Contributory Factors in Surgical Incidents as Delineated by a Confidential Reporting System

Faisal Mushtaq[1], Ciaran O'Driscoll[2], Frank CT Smith[3], Denis Wilkins[4], Narinder Kapur*[5], Rebecca Lawton[1,6]

[1]School of Psychology, Faculty of Medicine & Health, University of Leeds, Leeds, West Yorkshire, United Kingdom

[2]Division of Psychiatry, University College London, London, UK

[3]Faculty of Health Sciences, University of Bristol, UK

[4]Derriford Hospital, Plymouth, UK

[5]Research Department of Clinical, Educational and Health Psychology, University College London, London, United Kingdom

[6]Bradford Institute for Health Research, Bradford, West Yorkshire, United Kingdom

*Correspondence and reprint requests can be addressed to Narinder Kapur, Research Department of Clinical, Educational and Health Psychology, University College London, London, United Kingdom. email: n.kapur@ucl.ac.uk, Tel: 0208 907 3366

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Abstract

Background: Confidential reporting systems play a key role in capturing information about adverse surgical events. However, the value of these systems is limited if the reports that are generated are not subjected to systematic analysis. The aim of this study was to provide the first systematic analysis of data from a novel surgical confidential reporting system in order to delineate contributory factors in surgical incidents and document lessons that can be learned.

Materials and Method: One-hundred and forty-five patient safety incidents submitted to the UK Confidential Reporting System for Surgery (CORESS) over a 10-year period were analysed using an adapted version of the empirically-grounded Yorkshire Contributory Factors Framework (YCFF).

Results: The most common factors identified as contributing to reported surgical incidents were cognitive limitations (30.09%), communication failures (16.11%) and a lack of adherence to established policies and procedures (8.81%). The analysis also revealed that adverse events were only rarely related to an isolated, single factor (20.71%) – with the majority of cases involving multiple contributory factors (79.29% of all cases had > 1 contributory factor). Examination of active failures – those closest in time and space to the adverse event – pointed to frequent coupling with latent, systems-related contributory factors.

Conclusions: Specific patterns of errors often underlie surgical adverse events and may therefore be amenable to targeted intervention, including particular forms of training. The findings in this paper confirm the view that surgical errors tend to be multi-factorial in nature, which also necessitates a multi-disciplinary and system-wide approach to bringing about improvements.

Keywords: Safety Incidents, Adverse events, Contributory Factors, Cognitive Factors, Latent Contributors

Introduction

The Institute of Medicine's seminal report, "To Err is Human" (1), helped to fuel intense debate and research on the nature, frequency and magnitude of surgical error (2,3). The focus on surgery has been particularly considerable given the self-evident link between errors in the operating theatre and patient safety (4).

To improve quality and safety, the surgical field, borrowing concepts from other high-risk industries (5), has heavily promoted the use of incident reporting systems. Yet, such systems have been criticised as only providing a superficial impression of safety improvement (6–8). Notably, in contrast, the aviation industry regularly changes policy and practice on the basis of this information (9-11).

Within individual hospitals, the quality and quantity of feedback is highly variable (8,9) and often generic, thus limiting specialty specific learning. In response, the Confidential Reporting System for Surgery (CORESS) was established (10). Modelled on aviation systems, CORESS was seen as an innovative development to produce a specialty-specific error reporting and learning system with, uniquely, a one-to-one mapping between incident report and feedback.

The past two decades of healthcare research have seen the development of a number of theoretically grounded frameworks that provide a structured approach to incident analysis (11–14). The recently validated, evidence-based framework, the Yorkshire Contributory Factors Framework (YCFF) (15), recognises the broad spectrum of possible causes of hospital based patient safety incidents. Central to the YCFF is a system-based approach to understanding errors, where adverse events are viewed as a consequence of gaps at multiple levels of a system (16) – the product of a cumulative effect that can include active and latent failures.

The aim of this study was to establish the factors most commonly contributing to surgical incidents by applying the YCFF to CORESS reports.

