing SoTD relationship to level start dates.***

| Definition | +/- 90 day error window N (%) | +/- 180 day error window N (%) |
|---|---|---|
| SoTD matches any ST3 placement start date | 1203 (75.0) | 1208 (75.4) |
| SoTD matches ST1 placement start date | 128 (8.0) | 128 (8.0) |
| SoTD matches ST2 placement start date | 57 (3.6) | 57 (3.6) |
| SoTD matches ST4 placement start date and has an ST3 start date within a year | 81 (5.1) | 82 (5.1) |
| SoTD matches ST4 placement start date and does not have an ST3 start date within a year | 32 (2.0) | 32 (2.0) |
| No ST3 placement listed | 38 (2.4) | 38 (2.4) |
| SoTD unmatched to ST1, ST2, ST3 or ST4 placement start dates | 64 (4.0) | 58 (3.6) |
| Total | 1603 (100.0) | 1603 (100.0) |

***SoTD= start of training date. ST = specialist trainee year. N= Number of trainees. %= % of total dataset***

### 3.3.2 Error within start of training date variable

Reasons for error within the SoTD variable and the number of trainees in each category is shown in Table 10.

*Table 10 Start of Training Date error*

| Reasons for error within start of training date variable | Number of trainees, n(%) | Explanatory text/ figure | Results text |
|---|---|---|---|
| Error between SoTD and placement start dates (Aug/ Oct, Feb/April)/ Administrative error/ data entry discrepancy | 163 (10.2)^ | Section 3.1.1.1<br>Section 3.1.1 | Section 3.3.2.1 |
| SoTD matches ST1 start date | 128 (8.0) | Section 1.4.3.2 | Section 3.3.2.1 |
| SoTD matches ST2 start date | 57 (3.6) | Section 1.4.3.2 | Section 3.3.2.3 |
| SoTD matches ST4 start date | 113 (7.0) | Section 1.4.3.3 | Section 3.3.2.4 |
| SoTD unmatched to ST1, ST2, ST3 or ST4 placement start dates | 102 (6.4) | - | Section 3.3.2.5 |
| SoTD exact match | 1040 (64.9) | Section 3.1.1 | Section 3.3.2.1 |
| Total | 1603 (100.0) | | |

***SoTD = start of training date. %= % of the total dataset, n=1603. ^ = all had ST3 start dates within +/- 90 days of SoTD***

#### 3.3.2.1 Trainees with a SoTD that matched ST3 placement start date

There were 1040 trainees (64.9%) in the dataset who had a SoTD that exactly matched an ST3 placement start date. A further 163 trainees (10.2%) had a SoTD that matched an ST3 placement start date with a +/- 90 day error window. These trainees are presumed to be those with data entry discrepancy or differences in changeover dates and specialty training start dates.

#### 3.3.2.2 Trainees with a SoTD that matched ST1 placement start date

There were 128 trainees (8.0%) with a SoTD that matched start date of a ST1 placement. There were 90 trainees who progressed from the start of ST1 to ST3 within 2 years (within 180- day window). There were 38 trainees who took longer than 2 years between the start of ST1 and the start of ST3. Of these "non-progressing" trainees, 14 had a break in training between ST2 and ST3 of a median 942.5 days (IQR 607 – 1186, range 365 – 1506). The remaining 23 trainees had an extended training time at ST1/ST2 levels of a median 1154 days (IQR 1091- 1516, range 914 – 2554) and then subsequently progressed directly into an ST3 placement. One trainee had missing end of placement data.

#### 3.3.2.3 Trainees with a SoTD that matched ST2 placement start date

There were 57 trainees (3.6%) with a SoTD that matched the start date of a ST2 placement. Of these, 43 trainees (75.4%) progressed from the start of ST2 to ST3 within 1 year (plus 180-day window).

Fourteen trainees (24.6%) took longer than 1 year between the start of ST2 and the start of ST3. Of the "non-progressing" trainees, three had a break in training between ST2 and ST3 with a mean duration of 1240.7 days (range 1154 – 1412).

The remaining 11 trainees (19.3%) had an extended time in ST2 training with a median duration of 790 days at ST2 level (IQR 734-1098, range 715-1518) and then progressed directly into an ST3 placement.

Fifty-one trainees (89.5%) spent 1 year at ST3 level. All trainees with prolonged ST3 placements subsequently continued through training to ST7/8.

#### 3.3.2.4 Trainees with a SoTD that matched ST4 placement start date

There were 113 trainees (7.0%) with a SoTD that matched ST4 placement start dates. The effect of varying the error window used to match from the start of an ST4 placement retrospectively to the beginning of the trainee's most recent ST3 placement start date is show in Table 11.

*Table 11 Effect of varying the window between ST4 placements and the preceding ST3 placement*

| Match window (days) | SoTD/ ST4 start match and has an ST3 start date within a year, N (%) | SoTD/ ST4 start date match does not have an ST3 start date within a year, N (%) |
|---|---|---|
| 365 | 41 (2.6) | 72 (4.5) |
| 455 | 77 (4.8) | 36 (2.3) |
| 545 | 81 (5.1) | 32 (2.0) |

***SoTD= start of training date. ST = specialist trainee year. N= Number of trainees. %= of total dataset.***

When a 365-day window was used, 72 trainees were classified as not having a ST3 placement in the preceding year and thus would be excluded from the cohort. However, when the window prior to the ST4 date was widened to 545 days, the number of trainees who did not have a ST3 placement within the past year decreased to 32. The four trainees who were excluded when narrowing to a 455 window were all checked using individual data and were appropriate to remain in the cohort. Therefore, a window of 545 days between ST4 placement start date and a preceding ST3 placement start date was used, as described in 3.2.2.5.

*3.3.2.4.1 ST4 start date matched to SoTD and ST3 placement within 1 year*

Using this strategy (preceding ST3 placement start date within 545 days), there were 81 trainees with a SoTD that matched the start of a ST4 placement and whose most recently recorded ST3 placement start date was within one prior year.

Trainees spent a median 363 days (IQR 363- 370, range 55- 505) in the most recently recorded ST3 post. The longest duration of time spent in an ST3 post was 505 days (1 year and 140 days). Eleven trainees (13.6%) had recorded final ST3 placements of less than 275 days, six of whom had placements listed of less than 180 days duration. Sixty-seven trainees (82.7%) had spent between 275 days and 455 days in their final ST3 placement.

Trainees in this group spent a median 370 days in total in all placements recorded as ST3 level (IQR 364 – 664, range 61-2195). Twenty-three trainees (28.4%) had spent more than 545 days at ST3 level. Reasons for spending more than one year at ST3 level may include less than full time trainees (not coded for in the dataset), academic trainees (n=2 in this sub-group), out of programme placement or time spent in a non-NTN ST3 post (not coded for) or training level not updated appropriately within the data.

##### *3.3.2.4.2 ST4 start date matched to SoTD but no ST3 placement within a year*

There were 32 trainees who did not have an ST3 placement start date one year (plus 180 day window) prior to the start ST4/SoTD. These trainees were excluded from the cohort.

#### 3.3.2.5 SoTD unmatched to ST1/ST2/ST3 or ST4 start dates

There were 102 trainees with a SoTD that did not match the start date of a recorded ST1/ST2/ST3 or ST4 placement. Of these, 64 trainees had recorded ST3 placements. One trainee had not progressed beyond ST3 level and was excluded from the cohort. Four trainees had spent longer than a single year at ST3 level and were excluded from the cohort as it was not possible to accurately predict a corrected SoTD for these trainees.

There were 38 trainees who had no ST3 placements listed at all. It was not possible to create corrected start dates for these trainees and so they were excluded from the cohort.

### 3.3.3 Status in Training

The status in training of the trainees in the original and updated dataset is shown in Table 12.

***Table 12 Status in Training of trainees***

| Status in training | Original dataset N (%) | Updated dataset N (%) |
| --- | --- | --- |
| Awaiting Certification Documents | 130 (8.1) | 118 (7.4) |
| In Training | 1106 (69.0) | 1106 (69.0) |
| Pending SAC Recommendation | 2 (0.1) | 2 (0.1) |
| Recommended for Certification | 365 (22.8) | 375 (23.4) |
| Left training | - | 2 (0.1) |
| Total: | 1603 | 1603 |

***N= number of trainees. %= % of total dataset. SAC= Specialty Advisory Committee.***

A further ten trainees who had originally been coded as "Awaiting Certification Documents" had been recommended for Certification with a CCT date prior to 1st June 2016 in the updated data provided by the ISCP data manager. This increased the total number of trainees in the dataset who had been recommended for Certification to 375 (23.4%). Two trainees had been recoded as "Left training" from an original status of "Awaiting Certification Documents".

#### 3.3.3.1 CCT date and time in training

The median time in training for those who had been recommended for Certification was 6.00 years (IQR 6.0-7.0 years, range 2.0- 9.3 years). Eight trainees had < 5.5 years total training time in the Completed Training cohort. Five trainees had additional training periods which had apparently been counted towards total time for completion of training. The training start dates were corrected for each individual to include these training periods.

The remaining three trainees with short total training periods appeared to be trainees from the previous Calman training system and were excluded from the cohort.

### 3.3.4 End dates for trainees remaining in training

#### 3.3.4.1 No recent placements

There were 40 trainees with no recorded start or end dates for placements since January 2014 but were still coded as "in training". These trainees were excluded from the cohort in addition to the two trainees identified by the JCST data manager as having left training.

#### 3.3.4.2 Time spent in last training stage

There were 128 trainees who had recorded <0.9 years in total for training. There were trainees appointed to General Surgery NTNs commencing August or October 2015. These trainees were excluded from the cohort.

The median time recorded in the last training stage prior to 1st May 2016 was 370 days, IQR 363 - 370, range 1 - 2372 days. Eighty-four trainees (7.48%) recorded a last completed stage of less than 270 days. On further evaluation, these trainees had further placements listed, at the same ST level, going beyond 1st May 2016. The 84 trainees with a short (<270 days) final stage of training had an end date set for the penultimate completed stage of training. In this group, the median time spent in the penultimate stage of training was 364 days (IQR 363- 370 days, range 181 – 1826 days).

### 3.3.5 Total exclusions

A total of 249 trainees (15.5%) were excluded from the dataset following exploration of start and end dates. Reasons for exclusion are shown in

Figure 9.

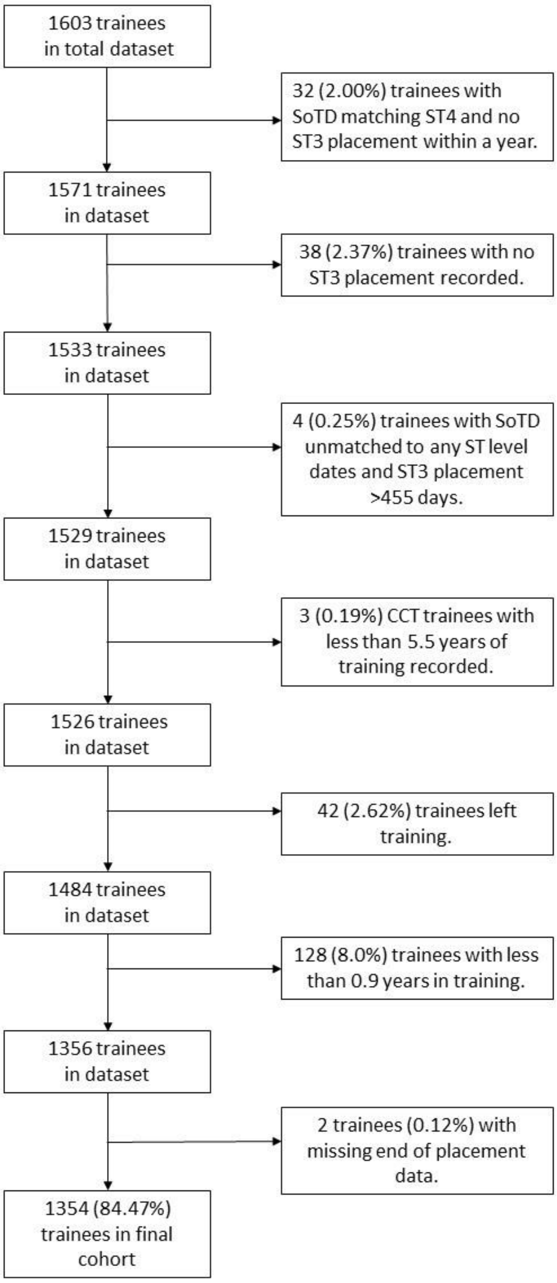



***Figure 9 Flow diagram for exclusion of trainees from the dataset***

***% = % of original dataset***

### 3.3.6 Cohort Demographics

The demographics of the cohorts are described in Table 13 .

*Table 13 Cohort demographics*

| | **Completed training group (n=360)** | **In- Training group (n=994)** | **Total dataset (n= 1354)** |
|---|---|---|---|
| Males n (%) | 283 (78.6)^ | 637 (64.1)$ | 920 (67.9)* |
| Females n (%) | 77 (21.4)^ | 357 (35.9)$ | 434 (32.1)* |
| Age at start of training, years Median (IQR)∞ | 30.8 (29.4- 33.1)∞ | 30.3 (28.8- 32.5) | 30.4 (28.9- 32.6)∞ |
| Total time in training, years Median, IQR, (Range) | 6.0,<br>6.0- 7.0, (5.7- 9.3) | 3.5,<br>2.0- 5.1, (1.0- 8.7) | - |
| Region | N (%) | N (%) | N (%) |
| H.E. East Midlands | 22 (6.1)^ | 68 (6.8) $ | 90 (6.6)* |
| H. E. East of England | 13 (3.6)^ | 43 (4.3) $ | 56 (4.1)* |
| H.E. Kent, Surrey and Sussex | 0 | 44 (4.4) $ | 44 (3.2)* |
| London (combined) | 66 (18.3)^ | 212 (21.3) $ | 277 (20.5)* |
| H.E. North East | 36 (10.0)^ | 47 (4.7) $ | 83 (6.1)* |
| H.E. North West | 30 (8.3)^ | 112 (11.2) $ | 142 (10.5)* |
| H.E. South West | 29 (8.1)^ | 70 (7.0) $ | 99 (7.3)* |
| H.E. Thames Valley | 11 (3.1)^ | 32 (3.2) $ | 43 (3.2)* |
| H.E. Wessex | 12 (3.3)^ | 51 (5.1) $ | 62 (4.6)* |
| H.E. West Midlands | 17 (4.7)^ | 76 (7.6) $ | 93 (6.9)* |
| H.E. Yorkshire and the Humber | 43 (11.9)^ | 69 (6.9) $ | 112 (8.3)* |
| NHS Education for Scotland (combined) n (%) | 46 (12.8)^ | 114 (11.5) $ | 160 (11.8)* |
| Northern Ireland Medical and Dental Training n (%) | 19 (5.3)^ | 19 (1.9) $ | 38 (2.8)* |
| Wales n (%) | 16 (4.4)^ | 39 (3.9) $ | 55 (4.1)* |

***IQR= Inter-quartile range. *= % of total cohort. ^= % of Completed Training group. $= % of In-Training group. ∞= only trainees with valid date of birth data included in analysis. N=47 had missing data. H.E.= Health Education***

There were 360 trainees (26.6%) who had been recommended for Certification and 994 trainees (73.4%) who remained in training.

Of the entire cohort, 434 trainees were female (32.1%) and 920 (67.9%) were male. Of the male trainees, 283 had been recommended for Certification (30.8% of the males in the total cohort) compared with 77 of the female trainees recommended for Certification (17.7% of the females in the total cohort).

Forty-seven trainees had missing date of birth data. The median age at start of specialty training was 30.4 years (range 26.5 – 44.7 years) for the whole cohort. The median age at start of training for female trainees was 29.8 years and 30.9 years for male trainees ($p<0.001$).

The median age at the end of training was 36.6 years (range 33.2- 49.1 years) for female trainees who had been recommended for Certification and 37.7 years (range 33.2- 48.3 years) for male trainees who had been recommended for Certification ($p<0.001$). (Table 13)

The median years spent completing training for the CCT cohort was 6.00 years (IQR 6.0-7.0, range 5.7- 8.6 years).  Female trainees spent longer in training than male trainees prior to being recommended for Certification ($p<0.01$) with female trainees taking a median 6.5 years to complete training and male trainees taking a median 6.0 years to complete training.

## Section 3.4 Discussion

### 3.4.1 Main findings

This chapter describes the assessment of training demographic data for a national cohort of UK General Surgery specialty trainees. This work has carefully and methodically assessed the SoTD for each trainee and adjusted this where necessary to reflect the start of specialty surgical training (ST3 level). This work has considered the individualised setting of the end date for the cohort and taken steps to ensure this is in keeping with the last complete stage of training undertaken.

### 3.4.2 Strengths and limitations

A strength of this study is the meticulous assessment of SoTD. The finding that 65% of trainees had exact matches between SoTD and ST3 placement start dates is reassuring. Only 9.4% of the initial dataset (n=150 trainees) had the SoTD adjusted. Whilst decisions to adjust SoTD were made after assessing sub-groups of trainees carefully, the assumptions made could bring error into the dataset. There may be trainees in the In Training cohort who have an additional LAT year of training and are intending to count this towards total training time for Certification but remain unidentified in the dataset. This may result in a year of training having been excluded from the cohort in this group of trainees and therefore bias any subsequent analysis pertaining to experience during surgical training.

The use of windows to allow for discrepancy between registered start dates and regional variation in changeover dates (e.g. August to October) may have resulted in additional months of training being either included or excluded. However, given the use of 90-day windows, it is likely that this error is only up to 3 months and it is reasonable to accept this in the context of a 6-year training programme. Furthermore, the proportion of trainees affected by this potential for small error is low (10.2%, n=163).

End of cohort date setting may have introduced error by setting this date part-way through a stage of training. Steps have been taken to minimise this likelihood but the possibility still remains. The resultant effect would be that a trainee has incomplete data for their most recent stage of training and bias any conclusions drawn relating to stage-specific experience.

The tendency to exclude trainees with non-standard training time in the sub-group of those with SOTD that matched ST4 start dates could result in a selection bias in the cohort. However, given that there were only 36 trainees (2.2% of the total dataset) with SOTD that matched ST4 who did not have an ST3 start date listed in the preceding 1 year, it is likely that this error is small. Less than Full Time trainees should have ST3 placements listed within the prior year rather than a gap in their timelines. Therefore, it is more likely that these trainees represented those with time taken out of programme who were excluded at this stage of data cleaning. Time taken for training out of programme (Section 1.4.3.5) is unquantified within the data assessed in this work but may explain some of the non-standard training time observed in this dataset. Out of programme time is explored in Chapter 4.

Female trainees take longer in training before being recommended for Certification compared with the male trainees (median 6.4 years vs 6.0 years, $p < 0.001$). Furthermore, whilst 32.1% (n= 434) of total trainees included in the study are female, only 21.4% (n=77) of the Completed Training cohort are female. This suggests that females are disproportionately under-represented in the Completed Training cohort, presumably because they take longer to complete training thus remain in the In Training cohort. Reasons for female trainees taking longer to complete training include the need for maternity leave and increased likelihood of working less than full time. This is assessed further in Chapter 4.

Less than full time (LTFT) training is unaccounted in this data. Adjusting start dates by a standard single year would not be representative of an entire training stage for those trainees working as LTFT. This could impact the subsequent inclusion of training data in a small proportion of trainees. However, in 2011 there were only 151 LTFT trainees across all surgical specialties.[135] All training data after the point of start date is included, regardless of LTFT state. Therefore, the resulting degree of error is likely to be small.

Whilst there is opportunity for residual error within the training dates, trainees' ISCP portfolios are reviewed by their CS, AES and TPD. Training Programme Directors are required to approve trainee's placements within ISCP and in doing so, provide a degree of data validation. Expected completion of training dates are input by the JCST and strictly calculated following any periods of time out of programme or change to working LTFT, minimising likelihood of error within this field.

### 3.4.3 Other literature

There are only a few studies reporting demographics and time in training for a General Surgery trainee cohort in the UK. Published time in training and demographics are described in Table 14. Thomas *et al* [136] reported a similar gender ratio for trainees in training with males accounting for two-thirds of trainees. In Thomas' other study of trainees recommended for Certification it is reported that female trainees take a significantly longer period of time to be recommended for Certification compared to male trainees.[97] Thomas *et al* used similar data used in this study but taken from the documentation submitted for Certification. There was no detailed analysis of trainee timelines or adjusting of time in training, for example to reflect LAS/LAT posts. This might explain the inclusion of a trainee with apparently 11.8 years of training in the Thomas study.[97] Similarly, Allum *et al* used submitted logbooks for Certification. The authors did not report the proportions of male and female trainees included. The mean total time in training reported was 6 years but with a range of 4.8 years to 7.3 years. Allum *et al* did not present an explanation for the range of total training time but this non-standard training time is likely to have biased the results presented.[92]

*Table 14 Comparative studies of trainee demographics*

| Study | Study period | In training/ CCT | Total trainees | Males N (%) | Females N (%) | Length of training (years) Median, (Range) | |
|---|---|---|---|---|---|---|---|
| | | | | | | Males | Females |
| Allum *et al*[92] | 2010-2011 | CCT | 58 | - | - | 6.0 (4.8 – 7.25)* | |
| Thomas *et al*[136] | 2007-2012 | In training | 91 | 59 (64.8) | 32 (35.2) | - | |
| Thomas *et al*[97] | 2012-2013 | CCT | 155 | 119 (76.8) | 36 (30.3) | 6.0 (5.3- 9) | 7.1 (5.9- 11.8) |
| This study | 2007 - 2016 | CCT | 344 | 270 (78.5) | 74 (21.5) | 6.0 (5.7- 8.5) | 6.5 (5.9- 8.6) |
| | | In Training | 957 | 613 (64.1) | 344 (35.9) | - | - |

***N= number. %= % of total cohort. CCT= Certificate for completion of training. *= no gender split data given, whole cohort.***

### 3.4.4 Conclusion

The work described in this chapter has assessed the accuracy of training timelines for use in subsequent chapters. It has maximised the number of trainees and associated data available for subsequent analysis whilst excluding trainees with unsuitable data. Two cohorts have been defined for analysis: a cohort of trainees who were in training at the time of data extraction (1st June 2016) and a cohort of trainees who had completed training by the same time. These cohorts will subsequently be referred to as In Training and Completed Training. The cohorts have been described with reference to age, gender and time in training and they appear comparable to other published literature.

# Chapter 4 Time Out of General Surgery Specialty training in the UK

## Section 4.1 Introduction

Surgical training worldwide varies dramatically.[137] Many countries have curricula that are designed to include, alongside essential clinical skills training, a period of research. The USA has no single standardised requirement for research during General Surgery residency training with individual training programmes setting academic requirements.[138] Typically, US medical school graduates choosing to pursue a career in General Surgery will spend five years in General Surgery training with the option of taking additional time for research and subspecialty training in the form of fellowship periods. Ellis *et al* reported a rise in the number of General Surgery trainees taking time out for research in the USA with an increase in the proportion of trainees undertaking more than one year for research from 9.8% between 1990-1999 to 22.4% between 2000-2009.[139] In addition, Robertson *et al*'s 2006 survey of USA General Surgery programme directors reported a mean research fellowship duration of 1.7 years (in those residents who had undertaken research) with 52% of residents spending two years on a research fellowship.[138] These changes have resulted in an extension to training meaning many trainees do not become independent practitioners until a decade after graduation.[138]

General surgery trainees in the UK may choose to take time out of training for research, training in another area or for parental leave.[88](Section 1.4.3.5)

Taking time out of training for research in the UK would usually be for a minimum of a two-year period.[88] Time out of training in the UK can be taken at any time after completion of the first year of specialty training and can be considered akin to US mid-training fellowship periods.

Within UK general surgical training, trainees are expected to meet minimum academic standards which include publishing three peer- reviewed publications and presenting at three international or national meetings by completion of training.[7] These academic requirements are likely to remain in some form in any new curricula.[55, 56, 140] Trainee involvement in surgical research collaboratives [89, 141-144] has increased interest in surgical research amongst trainees.[145-147] Furthermore, there is support for the inclusion of clinical trial involvement within surgical training. [148-151] Thus far there has been no formal assessment of these drivers on time out of training for research in UK surgical training and its impact on training duration.

### 4.1.1 Aims

This study aimed to quantify the number of UK General Surgery trainees taking time out of training, the types of out of training periods (e.g. research, additional training or parental leave), the duration of such time periods and to assess the impact of out of training periods on the time taken to complete General Surgery specialty training.

## Section 4.2 Methods

### 4.2.1 Data sources and management

This study used routinely collected data from the ISCP (Section 1.5.1) and the JCST SIMS database (Section 1.5.2). The data from the two databases were linked using the unique identifier GMC number and then anonymised by the ISCP data manager. All data management and analysis were performed using Stata 14 (Statacorp, Texas 77845 USA).

