

Non-technical skills of the operating theatre scrub nurse: literature review

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Abstract

Title. Non-technical skills of the operating theatre scrub nurse: literature review.

Aim. This paper is a report of a review to identify the non-technical (cognitive and social) skills used by scrub nurses.

Background. Recognition that failures in non-technical skills contributed to accidents in high-risk industries led to the development of research programmes to study the role of cognition and social interactions in operational safety. Recently, psychological research in operating theatres has revealed the importance of non-technical skills in safe and efficient performance. Most of the studies to date have focused on anaesthetists and surgeons.

Data sources. On-line sources and university library catalogues, publications of the Association for Perioperative Practice, National Association of Theatre Nurses and Association of Peri-Operative Registered Nurses were searched in 2007.

Review methods. Studies were included in the review if they presented data from scrub nurses on one or more of their non-technical skills. These findings were examined in relation to an existing medical non-technical skills framework with categories of communication, teamwork, leadership, situation awareness and decision-making.

Results. Of 424 publications retrieved, 13 were reviewed in detail. Ten concerned communication and eight of those also had data on teamwork. In 11 papers teamwork was examined, and one focused on nurses' situation awareness, teamwork and communication. None of the papers we reviewed examined leadership or decision-making by scrub nurses.

Conclusion. Further work is needed to identify formally the non-technical skills which are important to the role of scrub nurse and then to design training in the identified non-technical skills during the education and development of scrub nurses.

Keywords: cognitive, literature review, non-technical skill, operating theatre, scrub nurse, teamwork

Introduction

Modern surgery requires a group of people with a variety of skills to work together effectively to deliver patient care. In

addition to their technical expertise, members of an operating theatre (OT) team will use a range of 'non-technical' skills. These are the cognitive and social skills that complement technical skills to achieve safe and efficient practice. The

main skill categories are situation awareness, decision-making, teamwork, communication, leadership and managing stress and fatigue (Flin *et al.* 2008). Non-technical skills are distinct from psychomotor skills (Reilly & Oermann 1985), as they involve interactions between team members (e.g. communication, teamwork and leadership) or thinking skills such as the ability to read and understand situations or to make decisions, all of which assist with task execution. Taxonomies of these non-technical skills have already been identified for anaesthetists' and surgeons' performance in the intra-operative phase of surgical procedures. Another key member of the theatre team is the scrub nurse, who works directly with one or more surgeons while they are operating on the patient (the term scrub nurse will be adopted here, although this position is sometimes called an instrument nurse or practitioner). As there does not appear to be any taxonomy of non-technical skills for scrub nurses, a new research project has been established to identify these skills. The first stage in this process is to review the published literature on the scrub nurses' role to determine the cognitive and social skills required for expert nursing practice during an operation.

Background

Non-technical skills in high risk work settings

In the late 1970s, it was acknowledged within the aviation industry that failures in pilots' non-technical skills contributed to accidents. This led to the development of special research programmes to identify these skills and, subsequently, to the design of non-technical skills training courses called Crew Resource Management (CRM) to reduce error and improve the performance of flight crews (Wiener *et al.* 1993). Since their inception in the 1980s, CRM courses have evolved and in the United Kingdom (UK) the Civil Aviation Authority (CAA 2006) requires all commercial pilots to attend an annual CRM training course which covers six core topics:

- Communication/interpersonal skills.
- Situation awareness.
- Problem-solving/decision-making/judgement.
- Leadership.
- Stress and fatigue management.
- Critique (e.g. analysis and planning).

Each airline operator is responsible for devising training in these skills in a way which suits their company's operations and culture. Once the CRM training commences, it is then important to ensure that trainees are given feedback on their progress. It is also vital to evaluate the effectiveness of the

CRM training and, although this can be performed using attitude surveys, one of the most valuable methods of judging whether training has resulted in knowledge transfer and improved skill execution is to rate performance by observing individuals during task execution. To increase the reliability and objectivity of these observations, behavioural rating tools have been developed. For example, a recommended tool for rating airline pilots' behaviour is called NOTECHS and was developed by European pilots and psychologists (O'Connor *et al.* 2002). A behavioural rating tool is developed by identifying the non-technical skills relevant to the task domain and devising a rating system to assess them. Normally, examples of good and poor behaviours in each non-technical skill category are provided, sometimes for each point on the rating scale. Data from a reliable behaviour rating tool can then be used to rate individuals' performance of non-technical skills objectively and to enable constructive feedback to be generated. In addition, these rating data can be used to assess the effectiveness of the training programme in changing or maintaining the desired behaviour (non-technical skills) of the individual during task execution.