Methods

All complete and anonymised safety incidents reports published by the CORESS advisory committee (coress.org.uk) over a ten-year period (reports between February 2005 and August 2015) in January 2016 were extracted. This total of 145 included reports describing diagnostic or operative errors, technical failures, regulatory or procedural limitations or unsafe practices/protocols. The reports included reporter and feedback comments made by the CORESS Advisory Committee. The latter were removed before being shown to the coders to avoid the classification process being biased by the committee's recommendations. Permission was obtained from the advisory commiteee to examine these anonymised, publically available data.

The Yorkshire Contributory Factors Framework

Inherent within the YCFF is the recognition that adverse incidents can arise from errors at the sharp end (e.g. healthcare professional forgetting a key step of a protocol), but also have more distal causes (latent organisational deficiencies that could have been brewing in the system for years). The framework specifically identifies 19 factors, hierarchically ordered and arranged in order of proximity (in time and space) to the adverse event across 5 classes, described in **Table 1**.

[INSERT TABLE 1 HERE]

To ensure that key contributory factors were identified without inferring beyond the information provided in the report, each patient safety incident was analysed by two non-surgeon reviewers - one a neuropsychologist and the other an expert in human factors. The primary raters were each paired with a senior surgeon, who were consulted on cases that were considered to require technical knowledge of specific medical procedures (n = 31).

To enhance inter-rater reliability, 20 cases were first analysed by both reviewers independently. Agreement at this stage was moderate (Cohen's kappa: .49), therefore a detailed checklist, with input from surgeons, FCTS and DW and human factors expert (RL), was produced, with examples within each of the 19 domains that were relevant in the context of surgical incidents. Further modification of the checklist was undertaken and after two iterations on 10 randomly selected reports from a sample of 20, a high level of inter-rater reliability ($\alpha \geq .80$) was achieved between the two primary raters on this subset of the data. The remaining 125 reports were randomly allocated to the two primary raters and independently assessed.

Results

The frequency of the identified contributory factors for the raters was logged (total of 329 factors from the 145 reports; **Figure 1**). Cognitive limitations (n = 99; 30.09%), communication systems issues (n = 53; 16.11%) and policy and procedure (n = 29; 8.81%) factors were the most frequently identified in these incident reports. To provide a more coherent picture of these 19 factors, these data were organised based on the hierarchical classification proposed by the YCFF (**Figure 1** inset), ordering by proximity of the factor to the incident, in time and space.

Situational factors, particularly those associated with task characteristics (specifically, the novelty and difficulty of performing the surgery) were logged in 15.5% (n = 51) of incidents. Local working conditions issues were classified in 18.54% (n = 61) of the event, with issues related to clarity around roles and responsibilities and low staff to patient ratios. Factors furthest from the error in time and space - latent organizational (n = 42), and external factors (n = 11), were identified in 16.11% of incidents. Often the contribution of these reflected issues around surgical technologies (i.e. design, adequacy and availability) and issues around policies and protocols (specifically, lack thereof) hindering performance.

