May 2019

SNS RESEARCH BRIEF *nr* 54

Medical training for future healthcare

PHYSICIAN TRAINING, Specialist training, and life-long learning must be adapted to accommodate the rapid developments that are taking place in healthcare and medicine. Technological advances within visualisation, simulation, and artificial intelligence (AI) create new interactions between humans and machines – but education and training are lagging behind. Psychologically challenging situations also place new demands on training in order to combat burnout, high staff turnover, and to prevent professionals from leaving point-of-care work.

This report describes some of the challenges and needs that medical training and education face at all levels. We have identified the challenges and needs based on our own experiences, current research, and ongoing discussions. We also propose some measures for improvements, such as changing the selection requirements for specialist training, systematising continuing medical education, and international accreditation of training centres.

HEALTHCARE AND MEDICINE IS A HIGH-RISK ORGANISATION. A healthcare-related adverse event occurs in about 8 per cent of all healthcare episodes. This corresponds to about 100,000 cases a year in Sweden. To minimise the risks and ensure evidence-based and cost-effective healthcare, all levels of education and training require constant updating.

HIGH RATES OF STAFF TURNOVER AND SICK LEAVE IN CURRENT HEALTHCARE. Multiple factors have been shown to increase the risk of mental illness, prolong the periods of sick leave, and intensify the desire to leave direct patient related work or the medical profession. In those studying for a career in healthcare and medicine, examples include unmet expectations, ill-defined professional requirements, high workloads, lack of ability, and a lack of support in handling work tasks.

NO CONTINUING MEDICAL EDUCATION REQUIREMENTS. When a newly appointed specialist in Sweden starts a professional career, there are currently no formal requirements for her to engage in continuing medical education or training efforts that will ensure that new technology is used in a safe, effective, and evidence-based manner.

AUTHORS

Li Felländer-Tsai, professor, senior consultant of orthopaedics, Karolinska Institutet and Karolinska University Hospital

Annika Östman Wernerson, professor, senior consultant of pathology, Karolinska Institutet and Karolinska University Hospital

Anders Bergenfelz, professor, senior consultant of surgery, Lund University and Skåne University Hospital

SNS RESEARCH BRIEF | The objective of the SNS Research Brief series is to make research accessible for decision-makers in politics, business and the public sector. Financial support has been granted from the Jan Wallander and Tom Hedelius Foundation. Responsibility for the analysis and the conclusions in the research briefs rests with the authors alone.

Design: Patrik Sundström / Allan Seppa

New technologies and modernised training bring with them major opportunities for supplying healthcare and medicine with competencies. The constant endeavour to provide patients with safe, evidence-based and cost-effective care is also beset with challenges.

The purpose of this report is to describe the challenges and requirements as well as to assess new training methods relevant to physician basic and specialist education and training.[1] Medical school currently lasts 5½ years in Sweden. It is followed by an internship that leads to licensure, which is then succeeded by target-based supervised specialist training. This process is currently under revision. Basic training will cover 6 years and provide licensure directly. The current clinical internship (allmäntjänstgöring) will be replaced by a basic internship (bastjänstgöring) before specialization. Specialist training will thus also have to be updated.

The development and creation of new knowledge and technology in healthcare and medicine is rapid. At the time a newly graduated physician has completed specialist training, much of the body of knowledge will already have shifted and become obsolete. New knowledge, methods, and techniques are constantly replacing the old, which in turn places great demands on the development of competencies. In spite of the high risks involved in healthcare and medicine, Sweden is one of the few countries in Europe where continuing education for medical specialists remains unregulated. Once a physician has obtained specialist competencies, there is no regimen in place to monitor related continuing medical education. In other high-reliability domains, recurrent relicensure (formalised retesting) is organised and monitored. There is a need for healthcare and medicine to develop their own culture related to patient safety issues.

Organisations that operate in high-hazard domains, so-called high-reliability organisations – e.g. the aeronautics and nuclear power industries – are characterised by prioritising safety work over all other considerations. In such organisations, systematic training using simulation methodologies and regularly performed continuous training with certification are important cornerstones. New technologies such as digitalisation, visualisation, and simulation coupled with artificial intelligence, algorithms, and applications present a paradigm shift and spotlight medical ethics. The capabilities of humans are no longer keeping pace with machines and human-technology interaction therefore involves completely new requirements and demands. In order to ensure effective, safe and good health and medical care, these requirements entail changes to work methods and systematic training.

Methods and approaches to work related to basic and specialist education and training and continuing education must therefore be updated. Improved processes to ensure precision, candidate selection, and quality in supervising and guiding tomorrow's specialists are needed to reduce stress and to be able to retain staff and maintain competencies in healthcare and medicine.

From a high-hazard organisation to a high-reliability organisation

Primum non nocere – "first, do no harm" – is an old expression in the medicine and bioethics fields. Healthcare and medicine is a high-hazard domain. Adverse events occur in about 8 per cent of all episodes of care. That corresponds to about 100,000 cases a year in Sweden.[2] Half of these events are avoidable. Moreover, every tenth adverse event results in lasting harm or functional impairment.

The American professor of surgery William Halsted (1852–1922) became very influential in the area of surgeon training in the late-19th century. In order to concretise the risks involved in surgery, he coined the dramatic expression: "The only weapon with which the unconscious

1. The report was reviewed by Pelle Gustafson, associate professor of orthopaedics at Lund University and medical director, Landstingens Ömsesidiga Försäkringsbolag (Löf).

2. Swedish National Board of Health and Welfare: https://patientsakerhet.socialstyrelsen.se/om-patientsakerhet/matningar-och-resultat (retrieved on 30 March 2019).

patient can immediately retaliate upon the incompetent surgeon is haemorrhage."[3] Much has happened since Halsted was active over a century ago. Public health and the medical care fields have improved and nowadays patients justifiably have greater expectations of the quality, availability, and outcomes of the care they receive. Technology developments require that basic education, specialist training, and continuing education be updated constantly to minimise the risk and ensure the provision of evidence-based and cost-effective medical care.

Human factors are important when things go wrong

In many instances, humans – often when interacting with machines – are the direct trigger for medical mishaps. However, most often, it is the underlying safety lapses and systemic errors that contribute to this. Such errors, seldom discussed, might include a lack of standardisation and insufficient education and systematic training to ensure relevant expertise and competencies. The challenges related to handling rapid flows of information, big volumes of data, and new visualisation technologies increase the complexity of the health and medical care domain and place high demands on its practitioners.

Research into the role of human factors within health and medical care institutions is extraordinarily important to ensure the implementation of effective measures to reduce the rate of human errors. In addition to systematising the learning of technological skills, non-technological skills – such as behaviour, situation awareness, attitudes, and decision-making under stress – can also be trained by means of patient simulators.[4]

What can healthcare and medicine learn from other high-reliability organisations?

A modern society demands that its health and medical care field is developed into a high-reliability organisation,[5] such as for example, the aeronautics, nuclear power, and offshore industries. Systematic simulator training and continuous certification act as cornerstones in those industries' safety culture. Serious events involving deaths and disasters, which often receive extensive media attention, have paved the way for this to become received wisdom. The costs related to a systematic simulator training of pilots, air traffic controllers, and cabin staff are already included and earmarked in ticket prices and are regulated by the United Nation body, International Civil Aviation Organization (ICAO). The nuclear power industry has similar measures in place. However, healthcare and medicine have not come as far in this area.