### 4.2.2 Study Population

This consisted of all General Surgery trainees registered for specialty training from 1st August 2007 in the United Kingdom until 1st June 2016. The definition of the study cohort, including In Training and Completed Training cohorts is described in Chapter 3.

### 4.2.3 Statistical analysis

#### 4.2.3.1 Analysis of time spent out of training

The proportion of trainees taking time out of training, type of out of training period, and time taken out of training were quantified and compared between the Completed Training and In-Training groups. Sick leave, exceptional leave and career break categories were grouped together to prevent the reporting of data below the level of five individuals. Variation by gender and region of training was assessed. Proportions were compared using chi-squared, Mann-Whitney U and Z-test where appropriate and statistical significance taken at $p<0.05$.

A standardised comparison between the In-Training and Completed Training groups was made by analysing the proportion of trainees taking time for research in the first three years of training only for both groups. The first three years of data were used following the observation during analysis that the majority of research periods were taken within the first three years of specialty training and to enable a standardised time comparison between the two groups.

#### 4.2.3.2 Analysis of total time spent in training

An unadjusted total time in training was calculated as the time from the start of training date to either the date the trainee completed training or the cohort end date for the Completed Training or In Training groups respectively. Following definition of periods out of training which did not count towards training time (all periods except those categorised as OOPT), an adjusted time in training was calculated for the Completed Training group by excluding these time periods from total training time. Variation in adjusted and unadjusted total training time was assessed by gender and region.

A predicted unadjusted total time in training was calculated for the In-Training group as time from the start of training date to the JCST predicted date for completion of training and included all out of training periods undertaken to date. Total unadjusted time in training in the Completed Training group was compared with the predicted unadjusted total time in training in the In Training group.

# Section 4.3 Results

## 4.3.1 Cohort definition and demographics

Exclusions from the dataset are described in Section 3.3.5 and Figure 9 (page 131) with demographics of the dataset described in Section 3.3.6 and Table 13.

### 4.3.1.1 Out of programme periods

There were 961 out of programme episodes taken by a total of 708 trainees (52.3% of the whole group). Of the trainees who had completed training, 165 (45.8%) had taken at least one out of training period. Comparatively more of the In-Training group, (n= 543, 54.6%) had taken at least one out of training period ($p<0.01$) (Table 15).

*Table 15 Total adjusted and unadjusted time in training and number of out of programme periods taken*

| | **Completed training group (n=360)** | **In- Training group (n=994)** | **Total dataset (n= 1354)** |
|---|---|---|---|
| Total adjusted time in training, years<br>Median (IQR) | 6.0 (6.0- 6.5) | 3.0 (2.0- 4.3) | 4.0 (2.0- 6.0) |
| Total unadjusted time in training, years<br>Median (IQR) | 6.0 (6.0- 7.0) | 7.0 (6.0-8.5)˜ | - |
| Number of out of training periods taken | | | |
| 0 (n (%)) | 195 (54.2)^ | 451 (45.4) $ | 646 (47.7)* |
| 1 (n (%)) | 121 (33.6)^ | 398 (40.0) $ | 519 (38.3)* |
| 2 or more (n (%)) | 44 (12.2)^ | 145 (14.6) $ | 189 (139.6)* |

***IQR= Inter-quartile range. ^= % of Completed Training group. $= % of In-Training group ˜= predicted total unadjusted time in training.***

The total time taken out of training in the Completed Training group, for those who had undertaken a period out of training, was a median of 1.0 year (IQR 0.6- 1.2 years). The total time taken out of training in the In-Training group, for those who had undertaken a period out of training, was a median of 2.0 years (IQR 1.2 – 3.0 years) ($p<0.01$). (Table 16)

*Table 16 Number of trainees and time taken for different types of out of training period*

| Completed Training group | | | | | | |
|---|---|---|---|---|---|---|
| | **Males (n= 283)** | | **Females (n= 77)** | | **Total (n=360)** | |
| **Type of out of training period** | **Number of trainees (%)** | **Total time taken, years (IQR)** | **Number of trainees (%)** | **Total time taken, years (IQR)** | **Number of trainees (%)** | **Total time taken, years (IQR)** |
| Research | † | 2.0 (1.0- 2.1) | <5 | - | 22 (6.1)^ | 2.0 (1.0- 2.1)* |
| Training | 86 (30.4) | 0.8 (0.5- 1.0) | 26 (33.8) | 1.0 (0.5-1.0) | 112 (31.1)^ | 0.8 (0.5- 1.0) |
| Experience | 26 (9.2) | 0.5 (0.5- 1.0) | 6 (7.8) | 0.7 (0.5-1.0) | 36 (10.0) | 0.7 (0.5- 1.0) |
| Parental leave | <5 | - | † | 0.8 (0.6-1.1) | 21 (5.8)^ | 0.8 (0.6- 1.1)* |
| All out of training types combined | 115 (40.6) | 1.0 (0.5- 1.2) | 50 (64.9) | 1.0 (0.6- 1.5) | 165 (45.9)^ | 1.0 (0.6- 1.2)* |
| **In-Training group** | | | | | | |
| | **Males (n=637)** | | **Females (n= 357)** | | **Total (n= 994)** | |
| **Type of out of training period** | **Number of trainees (%)** | **Total time taken, years (IQR)** | **Number of trainees (%)** | **Total time taken, years (IQR)** | **Number of trainees (%)** | **Total time taken, years (IQR)** |
| Research | 243 (38.1) | 2.4 (2.0- 3.0) | 106 (29.6) | 2.0 (2.0- 3.0)* | 349 (35.1)^ | 2.0 (2.0- 3.0)* |
| Training | 51 (8.0) | 1.0 (0.5- 1.0) | 31 (8.7) | 1.0 (0.5- 1.0) | 82 (8.2)^ | 1.0 (0.5- 1.0) |
| Experience | 47 (7.4) | 1.0 (1.0- 1.0) | 32 (9.0) | 1.0 (1.0- 1.0) | 79 (7.9) | 1.0 (1.0- 1.0) |
| Parental leave | <5 | - | † | 1.0 (0.8- 1.7) | 117 (11.7)^ | 1.0 (0.8- 1.6)* |
| All out of training types combined | 322 (50.5) | 2.0 (1.5- 3.0) | 221 (61.9) | 2.0 (1.0- 3.0) | 543 (54.6)^ | 2.0 (1.2- 3.0)* |

***†= not reported to protect anonymity <5= fewer than 5 trainees. ^= p<0.01, chi-squared test. *= p<0.01, Wilcoxon rank sum test. All statistical comparisons are between the Completed Training and In-Training groups.***

A greater proportion of female trainees had undertaken any period out of training than male trainees in both the Completed Training and In-Training groups (64.9% of females vs 40.6% of males in Completed Training group, $p<0.01$; 61.9% of females vs 50.6% of males in In-Training group, $p=0.01$). This was due to female trainees taking parental leave in addition to other out of training periods whereas fewer than five male trainees had a period of formal parental leave recorded. Parental leave had been taken by fewer trainees who had completed training (5.8%) compared with the In-Training group (11.7%), ($p <0.01$). The median total time spent out of programme for parental leave was 0.8 (IQR 0.6- 1.1) years in the Completed Training group compared with a median 1.0 (IQR 0.8- 1.7) years in the In-Training group ($p<0.01$).

Of those who had completed training, 31.1% had taken time away from training for a further period of formal training with 96.4% of the additional training episodes occurring during the last 3 years of training (Table 16). The median time taken for additional training periods in the Completed Training group was 0.8 years (IQR 0.5-1.0 years). There was no difference in the proportion of male and female trainees undertaking additional periods of training in those who had completed training ($p=0.5$).

The proportion of trainees taking time out of training ranged widely between regions from 29.6% in the Kent, Surrey and Sussex region to 65.1% in the Thames Valley region ($p<0.01$). (Figure 10)

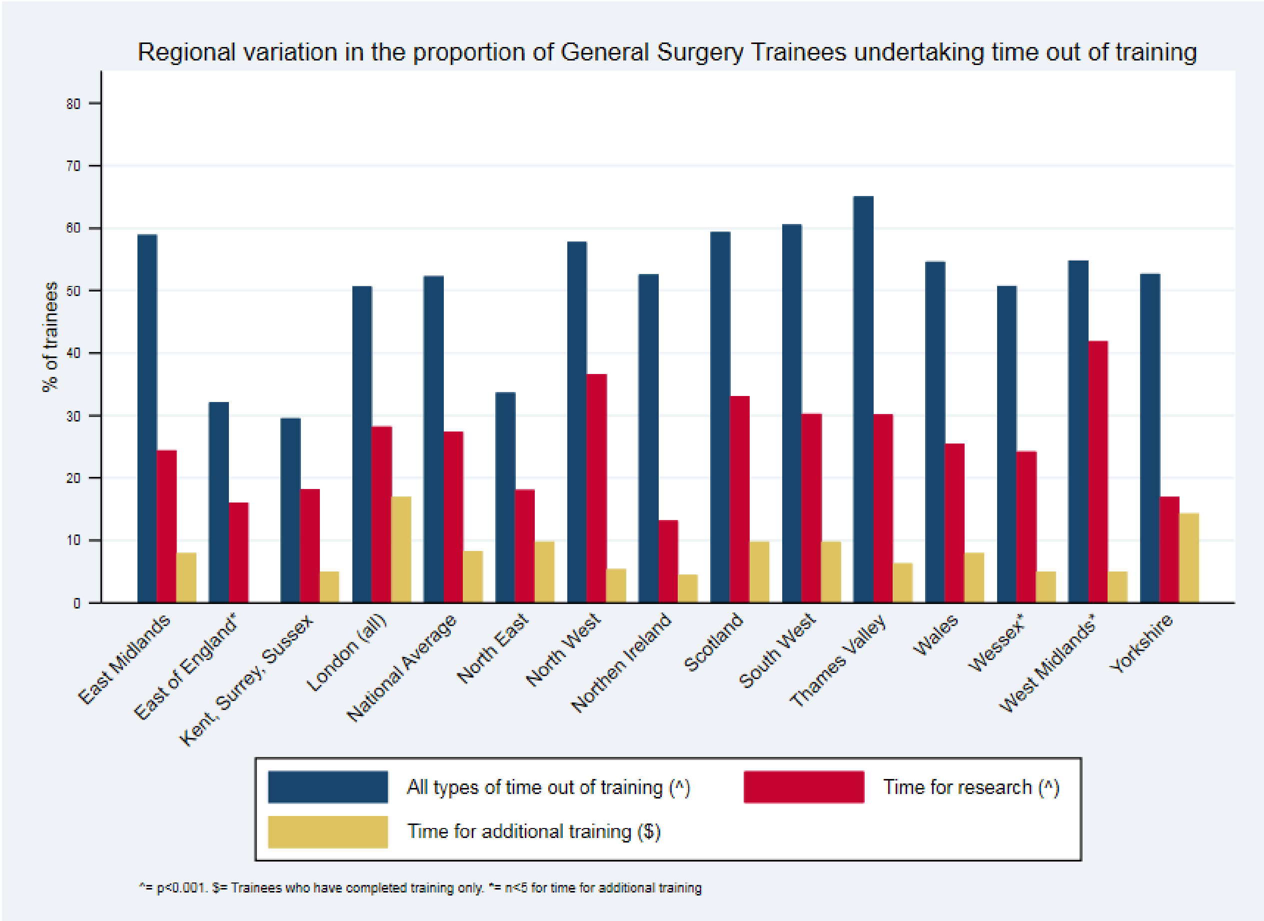



***Figure 10 Regional variation in the proportion of General Surgery Trainees undertaking time out of training***

#### 4.3.1.2 Out of Programme Research

A greater proportion of trainees in the In-Training group had taken time out of training for research compared to the trainees in the Completed Training group (35.1% vs. 6.4 %, $p<0.01$). The duration of time taken out of training for research was unimodal in the Completed Training group with 13 trainees (59.1%) taking two years for research. The duration of time taken out of training for research was bimodal in the In-Training group with 146 trainees (41.8%) taking 2 years and 119 trainees (34.1%) taking three years.

There was no difference between the proportion of male and female trainees taking time out of training for research in those who had completed training ($p= 0.7$). However, in the In-Training group, a higher proportion of males (38.3%) had undertaken research out of training compared with female trainees (29.7%) ($p <0.01$)(Table 16). The proportion of trainees taking time out of training for research varied widely from 13.2% in Northern Ireland to 41.9% in the West Midlands ($p<0.01$). (Figure 10)

When the total time in training was standardised to the first three years of training for both groups, the difference in proportion of trainees taking time out of training for research was accentuated with 3.6% of those who had completed training undertaking research periods compared with 24.3% of the In-Training group ($p<0.01$).

### 4.3.2 Time in training

#### 4.3.2.1 Completed Training group

The unadjusted total time in training for those who had completed training was a median of 6.0 years (IQR 6.0- 7.0; range 5.7 to 9.3 years). The unadjusted total time in training was higher for females in this group with a median of 6.5 (IQR 6.0- 7.3) years compared with a median of 6.0 (IQR 6.0- 6.9) years for the male trainees who had completed training (p= 0.01).

The adjusted total time in training for the Completed Training group remained a median of 6.0 (IQR 6.0- 6.5) years following exclusion of appropriate out of training periods (Table 15). When out of training periods had been excluded, there was no difference between males and females or by region in the total time spent in training (p = 0.9 and p=0.3 respectively).

#### 4.3.2.2 In-Training group

The predicted unadjusted total time in training was a median of 7.0 (IQR 6.0- 8.5) years for the In-Training group. When this was limited to those who had already undertaken a period out of training, the predicted unadjusted total time in training increased further to a median of 8.0 years (IQR 7.0- 9.0 years). The predicted unadjusted total time in training did not vary between male and female trainees who had already undertaken a period out of training in the In-Training group.

## Section 4.4 Discussion

### 4.4.1 Main findings

This study has quantified the number of UK General Surgery trainees taking time out of training, the types of out of training periods and the duration of such periods. This study has demonstrated a changing trend in taking time out of UK General Surgery specialty training, particularly for research. This is evidenced by the greater proportion of In-Training trainees taking time out of training for research compared with those who had completed training. Furthermore, the proportion of trainees undertaking formal research periods in the In-Training group may still be under-reported in this study as some trainees in the analysis may go on to take time out of training for research in the future course of their specialty training. This research trend is further evidenced by the marked difference in the proportion of trainees taking time out of training for research when training time was standardised to the first three years of training in both cohorts. Not only are more trainees taking time out of training for research, but they are tending to take longer away from training, resulting in up to two years additional total time in specialty training for a large proportion of trainees.

### 4.4.2 Strengths and limitations

This is the first study to utilise linked ISCP and JCST data to form a large, representative cohort of General Surgery trainees from a single country. This has allowed accurate ascertainment of training start dates and periods of time out of training. Inevitably, small errors in data entry and measurement of time may still be present. The regional variation in the number of trainees taking time out of training highlights the necessity of national data use in our study. Reporting single region data could be misleading whereas we have been able to provide a more representative view of training time in the UK. Prior studies in the US have either focused on single region data or relied on self-reported questionnaires which may be prone to bias. This study excluded a small proportion of trainees (4.6%) from the original dataset owing to inability to define when trainees started specialty training. However, the exclusion of this small group of trainees with non-standard training has made the findings more representative of standard UK surgical training. It is acknowledged that trainees may have undertaken formal research periods prior to commencing specialty training rather than during the course of specialty training, thus biasing the findings of this study. National data to support this suggestion do not exist, thus it is not possible to quantify how many of the trainees in the Completed Training group had undertaken formal research prior to commencing specialty training. However, carrying out research prior to specialty training does not affect the duration of specialty training or workforce planning issues resulting from taking time out of a specialty training programme.

### 4.4.3 Other literature

Previous studies of surgical training have been small or restricted to non-representative samples or have not quantified research training periods. For example, Thomas *et al* studied 155 trainees who had completed training between November 2012 and December 2013 using trainee CVs and ISCP data.[97] They described a median total training time for their cohort of 6 years (range 5.25 – 11.75 years) with female trainees taking longer to train (median 7.1 years, range 5.9 – 11.75 years.[97] However, the authors did not describe time out of training or report adjusting for such periods. Allum *et al* studied the electronic operative logbooks and logbook consolidation sheets of 58 General Surgery trainees applying for completion of training in 2010 and 2011.[92] They reported a mean total of 6 years (range 4.8 – 7.25 years) in General Surgery training but excluded trainees who had taken time out of training. The use of JCST data, description of out of training periods and the exclusion of out of training periods not counting towards training time has improved the reflection of time in training in our study.

Our findings show that the distribution of time spent in research is similar to that in the USA. A 2006 USA survey of General Surgery residency programme directors reported that 36% of General Surgery residents undertook a research fellowship with a mean duration of 1.7 years. There was a modal distribution of time spent in research with 41% spending one year, 52% two years and 27% three or more years.[138] In our study, trainees were most likely to undertake a minimum of two years of research which is in keeping with UK guidelines that time spent out of training for research should normally be for a higher degree (the minimum time required for such qualifications is two years).[88] In contrast to the UK curriculum, USA training programmes have variable requirements for research with the Robertson *et al* study reporting 126 of 199 programmes requiring research time with these requirements varying in nature between full time, part time or a single research project.[138] A

USA study from a single university-based residency programme looked at the changing practice of residents undertaking research fellowships of minimum one-year duration. It reported a doubling of the proportion of trainees undertaking research from 9.8% between 1990- 1999 to 22.4% between 2000-2009.[139] The authors attributed this rise to the increased research fellowship opportunities available in the later time period. This study is of a single, large training programme and may not be representative of the USA, with the proportion of trainees undertaking a research fellowship reported to be comparatively greater at 36% in Robertson *et al*'s national survey of programme directors.[138]

A desire for an improved work-life balance may also explain the increasing propensity for taking time out of training.[152] A 2017 systematic review investigating the prevalence and causes of attrition in general surgical training reported an attrition rate of 18% with poor lifestyle as the most commonly reported reason for leaving.[153] Formal research was reported in a USA survey to be associated with attainment of speciality training fellowships following completion of residency, which was deemed important in attaining a specialty specific permanent post.[138] This outcome was desirable for an improved work life balance in a separate survey of General Surgery residents' views on career goals.[154] It is also possible that trainees view time out of training as an opportunity to temporarily improve quality of life. Lebares *et al* found a burnout prevalence of 69% in their survey of US General Surgery residents.[155] Scores for stress and anxiety were significantly lower in those residents undertaking lab research rather than those in clinical training. Therefore, it may be that a desire to take a break from clinical training for work-life balance reasons or perceived improved career prospects following research periods are contributing to trainees increasingly choosing to take time out.

#### 4.4.4 Conclusion

The findings of this study, with an increasing number of trainees taking time out of General Surgery specialty training, should be considered by programme directors who have responsibility for both delivering the local surgical workforce and meeting trainee needs. The tendency to taking time out of training and its subsequent increase in time in specialty training should be considered when redesigning curricula both in the UK and USA, where these trends have been identified, and also in other countries to ensure future workforce needs are met in a time of reducing surgical trainee numbers.[156-159]

# Chapter 5 The Procedure Based Assessment and its Correlation with Operative Experience

## Section 5.1 Background

The Procedure Based Assessment (PBA) is a workplace-based assessment for evaluating technical skill and is a key component of the programme of assessment in UK General Surgery training.[26](Section 1.1.3.1) The PBA was assessed by a Health Technology Assessment programme by Beard *et al* in 2011.[18] A focus of the Beard *et al* study was the evaluation of the reliability and validity of the PBA. The validity hypotheses tested are described in Section 1.1.3. In summary, the hypotheses centre around an association between both increasing operative experience and time in training with higher PBA global scores.

The authors reported that the PBA demonstrated good evidence for use as an assessment of technical skill. The Beard *et al* study was undertaken in a single training region across three hospitals with only 85 trainees undertaking assessments. The 85 trainees were from a mix of specialties (Cardiac Surgery, General Surgery, Orthopaedic Surgery, Vascular Surgery and Obstetrics and Gynaecology). The procedures judged were as diverse as diagnostic laparoscopy and coronary artery bypass grafting. However, despite the diversity of trainee specialties and procedures, all assessments were grouped together for the purposes of statistical analysis pertaining to assessment reliability and validity. This analysis, however, was the basis for the subsequent adoption of the PBA by surgical training programmes in the UK as both a formative and summative assessment tool with requirements for PBA outcomes defined in requirements for certification.[7](Section 1.4.4.5)

More recently, three UK studies have published analyses linking operative experience and PBA outcomes.[19, 20, 44] Each of these were of single training regions (Wales and Yorkshire/ Humber) with low numbers of trainees included, limiting the generalisability of conclusions drawn and the reliability of results presented. Only the study by De Siqueira *et al* presented a correlation analysis between operative experience and PBA outcomes in three index procedures (cholecystectomy, segmental colectomy and Hartmann's procedure).[19] The two studies from Wales focused on a median numbers of procedures undertaken prior to award of Level 4 PBA.

The understanding of the association between PBA outcome and operative experience is therefore limited to a study of heterogeneous trainees and specialties in a trial setting and two single regions with low numbers of trainees studied. It is presently not known how operative experience relates to assessment outcomes in a large population of surgical trainees with routinely collected, real-time data. It is not understood if and how this varies for separate index procedures within General Surgery, despite PBA outcomes being a key aspect of certification requirements. Furthermore, it is not known how the present expectations for operative experience at completion of training relate to attainment of the PBA outcomes.

### 5.1.1 Aims

The aim of this work was to assess the relationship between operative experience and the PBA. This study aimed to evaluate the construct validity of the PBA with reference to the association between PBA level awarded and operative experience, time in training and ST level. The final aim of this study was to calculate the number of operations undertaken prior to award of Level 4 PBA in UK General Surgery index procedures.

## Section 5.2 Methods

### 5.2.1 Data sources and management

This study used routinely collected data from the ISCP (Section 1.5.1), the JCST SIMS database (Section 1.5.2) and the eLogbook database (Section 1.5.3).

Data from all databases were extracted by the relevant data managers. The data was then linked using the unique identifier (GMC) number and anonymised by the ISCP data manager. All subsequent data management and analysis was performed using Stata 14 (Statacorp, Texas 77845 USA).

### 5.2.2 Study population

The cohort evaluation and set up for this study is described in Chapter 3. Any periods of training recorded as Out Of Programme (OOP) which do not count towards training (any OOP period other than OOPT) were excluded from the study period in accordance with the Gold Guide for Postgraduate Specialty Training.[88]

#### 5.2.2.1 Cohort selection

##### *5.2.2.1.1 Trainee selection*

Any trainees without complete stage of training data (stage specific start and end dates) were excluded. Trainees identified as completed training were analysed as a subset cohort representative of the outcomes of an entire training programme.

##### 5.2.2.1.2 Procedure selection

The UK General Surgery requirements for completion of training include three Level 4 PBAs in each of the 6 General Surgery index procedures.[7](Section 1.4.4.5.3) Procedures included under the umbrella term "Emergency Laparotomy" are diverse ranging from simpler procedures such as division of a band adhesion to repair of a ruptured Abdominal Aortic Aneurysm (Appendix 4: Index procedure algorithms). Emergency laparotomy was not included given the range of procedures represented and difficulty in drawing meaningful conclusions about numbers needed for competency attainment.

##### 5.2.2.1.3 Procedure Based Assessments

Trainees recording a minimum single PBA for any of the included index procedures were included in the cohort. Trainees who had not recorded a PBA in any of these index procedures were not included as it was assumed they were not engaged in the assessment process. Any PBAs undertaken in a simulated setting or assessed by non-Consultant assessors were excluded in keeping with the JCST requirements for certificate of completion of training.

The demographics for the total cohort were quantified using simple summary statistics.

### 5.2.3 Construct Validity assessment

Operative experience, ST level and total adjusted time in training (excluding OOP periods except OOPT) were calculated for the first PBA awarded at each level for each trainee. Correlation between operative experience and PBA level awarded was assessed using Spearman's rank co-efficient for each index procedure. Spearman's rank-order correlation was chosen given the ordinal nature of PBA level rather than treating this as a continuous variable. A positive relationship between increasing operative experience and PBA level was taken at values of 0.50 and over with significance at p-values of <0.05.

### 5.2.4 Operative Experience

The proportion of trainees awarded a first and third Level 4 PBA was calculated with the number of trainees who had ever recorded a PBA in that index procedure as the denominator for the whole cohort. This was to account for those trainees remaining in training who may not have had the opportunity to undertake index procedure specific assessments yet (for example, may not have undertaken an upper gastrointestinal post and therefore not been exposed to cholecystectomy yet).

The proportion of trainees awarded a first and third level 4 PBA was calculated with the total number trainees in the completed training cohort as the denominator. All trainees who had completed training should have had the opportunity to undertake all index procedure assessments.