Crew Resource Management courses are also used in other high risk work settings, such as nuclear power, military and shipping (Flin *et al.* 2008). In recent years there have been efforts to extend research and training in non-technical skills into areas of acute healthcare services, such as surgery, trauma centres and intensive care units (ICU) (Baker *et al.* 2007). Work in anaesthesia (Fletcher *et al.* 2004), surgery (Yule *et al.* 2006a, 2006b), ICU (Reader *et al.* 2006) and neonatal resuscitation (Thomas *et al.* 2004) has identified non-technical skills taxonomies and behavioural rating systems for doctors, and these are now being used in professional training and formative assessment. Tools have also been developed to observe and rate non-technical skills in OT teams (Undre *et al.* 2006). To date, less attention seems to have been given to the non-technical skills of nurses, yet the scrub nurse in particular is a key member of a surgical team.

The nursing skills which are of particular interest are the cognitive and social skills that can be rated from observed behaviour in theatre. Other non-technical skills usually included in CRM training are the management of stress and fatigue, with which theatre nurses undoubtedly have to deal. However, as these would not usually be included in a skill-set designed for behaviour rating, because of difficulties in accurately judging these from observed behaviour (Flin *et al.* 2003b), they were not included in the search for this review. Non-technical skills complement a practitioner's technical skills, and a brief summary is given next of the technical skills and duties of the scrub nurse/practitioner.

Role of the scrub nurse

The traditional responsibilities of the scrub nurse include ensuring that they are correctly 'scrubbed up', preparation of the instruments, trolleys and sterile supplies needed for the surgery, maintaining a sterile environment, providing skilled assistance to the surgeon during the operation, and performing the swab/instrument count at the end of the procedure (Taylor & Campbell 2000b). There are standard texts on the tasks and responsibilities of theatre nurses, but the scope and definition of the role of scrub nurse have been the subject of debate because their duties and responsibilities have changed over the years (McGarvey *et al.* 2000). However, the focus of most writing on scrub nurses has predominantly been on defining their technical duties, particularly in relation to assisting the surgeon (Woodhead 1995, Hind 1997, McGarvey *et al.* 2000), rather than examining the non-technical skills required to do the job effectively. Embedded within those descriptions of technical skills are cognitive skills (such as anticipation or making appropriate decisions) and teamwork skills, e.g. communicating effectively during the procedure (with the surgeon, circulating nurse and other team members).

Internationally, the qualifications/courses necessary before becoming a scrub nurse vary. In the UK, registered nurses may apply for a post in theatre upon completion of the initial three-year pre-registration programme. There is currently no national secondary qualification required to become a scrub nurse, although there are specialized courses which scrub nurses can attend at college or university. However, these are not a requirement for the post and are often only taken by nurses who are aiming to obtain a nursing qualification. Thus, it appears that scrub nurses acquire their expertise largely by learning once they are working in the role.

The review

Aim

The aim of the review was to identify the non-technical (cognitive and social) skills used by scrub nurses.

Design

This review followed a systematic search informed by Cochrane (Green & Higgins 2005) and also drew on the design of previous literature reviews for anaesthetists' (Fletcher *et al.* 2002) and surgeons' (Yule *et al.* 2006a) non-technical skills. The non-technical skill categories used to classify the identi-

fied skills were derived from previous systems: Non-technical skills for anaesthetists (ANTS) (Flin *et al.* 2003a) and non-technical skills for surgeons (NOTSS) (Flin *et al.* 2006b). The five skill categories, with definitions of an element in each category, to be searched for scrub nurses were:

- Communication – skills for exchanging information.
- Teamwork – skills for working in a group context to ensure effective task completion and team member satisfaction.
- Situation awareness – skills for developing and maintaining an overall understanding of the work setting and for anticipating future states.
- Leadership – skills for directing and supporting others and for maintaining a high standard of clinical care.
- Decision-making – skills for reaching a judgement to select a course of action or to make a diagnosis about a situation.

