Comparison of Canadian and Swiss Surgical Training curricula: Moving on towards competency-based surgical education.

Henry Hoffmann, MD¹, Daniel Oertli, MD¹, Salome Dell-Kuster, MD, MSc^{1,2}, Rachel Rosenthal, MD, PhD¹, Richard Reznick, MD³, Hugh MacDonald, MD³

¹Department of General and Visceral Surgery, University Hospital Basel, Basel, Switzerland

²Basel Institute for Clinical Epidemiology and Biostatistics, University Hospital Basel, Basel, Switzerland

³Department of Surgery, Queen's University, Kingston, Ontario, Canada

Corresponding author:

Henry Hoffmann, MD

Department of Surgery

University Hospital Basel

Spitalstasse 21, 4031 Basel (Switzerland)

Mail to: henry.hoffmann@usb.ch

Abstract

Objective: Quality of surgical training in the era of resident duty hour restrictions (RDHR) is part of an ongoing debate. Most training elements are provided during surgical service. Since exposure to surgical procedures is important but time-consuming, RDHR may affect quality of surgical training. Providing structured training elements may help to compensate for this shortcoming.

Design: This binational anonymous questionnaire-based study evaluates frequency, time and structure of surgical training programs at two typical academic teaching hospitals with different RDHR.

Setting: Departments of Surgery of University of Basel (Basel, Switzerland) and the Queen's University (Kingston, Ontario, Canada).

Participants: Surgical consultants and residents of the Queen's University Hospital (Kingston, Ontario, Canada) and the University Hospital Basel (Basel, Switzerland) were eligible for this study.

Results: Questionnaire response rate was 37% (105/284). Queen's residents work 80h per week, receiving 7h of formal training (8.8% of work week). Basel residents work 60h per week, including 1h of formal training (1.7% of working time). Queen's faculty and residents rated their program as "structured or "rather structured" in contrast to Basel faculty and residents who rated their programs as "neutral" in structure or "unstructured". Respondents identified specific structured training elements more frequently at Queen's than in Basel. Two thirds of residents' responded that they seek out additional surgical experiences through voluntary extra work. Basel participants articulated a stronger need for improvement of current surgical training. While Basel residents and consultants in both institutions fear negative impact of RDHR on the training program, this was not the case in Queen's residents.

Conclusions: Providing more structured surgical training elements may be advantageous in providing optimal quality surgical education in an era of work hour restrictions.

Keywords: Surgical education, resident duty hour restriction, structured surgical training.

Introduction

Several European countries are faced with an ongoing debate about quality of surgical training in the era of resident duty hour restrictions (RDHR). In 2005, the Swiss government implemented a 50 hour RDHR per week for all residency programs, responding to the rising concerns of patient safety¹⁻⁶ with unrestricted working hours. Likewise, the European Union⁷, the United States of America⁴ and Canada⁸ have implemented compulsory RDHR with different limits of maximum allowed working hours.

Apart from patient safety concerns¹⁻⁶ it is still a matter of debate as to whether RDHR have a negative impact on the residents' exposure to surgical procedures and therefore on the quality of surgical education⁹⁻¹³. Evidence is mixed, and there are bodies of evidence that suggest that RDHR both do, and do not adversely affect surgical training. For example, Meoonesingh and colleagues reported that the imposed 80 hour RDHR in the United States does not seem to have affected patient safety and has had limited effect on postgraduate training¹⁴. Additionally, Sadaba and Urso report that alternative working patterns can be deployed to preserve the exposure of residents to surgical procedures¹³. Reports also suggest that diminished training time does not necessarily translate into a decline in surgical competence¹⁵. Notwithstanding several reassuring reports, there have been numerous opinions and some evidence, that RDHR have adversely affected surgical training. For example, Canadian surgical faculty members believe that RDHR restrictions will have a negative impact on both surgical education and preparation for a surgical career¹⁶. The RDHR in the United States has led to a decrease in numbers of cases performed by trainees^{9,13}, compromising exposure to surgical problems¹⁷. Surgical residents report serious concerns about their procedural competence¹⁸, resulting in suboptimal experiences^{10,19}. There are similar reports from Europe,

indicating that up to one third of surgical trainees are dissatisfied with their training, citing concerns over RDHR and administrative overload²⁰. A recent survey among Swiss surgeons revealed that the 50 hour RDHR may have a negative effect on surgical training and the quality of patient care²¹. However, most published reports are of limited quality and show conflicting results, suggesting that firm conclusions cannot be made¹⁴.