Special training centres to ensure the safe, systematic training of technical and non-technical skills (conduct and teamwork) are starting to become an established and natural part of the current training and continuing education of physicians and other medical staff. Advanced medical simulator training provides opportunities for individualised training of basic skills for meeting predetermined criteria levels. As with the improved reliability within the aeronautics industry, this allows for patients to receive safer and higher-quality medical care.

Modern training and continuing medical education

There has been a knowledge explosion within the medical sciences and the introduction of new advanced technologies within healthcare and medicine. However, in Sweden there are no statutory or regulatory requirements for specialist physicians to maintain their competencies. The mantra remains: "Once a specialist, always a specialist." The responsibility for maintaining and monitoring one's competencies and professional privileges resides with the employer and the individual physician. A national approach is missing.

In Sweden, the number of continuing medical education days declined from 8.5 days in 2004 to 6 days in 2015. There is a great deal of variation between different county councils.[6]

3. Halsted (1912).
4. Flin *et al.* (2006).
5. Patient Safety Network: https://psnet.ahrq.gov/primers/primer/31/high-reliability (retrieved 30 March 2019).
6. Dahl (2016).

Internationally, several countries have introduced Continuing Medical Education with CME points. The individual physician can earn a given number of points over a year, which then serve as evidence of the physician's completed continuing medical education. Many countries, such as the United States, the United Kingdom, and the Netherlands, have even introduced reaccreditation of specialists. It is still not clear whether such initiatives will lead to better quality of care. However, it is notable that the continuing medical education for specialist physicians in Sweden is neither defined in education content or time. There is a risk that this has a negative effect on healthcare and medicine with respect to evidence-based treatments based on up-to-date knowledge and technology.

Systematic training involving simulation methodologies

In addition to theoretical skills, critical thinking, and reflection, medical education is focused on skills and attitude. Practical skills in the form of a certain dexterity must be part of the training just like communication and teamwork skills. The approach and procedures must be systematic in nature, a fact that researchers like Ericsson and colleagues have described clearly with respect to expert competency development.[7] Simulation is a powerful tool for behavioural modification, and it has become increasingly common in recent years. Simulation technology effectively allows you to create a reality in a controlled environment with suspension of disbelief. Patient simulators can be used for training both technical and non-technical skills (teamwork). As with all advanced new technology, using patient simulators is not an objective in itself. It is a tool designed with patient safety in mind to teach basic skills before applying these skills to patients. However, training should be structured for evidence-based purposes. Failing that, there is a risk that it might shape incorrect behaviours and incur unnecessary costs.

Systematic training using check lists[8] and advanced simulation technology are relevant options today. The benefits are obvious. Training can be customised and adapted to individual background factors and skills. It is no longer acceptable or ethically acceptable to practise new technologies directly on patients.[9]

However, advanced simulation devices are expensive, and prices vary greatly. Expensive devices are not always necessarily better than less expensive ones. Maintenance, instruction resources, and the time allocated to training instead of clinical production generating direct financial revenue are currently seen as costs. Essentially, it is an investment cost that, in the long term, will result in lower costs because fewer errors will be made. However, in today's short-term pricing models, training costs are offset in revenue-generating patient treatment, which results in a dilemma.

Motivation and three-dimensional ability important for simulator performance

Development, evaluation, and validation of medical simulator training must go hand-in-hand with implementation. Modern research has shown that factors such as motivation and visual-spatial ability – i.e. the ability to orient oneself to surroundings three-dimensionally – are important for developing technical and optimal collaborative skills. For example, in one study, medical students were tested for three-dimensional mental rotation skills and performance in surgical simulators for laparoscopic surgery. The findings showed that three-dimensional mental rotation skills are important for performance in surgical simulators.[10]

In a different study, medical students were asked to train systematically on various video games and this was linked to their performance in validated simulators for minimal invasive surgery before and after training. It found that training in video games loaded with three-dimensional environments – as in minimal invasive surgery – improved the performance in surgical simulators with similar contexts.[11] In

7. Ericsson *et al.* (2018).
8. Haynes *et al.* (2011).
9. Reznick and McRae (2006).
10. Schlickum *et al.* (2011).
11. Schlickum *et al.* (2009).

yet another study, a positive correlation was identified between students' motivation to participate in simulation exercises and their attitudes to patient safety.[12]

Full-scale simulation to train teamwork

Full-scale simulation can also be applied to train teamwork. An example is Crew Resource Management (CRM), which features authentic inter-professional care teams with representatives from multiple different professions. The objective is to customise the training and education optimally to the available technical level in healthcare and medicine. This allows teams to benefit from all the opportunities that new technology has to offer by taking into consideration all the resources of a team for the purpose of maximising patient safety.

In a high-technology environment with well-trained staff that work in inter-professional teams, with a high flow of information and the demand that decisions be made under stress, it is well known that non-technological skills and behaviour are prerequisites for working safely. These are usually summarized in the term Crew Resource Management (CRM). Advanced patient simulation will enable interprofessional training of scenarios relevant for critically ill patients. In a study where junior and senior surgeons' results in a simulated haemorrhaging scenario were studied, the senior surgeons had better technical skills than their juniors, but there were no differences between the groups with respect to collaboration skills.[13]

In a different study, medical students training simulation based and target-focused teamwork were videotaped training in emergency medical scenarios. The results showed that systematic and targeted training led to a measurably improved cooperation capacity.[14] Training in medical simulators allows for immediate feedback and the ability to stop the clock in a clinical scnario for self-reflection and teaching in a manner that would be impossible in reality. In other words, patient simulation is a unique training tool. Advanced medical simulation explicitly makes it feasible to teach the intellectual process of medical decision making. This represents an upgrade of the pedagogy and a step away from the notion that observation and auscultation automatically result in a knowledge transfer.

Basic training should therefore be performed in a safe, simulated and validated environment where skills and behaviour can be taught correctly without using patients as study objects. It is equally important for instruction to take place under reliable and safe conditions so as to avoid negative feelings that might affect the instruction and learning process negatively.

How can AI and machine learning be applied to healthcare and medicine?

The development of new methods has always been a natural part of healthcare and medicine. It is important to emphasise that technology itself is not a reason for developing new methods. The legitimate reason must always be improved and better healthcare and medicine for the patients. Machine learning and artificial intelligence (AI) have changed our understanding of the apparently endless potential inherent in great quantities of information, i.e. big data. However, AI is not without risks and it requires new approaches to education, training, and continuing medical education. Access to and confidence in AI-based medical decision support have increased significantly despite the lack of training and education of the medical profession. This means that both critical investigation and ethics discussions in the medical profession need to speed up.