Median operative experience at the point of each PBA undertaken was calculated. Operative experience was defined as total operations recorded as non-assisting supervision codes up to and including the date of the first and third level 4 PBA. Operative experience was calculated using the eLogbook algorithms for index procedures. (Appendix 4: Index procedure algorithms) Any operations recorded in the trainee's eLogbook undertaken outside of the study period or whilst the trainee was on an OOP period not contributing towards training were excluded.

# Section 5.3 Results

## 5.3.1 Cohort Demographics

### 5.3.1.1 Exclusions

There were 1354 trainees in the initial dataset (Section 3.3.6). A total of 76 trainees were excluded. Seventy trainees had missing stage of training dates and were excluded. Of the remaining 1284 trainees, 1278 had recorded a minimum single PBA in any of the studied index procedures. The number of trainees recording a minimum single PBA for each of the index procedures was 1247 for cholecystectomy, 1144 for segmental colectomy, 1208 for appendicectomy, 1234 for inguinal hernia repair and 890 for Hartmann's procedure. Demographics for the total cohort are shown in Table 17.

***Table 17 Demographics of the total cohort***

| | | | |
|---|---|---|---|
| Total in cohort, n | 1278 | | |
| Age* median (IQR) (Years) | 30.4 (28.9- 32.6) | | |
| Sex, n (%) | Male | Female | |
| | 865(67.7) | 413 (32.3) | |
| Status in training, n (%) | Completed Training | In Training | |
| | 311 (24.3) | 967 (75.7) | |
| Number of OOP periods, n (%) | 0 | 1 | 2+ |
| | 604 (47.3) | 493 (38.6) | 181(14.2) |
| Number of OOPR periods, n (%) | None | One or more | |
| | 917 (71.8) | 361 (28.2) | |
| Number of trainees undertaking an index procedure PBA, n(%) | | | |
| Cholecystectomy | 1247 (97.6) | | |
| Segmental colectomy | 1144 (89.5) | | |
| Inguinal hernia repair | 1234 (96.6) | | |
| Appendicectomy | 1208 (94.5) | | |
| Hartmann's procedure | 890 (69.6) | | |

***IQR= inter-quartile range. n = number. OOP= Out of programme. OOPR= Out of programme research.***
****missing data in 44 trainees, age at start of training.***

### 5.3.2 Construct Validity

#### 5.3.2.1 Whole cohort

A total of 16542 PBAs undertaken by 1278 trainees were included in the study. The mean number of PBAs completed per trainee was 12.9. The total number of PBAs recorded for each index procedure ranged from 1935 assessments in Hartmann’s procedure to 4122 assessments in cholecystectomy.

The median number of procedures undertaken at award of each PBA level is shown in Table 18.

*Table 18 Number of trainees awarded a PBA at each level and the median number of operations undertaken*

| | Cholecystectomy (Total PBAs = 4122) | | Segmental colectomy (Total PBAs = 3044) | | Appendicectomy (Total PBAs = 3604) | | Inguinal hernia repair (Total PBAs = 3837) | | Hartmann's procedure (Total PBAs = 1935) | |
|---|---|---|---|---|---|---|---|---|---|---|
| PBA level | Trainees, n(%)^ | Median operations, n(IQR) | Trainees, n(%)^ | Median operations, n(IQR) | Trainees, n(%)^ | Median operations, n(IQR) | Trainees, n(%)^ | Median operations, n(IQR) | Trainees, n(%)^ | Median operations, n(IQR) |
| 1 | 33 (0.8) | 9 (2-16) | 9 (0.3) | 9 (4-34) | 4 (0.1) | 7 (4-13) | 20 (0.5) | 10 (4-22) | 6 (0.3) | 1 (1- 2) |
| 2 | 906 (21.9) | 7 (3- 16) | 826 (27.1) | 6 (2- 11) | 263 (7.3) | 10 (5- 24) | 508 (13.2) | 9 (3- 25) | 354 (18.3) | 2 (1- 4) |
| 3 | 1163 (28.2) | 16 (7- 29) | 897 (29.5) | 11 (6-19) | 759 (21.1) | 15 (7- 34) | 953 (24.8) | 13 (5- 25) | 574 (29.7) | 4 (3- 7) |
| 1st 4 | 835 (20.3) | 47 (28- 70) | 584 (19.2) | 27 (17- 40) | 1077 (29.9) | 32 (16- 58) | 1010 (26.3) | 28 (14- 45) | 504 (26.0) | 8 (5- 11) |
| 2nd 4 | 657 (15.0) | 63 (42- 87) | 426 (14.0) | 35 (24- 52) | 870 (24.1) | 55 (31- 82) | 779 (20.3) | 40 (25- 61) | 309 (16.0) | 10 (8- 13) |
| 3rd 4 | 531 (12.9) | 72 (48- 99) | 302 (9.9) | 43 (29- 61) | 631 (17.5) | 69 (42- 98) | 567 (14.8) | 48 (32- 71) | 188 (9.7) | 12 (9- 16) |

***PBA= procedure based assessment. IQR= Inter quartile range. ^= percentage of the total PBAs undertaken for each index procedure.***

A positive correlation was found between increasing operative experience and increasing PBA level achieved. Strength of association varied by index procedure and exposure variable. Strength of association between operative experience and PBA level was greater in the more complex procedures (segmental colectomy and cholecystectomy, $r = 0.70$, $p < 0.0001$) than in the simpler procedures (appendicectomy and inguinal hernia repair, $r = 0.55$ and $r = 0.52$ respectively, $p < 0.0001$). Strength of association between ST level and PBA level varied from $r = 0.51$ for appendicectomy and inguinal hernia repair to $r = 0.60$ for Hartmann's procedure ($p < 0.0001$). (Table 19)

***Table 19 Construct validity in the whole cohort: correlation coefficients for association between PBA level achieved and operative experience, ST level and time in specialty training using the first time each PBA level was achieved***

| Index procedure | Number of trainees in analysis | Number of PBAs in analysis | Correlation co-efficient for association between exposure variable and PBA level | | |
|---|---|---|---|---|---|
| | | | Number of procedures | ST level | Time in training |
| Colectomy | 1144 | 3044 | 0.70* | 0.68* | 0.65* |
| Cholecystectomy | 1247 | 4122 | 0.70* | 0.66* | 0.63* |
| Hartmann's procedure | 890 | 1935 | 0.65* | 0.69* | 0.64* |
| Inguinal hernia repair | 1234 | 3837 | 0.52* | 0.51* | 0.50* |
| Appendicectomy | 1208 | 3604 | 0.55* | 0.51* | 0.51* |
| All index procedures together | 1278 | 16542 | 0.62* | 0.53* | 0.51* |
| Beard *et al* study^ | 85 | 749 | 0.50 | 0.71 | 0.56 |

***p<0.0001 ^ all procedures pooled for construct validity analysis. PBA= procedure based assessment.***

#### 5.3.2.2 Completed Training cohort

There were 311 trainees who had completed training. Those who had completed training had undertaken a total of 4636 PBAs with a mean 14.1 assessments per trainee. The number of index procedure specific assessments undertaken ranged from 731 PBAs for Hartmann's procedure to 1191 PBAs for cholecystectomy. The number of trainees awarded a PBA at each level and the median procedures undertaken at that level is shown in Table 20.

***Table 20 Number of trainees in completed training cohort undertaking index procedure PBAs at each level of PBA awarded and median operations undertaken.***

| | Cholecystectomy (Total PBAs =1191) | | Segmental colectomy (Total PBAs =1107) | | Appendicectomy (Total PBAs =758) | | Inguinal hernia repair (Total PBAs =949) | | Hartmann's procedure (Total PBAs =731) | |
|---|---|---|---|---|---|---|---|---|---|---|
| PBA level | Trainees, n(%)^ | Median operations, n(IQR) | Trainees, n(%)^ | Median operations, n(IQR) | Trainees, n(%)^ | Median operations, n(IQR) | Trainees, n(%)^ | Median operations, n(IQR) | Trainees, n(%)^ | Median operations, n(IQR) |
| 1 | 6 (0.5) | 17 (12-91) | 3 (0.3) | 9 (1-67) | - | - | 2 (0.2) | 38 (21-54) | 1 (0.1) | 2(-) |
| 2 | 163 (13.7) | 16 (7-37) | 161 (16.0) | 12 (6-17) | 27 (3.6) | 25 (9- 34) | 86 (9.1) | 35 (17-53) | 58 (7.9) | 4 (2-6) |
| 3 | 290 (24.3) | 25 (13- 43) | 256 (25.4) | 17 (10-25) | 104 (13.7) | 32 (14- 60) | 186 (19.6) | 26 (12- 47) | 167 (22.8) | 5 (3-8) |
| 1st 4 | 284 (23.8) | 60 (38- 83) | 247 (24.5) | 32 (19- 44) | 266 (35.1) | 53 (27- 86) | 278 (29.3) | 38 (21- 60) | 240 (32.8) | 8 (5- 12) |
| 2nd 4 | 240 (20.2) | 77 (53- 101) | 195 (19.4) | 44 (28- 62) | 218 (28.8) | 83 (56- 119) | 227 (23.9) | 55 (36- 84) | 162 (22.2) | 10 (8- 14) |
| 3rd 4 | 208 (17.5) | 89 (65- 115) | 145 (14.4) | 52 (31- 74) | 143 (18.9) | 101 (75- 131) | 170 (17.9) | 65 (47- 90) | 103 (14.1) | 13 (10-17) |

***PBA = Procedure based assessment. IQR= Inter quartile range. ^= percentage of the total PBAs undertaken for each index procedure.***

A positive correlation was found between increasing operative experience and increasing PBA level. The association was greatest for colectomy and cholecystectomy ($r = 0.62$, $p < 0.001$) but a weaker association observed in inguinal hernia repair (0.40, $p < 0.001$). Strength of association between ST level or time in training and PBA levels awarded varied by index procedure and was $r=0.52$ and $r=0.50$ respectively when all procedures were grouped together ($p<0.001$). (Table 21)

***Table 21 Construct validity in the Completed Training cohort: correlation coefficients for association between PBA level achieved and operative experience, ST level and time in specialty training using the first time each PBA level was achieved.***

| Index procedure | Number of trainees in analysis | Number of PBAs in analysis | Correlation co-efficient for association between exposure variable and PBA level | | |
|---|---|---|---|---|---|
| | | | Number of procedures | ST level | Time in training |
| Colectomy | 296 | 1007 | 0.62* | 0.65* | 0.64* |
| Cholecystectomy | 309 | 1191 | 0.62* | 0.60* | 0.61* |
| Inguinal hernia repair | 299 | 949 | 0.40* | 0.43* | 0.43* |
| Appendicectomy | 274 | 758 | 0.51* | 0.50* | 0.50* |
| Hartmann’s | 272 | 731 | 0.54* | 0.60* | 0.58* |
| All index procedures together | 311 | 4636 | 0.59* | 0.52* | 0.50* |
| Beard *et al* study^ | 85 | 749 | 0.50 | 0.71 | 0.56 |

***p<0.0001 ^ all procedures pooled for construct validity analysis. PBA= procedure based assessment.***

### 5.3.3 Operative experience at award of Level 4 PBA

#### 5.3.3.1 Whole cohort

Of those trainees who had completed a PBA in segmental colectomy, 51% (n= 584) had been awarded a Level 4 PBA. The median number of operations at award of first Level 4 PBA was 27 (IQR 17- 40). Of those trainees who had completed a PBA in appendicectomy, 89.2% (n= 1077) had been awarded a Level 4 PBA. The median number of appendicectomies at award of first Level 4 PBA was 32 (IQR 16-58). (Table 22)

The proportion of trainees who had been awarded three Level 4 PBAs was 26.4% (n=302) for segmental colectomy, 9.7% (n= 188) for Hartmann's, 42.6% (n= 531) for cholecystectomy, 45.9% (n=567) for inguinal hernia repair and 52.2% (n=631) for appendicectomy. The median number of procedures undertaken at award of third Level 4 PBA was 69 (IQR 42- 98) for appendicectomy, 48 (IQR 32- 71) for inguinal hernia repair, 72 (IQR 48-99) for cholecystectomy and 43 (IQR 29- 61) for segmental colectomy. (Table 22)

***Table 22 Number of trainees awarded a Level 4 PBA and median number of procedures undertaken by award of first and third Level 4 PBA in the whole cohort studied (n= 1278).***

| Whole cohort, n=1278 | | | | |
|---|---|---|---|---|
| | One Level 4 PBA | | Three Level 4 PBAs | |
| | Number of trainees, n (%)^ | Median operations to 1$^{st}$ L4 PBA, n (IQR) | Number of trainees, n(%)^ | Median operations to 3$^{rd}$ L4 PBA, n (IQR) |
| Cholecystectomy, n=1247 | 835 (67.0) | 47 (28- 70) | 531 (42.6) | 72 (48- 99) |
| Segmental colectomy, n=1144 | 584 (51.0) | 27 (17- 40) | 302 (26.4) | 43 (29- 61) |
| Appendicectomy, n=1208 | 1077 (89.2) | 32 (16- 58) | 631 (52.2) | 69 (42- 98) |
| Inguinal hernia repair, n=1234 | 1010 (81.8) | 28 (14- 45) | 567 (45.9) | 48 (32- 71) |
| Hartmann's, n=890 | 504 (56.6) | 8 (5- 11) | 188 (21.1) | 12 (9- 16) |

***^= % of the number of trainees recording a single PBA at any level in that index procedure. PBA= procedure based assessment. L4= Level 4***

The proportion of those who had achieved a Level 4 PBA at different operative experience increments is shown in Table 23. The proportion of those who had achieved the UK indicative operative experience requirements by the first Level 4 was 34.2% (n=200) for colectomy, 87.7% (n=886) for inguinal hernia repair, 54.6% (n=456) for cholecystectomy and 87.4% (n=941) for appendicectomy.

*__Table 23 Proportion of trainees (whole cohort) awarded first Level 4 PBA at increasing operative experience__*

| | 1x Level 4 PBA obtained, n (%) | | | | |
|---|---|---|---|---|---|
| Number of operations | Cholecystectomy | Segmental colectomy | Appendicectomy | Inguinal hernia repair | Hartmann's |
| <10 | 37 (4.4) | 66 (11.3) | 171 (15.9) | 180 (17.8) | 366 (72.6) |
| <20 | 114 (13.7) | 200 (34.2) | 362 (33.6) | 377 (37.3) | 493 (97.8) |
| <30 | 224 (26.8) | 345 (59.1) | 515 (47.8) | 557 (55.2) | 504 (100.0) |
| <40 | 344 (41.2) | 443 (75.9) | 658 (61.1) | 714 (70.7) | |
| <50 | 456 (54.6) | 514 (88.0) | 745 (69.2) | 817 (80.9) | |
| <60 | 546 (65.4) | 553 (94.7) | 832 (77.3) | 886 (87.7) | |
| <70 | 628 (75.2) | 567 (97.1) | 893 (82.9) | 938 (92.9) | |
| <80 | 684 (81.9) | 574 (98.3) | 941 (87.4) | 963 (95.4) | |
| <90 | 741 (88.7) | 578 (99.0) | 976 (90.6) | 983 (97.3) | |
| <100 | 769 (92.1) | 580 (99.3) | 997 (92.6) | 991 (98.1) | |
| <110 | 794 (95.1) | 582 (99.7) | 1024 (95.1) | 996 (98.6) | |
| <120 | 808 (96.8) | 583 (99.8) | 1040 (96.6) | 1002 (99.2) | |
| <130 | 814 (97.5) | 583 (99.8) | 1045 (97.0) | 1006 (99.6) | |
| <140 | 821 (98.3) | 583 (99.8) | 1052 (97.7) | 1008 (99.8) | |
| <250 | 835 (100.0) | 584 (100.0) | 1077 (100.0) | 1010 (100.0) | |

*__PBA= Procedure based assessment__*

#### 5.3.3.2 Completed training only cohort

There were 311 trainees who had completed training. The proportion of trainees awarded one Level 4 PBA ranged from 77.2% (n=240) for Hartmann's procedure to 91.3% (n=284) for cholecystectomy. The median number of operations undertaken by award of first Level 4 PBA was 60 (IQR 38-83) for cholecystectomy, 32 (IQR 19- 44) for segmental colectomy and 53 (IQR 27- 86) for appendicectomy. (Table 24)

The proportion of trainees who had been awarded three Level 4 PBAs in the completed training cohort varied from 33.1% (n= 103) for Hartmann's procedure to 66.9% (n= 208) for cholecystectomy. The median number of operations undertaken by award of third Level 4 PBA was 89 (IQR 65 115) for cholecystectomy, 52 (IQR 31-74) for segmental colectomy and 101 (IQR 75-131) for appendicectomy. (Table 24)

***Table 24 Number of trainees awarded a Level 4 PBA and median number of procedures undertaken by award of first and third Level 4 PBA in the completed training cohort (n=311)***

| Completed Training Cohort, n=311 | | | | |
|---|---|---|---|---|
| Index procedure | One Level 4 PBA | | Three Level 4 PBAs | |
| | Number of trainees, n(%)^ | Median operations to 1st L4 PBA, n (IQR) | Number of trainees, n(%)^ | Median operations to 3rd L4 PBA, n (IQR) |
| Cholecystectomy | 284 (91.3) | 60 (38- 83) | 208 (66.9) | 89 (65-115) |
| Segmental colectomy | 248 (79.7) | 32 (19- 44) | 145 (46.6) | 52 (31- 74) |
| Appendicectomy | 266 (85.5) | 53 (27- 86) | 143 (46.0) | 101 (75- 131) |
| Inguinal hernia repair | 279 (89.7) | 38 (21- 60) | 170 (54.7) | 65 (47- 90) |
| Hartmann’s procedure | 240 (77.2) | 8 (5- 12) | 103 (33.1) | 13 (10- 17) |

***^= % of the number of trainees recording a single PBA at any level in that index procedure. PBA= procedure based assessment. L4= Level 4***

The proportion of Completed Training trainees who had been awarded a Level 4 PBA at different increments of operative experience is shown in Table 25. The proportion of Completed Training trainees who had met the indicative requirements for operative experience by award of one Level 4 PBA was 40.1% (n=114) for cholecystectomy, 27.1% (n=67) for segmental colectomy, 70.7% (n=188) for appendicectomy and 75.2% (n= 209) for inguinal hernia repair.

***Table 25 Number of procedures undertaken by award of first Level 4 PBA in completed training cohort***

| | 1x Level 4 PBA obtained, n (%) | | | | |
|---|---|---|---|---|---|
| Number of operations | Cholecystectomy | Segmental colectomy | Appendicectomy | Inguinal hernia repair | Hartmann's |
| <10 | 7 (2.5) | 17 (6.9) | 16 (6.0) | 26 (9.4) | 159 (66.3) |
| <20 | 22 (7.8) | 67 (27.1) | 46 (17.3) | 66 (24.5) | 230 (95.8) |
| <30 | 52 (18.3) | 118 (47.8) | 77 (29.0) | 105 (37.8) | 240 (100.0) |
| <40 | 81 (28.5) | 167 (67.6) | 106 (39.9) | 151 (54.3) | |
| <50 | 114 (40.1) | 202 (81.8) | 125 (47.0) | 180 (64.8) | |
| <60 | 143 (50.4) | 226 (91.5) | 154 (57.9) | 209 (75.2) | |
| <70 | 180 (63.4) | 233 (94.3) | 169 (63.5) | 237 (85.3) | |
| <80 | 205 (72.2) | 238 (96.4) | 188 (70.7) | 245 (88.1) | |
| <90 | 230 (81.0) | 242 (98.0) | 210 (79.0) | 258 (92.8) | |
| <100 | 245 (86.3) | 244 (98.8) | 218 (82.0) | 263 (94.6) | |
| <110 | 257 (90.5) | 245 (99.2) | 229 (86.1) | 268 (96.4) | |
| <120 | 264 (93.0) | 246 (99.6) | 238 (89.5) | 273 (98.2) | |
| <130 | 270 (94.4) | 246 (99.6) | 241 (90.6) | 275 (98.9) | |
| <140 | 275 (96.1) | 246 (99.6) | 247 (92.9) | 277 (99.6) | |
| <250+ | 284 (100.0) | 247 (100.0) | 266 (100.0) | 278 (100.0) | |

***PBA= Procedure based assessment***

## Section 5.4 Discussion

### 5.4.1 Main findings

This study has used national, routinely collected surgical training data to assess the relationship between operative experience and competency assessment outcomes (PBA Level 4). Construct validity of the PBA has been assessed with respect to operative experience, time in training and ST level and this study has demonstrated difference between General Surgery index procedures. This study has also evaluated the proportion of trainees who met current UK indicative operative experience requirements at the point of competency (defined by PBA). There is disparity between expected operative experience and competency acquisition with the median operations undertaken at award of Level 4 PBA lower than the current indicative requirement for appendicectomy and inguinal hernia. However, the median operations undertaken at award of Level 4 PBA in segmental colectomy was higher than the current UK requirements and equivocal for cholecystectomy.

### 5.4.2 Strengths and limitations

A limitation of this study is the use of surgical training repository databases for analysis. These data sources are not designed for epidemiological study and have inherent error within them. Careful data management has mitigated potential error as far as possible with analysis and correction of start dates and exclusion of trainees with incomplete data. This study is the largest to date using UK surgical training data and is strengthened by the use of an entire national cohort of trainees, mitigating against regional biases present in previous smaller studies.[19, 20, 44]

The use of a large population has enabled subset analysis of those trainees who had completed training. Analysis of the Completed Training cohort provides insight into the experiences of those who have completed an entire training programme. Conclusions about competency acquisition in this cohort are limited by the introduction of certification guidelines in 2013. Many of the trainees in the Completed Training cohort would not have been subject to these requirements, which were introduced flexibly for trainees who were nearing completion of training in 2013. Therefore, it is understandable that relatively low proportions of Completed Training trainees were awarded three Level 4 PBAs in the different index procedures (33.1% Hartmann's procedure, 66.9% Cholecystectomy, Table 24). The proportions of those achieving competency in the In Training cohort is biased by the understanding that trainees may yet go on to achieve competency and this is not accounted for within this study.

Procedure- based assessments are not completed on every occasion that a trainee undertakes an index procedure. Rather, the timing of index procedure assessments is dependent on caseload, access to trainers in theatre and is influenced by trainees engaging in the assessment process. Therefore, inferences of operative experience required for competency are limited when calculating operative experience at the point of award of Level 4 PBA. Furthermore, operative experience and assessments prior to specialty training are unaccounted within this study. It is likely that some trainees may have operative experience and undertaken PBAs in simpler procedures such as appendicectomy and inguinal hernia repair prior to specialty training, biasing the results for operative experience required for competency. Operative experience acquired during periods of Out of Programme for Experience and Out of Programme for Research have been excluded in keeping with legislation that all training required for certification is delivered in prospectively approved training programmes.[88] In order to compare outcomes in specialty training with current requirements, it was necessary to consider the same time periods as defined in the current UK curricula. However, procedures undertaken prior to specialty training and during OOP time inevitably contribute to the acquisition of competency. Thus the exclusion of these procedures limits the interpretation of the number of procedures required for competency as judged by Level 4 PBA with a likely underestimate of procedural numbers in these results.

The possibility of assessor bias may also limit the conclusions that can be drawn from this data. It is possible that a trainer assessing a Year One trainee may be hesitant to award Level 4 competency as it seems incongruous to the stage of training. Conversely, it may be more likely for a trainer to award Level 4 competency to a more senior trainee as they deem them to be experienced. Criterion referenced assessments (such as the PBA) are less prone to such issues but potential for assessor bias remains.

The current indicative experience requirements are based on the 25th centile of a small, selected cohort of trainees completing training in 2010/11 and are unrelated to any measure of competency. Whilst the results presented in this study are limited, this study provides some evidence for the operative experience thresholds for required competency, which appear to differ from current indicative experience requirements.

### 5.4.3 Other literature

Unlike the Beard *et al* study, this work has been able to evaluate index procedures individually and in doing so, has demonstrated difference between index procedure assessments.[18] The correlation co-efficients reported in this study for the association between number of procedures and PBA level attained are equivalent or greater than that reported by Beard *et al*.[18] The weakest association was seen with inguinal hernia repair and appendicectomy (r= 0.52 and 0.55 respectively, Table 19). This may reflect differences in the way competency is achieved in simpler procedures and the influence of operative experience prior to specialty training. Beard *et al* reported a correlation co-efficient of r= 0.71 when evaluating the association between ST level and PBA level. This is equivalent to the values in this study reported for segmental colectomy and cholecystectomy (r= 0.67 and r= 0.68 respectively). However, when evaluating the association between ST level and PBA outcome for inguinal hernia repair and appendicectomy, the strength of association was weaker (r= 0.53 and r= 0.51 respectively). This seems to add further evidence that PBA level outcomes are less valid as a reflection of competency in simpler procedures.