Notwithstanding conflicting data, few would argue that recent changes in the surgical training workplace have been profound. Rooted in an appropriate augmented focus on patient safety, there has been an associated diminution in the degree of independence given to trainees. The rapidly changing development in novel technologies has also resulted in a decrease in trainee experiences. These coupled with RDHR almost worldwide, has posed a serious threat to the integrity of surgical training. It is unlikely that any of these factors will lessen with time. Both, Canada and Switzerland are faced with this problem, albeit the Swiss challenge may be greater given the current stricter RDHR. One possible solution to the emerging dilemma may be the transformation of surgical curricula from pure unstructured, time-based, training to highly structured competency-based programs.

While competency-based education (CBE) has been defined for some aspects of medical training²², there has yet to be significant experience with CBE models in surgery. This notwithstanding, surgical education experts have early on identified the need for highly structured ex vivo training to compensate for the restricted exposure to surgical procedures. This has prompted the development of several initiatives that have used what is ostensibly a competency framework for surgical residency training^{23–31}. This framework is a relatively new concept and deploys evidence-based training models coupled with the assessment of residents' competency with validated tools in various domains³². The curriculum design aims to achieve competency by a variety of strategies: establishing a modular-based format to improve the flexibility of training; a focus on a rapid ascent to technical competence; diminishing wasted time and deploying frequent and multimodal assessment³³. Ferguson and colleagues have presented early experiences from such a framework,

demonstrating that residents exposed to this kind of curriculum may outperform those who have been trained in a traditional time-based, unstructured educational model³³. Highly structured competency-based programs have been shown to be effective^{23,27,33–35} and may indeed reduce the time required to establish competence³³, underlining their potential importance in addressing concerns of surgical training quality in the era of RDHR.

The general surgical training in Switzerland starts with a 6-year medical undergraduate education based on federal legislation, which is in the end conferred with a medical diploma of the Swiss Confederation³⁶. The Swiss Surgical Society (SGC-SSC) governs the postgraduate surgical training, which is typically hospital-based. The registered hospitals are categorized, with a predefined maximum length of residency in each category. The training curriculum contains two examinations; a basic examination after 2 years of surgical training and the specialist board examination after 6 years. The postgraduate training takes a minimum of 6 years. There are two distinct parts: basic training (2 years) and specialist training (4 years). Within these 6 years, there is a minimum requirement of 4 years in general surgery (including 3 months of anesthesia and/or intensive care). By the end of training Swiss trainees must present a signed catalog of their operative activities (logbook), prove that for each year they have accumulated 40 CME (Continuing Medical Education) points, take part in two annual assemblies of the Swiss Society of Surgery and four postgraduate training courses. After gaining board certification most trainees enter further training in surgical specialties (e.g. upper GI and colorectal surgery, vascular surgery, thoracic surgery, trauma surgery). However, recently a modular based surgical training curriculum containing emergency, general, abdominal, and trauma modules has been established. Legal implementation is scheduled for 2016 with a transition period of three years.

The Canadian surgical training curriculum starts directly after graduating from medical school, which in Canada is 4 years in length, except for two Canadian schools which have a three-year curriculum. All medical schools in Canada are “second entry” with an undergraduate degree usually required as a pre-requisite. Surgical training is five years in length, with many trainees opting for further

subspecialty training in the form of a post-training fellowship. The system is university-based, with programs administered and overseen by one of Canada's seventeen medical schools. Training takes place largely at university-affiliated hospitals and health care organizations. The Royal College of Physicians and Surgeons of Canada (RCPSC), which has a mandate for all of specialty medicine, sets standards for the curriculum, sets and administers two examinations, a Principles of Surgery examination and a Fellowship examination, usually at years 2 and year 5 of the curriculum. The RCPSC accredits postgraduate training programs and oversees maintenance of competence program for practicing specialists. Starting in 2017, the RCPSC will be moving specialty programs to a competency-based framework, an initiative that will take several years.

The availability and sophistication of simulation facilities varies widely. Queen's University (Kingston, Ontario, Canada) invested heavily in surgical simulation, including the opening of a new Clinical Simulation Center (CSC) in 2011, designed to facilitate the incorporation of more simulation activities in the surgical curriculum for residency education. The University Hospital Basel is a typical Swiss academic teaching hospital, providing surgical education for all surgical specialties. In 2013, Swiss surgical education began a transformation process towards a more modular-based surgical training program. This change is still in evolution.