Machine learning, which is based on mathematics and computer science, is defined as a system's ability to independently generate knowledge through algorithms by utilising and interpreting patterns in large quantities of data. The application of machine learning has brought about innovations in various areas, such as voice recognition, voice control, self-driving cars, and chat bots. The initially moderate attitude in the healthcare sector has now changed and the area is currently undergoing rapid expansion thanks to the availability

12. Escher *et al.* (2017).
13. Moorthy *et al.* (2006).
14. Wallin *et al.* (2007).

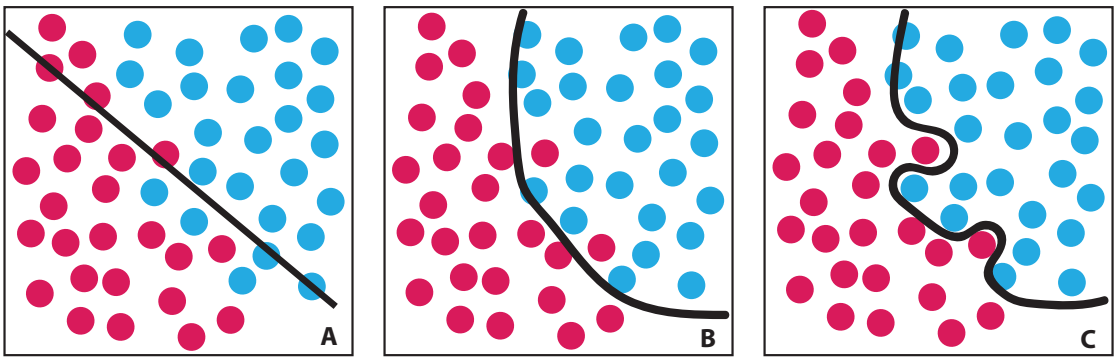

Figure 1. Models for artificial intelligence and machine learning must be optimised (B) for them to function correctly. Computers must learn the underlying structure of training data so that the model is not under-fitted (A) or over-fitted(C). Under-fitting can lead to underlying structures not being captured and over-fitting to having the model working only for training data but not in reality.

of large amounts of data and computer power. This must be linked to a balancing of regulatory and legal considerations, which are still lagging behind.

In the fundamental areas of medicine, such as medical imaging and visualization diagnostics (e.g. radiology, histology, and cardiac diagnostics), in some cases machine learning has been found to be equivalent or even superior to human ability, e.g. interpretation of mammography images and to predict mortality in suspected coronary artery disease.[15] In designing algorithms, measurement values and relevant references must be defined carefully to achieve the objective of the algorithm. Systematic monitoring of algorithms is also necessary. This must be done in close collaboration with experts. Risks involving bias and confounders must be addressed because the origin of the algorithms' underlying data can lead to erroneous interpretations. Similarly, the models must be optimised to avoid under-fitting and over-fitting (Figure 1).

Transparency, trust, and liability when using AI in health care and medicine

Within medicine, a discussion is ongoing about the ethics and regulatory aspects of AI that must be addressed as well as the risk analyses that must be made to minimise grey areas. It follows that liability issues must also be clarified in case of an adverse event or accident. There should be no doubt about who should be liable - the creator of the algorithm or the person who used the algorithm for decision support. From an ethics perspective, we must increase understanding, insight and transparency in the potentially self-learning and automated decision supports before they are commercialised, scaled up, and implemented in the health care system. Which granularity of descriptions and transparency should be required for physicians to be able to trust and stand behind increasingly autonomous decision support should also be defined. The trust between the health care provider and the patient must be guaranteed as the parties become more dependent on AI and machine-learning software as a third party, not least from a liability perspective. Transparency is necessary to be able to monitor commercial AI products to ensure that they receive adequate learning feedback, but also for society's requirements for allocating liability when products lead to unwanted or unexpected outcomes.

Value conflicts, privacy, and ethical challenges related to AI

There are also other considerations of interest that need to be balanced. For the development of AI to be successful, machine learning must be given access to large amounts of data. However, that sets up a conflict in values between, on the one hand, regulations and statutes that safeguard privacy and patient infor-

15. Gilbert *et al.* (2008), Motwani *et al.* (2017).

mation – traditionally a central part of medical ethics – and, on the other, access to large quantities of patient data required in order to develop AI tools for the health care sector. How much consideration should be given to patients when releasing information to train AI? What do you do with the groups of patients that cannot be asked, either because the database - which has originally been created for a different purpose - is outdated or because they are unable to make decisions for other reasons? Not infrequently, this results in a clash between how much value is placed on innovation on the one hand and on individual privacy on the other hand.

In a publicly funded health care system, there is also a need to discuss future pricing models for findings that are produced by algorithms and physical health and medical care personnel, respectively. This is necessary for future values, profits, costs and risks to be transparent and reasonable in relation to the efforts and stakes. All of these issues pave the way for new approaches to educating doctors and other staff in healthcare and medicine. Conditions must be created to be able to evaluate and manage data applications and decision support systems. In addition to liability issues, ethical aspects must be discussed so that they are not sacrificed at the altar of technology development. Ethics has always been a central element of both medical science and health care practice. A new chapter might need to be written for artificial intelligence and machine learning.[16]

Undergraduate education

Medical studies are continuously being revised in order to ensure that they remain relevant in content and structure. There are currently efforts underway to introduce a new six-year medical programme in Sweden that upon graduation will lead to licensure.[17] This restructuring will affect the entire education. It is important that we ask the question: What basic knowledge do future doctors need in order to understand the limitations of technology, sources of error, risks, and the pros and cons of various methods?

With no claiming of having performed a complete analysis, we highlight some examples of the challenges that the education of future doctors faces.

Basic medical knowledge in tomorrow's medical education

Medical research generates new knowledge at a rapid pace. This, of course, is positive. However, it is also a challenge to determin what medical students should learn and there is a risk of overloading the curriculum with too many details, in too little time, across too many different subject areas. Laboratory analyses are no longer performed manually; microscopic images and X-ray images are digitally processed; and the body's three-dimensional structure can be examined with advanced visualisation techniques. All this leads to new approaches and needs for prioritisation on what should be included in the upcoming six-year medical programme in Sweden. In the proposed curriculum, the importance of basic science, clinical sciences, and skills training is emphasised for integration throughout the entire undergraduate programme. We now need to make several priorities , for example, considerations as to whether students need to dissect bodies and participate in autopsies to learn anatomy and pathology; whether they need to perform laboratory work; learn how to use the microscope; or understand the background for and the interpretation of an ECG curve. Because this type of teaching is resource-intensive, one might choose to deprioritise these activities in view of the reduced resources for education.

Example: Clinical autopsies

The ability to relate to and manage diseases, injuries, death, and causes of death are all central parts of a physician's work. Autopsies are therefore important to give "answers" and to build knowledge. The proportion of deceased people who undergo autopsies has decreased dramatically in recent years, from about 50 per cent in the 1970s[18] to approx. 11 per cent in

16. Char *et al.* (2018).
17. Swedish Government Official Report [SOU] 2013:15.
18. Swedish National Board of Health and Welfare (2015).

2017.[19] Reasons for this include that diagnostic methods have improved considerably and that causes of death are therefore considered as known.[20] However, a number of studies have shown that errors often occur. In many cases important secondary diagnoses are missed. In two studies from the 1970s and 1990s, it was found that about 30 per cent of the cases relied on incorrect clinical diagnoses.[21]

In spite of improved diagnostics, a study from 2013 found that clinical diagnoses differed significantly before and after autopsy in about 24 per cent of the cases; and minor deviations were found in approximately 33 per cent.[22] On that basis, we can state that there is a risk of a deterioration of the quality of our registries regarding disease and cause of death. Since other studies have shown that the rate of cancer in a given region seems to decrease when the number of autopsies of older people declines, we risk getting wrong statistics on cancer diagnoses and thus a deteriorated knowledge base for which cancers are on the increase or decrease in the population.[23]

It is thus important that medical students participate in autopsies during their studies in order to understand their value as quality control. Furthermore, in their future professional role, they will need to be able to explain to relatives why an autopsy is needed and what knowledge this can provide. Not least, the autopsy can provide important information for both health care professionals and relatives.[24] The usefulness of clinical autopsies, staff attitudes, and student requirements for training in how to communicate with relatives about autopsies has recently been highlighted in a Swedish licentiate thesis.[25] Other studies show that medical students believe that autopsies are important[26] and that the ability to feel, twist, and turn, for example, an organ facilitates understanding and learning.[27]

In conclusion, it is obvious that new knowledge and new technology entail a need to analyse and discuss what basic knowledge future medical students should be able to handle and critically evaluate new methods and innovations. In light of the fact that the Swedish medical education will now be extended to six years and lead to medical licensure without the current internship (allmäntjänstgöring), new priorities and considerations are needed.