Given that PBAs are not undertaken at every operation, it may be that trainees are becoming competent prior to actually undertaking assessments and being awarded a Level 4 PBA. This could be explained by trainees undertaking these simple procedures unsupervised and therefore unable to complete a relevant assessment. Assessing data relating to trainee operative autonomy could provide evidence to support this hypothesis.

An alternative explanation is the “tick box” mentality that has been described in the use of workplace-based assessment tools.[27, 160-162] Shalhoub *et al* undertook a qualitative study of surgical trainee’s views on the use of PBAs within surgical training in 2017.[162] All 10 trainees interviewed described requirements for minimum numbers of assessments in surgical curricula driving a tick-box attitude which devalued their educational experience. If trainee’s attitudes toward completing PBAs are of a necessity to meet required certification standards, then it is less likely that PBA levels attained reflect the learning process with the number of operations at point of Level 4 PBA equating to experience thresholds for competency.

Phillips *et al* reported that surgical trainers felt PBA was the most beneficial WBA in a 2015 survey on the utility of WBAs within surgical training.[160] Shalhoub *et al* reported, in an analysis of the utilisation of WBA in national surgical training, that PBA was the most commonly used WBA in specialty training.[163] A survey of orthopaedic specialty trainees by Hunter *et al* in 2015 reported that trainees felt the PBA was a useful tool for learning but that this was strongly influenced by the enthusiasm of the trainer completing the assessment. Shalhoub *et al*'s qualitative PBA study reported similar themes with trainees suggesting that the assessments were more valuable as formative tools when trainers were fully engaged in the assessment process. The authors also reported that more than half of those interviewed described the ability to document progression through the use of PBA as a positive aspect.[162] The collective themes from these studies suggest that the PBA is valued as an educational and assessment tool within surgical training.

De Siqueria *et al* assessed operative experience and award of PBA outcomes.[19] The authors reported that trainees (n=8) undertook a mean 90 cholecystectomies and a mean 55 colectomies prior to award of three Level 4 PBAs. Brown *et al* also calculated the number of procedures undertaken at award of three Level 4 PBAs and reported a median of 87 procedures for cholecystectomy (total trainees, n= 30) and 45 procedures for segmental colectomy (total trainees, n=13).[44] Both studies included trainees who were in training as well as those who had completed training but are still limited by the very small numbers of trainees awarded three Level 4 PBAs.

When assessing the Completed Training cohort in this study (n=311), the proportion of trainees awarded three Level 4 PBAs varied from 46% (n=143) for appendicectomy to 66.9% (n=208) for cholecystectomy. This may be in part due to the timing of the introduction of standards. However, it is apparent that these trainees were all judged to be competent (as they were all recommended for Certificate of Completion of Training), in the absence of this "gold standard" for judging competency. A greater proportion of the In-

Training cohort had been awarded one Level 4 PBA, ranging from 77.2% (n=240) for Hartmann's procedure to 91.3% (n= 284) for cholecystectomy.

Similarly to the studies of De Siqueira *et al* and Brown *et al*, median number of procedures undertaken by award of one Level 4 PBA did not equate to the current UK indicative requirements. This study found that trainees undertook fewer appendicectomies and inguinal hernia repairs but more cholecystectomies and segmental colectomies than is required by the award of Level 4 PBA. (Table 22 and Table 24). In the whole cohort, the median number of segmental colectomies by award of first and third Level 4 PBA was 27 (IQR 17-40) and 43 (IQR 29-61) respectively with the current indicative number equalling 20 procedures. The current indicative number for appendicectomy is 80. By contrast, the median number of procedures undertaken by award of first and third Level 4 PBA was 32 (IQR 16-58) and 69 (IQR 42-98) respectively. The current indicative number of cholecystectomies is 50. The median number to first and third Level 4 PBA is 48 (IQR 28-70) and 72 (48-99) respectively. Therefore, there are two alternative ways of evaluating trainee operative experience and PBA outcomes in comparison to current indicative numbers; either by proportion of trainees achieving the competency requirements by the current indicative numbers or by the median number of procedures undertaken by award of competency. Neither approach demonstrate that current UK indicative number requirements equate to achievement of competency, as defined by the curriculum.

### 5.4.4 Conclusions

This study suggests that trainees are unlikely to have achieved competency at current experience requirements with only 34.2% and 65.4% of trainees awarded a first Level 4 PBA in segmental colectomy and cholecystectomy respectively at current indicative numbers (Table 23). However, the use of PBA in determining competency of trainees may be limited as it is not recorded at every operative procedure and correlation between experience and PBA outcomes varies by index procedure, suggesting difference in competency attainment. Evaluating other evidence, such as trainee autonomy, may provide further understanding of procedural competency in general surgical training.

# Chapter 6 Changing autonomy in operative experience through UK General Surgery training

## Section 6.1 Background

Decreasing operative experience during surgical training is a contentious issue internationally.[105, 108, 164-168] The systematic review described in Chapter 2 demonstrated wide variation in the operative experiences of General Surgery trainees worldwide. However, it has been recognised that simply undertaking a minimum number of procedures does not necessarily confer competency.[19, 137, 169]

The way in which competency is assessed around the world is changing with the uptake of the Entrustment concept. This is described in Section 1.2.1. In line with this model of entrustment, it could be reasonable to infer that a trainee who is trusted to perform a procedure independently (whether in an ad hoc or more formal decision making process) has been deemed competent, by their trainer.

Whilst data recorded relating to operative experience in surgical training has previously been reported, it has only been used to provide evidence solely related to attainment of procedural numbers.[97, 105, 108] Increasing trainee procedural competency is likely to be directly related to trainees being trusted to perform procedures with decreasing supervision. However, this has not been shown empirically. It may be possible to use existing, routinely collected operative experience data to observe and quantify this relationship. Assessing the types of procedures undertaken over time may also add evidence that a trainee is progressing to more complex operating. Assessment of operative experience data, with analysis of trainee progression through the supervision scale, alongside formal competency assessments for procedures, could demonstrate evidence of increasing trainer entrustment and the ability of a trainee to work with increasing autonomy performing more complex procedures.

### 6.1.1 Aims

The aim of this study was to determine how many operations (both in total and for General Surgery index procedures (IP), see Section 1.4.4.5.2) trainees undertake in General Surgery training and how the supervision of these changes over the course of training. A secondary aim was to assess whether routinely collected surgical training data from the UK could be used to provide additional evidence for the competency progression of an entire cohort of trainees with a reflection of entrustment decisions through the course of a training scheme.

## Section 6.2 Methods

### 6.2.1 Data sources

This study used routinely collected data from the ISCP (Section 1.5.1) and the JCST SIMS database (Section 1.5.2) the JCIE database (Section 1.5.4) and the eLogbook database (Section 1.5.3).

Data from all databases were extracted by the relevant data managers. The data was then linked using the unique identifier (GMC) number and anonymised by the ISCP data manager. All subsequent data management and analysis was performed using Stata 14 (Statacorp, Texas 77845 USA).

### 6.2.2 Study population and timeline

The cohort for this study was the Completed Training cohort described in Section 3.3.6. Trainees from the In Training cohort were excluded.

Trainees who did not have complete stage of training dates (start and end date for each level of training) were excluded. Any periods of training recorded as OOP which do not count towards training (any OOP period other than OOPT) were excluded from the study period in accordance with the Gold Guide for Postgraduate Specialty Training.[88]

The special interests of endocrine, General Surgery and transplant were combined to prevent reporting of five or fewer trainees. Oesophago-gastric (OG) interest and hepatopancreaticobiliary (HPB) special interests were combined with those declaring Upper Gastrointestinal (UGI) surgery and reported as a single group of UGI special interest trainees.

### 6.2.3 Operative experience analysis

Any procedures recorded in the eLogbook which do not count towards total operative numbers required for completion of training in the JCST guidance were excluded from the study (e.g. flexible sigmoidoscopy).[7]

Supervision levels were coded to reflect the supervision levels described by JCST (Assisting (A); Supervised, Trainer Scrubbed (STS); Supervised, Trainer Unscrubbed (STU); Performed (P); Training a more junior trainee (T)).[63] (Section 1.4.4.5.2) Any procedures coded as observed were excluded. Procedures coded as "Teaching a more junior trainee" were included under the supervision level "Performed" for the purposes of counting procedures undertaken unsupervised. Any operations recorded in the trainee's eLogbook undertaken outside of the study period or whilst the trainee was on an OOP period not contributing towards training were excluded. Any procedures recorded as undertaken in the private sector were excluded.

#### 6.2.3.1 Total operative experience

Total operative experience was calculated for each trainee, including procedures recorded as assisting.[7]

#### 6.2.3.2 Index procedure experience

Index procedure experience was calculated in accordance with the algorithms used to calculate IP summary data for the purposes of ARCP. Variation in number and type of IP undertaken by gender, region and stage of training were assessed. Variation in supervision level recorded by stage of training for each IP was assessed.

### 6.2.4 Procedural Competency Assessment outcomes

Trainee PBA outcomes were assessed and the trainee's stage of training was determined corresponding to the date of their first recorded Level 4 PBA. The proportion of trainees awarded their first Level 4 PBA was calculated for each stage of training. It was not possible to include Emergency Laparotomy due to the heterogeneity of procedures included within this umbrella term.

### 6.2.5 Analysis

Basic demographics were calculated for the included trainees and quantified using summary statistics. Variation by gender, region, special interest and supervision level were assessed using simple summary statistics and appropriate parametric and non-parametric tests (T-test and Chi-Squared). Kruskal-Wallis test was used to test for variance in index procedures between special interests (non-normally distributed data). Statistical significance was taken at $p<0.05$.

## Section 6.3 Results

### 6.3.1 Cohort demographics

Of the trainees in the dataset, 360 trainees had completed training. A further 49 trainees were excluded from the analysis as they did not have complete stage of training dates leaving a total of 311 trainees included in the study.

Of the 311 trainees included in the study, 243 trainees (78.1%) were male and 68 trainees (21.9%) were female. The median age at start of training was 30.7 years (IQR 29.3-32.9 years). The total time in training (excluding OOP periods not counted towards training) was a median 6.0 years (IQR 6.0- 6.5 years). Colorectal surgery was the most commonly declared special interest (40.5% of the cohort, n= 126). (Table 26)

*Table 26 Demographics of study cohort (n=311)*

| Demographics of included trainees (n=311) | | |
|---|---|---|
| Age at start of training, median (IQR) | | 30.7 (29.3-32.9) |
| Gender n (%) | Males | 243 (78.1) |
| | Females | 68 (21.9) |
| Time in Training (adjusted) median years (IQR) | | 6.0 (6.0-6.5) |
| Special interest n (%) | Colorectal | 126 (40.5) |
| | Upper Gastrointestinal | 76 (24.4) |
| | Breast | 45 (14.5) |
| | Vascular | 43 (13.8) |
| | General/ Transplant/ Endocrine | 21 (6.8) |

### 6.3.2 Total operative experience

The mean total operative experience for the cohort was 2060 (standard deviation (SD) = 535) procedures at completion of training. There was no significant difference in the mean total operations undertaken between genders (p= 0.29). Of the total operations recorded per trainee, a mean 493 (SD 212) operations were recorded as Assisted, 602 (SD182) as Supervised, Trainer Scrubbed, 198 (SD 153) as Supervised, Trainer Unscrubbed and 768 (SD 282) as Performed or Training a more junior trainee. There was no significant difference observed between genders in the total numbers of operations recorded at each supervision level.

Variation in total operative experience between special interest groups was seen with a range of means between 1865 (SD 619) procedures in the vascular trainee group and 2143 (SD 545) procedures in the colorectal trainee group (p=0.035).

### 6.3.3 Index procedure experience

Trainees completing training had undertaken a mean of 148 appendicectomies (SD 56), 117 inguinal hernia repairs (SD 44), 175 cholecystectomies (SD 90), 82 segmental colectomies (SD 48), 14 Hartmann's procedures (SD 8) and 114 emergency laparotomies (SD 42).

Wide variation was found between special interest groups for all index procedures undertaken (p <0.0001 across all index procedures). (Figure 11)

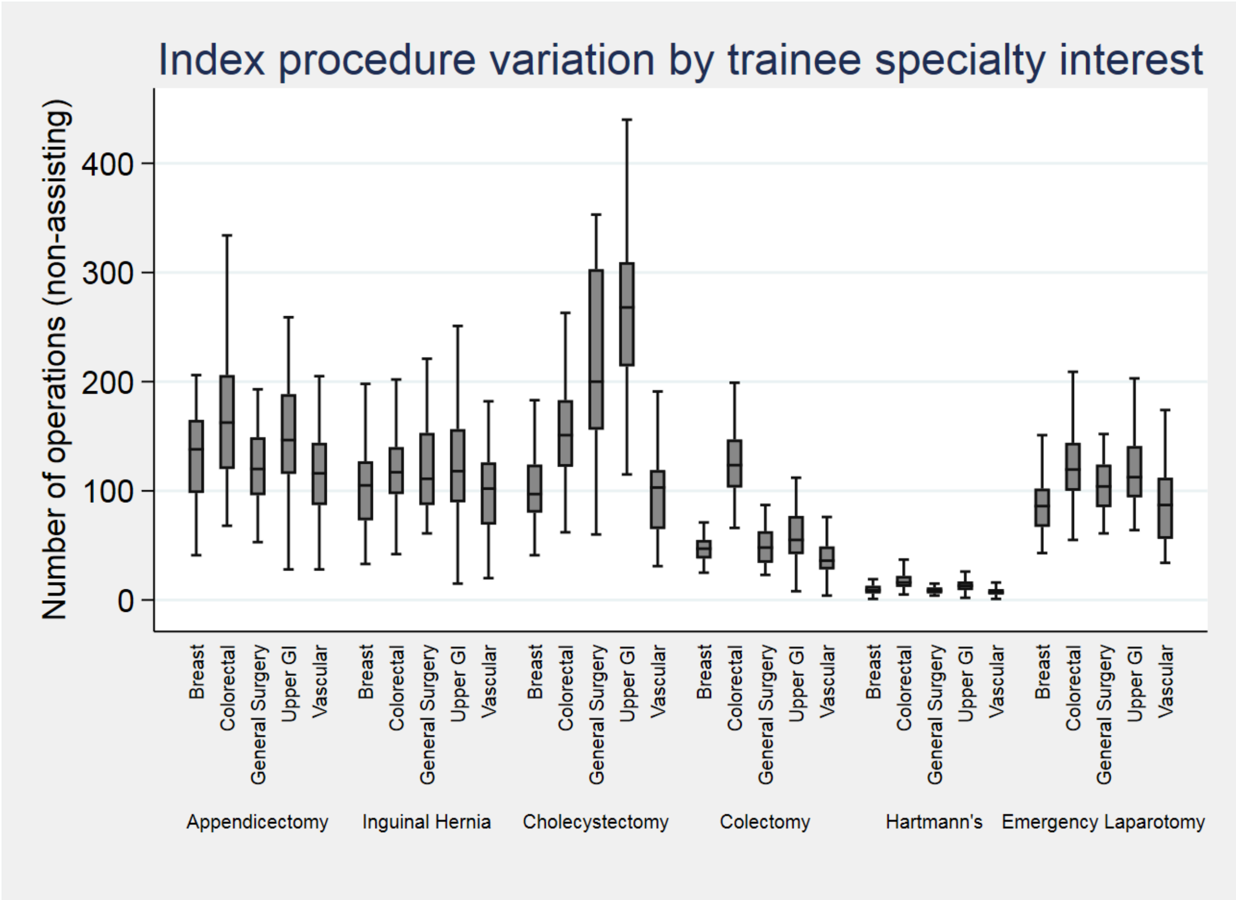



*Figure 11 Variation in the mean number of non-assisting index procedures at completion of training by special interest*

Analysis of variance showed that the association between special interest and number of segmental colectomies undertaken was statistically significant with colorectal trainees undertaking a median 124 segmental colectomies (IQR 103-147) compared with a median 36 segmental colectomies (IQR 28- 49) undertaken by vascular trainees ($p < 0.0001$). Upper GI trainees undertook the most cholecystectomies with a median 268 procedures (IQR 214- 310) compared with a median 103 cholecystectomies (IQR 65- 119) undertaken by vascular trainees ($p < 0.0001$). Breast special interest trainees undertook the fewest emergency laparotomies (median 86 (IQR 67-102)) compared with colorectal trainees who undertook a median 120 (IQR 100- 144) emergency laparotomies ($p < 0.0001$).

### 6.3.4 Changing volume of index procedures through training

Variation in the type of index procedures undertaken by training stage was seen.(Table 27)

***Table 27 Mean number of index procedures (non-assisting codes) undertaken per trainee (n=311) by training year***

| | Mean procedures per trainee (SD) | | | | |
|---|---|---|---|---|---|
| Training Year | Appendicectomy | Inguinal hernia | Cholecystectomy | Colectomy | Emergency laparotomy |
| 1 | 24 (15) | 19 (14) | 17 (18) | 6 (6) | 13 (9) |
| 2 | 25 (15) | 19 (14) | 23 (18) | 9 (8) | 16 (10) |
| 3 | 26 (15) | 18 (13) | 25 (21) | 9 (8) | 18 (12) |
| 4 | 24 (15) | 15 (14) | 26 (24) | 11 (10) | 21 (13) |
| 5 | 23 (19) | 12 (13) | 22 (26) | 12 (16) | 23 (16) |
| 6 | 19 (16) | 10 (10) | 20 (28) | 13 (14) | 23 (16) |
| Total $ | 148 (56) | 117 (44) | 175 (90) | 82 (48) | 114 (42) |

***$ Total across the 6 years of training.***

The most commonly undertaken IP as primary surgeon (non-assisting supervision codes) during the first year of training was appendicectomy with a mean 24 procedures recorded per trainee. The mean number of non-assisting appendicectomies recorded at each stage of special training remained relatively static reflecting the service provision of emergency General Surgery training in the UK. The mean number of non-assisting inguinal hernia procedures recorded decreased from 19 during the first year of training to 10 during the final year of training indicating the simpler caseload of early specialty training.

In contrast, the number of more complex IPs increased in throughout the course of training. The mean number of non-assisting emergency laparotomies undertaken rose throughout training from a mean of 13 procedures recorded during the first year of training to 23 procedures recorded during the final year of training.  The mean number of colectomies undertaken as primary surgeon increased from six during the first year of training to 13 during the final year of training.

### 6.3.5 Changing supervision of index procedures through training

The changing supervision levels recorded for each index procedure are shown in Figure 12, Figure 13, Figure 14, Figure 15, Figure 16 and Figure 17.

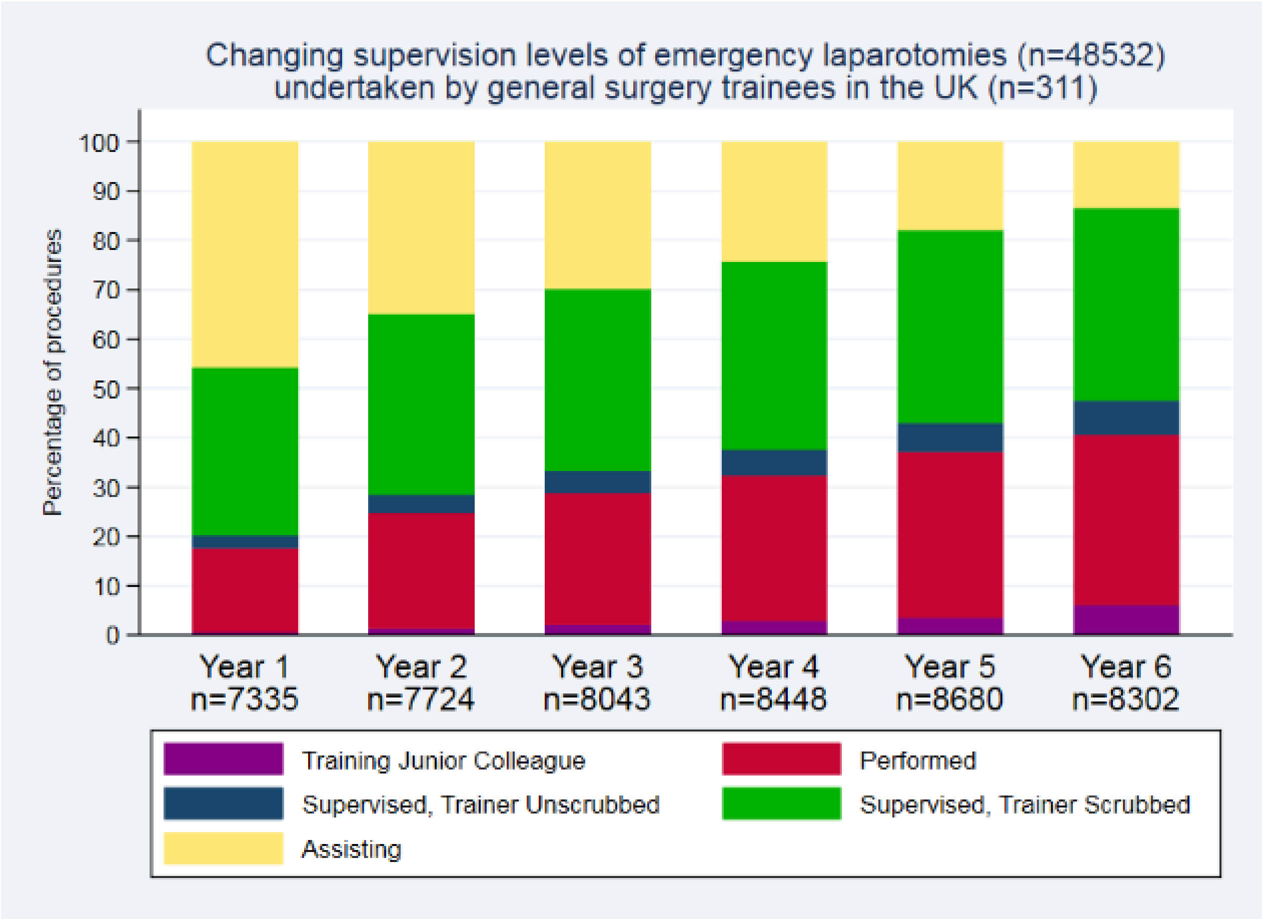



*Figure 12 Changing supervision levels of emergency laparotomies (n=48532) undertaken by General Surgery trainees in the UK (n=311)*