The objective of the study was to compare two surgical training programs in academic teaching hospitals in Switzerland and Canada, with the potential to identify opportunities for program enhancement through a comparison of the essential training elements of the two programs.

Material and Methods

In this binational cohort study, we conducted an online survey at Queen's University (Ontario, Canada) and the University Hospital Basel (Switzerland) during a two-month period in September and October 2014. The study was conducted according to the Swiss federal act on research involving human beings (Human Research Act, HRA) and the guidelines of good clinical practice (GCP), not

requiring ethical approval. In Canada, ethics approval was obtained at Queen's University (Ref. No. SURG-293-14, file 6012349). The study population consisted of both surgical residents and surgical faculty at both centers. Participation in this study was voluntary. Contact data and e-mail addresses of participants were provided by the central deanery of the Queen's School of Medicine, and by the University Hospital of Basel, respectively. E-mail invitations for the online-questionnaire were sent simultaneously to all participants (www.surveymonkey.com) in both locations. Regular e-mail reminders were provided to all participants once a week. The questionnaire consisted of 40 questions.

The questionnaire was iteratively modified through a review by three different authors; two content experts in surgery and medical education (HH and RKR) and one with expertise in questionnaire constructions (SDK). Subsequently our questionnaire was pilot tested on a subset of participants (n=5) followed by a careful revision of the questionnaire.

The first part provided questions regarding demographic data (e.g. age, sex, year of residency, marital status, and number of children). The second part focused on the nature of the curriculum with respect to structured and unstructured elements. The third part dealt with respondents' views on surgical training in the era of RDHR, and respondents' views on the challenges inherent in the need for service during surgical residency coupled with the need for formal training elements. Data were handled anonymously. The questionnaire results were downloaded from the online-survey tool as Excel spreadsheets (Microsoft Excel 2010™). The answers were compared between Canadian and Swiss participants. When data were normally distributed, data were expressed by mean and standard deviation (SD), otherwise as median and interquartile range (IQR).

We explored the extent to which specific training elements were part of the curriculum at Queen's versus Basel. These elements included: tutorial lectures, VR simulation training, surgical skills training, teaching ward rounds, use of objective assessments of technical and non-technical skills, the use of established benchmarks for performance and the use of post-operative debriefings. When the majority of these training elements were provided on a regular basis, embedded in a predefined

schedule, surgical training was defined as “structured”. When teaching was performed on an “ad-hoc”, irregular base, it was defined as “unstructured”. Both definitions were given to the participants in the questionnaire

The primary endpoint was comparison of surgical training elements in both institutions. Secondary endpoints were working time per week, frequency of structured and unstructured surgical training elements, and implementation of surgical training in daily practice, and the subjective perception of the quality of current surgical training.

Results

Questionnaires were distributed to participants in September and October 2014. Overall questionnaire response rate was 37% (105/284); 58% (43/74) at Queen’s University and 30% (62/210) at Basel University. Baseline characteristics of all participants are provided in Table 1.

While 86% (n=19) of Queen’s consultants and 57% (n=12) of Queen’s residents reported that their training program was, in general, structured or rather structured, this was only the case for 25% (n=7) of Basel consultants and 3% (n=1) of Basel residents (figure 1). Figure 2 outlines the degree to which structured surgical training elements are present at the study-site institutions. Sixty-eight percent of Queen’s consultants, 52% of Queen’s residents, 75% of Basel consultants, and 50% of Basel residents reported informal, “ad-hoc” tutorial assistance in the operating room. Informal teaching ward rounds was reported by 91% of Queen’s consultants, 62% of Queen’s residents, 79% of Basel consultants, and 59% of Basel residents respectively.

Median weekly working time was reported to be 60 hours (IQR 60-70) for Queen’s consultants, 80 hours (IQR 80-85) for Queen’s residents, 60 hours (IQR 53-65) for Basel consultants and 60 hours

(IQR 55-61) for Basel residents. Considering time spent in surgical training, Queen's consultants report a median of 7.5 hours (IQR 4-14.5) per week in formal structured surgical training, compared to a median of 1.25 hours (IQR 0-5) for Basel consultants. Queen's residents receive a median of 7 hours (IQR 4-10) of structured surgical training per week, compared to 1 hour per week (IQR 0-2) for Basel residents. Accounting for differences in weekly training hours, the proportion of dedicated structured teaching time for Queen's residents was 8.8% of the work week, compared to 1.7% for Basel trainees.