Professional development

Learning activities integrated in the practice of healthcare is an important part of studying medicine. It allows students to apply and integrate their knowledge and skills, while at the same time developing a professional approach that includes the pursuit of good patient safety. However, students' encounter with the complex health care environment often poses a number of challenges, not least emotionally. Many individuals working in healthcare and medicine describe pressures of high workloads and feelings of great tension.[28]

Example: Emotional challenges in organisation-integrated learning

In a qualitative study in which medical and nursing students were asked to describe situations that they experienced as emotionally stressful during their studies, a number of clinical environment situations were mentioned.[29] Here is an example of how a medical student described it:

> "During a clinical residency in psychiatry, there was a man who, through his interpreter, told us details about how he had lost his wife and children under terrible circumstances in a war and about the nightmares he was having. Both I and the interpreter cried. It was a powerful emotional experience and I still get tears in my eyes just by thinking about it".

The situations related to encounters with patients and to the norms and values that the students encountered in health care. Their sto-

19. Swedish National Board of Health and Welfare (2015), own calculations.
20. Ayoub and Chow (2008), and Burton *et al.* (2004).
21. Britton (1974), Alafuzoff and Veress (1993).
22. Kujipers *et al.* (2014).
23. Lindström *et al.* (1997), Lobow and Neufeld (2008).
24. Ayoub and Chow (2008).
25. Mjörnheim (2016).
26. Weurlander *et al.* (2012).
27. Weurlander *et al.* (2009), Pandey and Zimitat (2007).
28. Swedish Occupational Environment Authority (2016).
29. Weurlander *et al.* (2018).

ries were about patients' suffering and death, about witnessing health care professionals behaving unprofessionally, dilemmas about treating patients, about relating to patients as individuals, and concerns about "using" patients for their own learning. When asked how they handled or wanted to handle these situations, the students described their need for others' support, but also that they needed to "get used to it." In most cases, students spoke with other students and sometimes with supervisors. They described the importance of trusting the person they were talking to and having the opportunity to debrief soon after an event or encounter. In many cases, however, students had to handle situations on their own. Students' feelings of being unprepared at their encounter with suffering and death and their reaction to unprofessional behaviour of fully trained staff are described in several studies.[30] The latter can be particularly problematic: To whom should you turn if you experience that your supervisor is acting unprofessionally?

Learning how to handle both their patients' and their own reactions and feelings is an important part of professional development.[31] Increased understanding and awareness are needed about students´ experiences of unpleasant situations in the clinical environment of and their difficulties to talk about these situations. We should encourage students to talk about situations they find difficult and create room for discussion and reflection soon after the event. Professional development is an important part of the studies for various care professions. In order to better support students, it is important to create opportunities for reflection related to "the daily work" in addition to the students' various scheduled activities, such as seminars and reflection groups. The opportunities to reflect can probably be facilitated by longer coherent periods of clinical placements which have been proposed in the new six-year medical programme. The simulation exercises that are now being introduced broadly should be undertaken systematically and with instructors with adequate knowledge of behavioural science so that training achieves the intended effect.

30. Loftus (1998), Kelly and Nisker (2010), Benbassat (2013).

31. Shapiro (2011).

Emotions and learning

Our emotions affect us as individuals and contribute to how we may understand ourselves and others, not least our patients. Moreover, we know that emotions affect learning and cognitive processes.[32] Learning to control the emotions that arise in connection with unpleasant experiences – almost impossible to avoid in a health care environment – is important for professional development. By fostering a good learning environment, we can contribute to making experiences less stressful.

Challenges related to transitioning from studies to professional life

As a new professional, the individual should get to know new colleagues, understand the social context, and try to figure out one's own professional role. Many medical students experience the transition from studies to professional life as stressful and there are concerns about increased responsibilities and one's own abilities, something you do not like to talk to others about.[33] A lack of confidence in one's own professional abilities increases the stress level, which in turn leads to an increased risk of burnout.[34] In extensive studies of newly graduated nurses in Sweden, it was found that almost 30 per cent experienced pronounced symptoms of exhaustion sometime during the first three years of professional life.[35] The risk of burnout could be linked to factors both during education and at work. Factors during the education included an experience of a lack of professional preparation and uncertainty about one's own competence. Unmet professional expectations, ambiguous requirements related to the professional role, a high workload, and a lack of ability to handle duties were some of the factors that increased the duration of sick leave and the intention to leave the profession.

32. LeBlanc *et al.* (2015).

33. Lefroy *et al.* (2017), Sturman *et al.* (2017).

34. Schwarzer and Hallum (2008).

35. Gustavsson *et al.* (2013).

How to facilitate the transition to a professional life

A good transition to professional life can reduce stress, the fear of making errors, the risk of mental illness, and the desire to leave the profession. Research shows that the ability of new employees to manage stress is central to how they adapt to a new workplace and their willingness to remain in the organisation. The first 90 days have shown to be particularly important.[36] In general, it is believed that investing in introductory initiatives provides major competitive advantages.[37] Important components of successful introductory programmes include creating self-confidence by performing one's work well and having clear duties and responsibilities; in other words, it is important that new employees understand their role and what is expected of them, social integration, as well as knowledge of the organisation's culture. All these are important foundations for creating a good patient safety culture.[38]

Healthcare professionals exposed to traumatic events at work, such as severe patient complications and death, have been shown to lead to an increased risk of post-traumatic stress disorder, burnout, and depression (the so-called *second victim* effect). In a recent doctoral thesis from Uppsala University, it was found that every eight doctors and midwives in Swedish obstetric care clinics suffered from post-traumatic stress disorder.[39] Those who developed such a reaction also had worse experiences of support from colleagues and managers. Structured support programmes with well defined strategies are therefore necessary to prevent attrition and individuals leaving patient related work or the profession since it leads to unwanted staff turnover with increased pressure on those who remain. A vicious circle might easily arise.

36. Ellis *et al.* (2015), Bauer (2014).
37. Starck *et al.* (2012).
38. Bauer (2014).
39. Wahlberg (2018).

Example: Psychological intervention for newly graduated nurses

In a Swedish project, [40] a psychological intervention was developed (behaviour modification) in collaboration with health care providers. The aim was to provide newly graduated nurses with tools for reducing stress and managing challenges during their introductory phase into a profession where the workload is high and where errors might have major consequences. The study, which also included a national survey phase where a selected group of nurses were followed, showed that experiences with stress were common. By stimulating proactive behaviour to promote the engagement of the new employee, and by applying principles of cognitive behavioural therapy, stress could be prevented, and learning could be facilitated and thus contribute to the development of security in the occupation and professional competencies. This is important for the entire healthcare team to function optimally. However, in order to achieve socialisation, it is important that this type of individual intervention is supplemented with a good introduction to the workplace.

If we are to meet the future need for skilled professionals in health care, it is crucial to make it easier for new employees to minimise their risk of burnout and psychological illness and subsequent early withdrawal from the profession. The proposal for a six-year medical program in Sweden therefore emphasises the importance of an individualised and adapted introduction to health care.