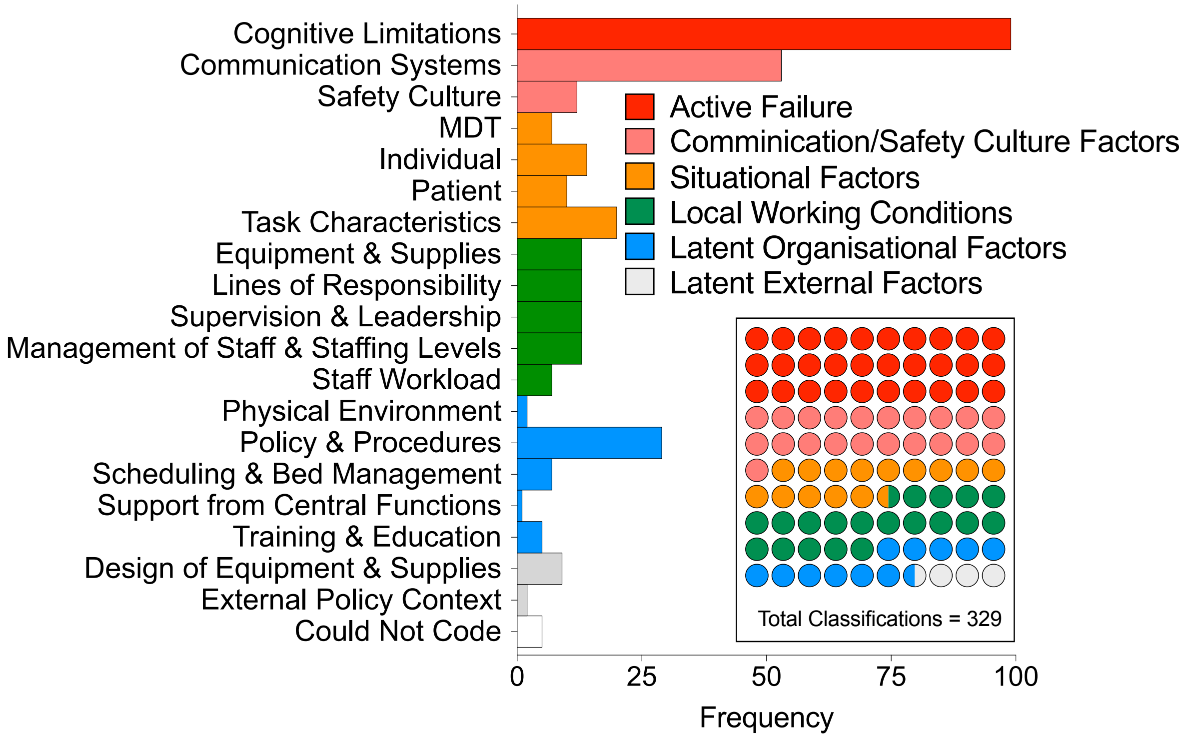

Figure 1: Safety incidents classified by factor based on the Yorkshire Contributory Factors Framework (YCFF). The inset displays a summary of the rate of the 329 classifications by a hierarchical classification separating the factors by their proximity in time and space to the adverse event – ranging from active failures (most proximal) to latent external factors (least proximal).

The data were further analysed to identify co-occurrence rates. Single factor incidents (i.e. only one contributory factor for an incident) accounted for 20.71% of the total number of reports. The data also revealed that the majority of incidents included two (42.14%) or three (24.2%) contributors (**Figure 2A**). The aim was to unpack this further by examining co-occurrence rates for each contributor. However, within the current dataset, it was only feasible to probe incident reports with our most frequent type of contributor – active failure (**Figure 2B**). Here, only 17% of reports showed that this factor was a sole contributor. Active failures were most often accompanied by situational factors (37.37% of cases), local working conditions (35.35%), latent external factors (25.25%) and communication and safety culture related contributors (37.37%).

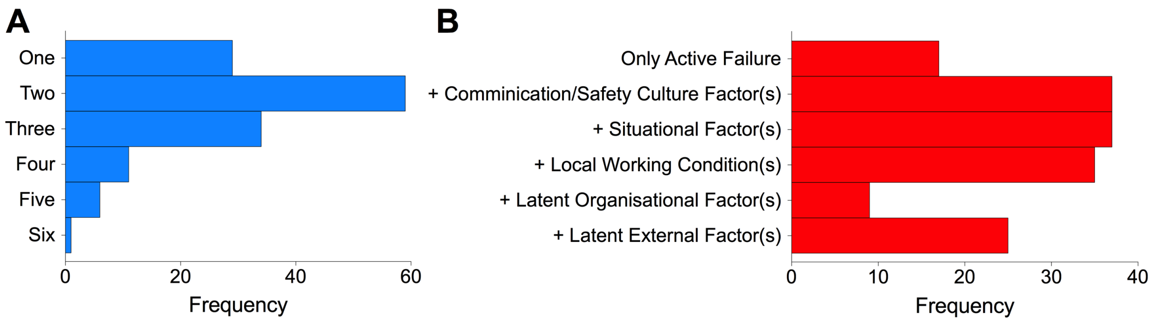

Figure 2: (A) Examination of the rate of co-occurrence of factors show that two and three contributors per incident were most prevalent; (B) From the subset of 99 cases classified as active failures- we found that these issues were often likely to co-occur with other contributors. These data show the frequency rates of each additional factor for these incidents.