As shown in figure 3, Queen's and Basel participants rated how successfully their current surgical training program was implemented into their daily work. Results indicated a trend towards a more successful implementation at Queen's. The vast majority of Basel residents and consultants articulated the need for improvement of their current surgical training program, while this held less true for Queen's participants (figure 4).

The majority of both Basel consultants (86%, n=24) and residents (79%, n=27), as well as Queen's consultants (95%, n=21) and residents (85%, n=17) believe that training outside operating rooms (e.g. VR stimulation training, surgical laboratory-based skills training) is an important component of surgical education. Following from that, the majority of all participants support the concept that training outside the theatre can benefit patient safety (Basel consultants 82%, n=23; Basel residents 80%, n=27; Queen's consultants 77%, n=15; Queen's residents 77%, n=16). Additionally, the majority of participants believe that training outside the theatre can improve surgical skills (Basel consultants 82%, n=23; Basel residents 82%, n=28; Queen's consultants 86%, n=20; Queen's residents 95%, n=20) and postoperative patient outcomes (Basel consultants 75%, n=21; Basel residents 65%, n=22; Queen's consultants 59%, n=14; Queen's residents 71%, n=15). Most Queen's residents have personal experience with VR simulation training (90%, n=19) and training in a surgical skills laboratory (95%, n=20) while this is only the case for 47% (n=16) of Basel residents for VR simulation

training and 53% (n=18) for training in surgical skills laboratories. However, there was a strong consensus in both institutions that structured surgical training outside the theatre cannot replace exposure to real patients (figure 5).

When asked whether RDHR has negatively impacted surgical training, the majority of all consultants and Basel residents felt that it does, while Queen's residents felt it does not (figure 6). Most Queen's consultants (86%, n=19) and Basel consultants (75%, n=21) believe that surgical residents actually perform less surgical procedures since RDHR restriction has been implemented. Conversely, this was felt to be true by only 25% (n=5) of Queen's residents and 48% (n=16) Basel residents. Sixty-five percent (n=18) of Basel consultants and 47% (n=16) of Basel residents, as well as 55% (n=12) of Queen's consultants and 48% (n=10) of Queen's residents reported that nonetheless some drawbacks, restrictions on working hours "were acceptable" for surgical training. However, some Basel and Queen's residents work voluntarily longer than they are officially sanctioned to gain more surgical experience (figure 7).

Conclusion

The survey results for surgical residents and consultants at Queen's University and Basel University Hospital showed relevant differences. Compared to Basel residents, Queen's residents work significantly longer and get proportionally more training time. The surgical training program at Queen's is viewed to contain more structured training elements than the Basel program. In general, Queen's faculty and trainees believe that formal educational components are successfully integrated with ongoing service requirements. In contrast, Basel participants strongly articulated the need for improvement in the structure of its current program. Faculty at both institutions and residents in Basel expressed concerns that RDHR is having a negative impact on surgical training. This however,

was not the perception for Queen's residents. Of note, residents at both institutions have voluntarily opted to augment their work hours to gain more surgical exposure.

This study contributes to the important discussion about quality and content of surgical education worldwide³⁷, in an era where RDHR challenge the integrity of surgical education, especially given trends towards lessening resident independence in light of rapidly evolving new technologies and an inexorable focus on patient safety. This study uniquely contributes to this discussion by evaluating the perception of residents and consultants from training programs in two different countries. Assuming that training of competent surgeons is a shared objective in surgical education worldwide, the comparison of surgical training programs in two different countries may shed light on the impact of RDHR on surgical training and the role of structured surgical training elements in the era of RDHR.

It is noteworthy that Basel consultants rated their program as more structured than did Basel residents, which is interesting given that the questionnaire provided clear definitions for the terms structured and unstructured. This may stem from the fact that Basel consultants are not very involved in the structured elements of surgical training, if one compares their involvement to that of Queen's faculty. This underscores the importance of faculty development in the quest for improved surgical education^{38,39}. Importantly, faculty development efforts benefit from the inclusion of all key stakeholders involved in the delivery of the training program. Important elements in a program of faculty development include the promotion of evidence-based practice, quality improvement, interdisciplinary teamwork and training systems. Transformation of training programs will also involve the dramatic increase in formative and summative assessment, coupled with the setting of transparent benchmarks linked to attestation of competence. In addition, optimization of surgical training necessitates the optimization of clinical facilities and the careful selection of training sites.