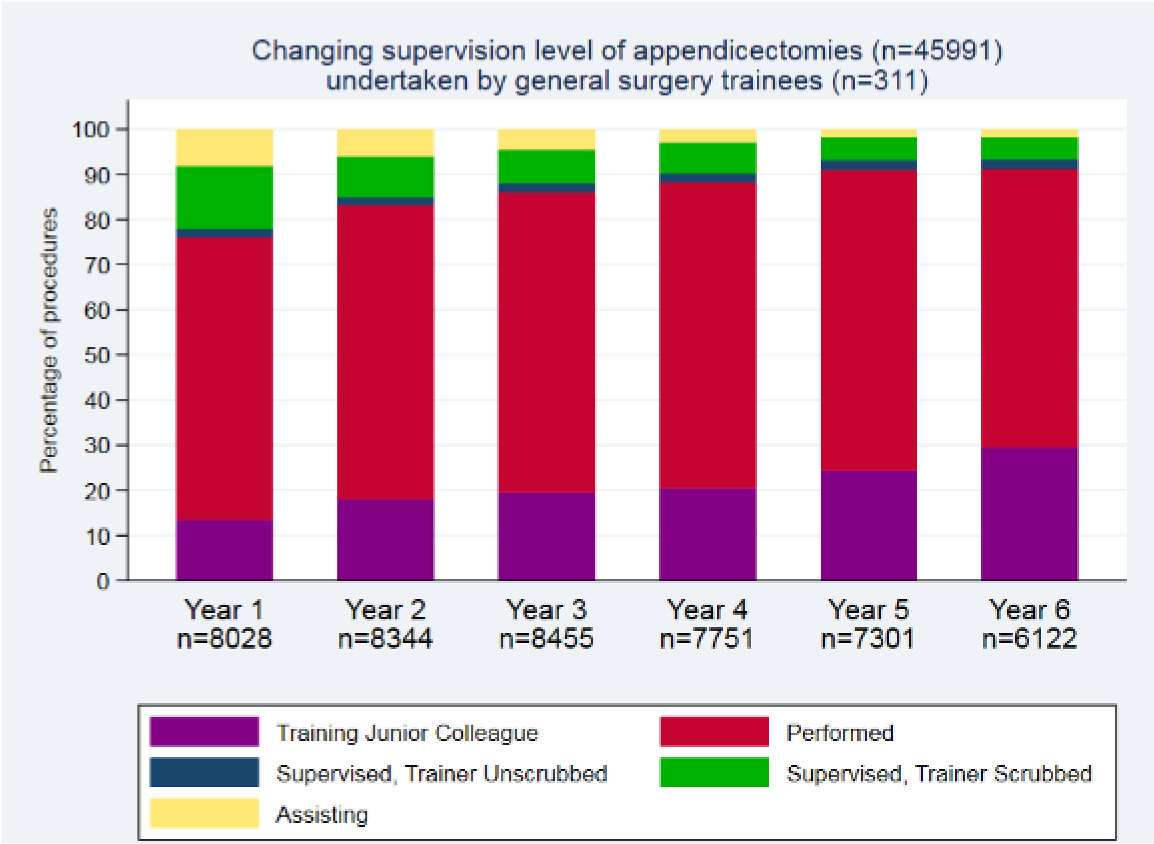



***Figure 13 Changing supervision level of appendicectomies (n=45991) undertaken by General Surgery trainees (n=311)***

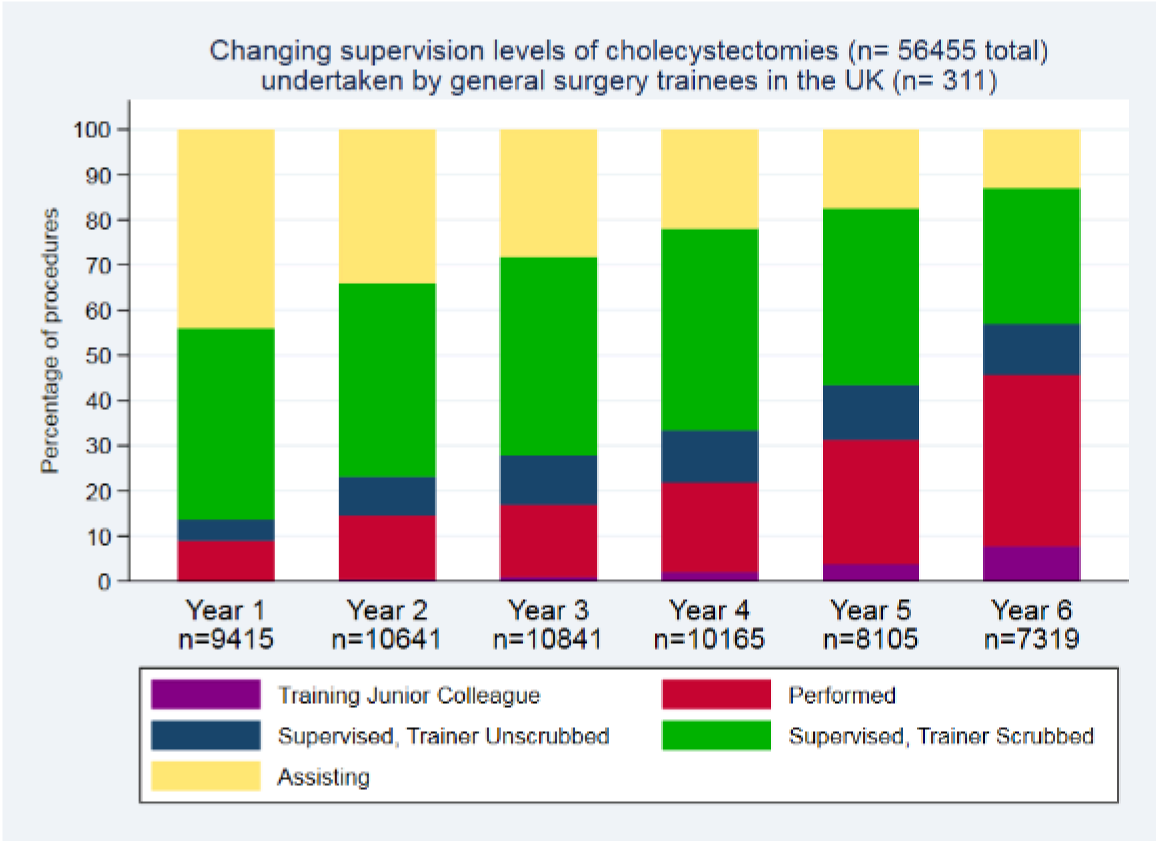



***Figure 14 Changing supervision levels of cholecystectomies (n=56455) undertaken by General Surgery trainees in the UK (n=311)***

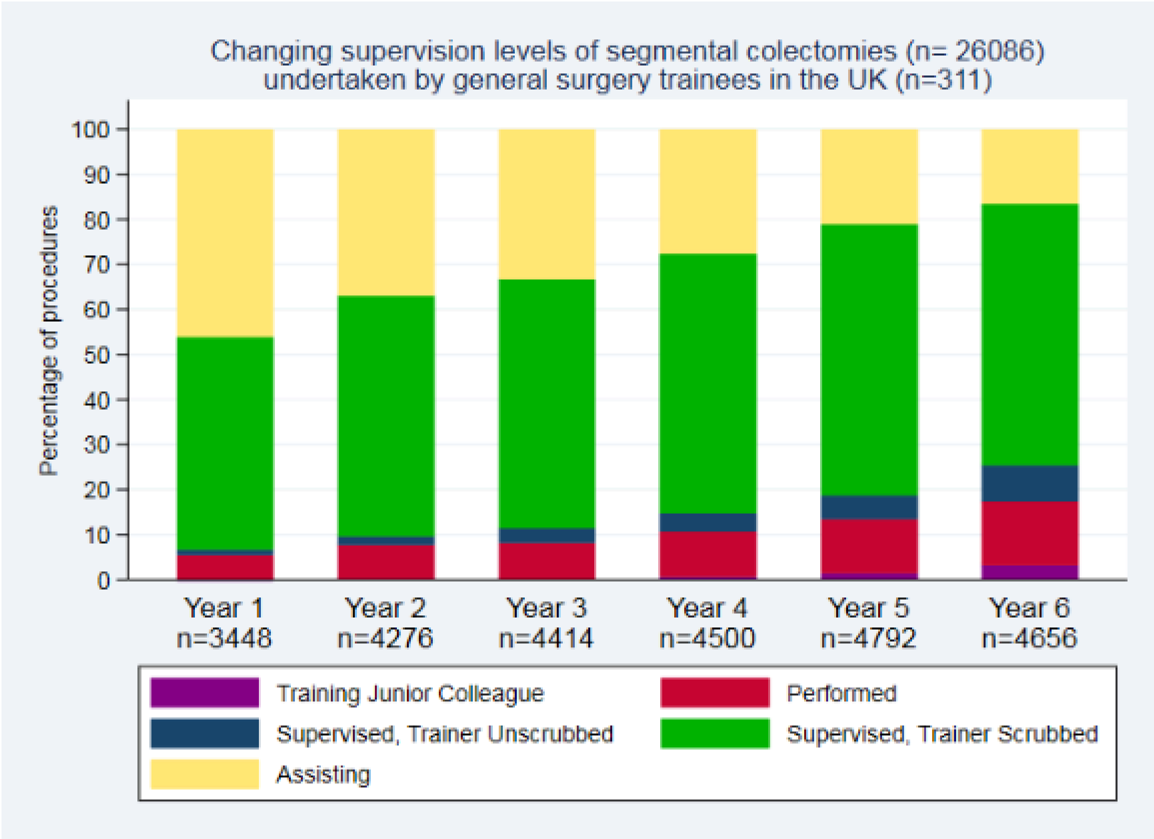



***Figure 15 Changing supervision levels of segmental colectomies (n=26086) undertaken by General Surgery trainees in the UK (n=311)***

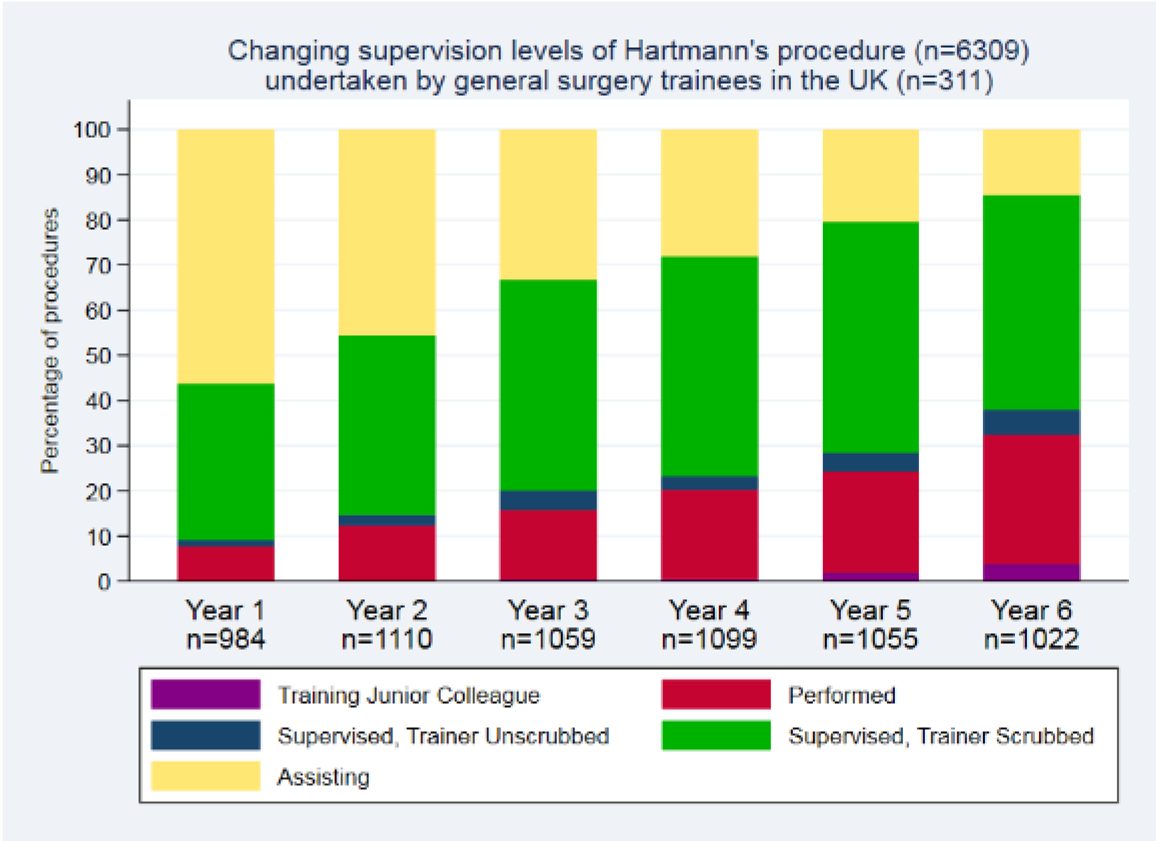



*Figure 16 Changing supervision levels of Hartmann's procedure (n=6309) undertaken by General Surgery trainees in the UK (n=311)*

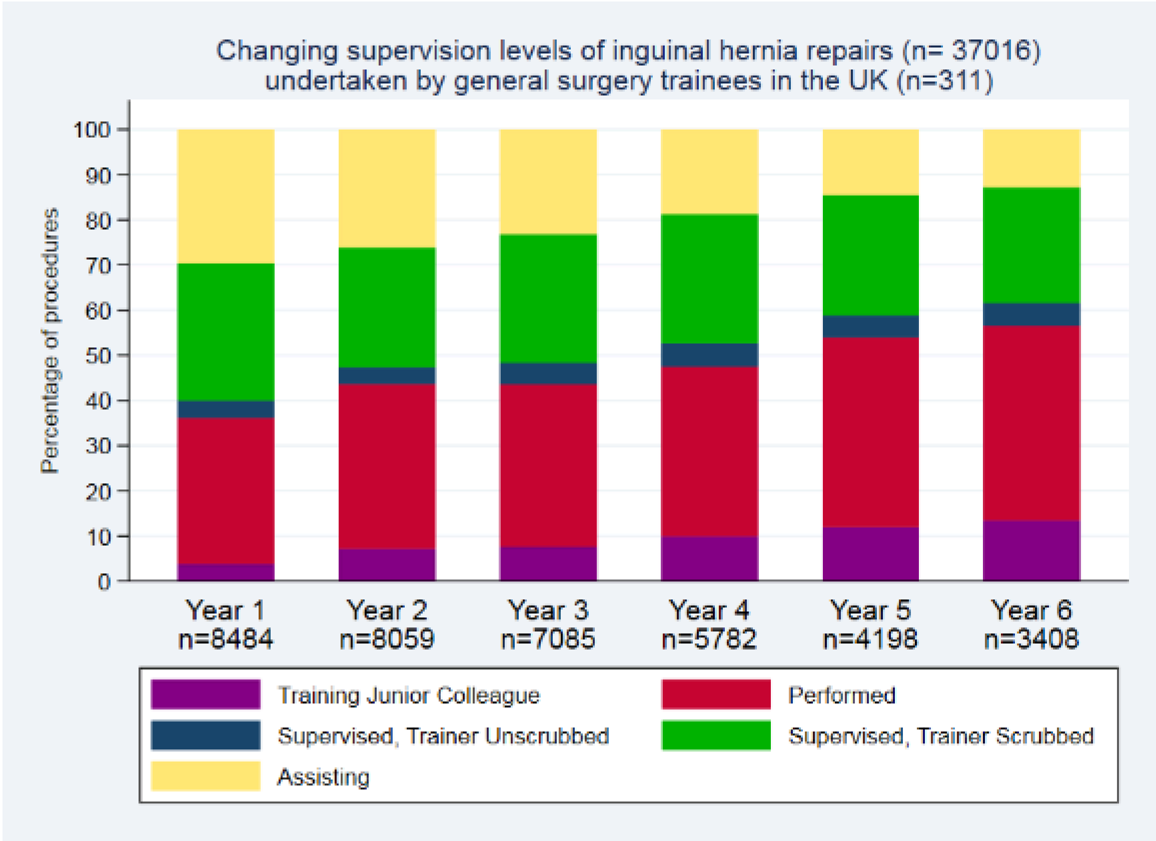



*Figure 17 Changing supervision levels of inguinal hernia repairs (n=37016) undertaken by General Surgery trainees in the UK (n=311)*

The proportion of index procedures recorded as unsupervised (Performed or Teaching a more junior colleague supervision codes) increased for all procedures as trainees progressed through training with a corresponding decrease in the number of procedures recorded as assisting. There was a difference in the pattern of change seen between the different index procedures.

Of the appendicectomies recorded during the first year of training, 78.0% were recorded as unsupervised indicating a degree of competency obtained in appendicectomy prior to commencing specialty training. The proportion of appendicectomies recorded as undertaken unsupervised increased to 91.2% during the final year of specialty training with 29.5% recorded as Teaching a more junior trainee. Of the cholecystectomies recorded during the first year of training, 11.9% were recorded as unsupervised, increasing to 47.2% during the final year of training (7.8% Teaching a more junior trainee).

Of the more typically complex operative procedures, a smaller proportion of procedures recorded as unsupervised was observed. During the first year of training, only 5.6% of segmental colectomies were recorded as unsupervised whilst the proportion of segmental colectomies recorded as unsupervised rose to 17.4% (14.1% Performed, 3.3% Teaching) during the final year of training.

Similarly, the proportion of emergency laparotomies recorded as unsupervised during the first year of training was 17.7% with an increase to

40.6% during the final year of training. For both segmental colectomy and emergency laparotomy, the proportion of procedures recorded as supervised training (Supervised, Trainer Scrubbed or Supervised, Trainer Unscrubbed) during the final year of training were high at 66.1% and 46.0% respectively, reflecting ongoing supervised training of trainees at a senior level.

### 6.3.6 Procedural Competency Assessment

The proportion of trainees awarded a Level 4 PBA by completion of training was 85.5% for appendicectomy, 79.7% for colectomy, 89.7% for inguinal hernia and 91.3% of trainees for cholecystectomy. Low numbers of trainees recorded a Level 4 PBA in the early years of specialty training for more complex procedures (9.0% and 18.3% of trainees completing the second year of training for segmental colectomy and cholecystectomy respectively) with a trend towards obtaining Level 4 PBAs later in training ($p < 0.05$). More trainees were awarded Level 4 PBAs in early years of training for less complex procedures (36.3% and 40.2% of trainees completing the second year of training for appendicectomy and inguinal hernia repair respectively) with no significant trend seen for award of Level 4 PBA by training stage ($p = 0.15$ appendicectomy; $p = 0.24$ inguinal hernia). (Table 28)

***Table 28 Number of trainees (total n=311) awarded a L4 Procedure Based Assessment (PBA) in General Surgery Index Procedures by training year***

| | Trainees achieving Level 4 PBA^ | | | |
|---|---|---|---|---|
| Training Year | Appendicectomy | Inguinal hernia | Cholecystectomy | Segmental colectomy |
| 1 | 48 (15.4%) | 43 (13.8%) | 10 (3.2%) | 7(2.3%) |
| 2 | 113 (36.3%) | 125 (40.2%) | 57 (18.3%) | 28 (9.0%) |
| 3 | 170 (54.7%) | 193 (62.1%) | 116 (37.3%) | 67 (19.6%) |
| 4 | 214 (68.8%) | 232 (74.6%) | 190 (61.1%) | 128 (41.2%) |
| 5 | 245 (78.8%) | 261 (83.9%) | 251 (80.7%) | 205 (65.9%) |
| 6 | 266 (85.5%) | 279 (89.7%) | 284 (91.3%) | 248 (79.7%) |
| P value for trend | 0.15 | 0.24 | <0.05 | <0.05 |

***^Cumulative total throughout years of training***

## Section 6.4 Discussion

### 6.4.1 Main findings

Using data relating to the entire course of training for all trainees in the UK this study has been able to map changing operative experience in a new way to provide empirical evidence of changing autonomy in surgical training. This study has described a change in types of procedure undertaken through the course of surgical training, evidencing progression from more simple procedures at the start of training to complex procedures by the completion of training. This study has demonstrated that as trainee seniority increases, the level of supervision of their operating decreases but that this trend differs between types of procedure, according to complexity. By using data from a formal assessment tool (PBA) this study has also described an increasing proportion of trainees achieving a competency standard in differing index procedures through the course of training. By using routinely collected national surgical training data in this way, this study has been able to demonstrate evidence of changing entrustment decisions through the course of an entire training programme for a national cohort of trainees.

### 6.4.2 Strengths and limitations

Previous studies of operative experience in General Surgery were limited to describing total operative numbers alone with several studies only using select groups of trainees, single region data or logbook consolidation sheets rather than centrally held, national data.[19, 20, 92, 97] This study is strengthened by its use of centrally held data from a national training scheme for an entire cohort of trainees. Use of complete training records, validated in real time by both trainees and trainers, along with annual review of individual trainee data, adds to the reliability of the data used. Careful data management to accurately calculate total index procedures, exclusion of procedures which do not count towards total operative experience and taking account of accurate training timelines all increase the reliability of data presented in this study. Inaccuracies in the degree of case supervision recorded by trainees may limit the reflection of independent practice in this study. However, clear definitions of supervision levels are published by the JCST and to overstate involvement in a case would be considered a probity issue with clear, negative consequences.[63] Furthermore, trainee logbooks are reviewed regularly throughout training placements by supervisors and at annual training reviews, adding a degree of validation to the data. A limitation of the study is acknowledged in the understanding that supervised vs unsupervised operating does not necessarily reflect a trainee's capability to perform a procedure but may merely reflect who was present in theatre. The limited availability of an assistant who is not the trainee's supervising trainer will inevitably impact on the supervision of cases, necessitating a supervision coding of Supervised, Trainer Scrubbed or Supervised, Trainer Unscrubbed rather than entirely unsupervised operating. Furthermore, explicit entrustment decisions taken by trainers for the purposes of summative competency assessment are more formal than the daily ad-hoc supervision decisions made by supervising trainers, which have many other influences including time of day, staff availability and urgency of the procedure. Whilst this limits the conclusions that can be drawn regarding entrustment decisions in UK practice from logbook data alone, this study has demonstrated the changing autonomy of trainees through training, reflecting increasing trust to perform procedures unsupervised.

The apparent anomalies of the small numbers of early specialty trainees recording complex procedures unsupervised (5.6% of colectomies recorded as unsupervised) and achieving competency assessments for independent practice (2.3% of trainees awarded a Level 4 PBA outcome) by completion of the first year of specialty training is acknowledged. This is explained by the varying operative experience and competency of trainees commencing specialty training in the UK. Some trainees, with completion of overseas training prior to entering UK General Surgery specialty training, are already technically proficient in a wide range of procedures. Some UK trainees may have completed further training or service provision years prior to specialty training and are experienced technically. It is likely that such trainees are allowed to undertake more complex procedures sooner, reflected in the small proportion of Year One and Year Two trainees undertaking colectomies (5.6% in Year One) or emergency laparotomies unsupervised (17.1% in Year One) and achieving Level 4 PBAs (2.3% in Year One and 9% in Year Two for colectomy). The use of the PBA data in this study, demonstrates that a proportion of trainees are judged to be competent to perform more complex procedures, even at early stages of training. The pattern of award of Level 4 procedural competency assessment relates to the changing supervision of index procedures, adding evidence to the supposition that procedural autonomy decisions appear to mirror entrustment decisions in the UK.

### 6.4.3 Other literature

Wagner *et al* recently published a study of the use of EPAs in the assessment of operative capabilities, together with the perceived and actual autonomy, of General Surgery residents in a single USA centre.[58] In keeping with the findings of decreased supervision through training in this study, the authors reported that perceived autonomy was greater in senior trainees than more junior trainees.[58] The authors reported that approximately 40% of faculty members said that trainees were not independently capable of performing inguinal hernia repair at any stage of training. Comparatively fewer trainees (less than 20%) reported not being trusted to perform inguinal hernia repairs independently.[58] In contrast, this study demonstrates that 56.5% of inguinal hernia repairs undertaken by final year trainees in the UK were performed unsupervised and 89.7% of final year trainees had been awarded a Level 4 PBA for inguinal hernia repair. The difference perhaps reflects the extended training duration in the UK and thus increased autonomy of trainees.

This study relates to the work of George *et al* with regard to trainee autonomy in General Surgery training. George *et al* undertook a study of 536 General Surgery trainees from a selection of US training programmes in 2015/16 and assessed trainee readiness for independent practice using a competency assessment tool and compared this with a judgement of trainee autonomy.[49] The authors described increasing autonomy and performance assessment results through training. However, only a small proportion of final year trainees demonstrated near independence. They concluded that US General Surgery trainees are not ready to independently practice even common core procedures (appendicectomy, inguinal hernia repair and cholecystectomy) at completion of training. Comparisons between US and UK General Surgery operative competency standards are limited by the notably different durations of training programmes. However, trainees completing both training schemes are free to practice independently with 20% of US General Surgery residents entering directly into independent practice at completion of training.[170] Eighty percent of US General Surgery residents undertake a period of post-residency fellowship training,[170] and 77% of General Surgery trainees in the UK[130] also pursue additional clinical fellowship periods in addition to standard UK training. This suggests that the majority of trainees in both countries feel the need to extend their clinical training prior to independent practice, whether for additional operative experience or other reasons such as further development of specialty interest or niche skill training.

Whilst comparison of outcomes between different General Surgery training schemes are limited by the variation in training curricula and cultures, the use of routinely collected data as described in this study could be applied internationally to training schemes which electronically record operative experience data. This study demonstrates a new and alternative way of using operative experience data beyond simple counting to add further evidence to competency attainment through the course of training.

### 6.4.4 Conclusion

The changing autonomy of trainees through the course of an entire training scheme for a national cohort, alongside formal summative competency assessments, may provide evidence of changing entrustment decisions made by trainers for different key procedures. Such methods could be used by other countries utilising electronic logbooks to further understanding of competency acquisition in surgical training.

# Chapter 7 Conclusions from this thesis

Prior to the work presented in this thesis, little was known about the outcomes of the General Surgery specialty training programme in the UK. I have described the published data relating to operative experience in General Surgery training globally and in doing so have provided context for the UK training programme.[137] The variation in operative experience at completion of training is marked but simply describing operative experience fails to establish how much operating is required for competency or how this should be assessed. The relationship between operative experience and competency was the focus of the rest of the work undertaken in this doctoral study.