Specialist education and challenges within surgery

Basic medical education and later specialist training are rigorous processes that target pre-defined objectives with courses, knowledge controls, and clinical practice. However, when newly appointed specialists in Sweden start their professional life, there are currently no formal requirements or monitoring to engage in continuing medical education or training that ensures that new technology is used in a safe, effective, and evidence-based manner. Over a

40. Gustavsson *et al.* (2017).

professional career of up to 40 years, one is presented with innovations such as new visualisation and surgical technologies, implants, instruments, interfaces, data applications, machine learning, and algorithms. As a clear illustration of the problem, one might mention the sharp increase in serious bile duct injuries that occurred in connection with the transition from open to laparoscopic gallbladder surgical procedures in Sweden,[41] and internationally,[42] and that only recently seems to have stabilised at the pre- laparoscopic technology levels.[43] Today, most often, available and sophisticated infrastructure is lacking to support a systematic and validated adaptation to new technologies and procedures. This affects patients, doctors, other healthcare professionals, health care facilities, and ultimately also the taxpayers' wallets by means of potentially unnecessary costs.

Surgical care injuries are a major problem

In a marker-based[44] patient record survey conducted at various Swedish hospitals, over 15 per cent of adverse events, such as injuries and complications, were detected in connection with surgical treatment in inpatient care. More than 60 per cent of these were believed to be avoidable. More than half of the injuries resulted in prolonged care or re-admission and nearly 5 per cent resulted in permanent injury or death.[45]

At the latest follow-up in 2017, surgery-related injuries were found in 2 per cent of all care cases, of which half were considered to be avoidable. Transposing this to the national level means that approximately 25,000 patients have suffered from surgical care injuries.[46] Surgery is therefore considered a high-hazard activity where errors at the individual, team, or organisational level can have catastrophic consequences for the individual patient. Another important factor involves errors related to medical implants that cause great suffering and prompt costly reoperations.[47] Unfortunately, the ability to trace implants is currently lacking. Thus, there is an extensive potential for improvement with improved knowledge and process thinking. Needless to say, the capability to trace implants by means, for example, of bar codes integrated with patient medical records and quality records is important for patient safety reasons.

A comparison with safety work within the aeronautical industry

Over the past 10-20 years, great efforts have been made to reduce injuries occurring in healthcare and medicine, including using different types of training initiatives, introduction of checklists, establishment of training and simulator centres, and incident reporting systems.

However, compared to other high-hazard organisations such as the aeronautical industry, the improvement efforts in healthcare and medicine as described above have a long way to go. A combination of measures – including the introduction of Crew Resource Management (CRM), checklists, improved technology and regular training in simulators of pilots – has brought down the risk of death per flight from 1 in 2 million flights from 1977 to 1986 to 1 in 11 million flights from 1987 to 1999.[48] According to the International Air Transport Association (IATA), from 2008 to 2017 the number of aircraft accidents decreased by 70 per cent from 3.6 per million flights in 2008 to 1.08 per million flights in 2017.[49] Aviation has therefore developed into a so-called High-Reliability Organisation (HRO).

Selection important for increasing patient safety

An HRO is characterised, among other things, by using validated and powerful selection tools to assess applicants for work within hazardous professions, for example pilots in the aero-

41. Larsson and Räf (2001).
42. Roslyn *et al.* (1993), Karvonen *et al.* (2007).
43. Mangieri *et al.* (2018).
44. In a marker-based patient record study, records are examined from a random selection of completed hospital care episodes. The purpose is to identify recorded data that might indicate injury by means of certain words or "markers."
45. Nilsson *et al.* (2016).
46. Swedish Association of Local Authorities and Regions (2018).
47. Cohen (2011), Osborne *et al.* (2018).
48. Schiavo (1997).
49. International Air Transport Association (2018).

nautical industry. Such tools are largely absent in health care, especially in the surgical disciplines. In surgical patient safety work, this lack of selection before employment for surgical specialist training has been called "the missing link."[50]

In the United States, it has been found that about 20 per cent of those accepted for employment for training as surgery specialists (so-called *residents*, in Sweden corresponding to ST-doctors) do not complete their education as planned.[51] Another study found that some form of support or corrective action had been taken for 31 per cent of those admitted in order for them to carry on and complete their training as planned.[52] Current and precise figures are missing from Sweden. However, there is indirect evidence that the cost of less successful recruitments is high.

Macho attitudes and personality traits in surgeons

Several international studies have identified important characteristics of a surgeon.[53] A study that included orthopaedic surgeons noted that dangerous personality traits, above the level considered dangerous for pilots, were found in 38 per cent of those surveyed.[54] Another study found that macho attitudes in surgeons co-varied with more re-admissions and reoperations.[55]

In a recent study from the southern healthcare region in Sweden, based on questionnaire responses from senior surgeons (operationally defined as older than 50 years, with an average of 25 years in the profession) and chiefs of surgery, 46 out of 54 surgeons (85 per cent) stated that they had experience with surgeons who were viewed as unfit for the profession. An interesting finding was that most of these were considered unfit because of "non-technical skills." The most frequently mentioned problem was poor judgment and difficulty in accepting feedback.[56]

In another study, about one-fifth of all residents were assessed to be problem-surgeons during their training - most because of competency problems in the area of non-technical skills.[57] A worrying report of occupational health problems, burnout and suicidal thoughts among surgeons has recently been published.[58] Although this study was conducted among North American surgeons, there is every reason to monitor this issue in Sweden as well.

Safer care with assessment tools when recruiting and training specialists in surgery

In Europe, the Royal College of Surgeons of Ireland (RCSI) has been at the forefront of developing selection processes for specialist training in surgery. A rigorous selection process has been established that includes standardised mini-interviews that evaluate clinical judgment, interpersonal skills, professional development, motivation, stress management, work ethics, and professionalism. Suitability tests have also been introduced for psychomotor skills, visual-spatial skills, and perception.[59] It is important to note that the purpose of the RCSI selection process is not to find the best applicants, but to identify candidates who "are likely to be unsuccessful in training or problematic as future surgeons" (quoted from RCSI Marking Guide).

However, there is no international consensus on which tools should be used for the selection for surgical training. In a survey article, 52 studies on selection tools were identified.[60] Among these, 23 tests were reviewed for personal attributes, 25 were visual-spatial tests, and 20 were dexterity tests. Moreover, the applicants' academic work and potential were assessed. The authors did not identify any particular test or combination of tests that possessed a sufficiently high level of precision to predict future technical suitability in the participants.

50. Paice *et al.* (2010).
51. Dodson and Webb (2005).
52. Yaghoubian *et al.* (2012).
53. Arora *et al.* (2009), Baldwin *et al.* (1999).
54. Bruinsma *et al.* (2015).
55. Kadzielski *et al.* (2015).
56. Hagelsteen *et al.* (2018).
57. Bergen *et al.* (2000).
58. Pei and Cochran (2018).
59. Traynor, Oscar, Royal College of Surgeons of Ireland (RCSI). Personal message of 14 December 2018.
60. Louridas *et al.* (2016).