As discussed before, the effect of RDHR on technical skill development and cognitive performance is undetermined. As such, it is important to shift the focus away from time of training towards the quality of the educational experience. Our study shows that the frequency of use of structured surgical training elements, such as VR training, surgical skills lab, teaching ward rounds or objective assessment tools, was higher at Queen's along with a better integration of those elements into the workweek of a resident. Considering that these elements have the potential to shorten the learning curve and accelerate a pathway to surgical competency^{27,28,34,35}, the broad adoption of augmented structure to surgical training is strongly recommended. Structured training programs have the potential to mitigate the potential negative aspects of a reduced workweek through an accelerated pathway to competence.

Queen's residents work significantly longer compared to their Basel colleagues, reflecting the findings of other studies^{17,21}. However, especially consultants at both Queen's and Basel expressed concern about the impact of RDHR on the number of performed surgical procedures, a finding reported in other studies^{9-11,14,21,40}. As a consequence, the majority of Swiss' and Queen's surgical residents self-reported that they circumnavigated the imposed RDHR by "volunteering" for additional work hours. Beside the need to accommodate for the ever-increasing amount of administrative work, this resident behavior is likely motivated by a desire to gain more surgical experience and is almost certainly a reflection of the residents' concern that RDHR impact negatively on their surgical training^{17,18}. This is concerning, since side effects of longer working hours, such as sleep deprivation, fatigue and impaired psychomotor skills, may jeopardize patient safety and surgical performance^{1,4,6}. In fact, longer working hours may not translate into better surgical training per se¹⁵. However, the majority of both Swiss and Canadian residents, in general, accept RDHR, which may be explained by purported benefits to lifestyle, resident wellbeing, and their concern about patient safety.

In our study, it would appear that Queen's trainees have the advantage of both a less stringent approach to work hour restrictions, and greater access to structured training elements in their program. Given the longevity of the existence of structured elements to surgical programming, which have been a feature of Canadian programs for decades, it is likely true that the existence of these elements is not because there is more training time in Canada, but that deliberate efforts have been made over the years, through the influence of accreditation bodies and possibly because all residency programs in Canada are university based and administered. In contrast, Basel residents are subject to a much stricter RDHR with less formal training time. This fact may be seen as a less favorable environment for optimal surgical training quality, confirming articulated concerns and findings of other studies^{9-11,14,21,40}. However, deployment of alternative working patterns can help to overcome this shortcoming¹³, without decline in surgical competence¹⁵.

The results of this survey affirm the widely held assumption that reduced training hours can, to some extent, be compensated for by incorporating a) more structure into the training program, b) increasing the rigor of assessment of surgical skills, and c) by addressing the balance between time allotted for service commitment and resident education. Thus, most residents and consultants at both institutions agreed that training outside traditional clinical venues (e.g. VR simulation) was of value, although we would caution that this type of training is an adjunct to, not a replacement for, hands on experience with real patients, a fact that is reflected in previous studies^{26-28,34,41}.

Focusing on Swiss training, it is highly unlikely that there will be retrenchment from the current reality of governmentally imposed work hour restrictions. As such, it will be important to optimize the quality of training in a given RDHR time frame by maximizing the educational components of every program. This may include a paradigm shift from a pure time-based, rather unstructured training towards one that is highly structured and based on competencies^{23,33}. This would demand the potential adoption of a new framework for surgical training by Swiss hospitals and surgical societies.

It is important to note that in recent years a positive change has been seen in Swiss training. For example, the Swiss institute of medical training and education (SIWF) has mandated the use of objective assessment tools such as DOPS (direct observation of procedural skills) and Mini-CEX (Mini Clinical Evaluation Exercise)^{39,42}. In keeping with the trend of increasing use of simulation in medicine, Basel has already set up VR simulation training facilities. However, the use of VR simulation in Switzerland is not widespread. The reasons for this inconsistency are multifactorial. To date surgical skills laboratory-based training is not a mandated part of Swiss surgical training programs. As such, there is no current obligation for all training sites to have these facilities. And indeed, the development of surgical skills laboratories is a significant investment, requiring dedicated facilities and trained faculty.