Discussion

The most common factors identified as contributing to reported surgical incidents were cognitive limitations, communication failures and a lack of adherence to established policies and procedures. Adverse events were only rarely related to an isolated, single factor, with the majority of cases involving multiple contributory factors.

The primary findings i.e. a high frequency of cognitive limitations, are consistent with and complement other recent attempts to systematically analyse error in healthcare. For example, Flin et al (17) found that the most frequent types of errors anesthetists experienced in complications for airway management related to situational awareness or cognitive processes preceding an action error. They most often found failures in attention, concentration, problem solving, decision-making and memory – which share substantial overlap with the cognitive limitations factor in the present study. Another recent human-factors based framework revealed task failure (comprising skill, rule and knowledge based analysis) featured in 157 out of 498 incidents (18).

The second most frequent factor related to communication system-related issues which also dovetails with previous work e.g. (19,20). In an analysis of malpractice claims - where the surgical errors led to patient injury, technical competence and communication breakdowns were the most frequently identified issues (21). A detailed analysis of 30 adverse surgical events using a systems theory based approach as an alternative to root cause analysis (22), highlighted the importance of communication systems – where unsatisfactory systems lead to inconsistent processes, causing delays and misunderstandings in the delivery of care. Whilst the current analysis could not tease apart the *types* of communication failure contributing to incidents, previous work has shown that the majority of communication breakdowns happen at one-to-one level between transmitter and receiver, often through status asymmetries, uncertainty over job responsibilities and during hand-overs (23).

It is important to stress that whilst cognitive factors were particularly frequent, they may be the end-point product of other factors increasing the probability of their occurrence. Some of the limitations of the present study can be separated into issues around quantity and quality of the reports. The CORESS has been active for over a decade, but yielded only a small number of reports. A recent survey of members of the Association of Surgeons of Great Britain and Ireland (ASGBI; across specialties) found that 47% of respondents reported a significant error in their own performance and 75% were aware of a colleague experiencing error (24). Yet, 12% of surgeons were unaware of the procedure for reporting an error and 59% felt more guidance is needed. Most surprisingly, 40% indicated that a confidential reporting system (such as the one created by the ASGBI a decade earlier) would increase the likelihood of them reporting an error. It appears that more work is required to engage the surgical community to increase reporting practices. One approach may be to incorporate error logging into annual appraisals. This might also address issues around the selective nature of submissions – which provide only a small window into the nature of adverse surgical events.

Alongside quantity, improving the *quality* of incident reports is also imperative. One recommendation is that the CORESS could change the layout and logging procedure (e.g. with prompts based on the factors we have identified) to allow one to reflect more on the incident. Such a step would be useful in discriminating between different types of cognitive limitations (25). Future research needs to evaluate the existing reporting method in light of our results and consider ways in which the reporting form could be optimised to improve data quality by aligning the information gathered with existing analysis tools (26).

Whilst the checklist created for framework analysis was designed to be objective, the fact that the two primary raters in this study were specialists in psychology and human factors may have introduced a form of implicit bias. It is also worth considering alternative, complementary methods that could facilitate our understanding of adverse events in surgery through high quality data. For example, some have suggested the adoption of a mandatory live recording of a procedure (27). The presence of a video after an adverse event would provide an information rich resource for identifying, reflecting and learning about errors (28,29) and could also be useful as an education tool for operating staff to improve intraoperative performance (30).

Whilst this analysis does not speak to preventability (indeed, retrospective interpretations of preventability may be in the eye of the beholder (31)), it is worth considering interventions that could act as remedial strategies to target these errors. Issues around equipment and supplies appear to be readily amenable to intervention. The development of smart graspers that provide haptic feedback to guide the surgeon provides an illustration of how surgical technologies can reduce errors relating to the trauma caused by forceful instrument grasping (32). Cognitive errors of misidentifying an appendix as a fallopian tube could be amenable to perceptual identification training that included morphed versions of each structure. Similarly, communication skills training may address some of the issues in surgery that were highlighted in this study (33).