Research into selection tools in Sweden

At present, a major interdisciplinary research project at University of Lund between medical faculty (Institution for Clinical Sciences in Lund [IKVL] and social science faculty (Institutions for Sociology and Psychology) is investigating the validity and reliability of a broad range of selection tools (standardised interviews, personality tests, generic dexterity tests, visual-spatial tests, and testing in laparoscopic simulators) and how they correlate with future outcomes during surgery training of already accepted resident physicians (ST physicians).[61]

Selection process in Sweden and internationally

The selection process for admission to specialist training in surgical specialties varies from national standardised admission with criteria and grading in Australia, the United Kingdom, and Ireland, to local admission models without standardised procedures or assessments, such as Sweden, Norway, and Finland.[62]

For the purposes of evaluating skills, it has been shown that standardised interviews are preferable to unstructured.[63] Standardised interviews are also used as part of the selection processes in Australia, the United Kingdom, and Ireland.[64]

In Sweden, county councils and regions establish a number of Swedish residency (ST) posts annually for all medical specialties including surgical specialties. These include so-called "grey resident posts", that is, where physicians collect various residencies on their own and customise their own training. Since specialist training is competency-based – i.e. targeted – it is entirely possible for an individual to switch workplaces and thereby structure her own competency portfolio. This means that there is a risk that the recruitment process and the assessment of the individuals trained as surgery specialists might become fragmented.

In a recent study, it was found that references, interviews, and assessments for 6-12 months of temporary work were the most common selection processes.[65] In summary, admission to specialist training in Sweden is not standardised and is not transparent for individuals.

Challenges within surgery training

The traditional method of studying surgery, the so-called apprenticeship model, served surgical training well for many years. The model required many years of training to reach specialist expertise. Thus, knowledge and craftsmanship were acquired in an unstructured way, *ad hoc* – that is, as allowed by opportunities. The education model relied on the physician's acquiring the requisite clinical knowledge through work in a clinic, department, in surgery, and on-call service, within a certain set time. This training was then supplemented, if necessary, with training in a subspecialty. The total duration for specialist training could therefore, in reality, approach 10-15 years. The main reason for the long training period is that surgery is not just a medical science but also a craft that requires extensive skills, both technical and non-technical.

From apprentice to simulation training

The apprenticeship model is now being questioned because of the exponential growth in medical knowledge and the introduction of new technologies and an increasing degree of subspecialisation. Working time constraints and social changes are contributing to the challenges facing surgical training. In other words, fewer hours are available for clinical training. Therefore, nowadays surgeon training in Sweden is competency-based and thus not strictly regulated in time.

It is on that basis that simulation centres have been introduced to remedy the lack of clinical practice. However, simulation training has been introduced within the current clinical education paradigm. The basic model for teaching and training has not been challenged. In other

61. Recruitment, evaluation tools, and training in virtual environments in the education of specialists in surgery, Swedish Ethics Review Board, Lund, 2016/1050.

62. Gardner *et al.* (2018).

63. Pedersen (2018).

64. Gardner *et al.* (2018).

65. Pedersen, Hanne, Department of Clinical Sciences, Lund (IKVL), Lund University. Personal message of 25 February 2019.

words, training by means of simulation has supplemented the apprenticeship model. The question is whether this is reasonable in light of how other high-hazard industries, such as the aeronautical industry, organise the training of pilots and other professionals. It may be argued that the training of doctors in general and surgeons in particular should be more effective and safer when performed and systematically evaluated in a simulation laboratory before clinical training begins.

A master's degree programme in surgery: A new way to train surgeons

It was against this backdrop that the Royal College of Surgeons of Ireland (RCSI) in Dublin recently introduced a one-year master's degree in *Surgical Science and Practice*.[66] The objective of the programme is to provide potential students with the requisite knowledge, skills, and behaviour to maximise their competitiveness before entering surgical training programmes anywhere in the world. The objective of the programme, taught by the RCSI's newly-inaugurated national surgical training centre, is to develop participants' clinical skills including the technical and non-technical skills required to be admitted to a postgraduate programme.

The programme is divided into six modules:

- Basic knowledge and clinical judgment;
- Basic clinical skills;
- Surgical-technical skills;
- Non-technical skills;
- Professional development and practice; and
- Research methodologies.

The programme's emphasis will be on practical and technical training in simulated environments. This represents a paradigm shift since a major part of the basic training will take place in simulator centres under controlled circumstances, before a point-of-care residency is commenced.

In Sweden, there are currently no programmes like this. However, it might very well be tried as a partnership between the health care sector and universities with the aim of making the training of surgeons safer, more structured, competency-based – and thereby more effective.

Accreditation of clinical training- and simulator centres

In recent years, clinical training centres (so-called KTCs) have been established at many hospitals throughout Sweden and Europe. Clinical training- and simulator centres provide training for many disciplines and professions and range from a single room with simple equipment used sporadically to large national centres with expensive equipment and permanent staff and much activity. There is a clear risk of over-establishment in the area, as well as unnecessary duplicate investments in expensive equipment. The expansion of the training centre concept largely lacks any national and regional perspective and a national level structure should be considered for optimal resource utilisation.

The European Union of Medical Specialists (UEMS) has created an accreditation organisation for clinical training centres, Network of Accredited Clinical Skills Centre in Europe (NASCE). Its primary purpose is to promote the highest standards in the education of doctors and other healthcare professions for the purpose of promoting patient safety. Moreover, NASCE aims to promote scientific studies in clinical education, training, and assessment.

NASCE is working to strengthen common European standards for clinical training and simulator centres through external assessments and accreditation. The objective of the accreditation is to create organisational support for state-of-the-art clinical competency training in the EU and countries associated with the EU. Accreditation is currently offered at two levels, with plans for a third level for local training centres.

The following components are evaluated as part of an accreditation:

- Management;
- Administration;
- Teachers;

66. Royal College of Surgeons of Ireland: http://rcsi.ie/mssp (retrieved on 30 March 2019).

- Students/course participants;
- Competencies; and
- Research and development.

In Sweden, the Centre for Advanced Medical Simulation and Training (CAMST), the Karolinska University Hospital, and the Practicum Clinical Skills Centre, Skåne University Hospital, have been accredited by NASCE. These two centres fulfil the established European criterion for "Multispecialty Format Centre Level," which is an important milestone in instituting a national quality framework. The accreditations may be seen as a quality-assured and well-timed evolution of Halsted's ambitions to advance knowledge and accept the responsibility for educating and training of the next generation.

Future planning and recommendations

Technical developments, rapid advances in medical knowledge, and high and justified patient safety standards, coupled with limited financial resources, are strong incentives to initiate a paradigm shift in clinical education within both basic and specialist training and continuing medical education. National coordination would contribute to evidence-based equitable health and medical care and reduced fragmentation, which would contribute to Sweden's competitiveness. The quality of organisation-integrated learning must be ensured, and the possibilities and limitations of new technologies must be introduced already during the physician's basic education.

AI and algorithms are predicted to have great potential. But they also constitute a grey area where the ethics and liability-related aspects must be investigated further to maintain trust. Regulating specialist training is high on the agenda to ensure that the specialists' knowledge is relevant and up-to-date. It is, of course, important to point out that international research has not proven that unregulated training provides poorer quality of care, compared to regulated training. However, this is most likely due to the complexity of the issue.

Health care quality is influenced by many factors other than continuing medical education: To name just a few, socio-economic factors, the structure of health and medical care and governance, availability of and access to health care, access to staff, and the quality of basic education. However, in our opinion, lifelong learning, with well-structured compulsory continuing medical education of specialists must be improved – likely under the supervision of an appropriate government agency – rather than pursuing today's fragmented system. It is simply not reasonable that the scope and quality of continuing medical education depend on current policy at individual hospitals or regions. In the future, the training of existing and future specialists should be performed with the integration of advanced medical simulation for both rational and economic reasons and for patient safety reasons. Systematic simulation-based training of future specialists should take place before initiating clinical service and also be integrated with the clinical training. Medical simulation-based training will be at the center-stage in the future and Sweden should, over time, also acknowledge a common European standard for simulator centres.