In order to understand outcomes in General Surgery training, it was important to clarify the time taken to train in the specialty of General Surgery in the UK and how that is changing. It was anecdotally felt that trainees previously completed early years surgical training prior to undertaking research and then applied for specialty surgical training, with a shift in recent years to moving straight into specialty training and then taking time OOP. The work presented in Chapter 4 provides a basis for this anecdotal evidence being correct and demonstrates that increasing proportions of trainees are choosing to take time out of specialty training to pursue other activities such as research and parental leave.[171] There is marked regional variation in those undertaking OOPR. This might be of interest to trainees applying to General Surgery specialty training and considering the likely future opportunities available to them. Reasons for regional variation are unclear but are likely multi-factorial with openness of TPDs to approving OOP requests, regional academic Consultant drivers for research and the presence of collaborative research groups increasing interest in research all playing a part.[89, 140] The increasing time taken to complete specialty training is an important consideration for both those responsible for local workforce planning and those managing the predicted future Consultant workforce needs.[172]

In Chapter 5, I have explored the association between operative experience and PBA outcomes. I have been able to undertake a more comprehensive analysis of this association than has previously been reported by using a national cohort of trainees and evaluating general surgery index procedures individually. The Beard *et al* study evaluating the construct validity of the PBA was limited by trial data from a single region and multiple specialties and procedures analysed as one.[18] I have demonstrated that there is a good correlation between increasing operative experience and PBA outcomes but that this is a stronger association for more complex procedures than in simple procedures. The data presented in this study could reflect differences in the way trainees use PBA depending on the complexity of the procedure. The presence of curricula targets can lead to attitudes of “tick-box” form completion and it may be that this is the case for the more simple procedures where strength of association between experience and PBA outcomes was weaker.[160-162]

This study has identified that the PBA as a lone measure of competency is limited, particularly in simple procedures. This study found no statistical evidence of increasing proportions of trainees achieving L4 competency through the course of training in appendicectomy and inguinal hernia repair. Therefore, it would appear that the PBA has limited validity in such procedures and methods of evaluating competency in these procedures should be reconsidered. However, the strong association between operative experience and PBA outcomes with trends for increasing competency acquisition through training in both cholecystectomy and colectomy add weight to the body of evidence for validity of the PBA in these more complex procedures.

A common criticism of the competency-based medical education system is the reductive nature of WBAs and that this can lead to trivialisation of assessments.[34, 162] The move away from individual "building block" assessments of trainees to broader of units of work (Entrustable Professional Activities) is well described in contemporary medical education texts.[33, 34, 60] The concept of entrustment had not previously been demonstrated within UK training data. The work undertaken in Chapter 6 evaluates the use of routinely collected operation supervision data to establish the changing autonomy of General Surgery trainees during surgical training. In doing so, I have been able to demonstrate the increasing autonomy of trainees through the course of training and the variation between General Surgery index procedures. PBA data is only recorded sporadically with trainees able to determine when to undertake assessments, which inevitably brings bias into any conclusions drawn relating to operative experience at the point of award of competency. Furthermore, the exclusion of procedures undertaken prior to specialty training and during OOP periods biases any conclusions about the number of procedures required to obtain competency with the results presented here likely underestimating the number of procedures required for Level 4 competency. However, the exclusion of both operative experience and assessment data from these time-periods is consistent with UK curriculum requirements thus increasing the relevance of results to the current training system.

Operation supervision data is recorded on every occasion a trainee undertakes a procedure. Therefore, evaluating the changing supervision of trainees could provide a clearer view of the changing competency, using the proxy of autonomy. However, there are clear limitations to the use of supervision data including recording bias with trainees either over or understating their involvement and influential factors on supervision such as staff availability, time of day, trainer unfamiliarity with a trainee and trainer attitudes towards risk. I have demonstrated difference in the supervision of trainees and award of competency assessments, particularly for simpler procedures such as appendicectomy. I have demonstrated that 78.0% of appendicectomies undertaken in the first year of specialty training were undertaken unsupervised. However, only 15.4% of trainees in the first year of specialty training had been awarded a Level 4 PBA. This mismatch between autonomy and competency assessment is notable and raises questions about both the supervision of trainees in theatre and the use of competency assessments for simple procedures. Is it appropriate that trainees undertake procedures unsupervised prior to documented evidence of trainer assessment of competency? Are the expert, trainer opinions that form entrustment decisions on an ad hoc basis in the theatres a more reliable assessment of trainee competency? The ongoing supervision of trainees undertaking complex procedures, even in the final year of training, is an important observation in this work. Reasons for Consultant supervision of senior trainees might include the absence of another available assistant or the appropriate commitment to ongoing refinement of surgical skill during senior training. Quality improvement projects such as the National Emergency Laparotomy Audit drive increasing Consultant surgeon presence in high-risk surgical cases could also be contributing to the observed proportion of supervised Emergency Laparotomy procedures amongst even senior trainees.[173, 174] However, the demonstration of unsupervised operative experience in the newly qualified Consultant provides further support for notion of  the ongoing preceptorship and support for newly- qualified Consultants.

### 7.1.1 Final conclusion

I have studied three measures that can be used to evaluate surgical trainee competency:

1. Numerical operative experience
2. Workplace- based assessments of technical skill
3. Autonomy of trainees in the operating theatre

I have provided evidence for all three measures and shown that each has a value in understanding trainee competency. I have begun to establish how these three measures work together and how they might be used in the future to establish trainee competency. The fourth, and important, method of trainee competency assessment is the subjective view of the expert, i.e. the supervising Consultant. It seems entirely appropriate that no single measure is used alone and rather operative experience, competency assessments, autonomy and Consultant opinion contribute towards a body of evidence that is evaluated to understand trainee competency.

The new knowledge and insights into UK general surgery training that I have presented in this thesis should be disseminated and presented to various stakeholder groups including those responsible for national surgical training, surgical trainers, trainees and patient and public representatives. These groups should give their perspectives on the results I have presented in order to determine different views on the setting of thresholds for operative experience and the use of competency assessments in surgical training.

The finding of the apparent limited value of PBA in assessing competency of simple procedures in specialty surgical training should be considered with review of possible alternative measures such as the use of autonomy data to better evidence competency acquisition. It is my view that a combined measure that includes autonomy evaluation would be a more accurate reflection of trainee competency, particularly for simple procedures such as appendicectomy and elective inguinal hernia repair.

The results presented in this thesis should be examined with respect to the future setting of general surgery index procedure indicative numbers with the numerical thresholds for competency in more complex procedures possibly increased and the thresholds for competency in simpler procedures either decreased or removed from the curriculum. Whilst the use of median number of procedures to attainment of Level 4 PBA is relatively crude, it does at least present a measure related to a standardised competency assessment as opposed to the current indicative numbers. As stated earlier in the thesis, the number of procedures to Level 4 PBA should be interpreted with caution given the exclusion of non-standard training time operating, potential for assessor bias and influence of timing of current requirements on the cohort studied.

Trainers using the PBA should all be trained to use the PBA as part of the professionalization of the surgical trainer role. This may increase both the educational value of the PBA as a formative feedback tool but also increase the reliability of competency judgements made using PBA.

Future work resulting from this thesis could include investigating the use of PBA and supervision level to create a combined measure of competency. Further statistical analysis assessing the relationship of a combined competency measure with operative experience could be developed to estimate predicted probabilities of competency over a range of operative experience thresholds. Evaluation of the operative experience, supervision and competency assessments of trainees undertaking Core Surgical Training programmes would add further understanding to competency acquisition in appendicectomy and inguinal hernia repair. Further studies investigating the effect of time out of training on PBA outcomes and supervision of trainees could help inform the development of a supported programme of training for those trainees returning to work after a period of OOP. Ultimately, the results, both in this thesis and from potential future work arising, could be used to improve the ways in which future surgeons are trained and assessed.

# Appendices

## Appendix 1: ISCP Data Fields and Tables

<u>Trainee tables</u>

**Relationship - Training History and Validation History**

This table can be used for a number of different pieces of data. It can be used for recording a training level, an appointment type, deanery, placement or a PBA.

*Relationship id :* Identifier relating to this data table.

*User unique identifier:* Identifier of the user inputting the date into this table.

*User type :* The type of user inputting data into this table: trainee, validator, rater, AES, CS or TPD.

*Record unique id:* ID for section which might be used as key to other tables. Ie. If relates to a PBA, then this will be the PBA id. Required for linking.

*Section:* Training level, Appointment type, Deanery or PBA or Placement- the type of information this table contains.

*Relationship start date:* Start date for section. If this section relates to a placement, this will be the start date of the placement.

*Relationship end date:* End date for section. If this section relates to a placement, this will be the end date of the placement.

**Placement**

*Placement unique identifier :* Identifier for this data table relating to a particular placement.

*Placement start date:* Start date of the placement

*Placement end date :* End date of the placement

*Specialty code :* Code for the specialty of the placement

*Organisation unique identifier:* Identifier for the hospital in which the placement is taking place.

**Trainee Details**

This data is inputted by the JCST from the SIMS database.

*Trainee id:* Unique identifier for the trainee

*Trainee contact number:* SIMS trainee unique ID- the ID that is in the SIMS database.

*Trainee name:* Trainee full name

*Trainee specialty:* Specialty of the trainee (i.e. General Surgery; orthopaedics; ENT etc)

*Trainee sub-specialty:* Surgical sub-specialty declaration. This should not be relevant as does not

*Training level id:* Trainee level. SIMS gets the information from ISCP on level.

*Start date in training:* Date that trainee started in training with an NTN.

*Certification type id and Certification type:* Identifier for the type of certificate that the trainee has; CCT, cesar cp or CCST. A CCT is where all training has been in prospectively approved posts and the commonest certification type for UK trainees.

*Certification expected date:* Date that trainee is expected to gain CCT.

*Calman or Irish:* Whether the trainee is an Irish trainee or a pre-ISCP curriculum trainee.

*Organisation unique id:* Identifier for the deanery that the trainee is registered to.

*Parent deanery name:* Deanery name that the trainee is registered to.

*Surgical programme id:* Specialty programme identifier. Some deaneries have more than one surgical training programme within them.

*CV received :* Date when the JCST received a CV from the trainee

*Armed forces:* Binary indicator of whether the trainee is a military trainee. 1= military, 0=not

*Status in training:* Training status in relation to CCT. The options are: In training, awaiting documentation for certification, pending SAC recommendation, recommendation for certification.

*Status date change:* Date that the trainee status in training last changed. This relates to the date that the form was changed, not the actual date of change.

*GMC number:* The trainee's registered GMC number

*IMC number:* Irish Medical Council number.

*GDC number:* General Dental Council number.

*National training number:* National training number identifier.

*Trainee surname:* Name of trainee

*Trainee forenames:* Name of trainee

*Trainee preferred forename:* Name of trainee

*Trainee initials:* Initials of trainee

*Trainee date of birth:* Trainee date of birth

*Status in training lookup id:* This is required for extracting the status in training information. CS requires this but is not needed for the dataset for analysis.

*Specialty lookup id:* Surgical specialty unique identifier. Refers to General Surgery/ orthopaedics etc.

*Sub-specialty lookup id:* Sub-specialty identifier.

*Enrolment with JCST date:* Date of enrolment with the JCST. This does not relate to start date in training- it is when the trainee gets around to registering the with JCST. Core trainees enrol with the JCST, higher trainees enrol with the SAC.

*Enrolment with surgical specialty date:* Date of enrolment with the surgical specialty association committee (SAC). No relation to a start of training date- just when the trainee enrols with the SAC.

*Notes:* Free text notes made by JCST Administrator regarding changes in training (Certification, ARCPs, other)

PBA tables

**PBA type**

*PBA unique id:* Identifier for this type of PBA

*PBA title:* Name of the PBA e.g. "hernia repair: inguinal"- corresponds to the above identifier.

*Specialty value:* Specialty for which the PBA was created. 1-10 for the specialties.

*PBA last update date:* Date that the form structure was last updated. Form administration rather than relating to an individual's assessment.

*PBA status:* Status in database. L - if Live in Website, D - deleted, H – Historicised (A PBA would be historicised if replaced by a different version. Questions may have been changed.)

*Create date:* Database administration relating to the form type.

**Assessment PBA**

*Assessment pba unique identifier:* Each separate PBA done by a trainee is given an ID. This is that identifier.

*PBA unique identifier:* Identifier for the PBA form. Links to the above "PBA type" table.

*Date of the event:* Date the procedure took place that this PBA refers to.

*Data recorded in the relationship table:* Assessor name/ email and GMC number. All discontinued in 2011.

*If rater has received training for this type of assessment:* Binary indicator variable for the type of training that the assessor has received. This column relates to the assessor ticking the box “No training”. 1= ticked, 0=blank

*If rater has received training for this type of assessment:* Binary indicator variable for the type of training that the assessor has received. This column relates to the assessor ticking the box “Read guidelines”. 1= ticked, 0=blank

*If rater has received training for this type of assessment:* Binary indicator variable for the type of training that the assessor has received. This column relates to the assessor ticking the box “Web-based or CD training”. 1= ticked, 0=blank

*If rater has received training for this type of assessment:* Binary indicator variable for the type of training that the assessor has received. This column relates to the assessor ticking the box “Face to face training”. 1= ticked, 0=blank

*Hospital in which the event took place:* The hospital identifier for where the assessment took place.

*Operation more difficult than usual?* Indicator for whether the trainee rated the operation as more difficult than average. 1= ticked, 0=blank

*If Operation is more difficult than normal than reasons are stated in this field:* Free text explaining why the operation was judged to be more difficult than usual.

*Performance level (from level 0 to 4):* Overall performance level of the PBA

*Trainee comments about the assessment:* Free text comments relating to the assessment written by the trainee

*Rater comments about the assessment:* Free text comments about the assessment written by the assessor

*Indicate if performed in a simulated environment:* Binary indicator of whether the PBA relates to simulation. 1= simulated. 0= not.

*Version of the assessment form:* Some PBAs have been rewritten and have different versions.

*Ocap pba unique identifier:* Only required for orthopaedic PBAs which were linked to OCAP.

*PBA complexity id:* Some PBAs have a complexity type. This does not relate to any of the General Surgery PBAs.

*PBA subtype id:* Some PBAs have a subtype. This does not relate to any of the General Surgery PBAs.

*Satisfaction rating about the method of assessment:* Trainee satisfaction with the method of assessment

*Satisfaction rating about the method of assessment:* Assessor satisfaction with the method of assessment

*Time taken for assessment:* The amount of time that the procedure took

*Time taken for feedback:* The amount of time taken for giving feedback

*Status of assessment in database:* This is the status of the form in the database. Form submitted/ form validated/ deleted. We will only require validated PBAs.

*Date when form started and saved:* Date when the PBA was initially started.

*User id of user who created the form:* ID of the person who created this individual PBA assessment

*Date of last update:* Date of update to the form. This is NOT the validation date.

*User id of user of made the update:* Identifier of the person who updated the form.

*Status of the form in the database - Visible in the website if value is "L". If deleted, value is "X" and "H" for historicised record.* Only require live assessments.

**Assessment PBA Rating**

*Assessment pba rating id:* Identifier for the competencies in this table.

*Assessment pba id:* Identifier that links this table to the PBA Assessment table

*PBA question id:* The identifier for the assessments in each domain (I.Consent, II. Pre operation, III. Pre operative.)

*Rating:* Rating of satisfactory, needs development or not seen.

*Rating comment:* Free text relating to each PBA binary outcome assessment point.

*Create date:* As before

**Assessment PBA section comments**

*Assessment PBA section comments:* Assessment section comments unique identifier.

*Assessment pba id:* The linking identifier

*PBA section id:* Identifier for the particular section

*Section comment:* Free text comment relating to that section

*Create date:* As before

**PBA Sections**

This relates to the design of the form rather than an assessment.

*PBA section ID:* Identifier for this table

Full table below:

| pba_section_id | section_title |
|---|---|
| 2 | I. Consent |
| 3 | II. Pre operation planning |
| 4 | III. Pre operative preparation |
| 5 | IV. Exposure and closure |
| 6 | V. Intra operative technique: global (G) and task-specific items (T) |
| 7 | VI. Post operative management |

*Type*

**PBA Questions**

All questions for every PBA are stored here. PBA id 100 (Compression hip screw inter fracture neck of femur) has 46 questions/competencies associated to it. This has no outcomes- it is purely related to form design.

ARCP tables

**ARCPs**

*ARCP meeting id:* This is a database identifier. It links the ARCP table with the ARCP trainees table.

*ARCP date:* Date when the ARCP was held. Entered by deanery staff or TPD.

*ARCP venue:* The venue of the ARCP.

*ARCP lay members:* Free text that identifies the lay members attending the ARCP.

*ARCP organiser:* Identifies the user who created the ARCP in the ISCP. This is usually the TPD or deanery administrator.

*ARCP type:* Binary indicator identifying whether the ARCP is an Interim (I) or Annual (A) ARCP. Setting an outcome is not mandatory for an interim ARCP and the form for this is different.

*ARCP outcome set for trainees:* When a form is created for an interim ARCP, the user has to decide whether to create an outcome option for the ARCP or not. Some interim ARCPs are for discussion of progress only and do not require an outcome. This is a binary indicator of whether the will be an outcome or not.

*Create_date:* This is when the form was created in the database. This is not the same as the date of the ARCP- just the date that the administrator started to create the forms for the ARCPs.

*Create_user:* This is an identifier for the user who created the form.

*Update_date:* The date that the form was last updated.

*Update_user:* Identifier for the use who last updated the form.

*Status:* This is whether the record is visible on the live site or not. For example, it may be 'X' if the form was deleted due to an error in creating it. 'L' is a live form- visible on the website and a part of the trainee's record.

**ARCP Panel**

*ARCP panel id:* The TPD or administrator can create a panel ID for the ARCP group and sets this for the trainee's ARCP meeting to avoid having to input all ARCP members repeatedly.

*ARCP meeting id:* Each ARCP has a unique identifier. It links every trainee seen on that day for that panel.

*ARCP panel member id:* Identifier for each of the ARCP panel members.

*ARCP Chair:* Binary indicator of whether a member of the panel is also Chair of the panel.

*Create date:* Same as before. The date the form was created, by whom, when it was last updated and by whom and whether the form is live or historicised.

**ARCP Trainees**

This table is unique to the trainee.

*ARCP trainee id:* This identifies the individual ARCP- there is a new ID for each ARCP the trainee has.

*ARCP meeting id:* Unique identifier for the ARCP meeting that is required internally to link the tables.

*Trainee ID:* This is the trainee unique identifier that is used throughout the individual's ISCP data.

*Global Objective id:* TPDs can set Global Objectives for each trainee. This field links to the global objectives set by the TPD using the global objective ID.

*ARCP outcome:* ARCP outcome given to the trainee.

*ARCP changes to the panel:* ARCP differences to the original panel, as detailed in ARCP panel table, recorded in free text box.

*ARCP detailed reasons:* Free text describing the reasons for the ARCP outcome.

*ARCP mitigating:* Free text describing any mitigating circumstances given for the ARCP outcome.

*ARCP competencies:* Free text describing any competencies which need to be developed.

*ARCP actions:* Free text describing any actions to be taken by the trainee.

*ARCP additional training time:* Free text describing any recommended additional training time required by the trainee.

*ARCP version:* There are two versions of the ARCP form. Coding of which type of ARCP documentation version this ARCP is.

*Trainee training level at ARCP:* The training level of the trainee at the time of the ARCP. This is ambiguous- some TPDs interpret this to be the current level of the trainee or the level of the trainee that the ARCP period refers to. If an ARCP is held after change-over date, these levels will differ.

*ARCP period covered:* This is the time period that the ARCP is referring to. Period covered can be entered manually (D) or by selecting the placements (P) to be assessed. This is a binary indicator of where the date information has come from- manual entry or placement selection.

*ARCP start date:* Start date of the time period that the ARCP is referring to (if entered manually).

*ARCP end date:* End date of the time period that the ARCP is referring to (if entered manually).

*Expected Certification Date:* This is the expected CCT date as entered by the TPD/ deanery admin staff. They can update this as a result of an outcome 3- with extension of training. This then flags up a change to the JCST and the JCST refer to this when updating CCT dates in the SIM database. It is a way of communicating a change in CCT date with the JCST but is not necessarily reliable. The most reliable CCT date is the one in the Trainee Details table.

*Previous revalidation date:* Relating to GMC revalidation dates.

*Expected revalidation date:* Relating to GMC revalidation dates.

*ARCP unresolved causes of concerns?* Binary response to the question "Are there any current known unresolved causes of concerns?"

*ARCP unresolved causes of concerns:* Free text explaining any concerns.

*Days out of training:* Number of days spent out of training during the ARCP period. The GMC require anything more than 2 weeks for sick/paternity/maternity/compassionate/carers leave to have the trainee CCT reviewed (not necessarily changed, but reviewed as a minimum).

*Academic training:* Binary indicator of whether the trainee is on an academic programme or not. 1= academic. 0=not. This may not necessarily reflect whether the trainee is on an academic training programme. Sometimes ticked if the trainee is on a teaching fellow year or similar.

*Training level at next rotation:* Selectable level for the trainee's training level at next rotation.

*Create_date/Create_user/Update_date/Update_user/Status:* Same as before. The date the form was created, by whom, when it was last updated and by whom and whether the form is live or historicised.

**ARCP trainee notes**

This corresponds to the section where the trainee can enter their own opinions about the ARCP.

*ARCP trainee notes id:* ARCP trainee notes section unique identifier.

*ARCP trainee id:* Identifier for the individual ARCP.

*Notes:* Free text entered by the trainee in response to the ARCP process and outcome.

*Create_date/Create_user/Update_date/Update_user/Status:* As before

**ARCP trainee placements**

*ARCP trainee placement id:* Unique identifier for the placement section within the ARCP.

*ARCP trainee id:* Identifier for the individual ARCP- links the tables.

*Placement id:* Unique identifier of placement selected in ARCP.

Required as we will need placement data for dates if the TPD has entered data for the ARCP using the placement method rather than manually.

*Create_date/Create_user/Update_date/Update_user/Status:* As before.

**ARCP v1 trainee details**

All the data that existed in the ARCP v1 table has been transferred into the updated ARCP tables. Therefore, we do not require this table separately.

*ARCP v1 trainees:* ARCP v1 trainees details unique identifier

*ARCP trainee id:* Unique identifier for individual ARCP

*ARCP start date:* ARCP period covered from.

*ARCP end date*: ARCP period covered to

*ARCP outcome:* ARCP outcome from 1-6. NULL if not recorded.

*Next revalidation date:* Date of next expected ARCP

*ARCP outcome:* Relating to if the trainee had an outcome 7

*ARCP outcome:* Relating to if the trainee had an outcome 8

*ARCP outcome:* Relating to if the trainee had an outcome 9

*ARCP detailed reasons:* Free text explaining the reasons for the ARCP outcome given.

*Training level at next rotation:* The ST level of the trainee at the next rotation.

*Next training stage:* Start date of the trainee's next training stage.

*Next training perc:* Next training %(Full time or LTFT %)

*Expected Certification Date:* This is the date that the trainee is expected to achieve CCT.

## Appendix 2: ISCP Data Specification April 2016

**NB. Trainees that have left** General Surgery **training are excluded from the cohort. Data from these trainees to be held by Cristel along with data detailed in Appendix 1.**

Data for all General Surgery trainees registered for training with an NTN from 1st August 2007 to 31st March 2016 will be provided according to the specification below. The data will be provided in four tables with the data requested coming from the tables indicated from the database:

1. Trainee details/demographics

2. PBA information

3. ARCP information

4. elogbook data

Free text variables have been requested for each of the first three tables and are indicated in the tables below and summarised in the Summary of Free Text Variables table. These data will be held by RCS and released only if requested by the investigators in the event they are needed. The four tables will be linked by a one person level identifier provided by RCS including the logbook data.