Search method

On-line sources including BioMed Central, PubMed Medline, NHS e-library, ScienceDirect, Scopus and Web-of-Science, plus University library catalogues, publications of the Association for Perioperative Practice (AfPP), National Association of Theatre Nurses (NATN), Association of peri-Operative Registered Nurses (AORN) and bibliographies from related research papers were also consulted. The search terms used were: theatre/scrub/instrument/nurse/practitioner AND; communication/discussion/relationships/surgeon/trust/lead/leadership/leader/team/teamwork/skill/decision/decision-making/situationawareness/operation/operatingroom/theatre/OT (see Figure 1 for the screening method used). There were no date restrictions and the search was conducted in 2007.

Search outcome

Of the 424 publications originally identified, 37 reported data collected in the OR, examined non-technical skills and included theatre nurse studies. Of those 37, only 13 papers included data pertaining to non-technical skills of theatre nurses.

Quality appraisal

Included papers were published in peer-reviewed journals ($n = 13$). Papers were only included if they fitted the criteria shown in the screening method in Figure 1. The papers comprised four interview studies, three observation studies, one which combined both those methods, two questionnaire studies, one discussion piece, a retrospective case study and one using a CRM training method.

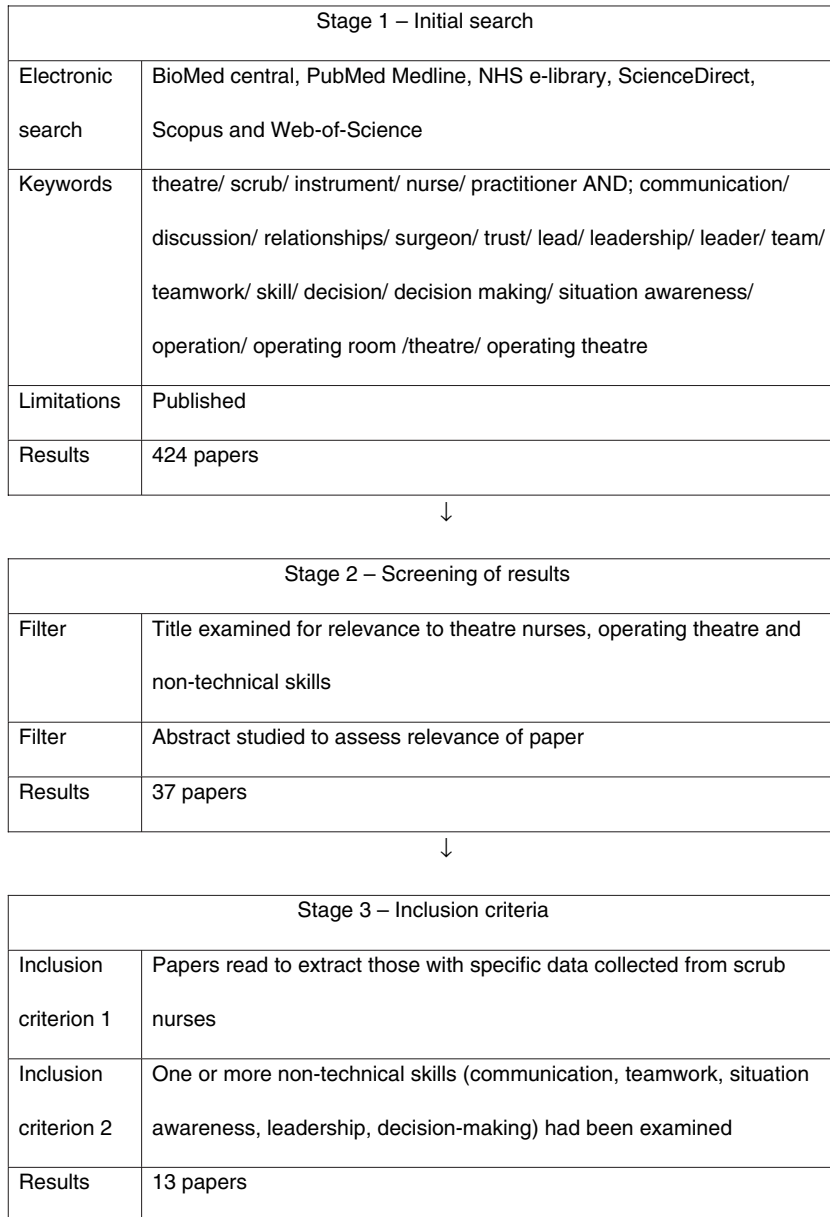


Figure 1 Literature review method.

Data abstraction

Table 1 shows which of the non-technical skills were examined in each of the 13 papers. The first author and a PhD student independently read the 37 papers and agreed that 13 met the final inclusion criteria. In addition to the 13 papers reviewed in detail, information from books on theatre nursing skills (e.g. Plowes 2000), findings from a Public Inquiry (Kennedy 2001) and other papers discussing relevant aspects of the scrub nurse role are also cited below to provide context for the review.

The information on scrub nurses’ skills was extracted by examining each of the 13 papers and noting all the behav-

iours related to cognitive and social skills. They were then categorized using an adapted version of a classification of NOTSS (Flin *et al.* 2006b). This method had been used previously as part of the identification process for medical professionals [anaesthetists (Fletcher *et al.* 2004) and surgeons (Yule *et al.* 2006b)].

Synthesis