Bibliography

Alafuzoff, I. and Veress, B. (1993). The selection for post-mortem examination: a retrospective analysis of 74 deceased surgical cases. *International Journal for Quality in Health Care* 5(4): 345–349.

Arora, S., Sevdalis, N., Suliman, I., Athanasiou, T., Kneebone, R. and Darzi, A. (2009). What makes a competent surgeon: experts' and trainees' perceptions of the roles of a surgeon. *The American Journal of Surgery* 198(5): 726–732.

Ayoub, T. and Chow, J. (2008). The conventional autopsy in modern medicine. *Journal of the Royal Society of Medicine* 101(4): 177–181.

Baldwin, P. J., Paisley, A. M. and Brown, S. P. (1999). Consultant surgeons' opinion of the skills required of basic surgical trainees. *British Journal of Surgery* 86(8): 1078–1082.

Bauer, T. N. (2014). Onboarding new employees. Maximizing success. *SHRM Foundation's Effective Practice Guideline Series,* 7.

Benbassat, J. (2013). Undesirable features of the medical learning environment: a narrative review of the literature. *Advances in Health Sciences Education* 18(3): 527–536.

Bergen, P. C., Littlefield, J. H., O'Keefe, G. E., Rege, R. V., Anthony, T. A., Kim, L. T. and Turnage, R. H. (2000). Identification of high-risk residents. *Journal of Surgical Research* 92(2): 239–244.

Britton, M. (1974). Diagnostic errors discovered at autopsy. *Acta Medica Scandinavica* 196(1–6): 203–210.

Bruinsma, W. E., Becker, S. J., Guitton, T. G., Kadzielski, J. and Ring, D. (2015). How prevalent are hazardous attitudes among orthopaedic surgeons? *Clinical Orthopaedics and Related Research* 473(5): 1582–1589.

Burton, E. C., Phillips, R. S., Covinsky, K. E., Sands, L. P., Goldman, L., Dawson, N. V. and Landefeld, C. S. (2004). The relation of autopsy rate to physicians' beliefs and recommendations regarding autopsy. *The American Journal of Medicine* 117(4): 255–261.

Char, D. S., Shah, N. H. and Magnus, D. (2018). Implementing machine learning in health care–addressing ethical challenges. *The New England Journal of Medicine* 378(11): 981.

Cohen, D. (2011). Out of joint: The story of the ASR. *BMJ* 342: d2905.

Dahl, A. S. (2016). Oansvarigt sätt att bedriva sjukvård. *Sjukhusläkaren,* 8 December. https://www.sjukhuslakaren.se/oansvarigt-satt-att-bedriva-sjukvard/ (retrieved on 30 March 2019).

Dodson, T. F. and Webb, A. L. (2005). Why do residents leave general surgery? The hidden problem in today's programs. *Current Surgery* 62(1): 128–131.

Ellis, A. M., Bauer, T. N., Mansfield, L. R., Erdogan, B., Truxillo, D. M. and Simon, L. S. (2015). Navigating uncharted waters: Newcomer socialization through the lens of stress theory. *Journal of Management* 41(1): 203–235.

Ericsson, K. A., Hoffman, R. R., Kozbelt, A. and Willams, A. M. (eds.). (2018). *The Cambridge Handbook of Expertise and Expert Performance*. Cambridge Handbooks in Psychology.

Escher, C., Creutzfeldt, J., Meurling, L., Hedman, L., Kjellin, A. and Felländer-Tsai, L. (2017). Medical student's situational motivation to participate in simulation based team training is predicted by attitudes to patient safety. *BMC Medical Education* 17(1): 37.

Flin, R., Yule, S., Paterson-Brown, S., Rowley, D. and Maran, N. (2006). *The nontechnical skills for surgeons (NOTSS) system handbook v1.2*. University of Aberdeen.

Gardner, A. K., Grantcharov, T. and Dunkin, B. J. (2018). The Science of Selection: Using Best Practices from Industry to Improve Success in Surgery Training. *Journal of Surgical Education* 75(2): 278–285.

Gilbert, F. J., Astley, S. M., Gillan, M. G., Agbaje, O. F., Wallis, M. G., James, J., Boggis, C. R. and Duffy, S. W. (2008). Single reading with computer-aided detection for screening mammography. *New England Journal of Medicine* 359(16): 1675–1684.

Gustavsson, P., Frögéli, E. and Rudman, A. (2017). *Säker, motiverad och skicklig: Forskningsbaserad intervention för att stimulera hälsa, arbetsengagemang och kompetens hos nya sjuksköterskor*. Rapport B2017:6. Stockholm: AFA Insurance.

Gustavsson, P., Hultell, D. and Rudman, A. (2013). *Lärares och sjuksköterskors hälsoutveckling och karriärvägar de första åren efter utbildning*. Rapport B2013:5. Stockholm: AFA Insurance.

Hagelsteen, K., Johansson, B. M., Bergenfelz, A. and Mathieu, C. (2018). Identification of Warning Signs During Selection of Surgical Trainees. *Journal of surgical education* 76(3): 684-693.

Halsted, W. (1912). Bulletin of the Johns Hopkins Hospital 1912; 23: 191.

Haynes, A. B., Weiser, T. G., Berry, W. R., Lipsitz, S. R., Breizat, A. H., Dellinger, E. P., Dziekan, G., Herbosa, T., Kibatala, P. L., Lapitan, M. C., Merry, A. F., Reznick, R. K., Taylor, B., Vats, A. and Gawande, A. A. (2011). Changes in safety attitude and relationship to decreased postoperative morbidity and mortality following imple-

mentation of a checklist-based surgical safety intervention. *BMJ Quality & Safety* 20(1): 102–107.

International Air Transport Association (2018). *Annual Review 2018*. Sydney: International Air Transport Association.

Kadzielski, J., McCormick, F., Herndon, J. H., Rubash, H. and Ring, D. (2015). Surgeons' attitudes are associated with reoperation and readmission rates. *Clinical Orthopaedics and Related Research®* 473(5): 1544–1551.

Karvonen, J., Gullichsen, R., Laine, S., Salminen, P. and Grönroos, J. M. (2007). Bile duct injuries during laparoscopic cholecystectomy: primary and long-term results from a single institution. *Surgical Endoscopy* 21(7): 1069–1073.

Kelly, E. and Nisker, J. (2010). Medical students' first clinical experiences of death. *Medical Education* 44(4): 421–428.

Kujipers, C. C., Fronczek, J., Van de Goot, F. R., Nissen, H. W., van Diest, P. J. and Jiwa, M. (2014). The value of autopsies in the era of high-tech medicine: discrepant findings persist. *Journal of Clinical Pathology* 67(6): 512–519.

Larsson, M. and Räf, L. (2001). Många gallgångsskador vid kolecystektomi. Klart samband med användning av laparoskopisk teknik. *Läkartidningen* 98(49): 5639–5642.

LeBlanc, V. R., McConnell, M. M. and Monteiro, S. D. (2015). Predictable chaos: a review of the effect of emotions on attention, memory and decision making. *Advances in Health Sciences Education* 20(1): 265–282.

Lefroy, J., Yardley, S., Kinston, R., Gay, S., McBain, S. and McKinley, R. (2017). Qualitative research using realist evaluation to explain preparedness for doctors' memorable "firsts". *Medical Education* 51(10): 1037–1048.