1. **Trainee Demographics**

| Field Name | Description | Table Source |
|---|---|---|
| Trainee Unique Identifier | Identifier used in each of the data tables to link data to trainee | Trainee Details/ SIMS |
| Trainee Date of Birth | Trainee date of birth in year and month. | Trainee Details/ SIMS |
| Trainee Gender | Gender descriptor of the trainee | SIMS |
| Trainee Specialty | Surgical specialty of the trainee- should all be General Surgery | Trainee Details/ SIMS |
| Start date in training | The data that trainee was given an NTN | Trainee Details/ SIMS |
| Certification expected date | The date that a trainee is expected to CCT | Trainee Details/SIMS |
| Deanery | Parent deanery name | Trainee Details/SIMS |
| Armed forces | Binary indicator of whether the trainee is a military trainee | Trainee Details/SIMS |
| Academic Training | Binary indicator of whether the trainee is on an academic programme or not. 1= academic. 0=not. This may not necessarily reflect whether the trainee is on an academic training programme. Sometimes ticked if the trainee is on a teaching fellow year or similar. | ARCP Trainees |
| Status in training | Categorical variable of training status in relation to CCT: in training/ awaiting documentation/ pending SAC recommendation/recommendation for certification | Trainee Details/SIMS |
| Placement dates | Start and end dates for placements | Relationship Table |
| Deanery of placement | The deanery that the placement took place in | Relationship Table |
| Trainee level and associated dates | The training level of the trainee plus associated start and end dates | Relationship Table |

| FOR THE VAULT | | |
|---|---|---|
| Certification type identifier | Identifier for the type of certificate a trainee has: CCT/ CESA CP. | Trainee Details/SIMS |
| Notes | Free text notes made by JCST administrator regarding changes in training | Trainee details/SIMS |

## 2. PBA

| Field Name | Description | Table source |
|---|---|---|
| Trainee unique identifier | The unique identifier for the trainee that all the PBA info relates to | |
| PBA Title | The title of the PBA e.g. inguinal hernia/ laparotomy/ hameorrhoidectomy | PBA type |
| Specialty value | The specialty for which the PBA was created. Coded 1-10 for the surgical specialties. | PBA type |
| PBA status | Status in database- live/ deleted/historicised. We only require live and historicised PBAs | PBA type |
| Date of the event | The date that the procedure took place on that this PBA refers to | Assessment PBA |
| Rater training for assessment | Categorical rating for if the trainer has received training for this type of assessment: variable repeated for “No/Read guideline/Web-based/CD training/ Face to face” | Assessment PBA |
| Operation more difficult than usual | Binary indicator of whether the operation was difficult | Assessment PBA |
| Performance Level | Overall global judgement of performance. Rated 0-4 | Assessment PBA |
| PBA question ID | The identifier for the assessments in each domain (I.Consent/ II Pre-operative etc) | Assessment PBA Rating |
| Rating | Rating of whether the trainee was judged to be satisfactory, needs development or not seen for each domain. | Assessment PBA Rating |
| Simulated/Not | Binary indicator of whether the PBA was performed in a simulated environment. 1= simulated, 0= not. | Assessment PBA |
| PBA complexity ID | Identifier for the complexity type of the PBA. | Assessment PBA |

| | | |
|---|---|---|
| Satisfaction rating- Trainee | The trainee satisfaction rating with the assessment | Assessment PBA |
| Satisfaction rating- Trainer | The trainer satisfaction rating with the assessment | Assessment PBA |
| Status of assessment form in database | Whether the form is submitted/ validated or deleted. We will only require validated PBAs | Assessment PBA |
| Date when form started and saved | The date that the user started to complete the PBA form | Assessment PBA |
| Validation date of the PBA | The date that the PBA from was validated | Relationship Table |
| Validator user type | The type of user inputting the validation information. Trainee/AES/CS/TPD/Consultant | Relationship Table/ User table |
| **FOR THE VAULT** | | |
| Reasons for difficult operation | Free text explaining why the operation was judged to be more difficult than usual | Assessment PBA |
| Trainee PBA Comments | Free text global summary comment from the trainee | Assessment PBA |
| Rater PBA Comments | Free text global summary comment from the rater | Assessment PBA |

### 3. ARCP

| **Field name** | **Description** | **Table source** |
|---|---|---|
| Trainee unique identifier | The unique identifier for the trainee that all the ARCP info relates to | ARCP Trainees |
| Data source | Whether the ARCP data is from ISCP or SIMS database | CS to create variable |
| ARCP Date | The date that the ARCP was held | ARCP |
| ARCP type | Binary indicator of whether ARCP is interim or annual. | ARCP |
| ARCP outcome set | If the form is for an interim ARCP, user can elect to set an outcome or not. This is a binary indicator of whether an outcome is set for the ARCP or not. | ARCP |
| ARCP outcome | The ARCP outcome given to the trainee | ARCP Trainees |
| Trainee Training level at ARCP | The training level of the trainee at the time of the ARCP. | ARCP Trainees |
| ARCP period covered | The time period that the ARCP is referring to. Binary indicator of where the date information has come from- manual entry or placement selection. | ARCP Trainees |
| ARCP start date | Start date of the ARCP time period | ARCP Trainees if entered manually.<br>Relationship (placement) table if placement selection |
| ARCP end date | End date of the ARCP time period | ARCP Trainees if entered manually. |

| | | |
|---|---|---|
| | | Relationship (placement) table if placement selection |
| ARCP unresolved causes of concerns? | Binary indicator of whether there are any unresolved causes of concerns | ARCP Trainees |
| Days out of training | Number of days spent out of training during the ARCP period. The GMC require anything more than 2 weeks for sick/paternity/maternity/compassionate/carers leave to have the trainee CCT reviewed (not necessarily changed, but reviewed as a minimum). | ARCP Trainees |
| Training level at next rotation | Selectable level for the trainee's training level at next rotation. | ARCP Trainees |
| **FOR THE VAULT** | | |
| ARCP detailed reasons | Free text describing the reasons for the ARCP outcome | ARCP Trainees |
| ARCP mitigating | Free text describing any mitigating circumstances for the ARCP outcome | ARCP Trainees |
| ARCP competencies | Free text describing any actions to be taken by the trainee | ARCP Trainees |
| ARCP additional training time | Free text describing any recommended additional training time required by the trainee. | ARCP Trainees |
| ARCP unresolved causes of concerns | Free text explaining any concerns | ARCP Trainees |

## 4. elogbook data

| Field Name | Description | Notes |
|---|---|---|
| Trainee unique identifier | Unique identifier for matching to the ISCP numbers. | Cristel will remove GMC numbers and replace with the linked identifiers. |
| YIT | Year in Training- relates to the ST level of the trainee recorded in the eLogbook | Need to confirm that YIT1= ST1. |
| Operation Date | The date that the operation was performed on | |
| Operation ID | Unique identifier for each individual operation | |
| Private | Binary indicator of whether operation was a private operation or NHS | Exclude all private operations for purposes of analysis |
| Patient age | Continuous variable of patient age. Extracted from patient DoB variable in eLogbook database. | |
| ASA grade | The American Society of Anaesthesiologists scoring grade for the patient | |
| Operation Code | The code that the operation is listed as. | Codebook provided of the list of operation codes. Still require algorithm for index procedures. |
| Operation Description | The name of the operation that the code corresponds to. | |
| Hospital Code | The code for the hospital that the operation was performed in | |
| Consultant | Unique identifier for the operation that the patient was under the care of. “Null” if not entered. | |
| Supervision | Supervision code for the operation | |

| | | |
|---|---|---|
| Supervision Text | The text that corresponds to the supervision code. | |
| CEPOD | The CEPOD (Confidential Enquiry Into Perioperative Deaths) code for the urgency that the operation was done | |
| Complication | Binary indicator of whether the patient has been recorded as having a complication | |
| Laparoscopy | Categorical variable indicating whether the procedure was laparoscopic approach. | |
| Is Emergency | Categorical variable reflecting whether the operation was emergency | |
| Time of Day | Categorical variable recording what time of day the operation was performed. | |
| Fatal Complication | Categorical variable recording whether a fatality was recorded | |
| Complication | Categorical variable recording type of complication | Is this specific to each operation? E.g. Haemorrhoidectomy has internal fistula as post-op complication. |
| Opside | Categorical variable indicating whether the operation refers left/right/bilateral? | Confirm with AL. Haemorrhoidectomy data has 0/1/4 as variables. No descriptors. |
| Patient Sex | Categorical variable | |

**Summary of free text variables requested in tables 1-3**

**These data are to be held by Cristel at the RCS for future queries.**

| **Field name** | **Description** | **Table source** |
|---|---|---|
| Certification type identifier | Identifier for the type of certificate a trainee has: CCT/ CESA CP. | Trainee Details |
| Notes | Free text notes made by JCST administrator regarding changes in training | Trainee details |
| Reasons for difficult operation | Free text explaining why the operation was judged to be more difficult than usual | Assessment PBA |
| Trainee PBA Comments | Free text global summary comment from the trainee | Assessment PBA |
| Rater PBA Comments | Free text global summary comment from the rater | Assessment PBA |
| ARCP detailed reasons | Free text describing the reasons for the ARCP outcome | ARCP Trainees |
| ARCP mitigating | Free text describing any mitigating circumstances for the ARCP outcome | ARCP Trainees |
| ARCP competencies | Free text describing any actions to be taken by the trainee | ARCP Trainees |
| ARCP additional training time | Free text describing any recommended additional training time required by the trainee. | ARCP Trainees |

| | | |
|---|---|---|
| ARCP unresolved causes of concerns | Free text explaining any concerns | ARCP Trainees |

## Appendix 3: Excluded operations

Colonoscopy - diagnostic

Colonoscopy - polypectomy / EMR

Colonoscopy - stent insertion

Colonoscopy - stricture dilatation

Colonoscopy - therapeutic (other)

Cricothyroidotomy

Diagnostic peritoneal lavage

ERCP - biliary manometry

ERCP - biliary stenting

ERCP - diagnostic

ERCP - endoscopic sphincterotomy

ERCP - pancreatic stenting

Oesophagoscopy - rigid

OGD - dilatation - balloon for achalasia

OGD - dilatation - oesophageal

OGD - dilatation - pyloric

OGD - endoscopic laser recanalisation

OGD - endoscopic mucosal resection

OGD - GI bleeding - endostasis

OGD - GI bleeding - variceal banding/sclerosis

OGD - oesphageal stenting

Paraphimosis - reduction

Arterial line

Biopsy - core

Central venous catheterisation

Chest drain - insertion

Fine Needle Aspiration

OGD - diagnostic

Peritoneal aspiration

Pleural aspiration

Sigmoidoscopy - flexible

Sigmoidoscopy - rigid (incl. Proctoscopy)

## Appendix 4: Index procedure algorithms

**Emergency Laparotomy**

Any of the below procedures PLUS CEPOD code urgent or immediate.

AAA - bifurcated graft - ruptured

AAA - tube graft - ruptured

Aorto-intestinal fistula repair

Colectomy - left

**obsolete (Colectomy - perf / obstr - lavage / anastomosis)

Colectomy - right

Colectomy - sigmoid

Colectomy - subtotal

Colectomy - total + ileorectal anastomosis

Colectomy - total + ileostomy

Colectomy - transverse

**obsolete (Colostomy - defunctioning)

Colostomy - formation

Combined transplant - multivisceral - donor

Duodenum - oversew / bleeding DU

Duodenum - perforated DU closure

**obsolete (Fistula - colovesical)

**obsolete (Fistula - operation for intestinal fistula)

Gastrectomy - subtotal

Gastrectomy - total

Gastric - antrectomy and Roux diversion

Gastric - gastrojejunostomy +/- vagotomy

Gastric - limited operation / oversew / perforated ulcer

Gastric - volvulus reduction / resection

Hartmann's - resection - perf / obstr

Ileocolic resection

Ileo-transverse by-pass

Intussusception - reduction

Intussusception - resection

**obsolete (Intussusception-reduction)

**obsolete (Intussusception-resection)

Laparoscopy - drainage of intrabdominal abscess/sepsis, no resection

Laparoscopy - inoperable malignancy +/- by-pass

Laparoscopy - post operative complications

Laparoscopy - small bowel resection

Laparotomy - division of adhesions

Laparotomy - drainage of intrabdominal abscess/sepsis, no resection

Laparotomy - inoperable malignancy +/- by-pass

Laparotomy - post operative complications

Laparotomy - small bowel resection

Laparotomy - staging/diagnostic, no other procedure

**obsolete (Laparotomy/laparoscopy - abdominal abscess/sepsis)

**obsolete (Laparotomy/laparoscopy - bowel ischaemia)

**obsolete (Laparotomy/laparoscopy - colectomy for bleeding)

**obsolete (Laparotomy/laparoscopy - division of adhesions)

**obsolete (Laparotomy/laparoscopy - inoperable malignancy +/- by-pass)

**obsolete (Laparotomy/laparoscopy - on table enteroscopy)

**obsolete (Laparotomy/laparoscopy - other)

**obsolete (Laparotomy/laparoscopy - perf / obstr - ileostomy)

**obsolete (Laparotomy/laparoscopy - post operative complications)

**obsolete (Laparotomy/laparoscopy - small bowel obstr/resection)

Liver - trauma - debridement/packing

Oesophagus - rupture repair

Pancreas - debridement/drainage of pancreatic abscess

Pancreas - distal pancreatectomy

Reconstruction - arterial - mesenteric

Rectum - anterior resection

Re-operation - inflammatory bowel disease

**obsolete (Re-operation - post-operative complication)

Spleen - splenectomy - trauma

Spleen - splenic repair / conservation

**obsolete (Trauma - gunshot injury)

**obsolete (Trauma - gunshot injury - laparotomy/laparoscopy)

**obsolete (Trauma - laparotomy/laparoscopy)

Urology - laparotomy - bladder

Urology – nephrectomy

**Appendicectomy**

Appendicectomy

Paediatric appendicectomy

**Inguinal hernia**

Hernia- inguinal

Hernia- inguinal recurrent

Hernia- laparoscopic- extraperitoneal

**Colectomy**

Colectomy – left

Colectomy perf/obstr/lavage/anastomosis

Colectomy- right

Colectomy – sigmoid

Colectomy- subtotal

Colectomy- total + ileorectal anastomosis

Colectomy- total +ileostomy

Colectomy – transverse

Ileocolic resection

**Hartmann’s**

Hartmann's - resection - perf / obstr

## Appendix 5: Indicative procedure PBA codes

**Appendicectomy**

Appendicectomy

Laparoscopic Appendicectomy Pilot v1

Emergency Appendicectomy

Paediatric Surgery: GI: Appendicectomy

**Inguinal hernia repair**

Elective: Hernia Repair- Inguinal

**Segmental Colectomy**

Right Hemicolectomy pilot v1

Colorectal- colectomy- right

Left Hemicolectomy pilot v1

Total Colectomy pilot v1

Colorectal- Generic segmental colectomy

**Cholecystectomy**

HPB- Laparoscopic cholecystectomy

HPB- Laparoscopic cholecystectomy v2

Oesophagogastric- Laparoscopic cholecystectomy

# References


1. The CanMEDS Framework. http://www.royalcollege.ca/rcsite/canmeds/canmeds-framework-e [accessed 6th May 2016].

2. Zerhouni YA, Abu-Bonsrah N, Mehes M, Goldstein S, Buyske J, Abdullah F. General surgery education: a systematic review of training worldwide. *Lancet* 2015;385 Suppl 2: S39.

3. ISCP General Surgery 2013 Syllabus. https://www.iscp.ac.uk/static/public/syllabus/syllabus_gs_2016.pdf [accessed 21st September 2016].

4. SCORE curriculum. http://portal.surgicalcore.org/public/curriculum [accessed 16th May 2016].

5. Borel-Rinkes IH, Gouma DJ, Hamming JF. Surgical training in the Netherlands. *World J Surg* 2008;32(10): 2172-2177.

6. American Board of Surgery: Booklet of Information- Surgery. https://www.absurgery.org/xfer/BookletofInfo-Surgery.pdf [accessed 1st June 2016].

7. Joint Committee for Surgical Training Certification Guidelines for General Surgery. https://www.jcst.org/quality-assurance/certification-guidelines-and-checklists/ [accessed 10th January 2016].

8. Kamali P, van Paridon MW, Ibrahim AMS, Paul MA, Winters HA, Martinot-Duquennoy V, Noah EM, Pallua N, Lin SJ. Plastic Surgery Training Worldwide: Part 1. The United States and Europe. *Plastic and Reconstructive Surgery – Global Open* 2016;4(3): e641.

9. Tchantchaleishvili V, Mokashi SA, Rajab TK, Bolman RM, III, Chen FY, Schmitto JD. Comparison of cardiothoracic surgery training in usa and germany. *J Cardiothorac Surg* 2010;5: 118-118.

10. The College of Surgeons of Hong Kong: Training requirements. http://www.cshk.org/cshk.php?page=page&menupageid=6066 [accessed 16th May 2016].

11. Intercollegiate Surgical Curriculum Programme www.iscp.ac.uk [accessed 16th May 2016].

12. van der Linden W, Warg A, Nordin P. National register study of operating time and outcome in hernia repair. *Arch Surg* 2011;146(10): 1198-1203.

13. Maruthappu M, Gilbert BJ, El-Harasis MA, Nagendran M, McCulloch P, Duclos A, Carty MJ. The influence of volume and experience on individual surgical performance: a systematic review. *Ann Surg* 2015;261(4): 642-647.

14. Schmidt C, Turrini O, Parikh P, et al. Effect of hospital volume, surgeon experience, and surgeon volume on patient outcomes after pancreaticoduodenectomy: A single-institution experience. *Arch Surg* 2010;145(7): 634-640.

15. Stolzenburg JU, Qazi HA, Holze S, Mende M, Nicolaus M, Franz T, Ho Thi P, Dietel A, Liatsikos E, Do M. Evaluating the learning curve of experienced laparoscopic surgeons in robot-assisted radical prostatectomy. *J Endourol* 2013;27(1): 80-85.

16. Tekkis PP, Senagore AJ, Delaney CP, Fazio VW. Evaluation of the learning curve in laparoscopic colorectal surgery: comparison of right-sided and left-sided resections. *Ann Surg* 2005;242(1): 83-91.

17. Li JC, Lo AW, Hon SS, Ng SS, Lee JF, Leung KL. Institution learning curve of laparoscopic colectomy--a multi-dimensional analysis. *Int J Colorectal Dis* 2012;27(4): 527-533.

18. Beard JD, Marriott J, Purdie H, Crossley J. Assessing the surgical skills of trainees in the operating theatre: a prospective observational study of the methodology. *Health Technology Assessment (Winchester, England)* 2011;15(1): i-xxi, 1-162.

19. De Siqueira JR, Gough MJ. Correlation between experience targets and competence for general surgery certification. *Br J Surg* 2016;103(7): 921-927.

20. Abdelrahman T, Long J, Egan R, Lewis WG. Operative Experience vs. Competence: A Curriculum Concordance and Learning Curve Analysis. *J Surg Educ* 2016;73(4): 694-698.

21. Foundation Programme: Curriculum and Assessment. http://www.foundationprogramme.nhs.uk/pages/curriculum-eportfolio/curriculum-assessment [accessed 21st February 2017].

22. Guidance for using the Case-Based Discussion (CBD) https://www.iscp.ac.uk/static/public/cbd_guidance.pdf [accessed 21st February 2017].

23. Guidance for using the Clinical Evaluation Exercise (CEX) https://www.iscp.ac.uk/static/public/cex_guidance.pdf [accessed 21st February 2017].

24. Guidance for using Surgical DOPS. https://www.iscp.ac.uk/static/public/sdops_guidance.pdf [accessed 21st February 2017].

25. Beard J, Rowley D, Bussey M, Pitts D. Workplace-based assessment: assessing technical skill throughout the continuum of surgical training. *ANZ J Surg* 2009;79(3): 148-153.

26. ISCP Surgical Curriculum: Assessment. https://www.iscp.ac.uk/surgical/assessment_overview.aspx [accessed 3rd December 2015].

27. Collete A. Academy of Medical Royal Colleges: Improving Assessment: Academy of Medical Royal Colleges; 2009.

28. Schuwirth LW, van der Vleuten CP. General overview of the theories used in assessment: AMEE Guide No. 57. *Med Teach* 2011;33(10): 783-797.

29. Cook DA, Beckman TJ. Current concepts in validity and reliability for psychometric instruments: theory and application. *Am J Med* 2006;119(2): 166.e167-116.

30. Gallagher AG, Ritter EM, Satava RM. Fundamental principles of validation, and reliability: rigorous science for the assessment of surgical education and training. *Surg Endosc* 2003;17(10): 1525-1529.

31. van Hove PD, Tuijthof GJ, Verdaasdonk EG, Stassen LP, Dankelman J. Objective assessment of technical surgical skills. *Br J Surg* 2010;97(7): 972-987.

32. Birkmeyer JD, Finks JF, O'Reilly A, Oerline M, Carlin AM, Nunn AR, Dimick J, Banerjee M, Birkmeyer NJ, Michigan Bariatric Surgery C. Surgical skill and complication rates after bariatric surgery. *N Engl J Med* 2013;369(15): 1434-1442.

33. Harris P, Bhanji F, Topps M, Ross S, Lieberman S, Frank JR, Snell L, Sherbino J. Evolving concepts of assessment in a competency-based world. *Med Teach* 2017;39(6): 603-608.

34. Lockyer J, Carraccio C, Chan M-K, Hart D, Smee S, Touchie C, Holmboe ES, Frank JR. Core principles of assessment in competency-based medical education. *Med Teach* 2017;39(6): 609-616.

35. Szasz P, Louridas M, Harris KA, Aggarwal R, Grantcharov TP. Assessing Technical Competence in Surgical Trainees: A Systematic Review. *Ann Surg* 2015;261(6): 1046-1055.

36. Ahmed K, Miskovic D, Darzi A, Athanasiou T, Hanna GB. Observational tools for assessment of procedural skills: a systematic review. *Am J Surg* 2011;202(4): 469-480.e466.

37. Crossley J, Marriott J, Purdie H, Beard JD. Prospective observational study to evaluate NOTSS (Non-Technical Skills for Surgeons) for assessing trainees' non-technical performance in the operating theatre. *Br J Surg* 2011;98(7): 1010-1020.

38. Gofton WT, Dudek NL, Wood TJ, Balaa F, Hamstra SJ. The Ottawa Surgical Competency Operating Room Evaluation (O-SCORE): A Tool to Assess Surgical Competence. *Acad Med* 2012;87(10): 1401-1407.

39. MacEwan MJ, Dudek NL, Wood TJ, Gofton WT. Continued Validation of the O-SCORE (Ottawa Surgical Competency Operating Room Evaluation): Use in the Simulated Environment. *Teach Learn Med* 2016;28(1): 72-79.

40. Reznick R, Regehr G, MacRae H, Martin J, McCulloch W. Testing technical skill via an innovative 'bench station' examination. *Am J Surg* 1997;173(3): 226-230.

41. Faulkner H, Regehr G, Martin J, Reznick R. Validation of an objective structured assessment of technical skill for surgical residents. *Acad Med* 1996;71(12): 1363-1365.

42. George BC, Teitelbaum EN, Meyerson SL, Schuller MC, DaRosa DA, Petrusa ER, Petito LC, Fryer JP. Reliability, validity, and feasibility of the Zwisch scale for the assessment of intraoperative performance. *J Surg Educ* 2014;71(6): e90-96.

43. Miller GE. The assessment of clinical skills/competence/performance. *Acad Med* 1990;65(9): S63-67.

44. Brown C, Abdelrahman T, Patel N, Thomas C, Pollitt MJ, Lewis WG. Operative learning curve trajectory in a cohort of surgical trainees. *Br J Surg* 2017;104(10): 1405-1411.

45. Royal College of Obstetricians and Gynaecologists: OSATS. https://www.rcog.org.uk/en/careers-training/about-specialty-training-in-og/assessment-and-progression-through-training/workplace-based-assessments/osats/ [accessed 22nd September 2018].

46. DaRosa DA, Zwischenberger JB, Meyerson SL, George BC, Teitelbaum EN, Soper NJ, Fryer JP. A theory-based model for teaching and assessing residents in the operating room. *J Surg Educ* 2013;70(1): 24-30.

47. Procedural Learning and Safety Collaborative: About SIMPL. http://www.procedurallearning.org/simpl/about-simpl [accessed 25th September 2018].

48. Larson JL, Williams RG, Ketchum J, Boehler ML, Dunnington GL. Feasibility, reliability and validity of an operative performance rating system for evaluating surgery residents. *Surgery* 2005;138(4): 640-647; discussion 647-649.

49. George BC, Bohnen JD, Williams RG, Meyerson SL, Schuller MC, Clark MJ, Meier AH, Torbeck L, Mandell SP, Mullen JT, Smink DS, Scully RE, Chipman JG, Auyang ED, Terhune KP, Wise PE, Choi JN, Foley EF, Dimick JB, Choti MA, Soper NJ, Lillemoe KD, Zwischenberger JB, Dunnington GL, DaRosa DA, Fryer JP. Readiness of US General Surgery Residents for Independent Practice. *Ann Surg* 2017;266(4): 582-594.

50. Williams RG, Sanfey H, Chen XP, Dunnington GL. A controlled study to determine measurement conditions necessary for a reliable and valid operative performance assessment: a controlled prospective observational study. *Ann Surg* 2012;256(1): 177-187.

51. Mason JD, Ansell J, Warren N, Torkington J. Is motion analysis a valid tool for assessing laparoscopic skill? *Surg Endosc* 2013;27(5): 1468-1477.

52. Datta V, Mackay S, Darzp ARA, Gillies D. Motion Analysis in the Assessment of Surgical Skill. *Computer Methods in Biomechanics and Biomedical Engineering* 2001;4(6): 515-523.

53. Macmillan AIM, Cuschieri A. Assessment of innate ability and skills for endoscopic manipulations by the Advanced Dundee Endoscopic Psychomotor Tester: predictive and concurrent validity. *The American Journal of Surgery* 1999;177(3): 274-277.

54. Van Sickle KR, III DAM, Gallagher AG, Smith CD. Construct validation of the ProMIS simulator using a novel laparoscopic suturing task. *Surgical Endoscopy And Other Interventional Techniques* 2005;19(9): 1227-1231.

55. Generic professional capabilities framework. Manchester, UK: General Medical Council; 2017.

56. Excellence by design: standards for postgraduate curricula. Manchester, UK: General Medical Council; 2017.

57. Moore D, Young CJ, Hong J. Implementing entrustable professional activities: the yellow brick road towards competency-based training? *ANZ J Surg* 2017;87(12): 1001-1005.