The resulting skills identified from the 13 papers all fitted into three of the five non-technical skill categories identified for the surgeons’ non-technical skill set (Yule *et al.* 2006b), namely communication, teamwork and situation awareness.

Table 1 Non-technical skill categories examined in the 13 included papers

Paper	Non-technical skill			
	Communication	Teamwork	Situation awareness	Decision-making
Awad <i>et al.</i> (2005)	X	X		
Baylis <i>et al.</i> (2006)		X		
Edmondson (2003)	X	X		
Flin <i>et al.</i> (2006a)	X	X		
Nestel and Kidd (2006)	X	X		
Riley and Manias (2006)	X	X	X	
Saunders (2004)	X			
Sevdalis <i>et al.</i> (2007)	X			
Sexton <i>et al.</i> (2000)	X	X		
Silen-Lipponen <i>et al.</i> (2005)	X	X		
Tanner and Timmons (2000)		X		
Timmons and Reynolds (2005)		X		
Undre <i>et al.</i> (2006)	X	X		

No behaviours were extracted from the papers that could be classified as scrub nurses' leadership or decision-making.

Results

Table 1 shows the non-technical skills discussed in each of the 13 papers reviewed. Of the 13 papers, 10 studied communication and eight of those also had data on teamwork. A total of 11 papers examined teamwork and one studied nurses' situation awareness, teamwork and communication. There were no papers which had data or examined leadership or decision-making of scrub nurses. The papers which were reviewed are now discussed, beginning with communication as it was the most frequently studied non-technical skill category in the reviewed set of papers.

Categories of scrub nurses' non-technical skills

Communication

The importance of communication is seen as a fundamental element of all types of nursing but the focus of the nursing literature has tended to be on communicating with the patient as opposed to with colleagues. The 10 papers with communication data referred to nurses listening and interpreting what others in the team were saying as well as competently conveying information. Some gave examples of good (clear and concise) and poor (using sarcasm, deliberately withholding information) communication. It is understood that within the OT, verbal communication is kept to a minimum (to prevent cross infection and aid concentration) and can be hampered because of the necessity of wearing surgical masks, therefore, eye contact and non-verbal cues, as well as verbal

clarification and reinforcement of what is being communicated should be demonstrated (Saunders 2004). It has also been recognized that all members of a theatre team require effective communication skills to enable the smooth running of the OT (Taylor & Campbell 2000a).