We conclude from this study that there are many theoretical and practical advantages to a highly structured training program. Preferably such programs would be competency-based, have dramatically enhanced programs of assessment, deploy ex-vivo skills training, include a structured surgical curriculum, and be complemented by an extensive program of faculty development.

Based on our results, it would be valuable to compare the clinical performance of Canadian and Swiss residents, who are exposed to different surgical training programs. This evaluation could rest upon three pillars of assessment: knowledge and analytical clinical reasoning using tools such as the Comprehensive Integrative Puzzle (CIP)⁴³, patient management, communication skills and problem solving using the Patient Assessment and Management Examination (PAME)⁴⁴, and finally technical skills using the Objective Structured Assessment of Technical Skills (OSATS)⁴⁵. However, this may be part of a subsequent study.

Since this is a questionnaire-based study, there are some limitations to the study. The overall response rate was rather low, which may create a selection bias, as participants who are more

interested in surgical education are more likely to have responded to our questionnaire. We attempted to optimize the response rate by personalizing the communications (using personalized letters, recognizable logos, and personal mailing addresses), using regular reminder mails, and by creating a participant-friendly questionnaire design. However, our overall response rate matches typical online-based questionnaire response rates⁴⁶. Analyzing the results derived from only two institutions may not allow drawing firm conclusions for other training hospitals, although both sites are typical academic training institutions in their respective countries.

In conclusion, the current traditional, rather time-based surgical training in Basel (Switzerland), which is subject to a slow change process, might benefit from changes to its surgical education programs, especially in an era of RDHR. Transformation to highly structured training program may address some of the challenges to current surgical training and may help to compensate for less training time. Any such changes will need to be actively studied to validate their effectiveness.

Acknowledgments

Funding: This study was supported by the Swiss National Science Foundation, SNF (Grant no. IZK0Z3_155757).

Conflict of interest statement: Rachel Rosenthal is an employee of F. Hoffmann-La Roche Ltd. since May 01, 2014. The present study has no connection to her employment by the company. Rachel Rosenthal continues to be affiliated with the University of Basel.

References:

1. Taffinder N, McManus I, Gul Y, Russell R, Darzi A. Effect of sleep deprivation on surgeons' dexterity on laparoscopy simulator. *Lancet*. 1998;352(9135):1191.
2. Jagsi R, Kitch BT, Weinstein DF, Campbell EG, Hutter M, Weissman JS. Residents report on

- adverse events and their causes. *Arch Intern Med*. 2005;165(22):2607-2613.
3. Landrigan CP, Rothschild JM, Cronin JW, et al. Effect of reducing interns' work hours on serious medical errors in intensive care units. *N Engl J Med*. 2004;351(18):1838-1848.
 4. Ulmer C, Wolman DM, Johns MME. *Resident Duty Hours: Enhancing Sleep, Supervision, and Safety*. National Academy of Sciences; 2009.
 5. Dawson D, Reid K. Fatigue, alcohol and performance impairment. *Nature*. 1997;388(6639):235.
 6. Weinger MB, Ancoli-Israel S. Sleep deprivation and clinical performance. *JAMA*. 2002;287(8):955-957.
 7. Axelrod L, Shah DJ, Jena AB. The European Working Time Directive. *JAMA*. 2013;309(5):447-448.
 8. Philibert I, Friedmann P, Williams WT. New requirements for resident duty hours. *JAMA*. 2002;288(9):1112-1114.
 9. Watson DR, Flesher TD, Ruiz O, Chung JS. Impact of the 80-hour workweek on surgical case exposure within a General Surgery residency program. *J Surg Educ*. 2010;67(5):283-289.
 10. Antiel RM, Reed D a, Van Arendonk KJ, et al. Effects of duty hour restrictions on core competencies, education, quality of life, and burnout among general surgery interns. *JAMA Surg*. 2013;148(5):448-455.
 11. Dennis BM, Long EL, Zamperini KM, Nakayama DK. The effect of the 16-hour intern workday restriction on surgical residents' in-hospital activities. *J Surg Educ*. 2013;70(6):800-805.
 12. Babu R, Thomas S, Hazzard MA, et al. Worse outcomes for patients undergoing brain tumor and cerebrovascular procedures following the ACGME resident duty-hour restrictions. *J Neurosurg*. 2014;121(2):262-276.
 13. Sadaba JR, Urso S. Does the introduction of duty-hour restriction in the United States