Given the increasing complexity and prevalence of endoscopic and robotic procedures, incidents linked to task characteristics and technical competence may increase over time. The opportunities offered by simulation training for surgical skill acquisition have been well documented (34–40), but the field has yet to fully exploit these methods (which may, in part, be due to system and resource related constraints). Interventions that directly target cognitive and motor preparation are showing promise. The benefits of “warming up” for optimal surgical performance are becoming clearer (41–43), with emerging evidence indicating that the risk of intra-operative errors related in perceptual identification and spatial orientation might be ameliorated by pre-operative interaction with virtual (44) and physical visual aids (45). However, such interventions are unlikely to work in isolation; healthcare delivery is a complex process involving the interactions of dynamical systems, and as such, interventions at the proximal level need to be considered in the context of the system in which they are embedded (46).

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References

1. Kohn LT, Corrigan JM, Molla S. To Err Is Human: Building a Safer Health System. Medicine I of, editor. Washington, D.C.: National Academy Press; 2000.
2. Bleich S. Issue Brief Medical Errors : Five Years After the IOM Report. 2005;
3. Stelfox HT, Palmisani S, Scurlock C, Orav EJ, Bates D. The "To Err is Human" report and the patient safety literature. Qual Saf Health Care. 2006;3(15):174–8.
4. Emmot D. Medical Errors in Surgery. Vol. 17, Bioethics Forum. 2001.
5. Kapur N, Parand A, Soukup T, Reader T, Sevdalis N. Aviation and healthcare : a comparative review with implications for patient safety. J R Soc Med. 2015;0(0):1–11.
6. Hollnagel E. Safety-I and Safety-II: The Past and Future of Safety Management. Farnham, UK: Ashgate; 2014.
7. Woodward S. Rethinking Patient Safety. Boca Raton, FL: CRC Press; 2017.
8. Macrae C. The problem with incident reporting. BMJ Qual Saf [Internet]. 2016;25(2):71–5.
9. Benn J, Koutantji M, Wallace L, Spurgeon P, Rejman M, Healey a, et al. Feedback from incident reporting: information and action to improve patient safety. Qual Saf Health Care [Internet]. 2009;18(1):11–21.
10. Lewis A, Taylor I. CORESS – A confidential reporting system for surgery. Ann R Coll Surg Engl. 2006;88:249–51.
11. Vuuren W van, Shea CE, Van der schaaf TW. The development of an incident analysis tool for the medical field [Internet]. 1997.
12. World Health Organization. The Conceptual Framework for the International Classification for Patient Safety Version 1.1 Final Technical Report [Internet]. Vol. 1,
13. Taylor-Adams S, Vincent C. Systems analysis of clinical incidents: the London protocol. Clin Risk. 2004;10(6):211–20.
14. Bagian JP, Gosbee J, Lee CZ, Williams L, McKnight SD, Mannos DM. The Veterans Affairs root cause analysis system in action. Jt Comm J Qual Improv. 2002 Oct;28(10):531–45.
15. Lawton R, Mceachan RRC, Giles SJ, Sirriyeh R, Watt IS, Wright J. Development of an

evidence-based framework of factors contributing to patient safety incidents in hospital settings : a systematic review. BMJ Qual Saf. 2012;21:369–80.

16. Reason J. Human Error. Cambridge University Press; 1990.

17. Flin R, Fioratou E, Frerk C, Trotter C, Cook TM. Human factors in the development of complications of airway management: Preliminary evaluation of an interview tool. Anaesthesia. 2013;68(8):817–25.

18. Mitchell RJ, Williamson A, Molesworth B. Application of a human factors classification framework for patient safety to identify precursor and contributing factors to adverse clinical incidents in hospital. Appl Ergon [Internet]. 2016;52:185–95.