Insufficient or ineffective communication between team members in the OT setting has been recognized as a contributing factor to some adverse events (Helmreich & Schaefer 1994). Lingard *et al.* (2004) recorded communication errors in 30% of surgical procedures observed although they did not specify how many of these were made by or involved the scrub nurse. A checklist was developed to promote team communication between the disciplines in the OT (Lingard *et al.* 2005). The extent of distraction suffered by surgical team members when there are case-irrelevant communications (CIC), such as questions about; a previous or future patient as opposed to the one currently on the table, equipment, telephone calls or bleeps within the OT was examined in one study (Sevdalis *et al.* 2007). It was found that the majority of these communications were intended for the surgeon and that visitors to the OT produced the most CICs but those addressed to the surgeons were not as distracting to the theatre team as communications intended for the nurse or anaesthetist. A focus group interview in a UK hospital concluded that there was general dissatisfaction with communication in the OT among the seven experienced theatre nurses who took part (Nestel & Kidd 2006) although this is a small sample from which to draw firm conclusions. It does seem that there is room for improvement regarding communication among members of the OT team.

In an attempt to improve communication, in a United States of America (USA) study CRM principles were used

with surgeons, anaesthesiologists and nurses in the OT. They perceived communication as good, poor and adequate respectively, indicating the inconsistent perceptions different team members have of their working relationship. Following implementation of a CRM-based technique, perceptions of communication were significantly improved for the surgeons and anaesthetists; however, there was no change seen in the nurses' views (Awad *et al.* 2005) although the authors suggest this may have been as a result of a methodological issue whereby not all nurses who were surveyed had received full exposure to the briefing process designed to improve communication within the team.

Another communication issue, particularly within the hierarchical structure of the OT is the issue of feeling free to speak up. This was examined when personnel were learning how to use new technology for cardiac surgery in the USA and across the 16 teams the researchers found that the difficulties staff reported were more behavioural than technical. Participants described the new equipment as being more communication-intensive, requiring all members of staff to communicate effectively, leading to most surgeons accepting that perfusionists would ask questions of them prior to the commencement of cases. Nurses explained that staff in the team had not been used to speaking up as they were afraid, or simply would not have dared do so, in the past. However, the implementation of the new procedures had forced staff to communicate and they had noticed staff listening to other members of the team and putting more credence into what they were saying, despite the fact that these communication patterns were contrary to the power-based communication norms the staff had been used to (Edmondson 2003). Communication is often difficult to detach from teamwork because communication in the OT setting is generally between members of a team.

Teamwork

As well as the medical staff (consultant surgeon, surgeon's assistant/registrar and anaesthetist), the minimum number of nursing staff in the perioperative team for an operation under general anaesthetic is normally three, and comprises anaesthesia assistant, scrub nurse/practitioner and circulating/floor practitioner. This multi-disciplinary team of professionals works together to complete the patient's anaesthetic and surgery successfully (Taylor & Campbell 2000a). We identified 11 papers that discussed teamwork, including behaviours such as memorizing surgeons' preferences and sharing information to aid teamwork and the effect on performance of stable vs. flexible theatre teams. Attitudes to teamwork and hierarchy were also common themes.

Researchers have examined teamwork in the field of medicine to try to develop ways to enhance patient safety and increase team cohesion to reduce error. Undre *et al.* (2006) found that members of the theatre team perceived its construction in different ways. Nurses largely felt that the theatre team was a single unit, in contrast with surgeons' impressions of being a member of a team which comprised several highly specialized subteams. Sexton *et al.* (2000) found low ratings of teamwork by surgical nurses when they rated interactions with consultant surgeons. Flin *et al.* (2006a) also found differing views of teamwork in the OT, as surgeons rated their quality of relationships with other consultants and nurses equally, whereas nurses rated teamwork and communication with other nurses higher than between themselves and surgeons.