- negatively affect the operative volume of surgical trainees? *Interact Cardiovasc Thorac Surg*. 2011;13(3):316-319.
14. Moonesinghe SR, Lowery J, Shahi N, Millen A, Beard JD. Impact of reduction in working hours for doctors in training on postgraduate medical education and patients' outcomes: systematic review. *BMJ*. 2011;342(January):d1580.
 15. Schijven MP, Reznick RK, ten Cate OTJ, et al. Transatlantic comparison of the competence of surgeons at the start of their professional career. *Br J Surg*. 2010;97(3):443-449.
 16. Maruscak AA, VanderBeek L, Ott MC, Kelly S, Forbes TL. Implications of current resident work-hour guidelines on the future practice of surgery in Canada. *J Surg Educ*. 2012;69(4):487-492.
 17. Sudarshan M, Hanna WC, Jamal MH, Nguyen LHP, Fraser S a. Are Canadian general surgery residents ready for the 80-hour work week? A nationwide survey. *Can J Surg*. 2012;55:53-57.
 18. Green SA, Poole GD. Resident work hours : Examining attitudes toward work-hour limits in general surgery , orthopaedics , and internal medicine. *BCMj*. 2010;52(2):84-88.
 19. Bell RH, Biester TW, Tabuenca A, et al. Operative experience of residents in US general surgery programs: a gap between expectation and experience. *Ann Surg*. 2009;249(5):719-724.
 20. von Websky MW, Oberkofler CE, Rufibach K, et al. Trainee satisfaction in surgery residency programs: Modern management tools ensure trainee motivation and success. *Surgery*. 2012;152(5):794-801.
 21. Businger A, Guller U, Oertli D. Effect of the 50-hour workweek limitation on training of surgical residents in Switzerland. *Arch Surg*. 2010;145(6):558-563.
 22. Frank JR, Mungroo R, Ahmad Y, Wang M, De Rossi S, Horsley T. Toward a definition of competency-based education in medicine: a systematic review of published definitions. *Med Teach*. 2010;32(8):631-637.
 23. Krajewski A, Filippa D, Staff I, Singh R, Kirton OC. Implementation of an intern boot camp

- curriculum to address clinical competencies under the new Accreditation Council for Graduate Medical Education supervision requirements and duty hour restrictions. *JAMA Surg.* 2013;148(8):727-732.
24. Grantcharov TP, Reznick RK. Training tomorrow's surgeons: what are we looking for and how can we achieve it? *ANZ J Surg.* 2009;79(3):104-107.
 25. Grantcharov TP, Reznick RK. Teaching procedural skills. *BMJ Br Med J.* 2008;336:1129-1131.
 26. Aggarwal R, Ward J, Balasundaram I, Sains P, Athanasiou T, Darzi A. Proving the effectiveness of virtual reality simulation for training in laparoscopic surgery. *Ann Surg.* 2007;246(5):771-779.
 27. Seymour NE, Gallagher AG, Roman S a, et al. Virtual reality training improves operating room performance: results of a randomized, double-blinded study. *Ann Surg.* 2002;236(4):458-463; discussion 463-464.
 28. Grantcharov TP, Kristiansen VB, Bendix J, Bardram L, Rosenberg J, Funch-Jensen P. Randomized clinical trial of virtual reality simulation for laparoscopic skills training. *Br J Surg.* 2004;91(2):146-150.
 29. Schijven MP, Jakimowicz J. The learning curve on the Xitact LS 500 laparoscopy simulator: profiles of performance. *Surg Endosc.* 2004;18(1):121-127.
 30. Grantcharov TP, Funch-Jensen P. Can everyone achieve proficiency with the laparoscopic technique? Learning curve patterns in technical skills acquisition. *Am J Surg.* 2009;197(4):447-449.
 31. Satava RM, Gallagher AG, Pellegrini CA. Surgical competence and surgical proficiency: definitions, taxonomy, and metrics. *J Am Coll Surg.* 2003;196(6):933-937.
 32. Alman BA, Ferguson P, Kraemer W, Nousiainen MT, Reznick RK. Competency-based education: a new model for teaching orthopaedics. *Instr Course Lect.* 2013;62:565-569.
 33. Ferguson P, Kraemer W, Nousiainen M. Three-year experience with an innovative, modular