Lindström, P., Janzon, L. and Sternby, N. H. (1997). Declining autopsy rate in Sweden: a study of causes and consequences in Malmö, Sweden. *Journal of Internal Medicine* 242(2): 157–165.

Lobow, L. S. and Neufeld, R. R. (2008). The autopsy and the elderly patient in the hospital and nursing home: enhancing the quality of life. *Geriatrics* 63(12): 14–18.

Loftus, L. A. (1998). Student nurses' lived experience of the sudden death of their patients. *Journal of Advanced Nursing* 27(3): 641–648.

Louridas, M., Szasz, P., de Montbrun, S., Harris, K. A., and Grantcharov, T. P. (2016). Can We Predict Technical Aptitude? *Annals of surgery* 263(4), 673–691.

Mangieri, C. W., Hendren, B. P., Strode, M. A., Bandera, B. C. and Faler, B. J. (2018). Bile duct injuries (BDI) in the advanced laparoscopic cholecystectomy era. *Surgical Endoscopy* 33(3): 724–730.

Mjörnheim, B. (2016). *Nyttan med klinisk obduktion. Vårdpersonalens roller och attityder*. Licentiate thesis, Karolinska Institutet.

Moorthy, K., Munz, Y., Forrest, D., Pandey, V., Undre, S., Vincent, C. and Darzi, A. (2006). Surgical crisis management skills training and assessment: a simulation-based approach to enhancing operating room performance. *Annals of Surgery* 244(1): 139–147.

Motwani, M., Dey, D., Berman, D. S., Germano, G., Achenbach, S., Al-Mallah, M. H., Andreini, D., Budoff, M. J., Cademartiri, F., Callister, T. Q. and Chang, H. J. (2017). Machine learning for prediction of all-cause mortality in patients with suspected coronary artery disease: a 5-year multicentre prospective registry analysis. *European Heart Journal* 38(7): 500–507.

Nilsson, L., Risberg, M. B., Montgomery, A., Sjödahl, R., Schildmeijer, K. and Rutberg, H. (2016). Preventable Adverse Events in Surgical Care in Sweden: A Nationwide Review of Patient Notes. *Medicine* 95(11).

Osborne, H., Devlin, H. and Barr, C. (2018). Revealed: faulty medical implants harm patients around the world. *The Guardian*, 25 November. https://www.theguardian.com/society/2018/nov/25/revealed-faulty-medical-implants-harm-patients-around-world (retrieved on 30 March 2019).

Paice, A. G., Aggarwal, R. and Darz, A. (2010). Safety in surgery: is selection the missing link? *World Journal of Surgery* 34(9): 1993–2000.

Pandey, P. and Zimitat, C. (2007). Medical students' learning of anatomy: memorisation, understanding and visualisation. *Medical Education* 41(1): 7-14.

Pedersen, H. (2018). Comparison of selection processes for surgical training: Sweden in an international perspective. Exam paper, Lund University.

Pei, K. Y. and Cochran, A. (2018). Workplace Bullying Among Surgeons – the Perfect Crime. *Annals of Surgery* 269(1): 43–44.

Reaves, J. (2001). A weighty issue: ever-fatter kids: interview with James Rosen. *Time*, 14 March. http://www.time.com/time/nation/article/0,8599,102443,00.html (retrieved on 14 July 2001).

Reznick, R. K. and MacRae, H. (2006). Teaching surgical skills – changes in the wind. *New England Journal of Medicine* 355(25): 2664–2669.

Roslyn, J. J., Binns, G. S., Hughes, E. F., Saunders-Kirkwood, K., Zinner, M. J. and Cates, J. A. (1993). Open cholecystectomy. A contemporary analysis of 42,474 patients. *Annals of Surgery* 218(2): 129.

Schiavo, M. (1997). *Flying blind: flying safe statistical summary of commercial jet aircraft accidents, worldwide operations 1959–97*, Boeing Commerical Aircraft Company. New York: Avon Books.

Schlickum, M. K., Hedman, L., Enochsson, L., Kjellin, A. and Felländer-Tsai, L. (2009). Systematic video game training in surgical novices improves performance in virtual reality endoscopic surgical simulators: a prospective randomized study. *World Journal of Surgery* 33(11): 2360–2367.

Schlickum, M., Hedman, L., Enochsson, L., Henningsohn, L., Kjellin, A. and Felländer-Tsai, L. (2011). Surgical simulation tasks challenge visual working memory and visual-spatial ability differently. *World Journal of Surgery* 35(4): 710–715.

Schwarzer, R. and Hallum, S. (2008). Perceived Teacher Self-Efficacy as a Predictor of Job Stress and Burnout: Mediation Analyses. *Applied Psychology* 57: 152–171.

Shapiro, J. (2011). Perspective: does medical education promote professional alexithymia? A call for attending to the emotions of patients and self in medical training. *Academic Medicine* 86(3): 326–332.

SOU 2013:15. *För framtidens hälsa – en ny läkarutbildning*. Stockholm: Fritzes.

Starck, R. J., Caye, M., von der Linden, C., Quiros, H. and Haen, P. (2012). *From Capability to Profitability: Realizing the Value of People Management*. Boston Consulting Group.

Sturman, N., Tan, Z. and Turner, J. (2017). "A steep learning curve": junior doctor perspectives on the transition from medical student to the health-care workplace. *BMC Medical Education* 17(1): 92.

Swedish Association of Local Authorities and Regions (2018). *Skador i vården – utveckling 2013–2017*. https://webbutik.skl.se/bilder/artiklar/pdf/7585-640-7.pdf?issuusl=ignore (retrieved on 4 March 2019).

Swedish National Board of Health and Welfare (2015). *Dödsorsaker 2014*. https://www.socialstyrelsen.se/publikationer2015/2015-8-1.

Swedish National Board of Health and Welfare (2018). *Statistik om dödsorsaker 2017. Appendix of Tables*. http://www.socialstyrelsen.se/publikationer2018/2018-10-17/.

Swedish Occupational Environment Authority (2016). *Arbetsmiljön 2015*. Arbetsmiljöstatistik Rapport 2016:2 Stockholm: Swedish Occupational Environment Authority.

Wahlberg, Å. (2018). *Second Victims in Swedish Obstetrics*. Diss., Uppsala University.

Wallin, C. J., Meurling, L., Hedman, L., Hedegård, J. and Felländer-Tsai, L. (2007). Target-focused medical emergency team training using a human patient simulator: effects on behaviour and attitude. *Medical Education* 41(2): 173–180.

Weurlander, M., Lönn, A., Seeberger, A., Hult, H. and Wernerson, A. (2018). How do

medical and nursing students experience emotional challenges during clinical placements? *International Journal of Medical Education* 9: 74–82.

Weurlander, M., Masiello, I., Söderberg, M. and Wernerson, A. (2009). Meaningful learning: students' perceptions of a new form of case seminar in pathology. *Medical Teacher* 31(6): e248–e253.

Weurlander, M., Scheja, M., Hult, H. and Wernerson, A. (2012). Emotionally challenging learning situations: medical students' experiences of autopsies. *International Journal of Medical Education* 3: 63–70.

Yaghoubian, A., Galante, J., Kaji, A., Reeves, M., Melcher, M., Salim, A., Dolich, M. and de Virgilio, C. (2012). General surgery resident remediation and attrition: a multi-institutional study. *Archives of Surgery* 147(9): 829–833.