58. Wagner JP, Lewis CE, Tillou A, et al. Use of entrustable professional activities in the assessment of surgical resident competency. *JAMA Surgery* 2017.

59. Entrustable Professional Activities (EPAs) and Applications to Surgical Training. https://www.facs.org/education/division-of-education/publications/rise/articles/entrustable [accessed 18th January 2018].

60. ten Cate O, Hart D, Ankel F, Busari J, Englander R, Glasgow N, Holmboe E, Iobst W, Lovell E, Snell LS, Touchie C, Van Melle E, Wycliffe-Jones K, Collaborators

obotIC-BME. Entrustment Decision Making in Clinical Training. *Acad Med* 2016;91(2): 191-198.

61. ten Cate O. Entrustability of professional activities and competency-based training. *Med Educ* 2005;39(12): 1176-1177.

62. ten Cate O. Nuts and Bolts of Entrustable Professional Activities. *J Grad Med Educ* 2013;5(1): 157-158.

63. eLogbook supervision codes PDF. http://e1v1m1.co.uk/wp-content/uploads/2013/11/Supervision-codes-help-guide.pdf [accessed 10th January 2016].

64. Sher JL, Reed MR, Calvert P, Wallace WA, Lamb A. Influencing the national training agenda. The UK & Ireland orthopaedic eLogbook. *J Bone Joint Surg Br* 2005;87(9): 1182-1186.

65. Shape of Training: Securing the future of excellent patient care. Final report of the independent review. London, UK: General Medical Council; 2013.

66. Digital N. Hospital Admitted Patient Care Activity, 2016-2017: Procedures and interventions; 2017.

67. Lewis FR, Klingensmith ME. Issues in general surgery residency training--2012. *Ann Surg* 2012;256(4): 553-559.

68. Yearly Case Log Reports for Graduating Residents. http://www.acgme.org/Data-Collection-Systems/Case-Logs-Statistical-Reports [accessed 1st April 2016].

69. Miguelena Bobadilla JM, Morales-García D, Iturburu Belmonte I, Alcázar Montero JA, Serra Aracil X, Docobo Durantez F, López de Cenarruzabeitia I, Sanz Sánchez M, Hernández Hernández JR. General Surgery Training in Spain: Core Curriculum and Specific Areas of Training. *Cirugía Española (English Edition)* 2015;93(3): 147-151.

70. Targarona Soler EM, Jover Navalon JM, Gutierrez Saiz J, Turrado Rodríguez V, Parrilla Paricio P. What do General Surgery Residents Operate During the Residency Program? An Analysis of the Applicability of the Specialty Program in General and Digestive Surgery. *Cirugía Española (English Edition)* 2015;93(3): 152-158.

71. Aphinives P. The Trainee's Operative Experiences for General Surgery in Thailand. *The Thai Journal of Surgery* 2014;35(4): 134-138.

72. General Medical Council Homepage. https://www.gmc-uk.org/ [accessed 13th June 2018].

73. The Royal College of Surgeons of England Homepage. https://www.rcseng.ac.uk/ [accessed 18th June 2018].

74. The Royal College of Surgeons of Edinburgh Homepage. https://www.rcseng.ac.uk/ [accessed 18th June 2018].

75. The Royal College of Physicians and Surgeons of Glasgow Homepage. https://rcpsg.ac.uk/ [accessed 18th June 2018].

76. The Royal College of Surgeons in Ireland Homepage. https://www.rcsi.com/dublin/ [accessed 18th June 2018].

77. Health Education England Homepage. https://hee.nhs.uk/ [accessed 8th July 2016].

78. NHS Education for Scotland Homepage. http://www.scotmt.scot.nhs.uk/ [accessed 21st February 2017].

79. Wales Deanery Homepage. https://www.walesdeanery.org/ [accessed 21st February 2017].

80. Northern Ireland Medical and Dental Training Agency Homepage. http://www.nimdta.gov.uk/ [accessed 21st February 2017].

81. Balla F, Garwe T, Motghare P, Stamile T, Kim J, Mahnken H, Lees J. Evaluating Coding Accuracy in General Surgery Residents' Accreditation Council for Graduate Medical Education Procedural Case Logs. *J Surg Educ* 2016;73(6): e59-e63.

82. Nygaard RM, Daly SR, Van Camp JM. General Surgery Resident Case Logs: Do They Accurately Reflect Resident Experience? *J Surg Educ* 2015;72(6): e178-183.

83. Meyerson SL, Teitelbaum EN, George BC, Schuller MC, DaRosa DA, Fryer JP. Defining the autonomy gap: when expectations do not meet reality in the operating room. *J Surg Educ* 2014;71(6): e64-72.

84. Joint Committee for Surgical Training Homepage. http://www.jcst.org/ [accessed 21st January 2017].

85. Modernising Medical Careers Inquiry Report. http://www.asgbi.org.uk/mmc-consensus/pdfs/MMC_InquiryReport.pdf [accessed 9th December 2016].

86. Paice E, Aitken M, Cowan G, Heard S. Trainee satisfaction before and after the Calman reforms of specialist training: questionnaire survey. *BMJ : British Medical Journal* 2000;320(7238): 832-836.

87. House of Commons Health Committee: Modernising Medical Careers Report. http://www.publications.parliament.uk/pa/cm200708/cmselect/cmhealth/25/25i.pdf [accessed 9th December 2016].

88. A Reference Guide for Postgraduate Specialty Training in the UK (Gold Guide 2016): Conference of Postgraduate Medical Deans of the United Kingdom 2016.

89. Jamjoom AAB, Phan PNH, Hutchinson PJ, Kolias AG. Surgical trainee research collaboratives in the UK: an observational study of research activity and publication productivity. *BMJ Open* 2016;6(2).

90. Promoting Excellence: Standards for Medical Education and Training. https://www.gmc-uk.org/-/media/documents/promoting-excellence-standards-for-medical-education-and-training-0715_pdf-61939165.pdf [accessed 13th June 2018].

91. Health Education England homepage. https://hee.nhs.uk/ [accessed 25th July 2017].

92. Allum W, Hornby S, Khera G, Fitzgerald E, Griffiths G. General Surgery Logbook Survey. *The Bulletin of the Royal College of Surgeons of England* 2013;95(4): 1-6.

93. eLogbook homepage. http://www.elogbook.org [accessed 3rd December 2015].

94. JCST Certification of Completion Training guidance. http://www.jcst.org/uk-trainees/str-trainees/certification-1/Certification%20dates%20from%20June%202016%20onwards [accessed 23rd November 2016].

95. ASA physical Status Classification System. https://www.asahq.org/resources/clinical-information/asa-physical-status-classification-system [accessed 7th July 2016].

96. Competition ratios: specialty training UK. https://specialtytraining.hee.nhs.uk/Competition-Ratios [accessed 3rd September 2018].

97. Thomas C, Griffiths G, Abdelrahman T, Santos C, Lewis W. Does UK surgical training provide enough experience to meet today's training requirements? *BMJ Careers* 2015.

98. Birkmeyer JD, Stukel TA, Siewers AE, Goodney PP, Wennberg DE, Lucas FL. Surgeon Volume and Operative Mortality in the United States. *N Engl J Med* 2003;349(22): 2117-2127.

99. Boudourakis LD, Wang TS, Roman SA, Desai R, Sosa JA. Evolution of the surgeon-volume, patient-outcome relationship. *Ann Surg* 2009;250(1): 159-165.

100. Chowdhury MM, Dagash H, Pierro A. A systematic review of the impact of volume of surgery and specialization on patient outcome. *Br J Surg* 2007;94(2): 145-161.

101. Independent Working Time Regulations Task Force. The Implementation of the Working Time Directive, and its Impact on the NHS and Health Professionals. . https://www.rcseng.ac.uk/government-relations-and-consultation/documents/wtd-taskforce-report-2014 [accessed 3rd May 2016].

102. Accreditation Council Graduate Medical Education: Common Program Requirements PDF. http://www.acgme.org/Portals/0/PDFs/Common_Program_Requirements_07012011[2].pdf [accessed 3rd May 2016].

103. Hanks JB, Ashley SW, Mahvi DM, Meredith WJ, Stain SC, Biester TW, Borman KR. Feast or famine? The variable impact of coexisting fellowships on general surgery resident operative volumes. *Ann Surg* 2011;254(3): 476-483; discussion 483-475.

104. Fryer J, Corcoran N, Darosa D. Use of the surgical council on resident education (SCORE) curriculum as a template for evaluating and planning a program's clinical curriculum. *J Surg Educ* 2010;67(1): 52-57.

105. Bell RH, Biester TW, Tabuenca A, Rhodes RS, Cofer JB, Britt LD, Lewis FR. Operative experience of residents in US general surgery programs: A gap between expectation and experience. *Ann Surg* 2009;249(5): 719-724.

106. Chung R, Pham Q, Wojtasik L, Chari V, Chen P. The laparoscopic experience of surgical graduates in the United States. *Surg Endosc* 2003;17(11): 1792-1795.

107. Accreditation Council for Graduate Medical Education: Case Log for Statistical Reports. https://www.acgme.org/acgmeweb/tabid/274/DataCollectionSystems/ResidentCaseLogSystem/CaseLogsStatisticalReports.aspx [accessed 24th March 2016].

108. Malangoni MA, Biester TW, Jones AT, Klingensmith ME, Lewis FR, Jr. Operative experience of surgery residents: trends and challenges. *J Surg Educ* 2013;70(6): 783-788.

109. McCoy AC, Gasevic E, Szlabick RE, Sahmoun AE, Sticca RP. Are open abdominal procedures a thing of the past? An analysis of graduating general surgery residents' case logs from 2000 to 2011. *J Surg Educ* 2013;70(6): 683-689.

110. Eckert M, Cuadrado D, Steele S, Brown T, Beekley A, Martin M. The changing face of the general surgeon: national and local trends in resident operative experience. *Am J Surg* 2010;199(5): 652-656.

111. Sachs TE, Pawlik TM. See one, do one, and teach none: Resident experience as a teaching assistant. *J Surg Res* 2015;195(1): 44-51.

112. Neville AL, Nemceff D, Bricker SD, Plurad D, Bongard F, Putnam BA. Open Appendectomy: No Longer an Intern Case. *The American Surgeon* 2012;78(10): 1178-1181.

113. Unawane A, Kamyab A, Patel M, Flynn JC, Mittal VK. Changing paradigms in minimally invasive surgery training. *Am J Surg* 2013;205(3): 284-288; discussion 288.

114. Carson JS, Smith L, Are M, Edney J, Azarow K, Mercer DW, Thompson JS, Are C. National trends in minimally invasive and open operative experience of graduating general surgery residents: implications for surgical skills curricula development? *Am J Surg* 2011;202(6): 720-726; discussion 726.

115. Alkhoury F, Martin JT, Contessa J, Zuckerman R, Nadzam G. The Impact of Laparoscopy on the Volume of Open Cases in General Surgery Training. *J Surg Educ* 2010;67(5): 316-319.

116. Simien C, Holt KD, Richter TH, Whalen TV, Coburn M, Havlik RJ, Miller RS. Resident operative experience in general surgery, plastic surgery, and urology 5 years

after implementation of the ACGME duty hour policy. *Ann Surg* 2010;252(2): 383-389.

117. Kairys JC, McGuire K, Crawford AG, Yeo CJ. Cumulative operative experience is decreasing during general surgery residency: a worrisome trend for surgical trainees? *J Am Coll Surg* 2008;206(5): 804-811; discussion 811-803.

118. Damadi A, Davis AT, Saxe A, Apelgren K. ACGME Duty-Hour Restrictions Decrease Resident Operative Volume: A 5-Year Comparison at an ACGME-Accredited University General Surgery Residency. *J Surg Educ* 2007;64(5): 256-259.

119. Bland KI, Stoll DA, Richardson JD, Britt LD, Members of the Residency Review C-S. Brief communication of the Residency Review Committee-Surgery (RRC-S) on residents' surgical volume in general surgery. *Am J Surg* 2005;190(3): 345-350.

120. Parsa CJ, Organ CH, Jr., Barkan H. Changing patterns of resident operative experience from 1990 to 1997. *Arch Surg* 2000;135(5): 570-573; discussion 573-575.

121. Liberman MA, Greason K. Residency training in advanced laparoscopic surgery: how are we doing? *Surg Laparosc Endosc Percutan Tech* 1999;9(2): 87-90.

122. Schoetz DJ, Jr. Colon and rectal surgery: a true subspecialty. *Dis Colon Rectum* 1998;41(1): 1-10.

123. Hopmans CJ, den Hoed PT, van der Laan L, van der Harst E, van der Elst M, Mannaerts GH, Dawson I, Timman R, Wijnhoven BP, JN IJ. Impact of the European Working Time Directive (EWTD) on the operative experience of surgery residents. *Surgery* 2015;157(4): 634-641.

124. Serra-Aracil X, Navarro Soto S, Hermoso Bosch J, Miguelena JM, Ramos JL, Martin Perez E, Garcia J, Estrada JL, Rodriguez-Sanjuan JC, Garcia DM, Roig JV, Docobo Durantez F, Landa-Garcia JI. [A prospective, multicentre study on the activity of general and digestive surgery residents based on the use of the computerised logbook]. *Cir Esp* 2012;90(8): 518-524.

125. PRISMA Checklist. http://www.prisma-statement.org/ [accessed 20th April 2016].

126. Royal College of Physicians and Surgeons of Canada. The Future of General Surgery: Evolving to meet a changing practice. http://www.royalcollege.ca/rcsite/education-strategy-accreditation/innovations-development/initiatives/future-general-surgery-project-e [accessed 11th July 2016].

127. Szasz P, Louridas M, de Montbrun S, Harris KA, Grantcharov TP. Consensus-based training and assessment model for general surgery. *Br J Surg* 2016;103(6): 763-771.

128. Borman KR, Vick LR, Biester TW, Mitchell ME. Changing Demographics of Residents Choosing Fellowships: Longterm Data from The American Board of Surgery. *J Am Coll Surg* 2008;206(5): 782-788.

129. Coleman JJ, Esposito TJ, Rozycki GS, Feliciano DV. Early Subspecialization and Perceived Competence in Surgical Training: Are Residents Ready? *J Am Coll Surg* 2013;216(4): 764-771.

130. Fitzgerald JEF, Milburn JA, Khera G, Davies RSM, Hornby ST, Giddings CEB. Clinical Fellowships in Surgical Training: Analysis of a National Pan-specialty Workforce Survey. *World J Surg* 2013;37(5): 945-952.

131. Accreditation Coucil for Graduate Medical Education Surgery Program Requirements and FAQs. http://www.acgme.org/Specialties/Program-Requirements-and-FAQs-and-Applications/pfcatid/24/Surgery [accessed 10th May 2016].

132. Ward ST, Mohammed MA, Walt R, Valori R, Ismail T, Dunckley P. An analysis of the learning curve to achieve competency at colonoscopy using the JETS database. *Gut* 2014;63(11): 1746-1754.

133. Wani S, Hall M, Wang AY, DiMaio CJ, Muthusamy VR, Keswani RN, Brauer BC, Easler JJ, Yen RD, El Hajj I, Fukami N, Ghassemi KF, Gonzalez S, Hosford L, Hollander

TG, Wilson R, Kushnir VM, Ahmad J, Murad F, Prabhu A, Watson RR, Strand DS, Amateau SK, Attwell A, Shah RJ, Early D, Edmundowicz SA, Mullady D. Variation in learning curves and competence for ERCP among advanced endoscopy trainees by using cumulative sum analysis. *Gastrointest Endosc* 2016;83(4): 711-719.e711.

134. Abdelrahman T, Long J, Egan R, Lewis WG. Operative Experience vs. Competence: A Curriculum Concordance and Learning Curve Analysis. *J Surg Educ*.

135. Harries RL, Gokani VJ, Smitham P, Fitzgerald JEF. Less than full-time training in surgery: a cross-sectional study evaluating the accessibility and experiences of flexible training in the surgical trainee workforce. *BMJ Open* 2016;6(4).

136. Thomas C, Elsey E, Boyce T, Catton J, Lewis W. Data from two deaneries regarding the ability of higher surgical training programmes to deliver curriculum targets. *The Bulletin of the Royal College of Surgeons of England* 2015;97(9): e50-e53.

137. Elsey EJ, Griffiths G, Humes DJ, West J. Meta-analysis of operative experiences of general surgery trainees during training. *Br J Surg* 2017;104(1): 22-33.

138. Robertson CM, Klingensmith ME, Coopersmith CM. Prevalence and cost of full-time research fellowships during general surgery residency: a national survey. *Ann Surg* 2009;249(1): 155-161.

139. Ellis MC, Dhungel B, Weerasinghe R, Vetto JT, Deveney K. Trends in Research Time, Fellowship Training, and Practice Patterns Among General Surgery Graduates. *Journal of Surgical Education* 2011;68(4): 309-312.

140. Lee MJ, Bhangu A, Blencowe NS, Nepogodiev D, Gokani VJ, Harries RL, Akinfala M, Ali O, Allum W, Bosanquet DC, Boyce K, Bradburn M, Chapman SJ, Christopher E, Coulter I, Dean BJF, Dickfos M, El Boghdady M, Elmasry M, Fleming S, Glasbey J, Healy C, Kasivisvanathan V, Khan KS, Kolias AG, Lee SM, Morton D, O'Beirne J, Sinclair P, Sutton PA. Academic requirements for Certificate of Completion of Training in surgical training: Consensus recommendations from the Association of

Surgeons in Training/National Research Collaborative Consensus Group. *International Journal of Surgery*;36: S24-S30.

141. Bhangu A, Kolias AG, Pinkney T, Hall NJ, Fitzgerald JE. Surgical research collaboratives in the UK. *The Lancet* 2013;382(9898): 1091-1092.

142. Milburn JA, Khera G, Hornby ST, Malone PS, Fitzgerald JE. Introduction, availability and role of simulation in surgical education and training: review of current evidence and recommendations from the Association of Surgeons in Training. *Int J Surg* 2012;10(8): 393-398.

143. Sonnadara RR, Mui C, McQueen S, Mironova P, Nousiainen M, Safir O, Kraemer W, Ferguson P, Alman B, Reznick R. Reflections on competency-based education and training for surgical residents. *J Surg Educ* 2014;71(1): 151-158.

144. Feanny MA, Scott BG, Mattox KL, Hirshberg A. Impact of the 80-hour work week on resident emergency operative experience. *Am J Surg* 2005;190(6): 947-949.

145. Pinkney TD, Calvert M, Bartlett DC, Gheorghe A, Redman V, Dowswell G, Hawkins W, Mak T, Youssef H, Richardson C, Hornby S, Magill L, Haslop R, Wilson S, Morton D. Impact of wound edge protection devices on surgical site infection after laparotomy: multicentre randomised controlled trial (ROSSINI Trial). *BMJ : British Medical Journal* 2013;347.

146. Multicentre observational study of performance variation in provision and outcome of emergency appendicectomy. *Br J Surg* 2013;100(9): 1240-1252.

147. GlobalSurg C. Mortality of emergency abdominal surgery in high-, middle- and low-income countries. *Br J Surg* 2016;103(8): 971-988.

148. Morton D, Bicknell CD. Should surgical training include involvement in a clinical trial? *BMJ : British Medical Journal* 2015;350.

149. Treasure T, Morton D. GRIST: Growing Recruitment in Interventional and Surgical Trials. *J R Soc Med* 2012;105(4): 140-141.

150. Blencowe NS, Cook JA, Pinkney T, Rogers C, Reeves BC, Blazeby JM. Delivering successful randomized controlled trials in surgery: Methods to optimize collaboration and study design. *Clinical Trials* 2017;14(2): 211-218.

151. GRANULE: Generating student recruiters for randomised trials. https://www.acpgbi.org.uk/content/uploads/2017/01/Granule-2016-article.pdf [accessed 8th September 2017].

152. Lambert TW, Smith F, Goldacre MJ. Why doctors consider leaving UK medicine: qualitative analysis of comments from questionnaire surveys three years after graduation. *J R Soc Med* 2018;111(1): 18-30.

153. Khoushhal Z, Hussain MA, Greco E, et al. Prevalence and causes of attrition among surgical residents: A systematic review and meta-analysis. *JAMA Surgery* 2017;152(3): 265-272.

154. Viola KV, Bucholz E, Yeo H, Piper CL, Bell RH, Jr, Sosa J. Impact of family and gender on career goals: Results of a national survey of 4586 surgery residents. *Arch Surg* 2010;145(5): 418-424.

155. Lebares CC, Guvva EV, Ascher NL, O'Sullivan PS, Harris HW, Epel ES. Burnout and Stress Among US Surgery Residents: Psychological Distress and Resilience. *J Am Coll Surg* 2018;226(1): 80-90.

156. Sammon J, Perry A, Beaule L, Kinkead T, Clark D, Hansen M. Robot-assisted radical prostatectomy: learning rate analysis as an objective measure of the acquisition of surgical skill. *BJU Int* 2010;106(6): 855-860.

157. Ian Eardley HS, David Wilkinson. Why a career in surgery is no longer the golden ticket. *BMJ Careers* 2005.

158. Improving Surgical Training: A proposal for a pilot surgical training programme. London, UK: The Royal College of Surgeons of England; 2015.

159. Reid-Lombardo K, Glass CC, Marcus SG, Liesinger J, Jones DB, Ssat. Workforce Shortage for General Surgeons: Results from the Society for Surgery of the Alimentary Track (SSAT) Surgeon Shortage Survey. *J Gastrointest Surg* 2014;18(12): 2061-2073.

160. Phillips AW, Madhavan A, Bookless LR, Macafee DA. Surgical Trainers' Experience and Perspectives on Workplace-Based Assessments. *J Surg Educ* 2015;72(5): 979-984.

161. Bindal T, Wall D, Goodyear HM. Trainee doctors' views on workplace-based assessments: Are they just a tick box exercise? *Med Teach* 2011;33(11): 919-927.

162. Shalhoub J, Marshall DC, Ippolito K. Perspectives on procedure-based assessments: a thematic analysis of semistructured interviews with 10 UK surgical trainees. *BMJ Open* 2017;7(3).

163. Shalhoub J, Santos C, Bussey M, Eardley I, Allum W. A Descriptive Analysis of the Use of Workplace-Based Assessments in UK Surgical Training. *J Surg Educ* 2015;72(5): 786-794.

164. Ahmed N, Devitt KS, Keshet I, Spicer J, Imrie K, Feldman L, Cools-Lartigue J, Kayssi A, Lipsman N, Elmi M, Kulkarni AV, Parshuram C, Mainprize T, Warren RJ, Fata P, Gorman MS, Feinberg S, Rutka J. A systematic review of the effects of resident duty hour restrictions in surgery: impact on resident wellness, training, and patient outcomes. *Ann Surg* 2014;259(6): 1041-1053.

165. Bruce PJ, Helmer SD, Osland JS, Ammar AD. Operative volume in the new era: a comparison of resident operative volume before and after implementation of 80-hour work week restrictions. *J Surg Educ* 2010;67(6): 412-416.

166. Carlin AM, Gasevic E, Shepard AD. Effect of the 80-hour work week on resident operative experience in general surgery. *Am J Surg* 2007;193(3): 326-329; discussion 329-330.

167. Bates T, Cecil E, Greene I. The effect of the EWTD on training in general surgery: an analysis of electronic logbook records. *The Bulletin of the Royal College of Surgeons of England* 2007;89(3): 106-109.

168. Elaine L, James ED, Kieran JOF, Timothy T, Richard R. A five-year review of operative experience and indicative numbers in urological training in the UK and Ireland. *Journal of Clinical Urology* 2017;10(6): 506-512.

169. Safavi A, Lai S, Butterworth S, Hameed M, Schiller D, Skarsgard E. Does operative experience during residency correlate with reported competency of recent general surgery graduates? *Can J Surg* 2012;55(4): S171-177.

170. Napolitano LM, Savarise M, Paramo JC, Soot LC, Todd SR, Gregory J, Timmerman GL, Cioffi WG, Davis E, Sachdeva AK. Are general surgery residents ready to practice? A survey of the American College of Surgeons Board of Governors and Young Fellows Association. *J Am Coll Surg* 2014;218(5): 1063-1072 e1031.

171. Elsey EJ, West J, Griffiths G, Humes DJ. Time Out of General Surgery Specialty training in the UK: A National Database Study. *J Surg Educ*.

172. Shape of the medical workforce: starting the debate on the future consultant workforce: Centre for Workforce Intelligence; 2012.

173. National Emergency Laparotomy Audit. https://www.nela.org.uk/NELA_home [accessed 24th September 2018].

174. The Higher Risk General Surgical Patient: Towards improved care for a forgotten group. https://www.rcseng.ac.uk/library-and-publications/rcs-publications/docs/the-higher-risk-general-surgical-patient/ [accessed 24th September 2018].