The working relationship between doctors and nurses has been the subject for study since Stein's classic paper (Stein 1967), in which this relationship was described as a 'game' where the nurse ultimately learned the art of making suggestions to the doctor without overtly doing so. It appeared that nurses believed that they could not, in any circumstances, challenge doctors' decisions because they felt that they held a subservient role to that of doctors. As then, several researchers have considered how this relationship has evolved (e.g. Hughes 1988, Stein *et al.* 1990, Porter 1991, Mackay 1993, Svensson 1996) and have offered differing views as to why the relationship has changed, but the general consensus is that the relationship has become more informal over time. In one study, it was identified that scrub nurses in five UK National Health Service hospitals perceived their main responsibility as 'not upsetting' the surgeon or 'keeping the surgeons happy'. The informal and friendly nature they reported between doctor and nurse in the OT, compared with wards, was caused by environmental differences between the departments (Timmons & Reynolds 2005). It has been suggested that this difference between hospital departments is because of the restricted access in theatre. In one UK study, a relaxed atmosphere, in contrast to the more formal professional exchanges in other areas, was observed, suggesting that medical staff view theatres as a more private environment than other departments. Because members of the public are denied access and patients are generally anaesthetized and unaware of staff conversations, joking, sarcasm and gossiping between medical and nursing staff within theatres was seen (Tanner & Timmons 2000). With medical advancement enabling an increasing number of procedures to require local as opposed to general anaesthesia, it may be that these informal/relaxed behaviours will be demonstrated less; however, no evidence of this has been reported to date.

Teams in the OT can either be flexible, where personnel are rotated, or stable, where members become used to working together as a unit. Within stable nurse teams in theatre, members may be multi-skilled and therefore alternate between scrub and circulating roles. Stable OT teams have been seen to help to combine team members' skills, enable advanced planning and promote safety in Finland, the UK and the USA by Silen-Lipponen *et al.* (2005). During their interviews with nurses, less experienced nurses admitted that in a strange team they felt unable to prepare or participate in the planning of the surgery. Nurses also demonstrated frustration towards the attitude of some surgeons, who seemed unaware that their operating style differed from that of their colleagues when they assumed that nurses would automatically know what equipment they required; this resulted in the nurses becoming flustered and prone to making mistakes, causing concern for patient safety. The benefits of a stable, trained team in laparoscopic surgery has been found to reduce operating time (Kenyon 1997), whilst Baylis *et al.* (2006) concluded that staff on unplanned leave being replaced in the team by temporary staff resulted in a higher incidence of complications.

Situation awareness

Situation awareness is defined as 'the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future' (Endsley 1995, p. 36). This perceptual skill has received extensive attention in aviation, as well as many other professions (Endsley & Garland 2000, Sneddon *et al.* 2006); however, it has been mentioned in only one theatre nursing report.

Perceptual and anticipatory cognitive skills are clearly critical for scrub nurses as an element of their expertise is to 'think ahead of the surgeon'. The scrub nurse has to assess the progress of the surgical task correctly and select the appropriate instrument for the next phase of the operation. An Australian study, in which nurses in three hospitals were observed, theatre nurses used 'judicial wisdom' to assess the behaviour and actions of the OT team by drawing on personal expertise and their own knowledge of surgical procedures, without the need to interrupt the operation by asking questions. It was argued that this demonstrated their ability to read surgeons' demeanour and sense the appropriate time for asking questions or interrupting surgery, and to ascertain when they were going to be finished, for example. The authors referred to the unobtrusive manner in which the nurse assesses the situation without interrupting as 'prudent silence' (Riley & Manias 2006, p. 1548) and this is also an example of both situation awareness and teamwork.

Riley (2006) also identified nurses' knowledge of surgeons' idiosyncratic methods of operating as a means of anticipating their instrument requirements during the operation. Despite the use of 'preference cards' which indicated surgeons' instrument requirements for different procedures, these were often found to be altered or unclear; they sometimes included a choice of instruments for a single procedural element, which was taken as an indication of the changeable nature of surgeons' requirements and made anticipating their needs much more difficult. Scrub nurses were also seen to manage surgeons in several ways, including becoming aware of which ones were always late, early or on time, so that they could anticipate the likelihood of the list for that day being completed.

Apart from the Riley (2006) study, situation awareness does not seem to have been studied for scrub nurses, but this is unsurprising as it has only recently been investigated for surgeons (Way *et al.* 2003); however, there have been some studies in other domains of nursing, such as neonatal intensive care (Militello & Lim 2006).