- competency-based curriculum for orthopaedic training. *J Bone Jt Surg Am*. 2013;166:1-6.
34. Palter VN, Orzech N, Reznick RK, Grantcharov TP. Validation of a structured training and assessment curriculum for technical skill acquisition in minimally invasive surgery: a randomized controlled trial. *Ann Surg*. 2013;257(2):224-230.
 35. Orzech N, Palter VN, Reznick RK, Aggarwal R, Grantcharov TP. A comparison of 2 ex vivo training curricula for advanced laparoscopic skills: a randomized controlled trial. *Ann Surg*. 2012;255(5):833-839.
 36. Givel J-C, Harder F. Surgery in Switzerland. *Arch Surg*. 1999;134:207-208.
 37. Mellinger JD, Damewood R, Morris JB. Assessing the quality of graduate surgical training programs: Perception Vs reality. *J Am Coll Surg*. 2015;220(5):785-789.
 38. Holmboe ES, Ward DS, Reznick RK, et al. Faculty development in assessment: the missing link in competency-based medical education. *Acad Med*. 2011;86:460-467.
 39. Beard J, Strachan A, Davies H, et al. Developing an education and assessment framework for the Foundation Programme. *Med Educ*. 2005;39(8):841-851.
 40. Masterson MF, Shrichand P, Maniate JM. Resident duty hours in Canada: a survey and national statement. *BMC Med Educ*. 2014;14 Suppl 1(Suppl 1):S9.
 41. Porte MC, Xeroulis G, Reznick RK, Dubrowski A. Verbal feedback from an expert is more effective than self-accessed feedback about motion efficiency in learning new surgical skills. *Am J Surg*. 2007;193(1):105-110.
 42. Adil M, Khan A, Gorman M, Gwozdziewicz L, Sobani ZA, Gibson C. Direct Observation of Procedural Skills (DOPS) as an Assessment Tool for Surgical Trainees. *J Pak Med Stud*. 2013;3(3):137-140.
 43. Ber R. The CIP (comprehensive integrative puzzle) assessment method. *Med Teach*. 2003;25(2):171-176.

44. MacRae HM, Cohen R, Regehr G, Reznick R, Burnstein M. A new assessment tool: the patient assessment and management examination. *Surgery*. 1997;122(2):335-343; discussion 343-344.
45. 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.
46. Watt S, Simpson C, McKillop C, Nunn V. Electronic Course Surveys: Does automating feedback and reporting give better results? *Assess Eval High Educ*. 2002;27(4):325-337.

Figure 1: Quality of structure of surgical training in the study-site institutions (percentaged distribution).

Figure 2: Structured training elements present in the study-site institutions (percentaged distribution).

Figure 3: Is your current surgical education program successfully implemented in the daily surgical work (percentaged distribution).

Figure 4: Do you think that the surgical training curriculum at your institution needs improvement? (percentaged distribution)

Figure 5: Can structured surgical training outside theatres (VR simulation, skills lab) partially replace surgical training in theatres? (percentaged distribution)

Figure 6: Do you think working hour restriction has a negative impact on surgical training and the amount of time spent in the operating theatre? (percentaged distribution)

Figure 7: How often do surgical residents work voluntarily longer to gain more surgical experience? (percentage distribution)

		All n=105	Basel* n=62	Queen's n=43
Age in years, median (IQR)*		35 (31 - 45)	35 (32 - 41)	37 (29.5 - 54)
Gender	Female, n (%)	30 (29%)	18 (29%)	12 (28%)
	Male, n (%)	75 (71%)	44 (71%)	31 (72%)
Level of seniority	Consultant, n (%)	50 (48%)	28 (45%)	22 (51%)
	Resident/Trainee, n (%)	55 (52%)	34 (55%)	21 (29%)
Surgical specialty	Trauma, n (%)	8 (8%)	8 (13%)	0 (0%)
	Vascular, n (%)	5 (5%)	4 (6%)	1 (3%)
	General, n (%)	29 (28%)	10 (16%)	19 (44%)
	Colorectal, n (%)	2 (2%)	1 (2%)	1 (2%)
	Orthopedic, n (%)	18 (17%)	8 (13%)	10 (23%)
	Other, n (%)	43 (41%)	31 (50%)	12 (28%)
Surgical experience (years), median (IQR)	All	5.5 (3 - 13.75)	7 (4 - 11)	4 (2 - 23)
	Consultants	14 (10 - 22.75)	12 (10 - 16.25)	23 (8.25 - 25.75)
	Residents / Trainees	3 (2 - 5)	4 (3 - 5)	2 (1 - 4)

Table 1: baseline characteristics. (*age of one participant missing)