19. Lear R, Riga C, Godfrey AD, Falaschetti E, Cheshire NJ, Herzeele I Van, et al. Multicentre observational study of surgical system failures in aortic procedures and their effect on patient outcomes. 2016;1467–75.

20. Gawande AA, Zinner MJ, Studdert DM, Brennan TA. Analysis of errors reported by surgeons at three teaching hospitals. Surgery. 2003;133(6):614–21.

21. Rogers SO, Gawande AA, Kwaan M, Puopolo AL, Yoon C, Brennan TA, et al. Analysis of surgical errors in closed malpractice claims at 4 liability insurers. Surgery. 2006;140(1):25–33.

22. Leveson N, Samost A, Dekker S, Finkelstein S, Raman J. A Systems Approach to Analyzing and Preventing Hospital Adverse Events. Jounral Paatient Saf [Internet]. 2016;0(0):47–58.

23. Greenberg CC, Regenbogen SE, Studdert DM, Lipsitz SR, Rogers SO, Zinner MJ, et al. Patterns of Communication Breakdowns Resulting in Injury to Surgical Patients. 2007;533–40.

24. White AD, Skelton M, Mushtaq F, Pike TW, Lodge JPA, Wilkie RM. Inconsistent reporting of minimally invasive surgery errors. 2015;1–5.

25. Croskerry P. The importance of cognitive errors in diagnosis and strategies to minimize them. Acad Med. 2003;78(8):775–80.

26. Gillespie A, Reader T. Healthcare Complaints Analysis Tool. London; 2015.

27. Makary MA. The Power of Video Recording. Jama [Internet]. 2013;309(15):1591.

28. Dimick JB, Varban OA. Surgical video analysis: an emerging tool for improving surgeon performance. BMJ Qual Saf [Internet]. 2015;24(8):490–1.

29. Bonrath EM, Gordon LE, Grantcharov TP. Characterising "near miss" events in complex laparoscopic surgery through video analysis. BMJ Qual Saf [Internet]. 2015;24(8):516–21.

30. Birkmeyer JD, Finks JF, O'Reilly A, Oerline M, Carlin AM, Nunn AR, et al. Surgical skill and complication rates after bariatric surgery. N Engl J Med [Internet]. 2013;369(15):1434–42.

31. Hayward RA, Hofer TP. Estimating hospital deaths due to medical errors: preventability is in the eye of the reviewer. Jama [Internet]. 2001;286(4):415–20.

32. Chandler JH, Mushtaq F, Moxley-Wyles B, West NP, Taylor GW, Culmer PR. Real-Time Assessment of Mechanical Tissue Trauma in Surgery. IEEE Trans Biomed Eng [Internet]. 2017;1–1.

33. Wilson JL, Whyte RI, Gangadharan SP, Kent MS. Teamwork and Communication Skills in Cardiothoracic Surgery. Ann Thorac Surg [Internet]. 2017;103(4):1049–54.

34. Al-Saud LMS, Mushtaq F, Allsop MJ, Culmer PC, Mirghani I, Yates E, et al. Feedback and motor skill acquisition using a haptic dental simulator. Eur J Dent Educ. 2016;11(4):1–8.

35. Mirghani I, Mushtaq F, Allsop M, Potter C, Tickhill N, Al-Saud LMS, et al. Capturing differences in dental training using a virtual reality simulator. Eur J Dent Educ. 2016;

36. Rosenthal R, Gantert WA, Scheidegger D, Oertli D. Can skills assessment on a virtual reality trainer predict a surgical trainee's talent in laparoscopic surgery? Surg Endosc [Internet]. 2006 Aug [cited 2013 Jul 25];20(8):1286–90.

37. Seymour NE, Gallagher AG, Roman S a, O'Brien MK, Bansal VK, Andersen DK, et al. Virtual reality training improves operating room performance: results of a randomized, double-blinded study. Ann Surg [Internet]. 2002 Oct [cited 2013 Mar 12];236(4):458-63-4.

38. Nickel F, Brzoska JA, Gondan M, Rangnick HM, Chu J, Kenngott HG, et al. Virtual reality training versus blended learning of laparoscopic cholecystectomy: a randomized controlled trial with laparoscopic novices. Medicine (Baltimore) [Internet]. 2015;94(20):e764–e764.