Decision-making and leadership

While scrub nurses are obviously required to make decisions and to engage with surgeons and other team members during intra-operative problem-solving, decision-making during operations does not seem to have been studied for scrub nurses, according to the 13 papers reviewed. A recent review of the surgical literature revealed that it has also rarely been studied for surgeons (Flin *et al.* 2007), and it is only in other areas of nursing such as critical care (Bucknall 2003, Cesna & Mosier 2004) that decision-making has been examined.

No research was found focussing on scrub nurses' leadership in the OT, perhaps because this is not seen as a key part of their role as there are more senior theatre nurses leading the whole team of nurses in a theatre or theatre suite, or scrub nurses take their lead from surgeons. It is possible that leadership is not required by scrub nurses, yet this would be a skill displayed in a situation where an experienced scrub nurse is working with a less experienced or trainee circulating nurse or with an inexperienced surgeon. Nursing leadership has been studied in other areas of the hospital; e.g. emergency departments and critical care (Nembhard & Edmondson 2006), and nurses' leadership style (Ward 2002) has also been examined.

Discussion

The study of scrub nurses' non-technical skills is a topic on which there has been very little direct focus but it is apparent that these skills are acquired and incorporated into the scrub

What is already known about this topic

- Studies of anaesthetists and surgeons in the operating theatre have shown the importance of non-technical skills for these theatre team members.
- Technical expertise alone does not ensure safe and effective practice scrub nurses.
- Non-technical scrub nurse skills are not procedural but rather are cognitive or social skills and can be categorized as communication, teamwork, leadership, situation awareness and decision-making.

What this paper adds

- Scrub nurses are crucial members of the theatre team and identifying the non-technical skills necessary to perform their role effectively is a first step towards training and rating these skills.
- Training programmes in the identified non-technical skills could then be developed and individual nurses' competence assessed.
- Communication, teamwork and situation awareness skills of scrub nurses may be important, although further research in this area is required.

nurses' performance. Some examples of scrub nurses' non-technical skills as represented in the literature are shown in Table 2.

Where interviewed or observed, it seems that nurses' input has been obtained with regard to the theatre team as a whole or as a consequence of investigating surgeons' skills, improving safety or reducing error in general terms within the OT.

Scrub nurses' ability to identify and cope with different surgeons' personalities and changing preferences is a skill which enables them to assess surgical situations, particularly

when a procedure is not going according to the original plan. They appear to be able to identify the changing behaviour of surgeons as well as absorbing clues in the theatre environment, so that they can adjust their own performance to assist surgeons effectively.

Traditionally in health care, it has usually been as a result of complications or fatalities that communication skills are scrutinized. For instance, communications were found to be 'strained' in the paediatric surgical unit of the Bristol Royal Infirmary when it was investigated following the high mortality rate of patients there, leading to recommendations that communication with colleagues should be improved (Kennedy 2001). At that time, the culture was such that less experienced nurses (and doctors) had a genuine fear of repercussions, were they to speak up about colleagues' (particularly surgeons') shortcomings.

Nurses' non-technical skills can be identified from the literature, although it may be that other non-technical skills are used by scrub nurses and these could be identified by using a different method of task analysis (Flin *et al.* 2008). Semi-structured interviews with experienced scrub nurses or observing their task execution might provide more examples of communication and teamwork and could also identify other skills and, whilst it is likely that scrub nurses will also use the skills of situation awareness, decision-making and teamwork, the component elements of these categories remain to be determined.

Conclusion

From this review of the literature it can be concluded that there is room for further work in this area to identify formally the non-technical skills which are important to the role of scrub nurse and then to develop a skill set. This could be used to design training in the identified non-technical skills during the education and development of scrub nurses. As theatre nurses are crucial members of surgical teams,

Table 2 Preliminary listing of scrub nurses' non-technical skills as represented in the literature

Skill category	Description*	Example
Communication	Exchanging information	Using non-verbal (hand signals) and verbal communication to assess surgeons' requirements/clarifying any issues which are unclear.
Teamwork	Establishing common understanding/co-ordinating team activities	Managing/not upsetting the surgeon/learning individuals' idiosyncrasies and adapting own behaviour to maintain a relaxed atmosphere.
Situation awareness	Gathering/understanding information/anticipating future state	Using experience to assess situation, able to assimilate details and anticipate future requirements of surgeon.