39. van Dongen KW, Ahlberg G, Bonavina L, Carter FJ, Grantcharov TP, Hyltander A, et al. European consensus on a competency-based virtual reality training program for basic endoscopic surgical psychomotor skills. Surg Endosc [Internet]. 2011;25(1):166–71.

40. Nagendran M, Gurusamy KS, Aggarwal R, Loizidou M, Davidson BR. Virtual reality training for surgical trainees in laparoscopic surgery. In: Gurusamy KS, editor. Cochrane Database of Systematic Reviews [Internet]. Chichester, UK: John Wiley & Sons, Ltd; 2013.

41. Pike TW, Pathak S, Mushtaq F, Wilkie RM, Mon-Williams M, Lodge JPA. A systematic examination of preoperative surgery warm-up routines. Surg Endosc Other Interv Tech. 2016;1–13.

42. Pike TW, Mushtaq F, Mann RP, Chambers P, Hall G, Tomlinson J, et al. Operating List Composition and Surgical Performance. Br J Surg. In Press.

43. Calatayud D, Arora S, Aggarwal R, Kruglikova I, Schulze S, Funch-Jensen P, et al. Warm-up in a virtual reality environment improves performance in the operating room. Ann Surg [Internet]. 2010 Jun;251(6):1181–5.

44. Kowalewski K-F, Hendrie JD, Schmidt MW, Proctor T, Paul S, Garrow CR, et al. Validation of the mobile serious game application Touch Surgery™ for cognitive training and assessment of laparoscopic cholecystectomy. Surg Endosc [Internet]. 2017;0(0):0.

45. Yiasemidou M, Glassman D, Mushtaq F, Athanasiou C, Williams M-M, Jayne D, et al. Mental practice with interactive 3D visual aids enhances surgical performance. Surg Endosc [Internet]. 2017;0(0):0.

46. Vincent C, Amalberti R. Safer Healthcare [Internet]. Safer Healthcare: Strategies for the Real World. 2016. 1-157 p.

Table 1: Yorkshire Contributory Factors Framework Structu

Factor	Description
Active Failures	Includes cognitive limitations- which encompass a broad spectrum of human performance related behaviours from lapses in judgement to sensorimotor errors. Examples include cutting corners that violate safe operating practices through to more implicit memory related factors.
Situational Factors	Covers multidisciplinary team (where issues may arise from professionals from different specialties working together, individual (the person delivering the care may have contributed to the failure e.g. through inexperience, attitude or stress induced by workload pressure), patient (clinical characteristics that increase probability of error e.g. dysphasic or suffering from cognitive difficulties) and task related factors (such as the novelty and risk of the procedure).
Local Working Conditions	Relates to local working conditions that can contribute to adverse events- such equipment and supplies (the availability and functionality of equipment), the lines of responsibility (and clarity around individual responsibility), supervision and leadership, management of staff (absence of skilled support) and staffing levels along with staff workload (e.g. ratio of staff relative to patient volume) and the physical environment (such as room layout, noise, lighting and temperature).
Latent Organisational Factors	Describes latent organisational factors- such as policy and procedures (e.g. poor quality or no standard operating procedures for equipment), bed scheduling factors – which result in treatment delays, the amount of support available from central services including clinical (availability of pharmacy or radiology support) through to non-clinical factors such as information technology and human. This class also includes training and education factors and the availability and appropriateness of induction training, and continuing professional development programmes.
Latent External Factors	Groups two latent external factors- the design of equipment and supplies (e.g. the design of the equipment impaired performance) and the external policy context- nationally driven directives that impact on the level and quality of resources available to hospitals with NICE guidelines and the European Working Time Directive as examples.
Overarching Factors	Incorporates communication systems (the effectiveness of the processes and systems in place for the exchange and sharing of information between staff, groups, departments and services) and safety culture issues (beliefs and practices surrounding the management of safety and learning from error) and is mapped across all five classes.