*Adapted from Yule *et al.* (2006b)

overall team performance – and ultimately patient safety – might benefit from the identification and study of these non-technical skills.

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Author contributions

LM & RF were responsible for the study conception and design. LM performed the data collection. LM performed the data analysis. LM was responsible for the drafting of the manuscript. LM & RF made critical revisions to the paper for important intellectual content. RF obtained funding. RF & LM provided administrative, technical or material support. RF & LM supervised the study.

References

- Awad S.S., Fagan S.P., Bellows C., Albo D., Green-Rashad B., De La Garza M. & Berger D.H. (2005) Bridging the communication gap in the operating room with medical team training. *American Journal of Surgery* **190**, 770–774.
- Baker D.P., Salas E., Barach P., Battles J. & King H. (2007) The relationship between teamwork and patient safety. In *Handbook of Human Factors and Ergonomics in Health Care and Patient Safety* (Carayon P., ed.), Lawrence Erlbaum Associates, Mahwah, NJ, pp. 259–271.
- Baylis O.J., Adams W.E., Allen D. & Fraser S.G. (2006) Do variations in the theatre team have an impact on the incidence of complications? *BMC Ophthalmology* **6**(13) doi: 10.1186/1471-2415-6-13.
- Bucknall T. (2003) The clinical landscape of critical care: nurses' decision-making. *Journal of Advanced Nursing* **43**(3), 310–319.
- CAA (2006) *Crew Resource Management (CRM) Training. Guidance for Flight Crew, CRM Instructors (CRMIs) and CRM Instructor-Examiners (CRMIEs)*. CAP 737, Version 2. Civil Aviation Authority, Gatwick.
- Cesna M. & Mosier K. (2004) Using a prediction paradigm to compare levels of expertise and decision making among critical care nurses. In *How Professionals Make Decisions* (Montgomery H., ed.), Lawrence Erlbaum Associates, Mahwah, NJ, pp. 107–117.
- Edmondson A.C. (2003) Speaking up in the operating room: how team leaders promote learning in interdisciplinary action teams. *Journal of Management Studies* **40**(6), 1419–1452.
- Endsley M. (1995) Toward a theory of situation awareness in dynamic systems. *Human Factors* **37**, 32–64.
- Endsley M. & Garland D. (2000) *Situation Awareness Analysis and Measurement*. Lawrence Erlbaum Associates, Mahwah, NJ.
- Fletcher G., McGeorge P., Flin R., Glavin R.J. & Maran N. (2002) The role of non-technical skills in anaesthesia: a review of current literature. *British Journal of Anaesthesia* **88**, 418–429.
- Fletcher G., Flin R., McGeorge P., Glavin R., Maran N. & Patey R. (2004) Rating non-technical skills: developing a behavioural marker system for use in anaesthesia. *Cognition Technology and Work* **6**, 165–171.
- Flin R., Fletcher G., Glavin R., Maran N. & Patey R. (2003a) *Anaesthetists' Non-Technical Skills (ANTS) System Handbook*. Retrieved from <http://www.abdn.ac.uk/iprc/ants> on 14 April 2008.
- Flin R., Martin L., Goeters K., Hoermann J., Amalberti R., Valot C. & Nijhuis H. (2003b) The development of the NOTECHS system for evaluating pilots' CRM skills. *Human Factors and Aerospace Safety* **3**, 95–117.
- Flin R., Yule S., McKenzie L., Paterson-Brown S. & Maran N. (2006a) Attitudes to teamwork and safety in the operating theatre. *The Surgeon* **4**, 145–151.
- Flin R., Yule S., Paterson-Brown S., Rowley D. & Maran N. (2006b) *Non-Technical Skills for Surgeons (NOTSS) System Handbook*. Retrieved from <http://www.abdn.ac.uk/iprc/notss>.
- Flin R., Youngson G.G. & Yule S. (2007) How do surgeons make intra-operative decisions. *Quality and Safety in Healthcare* **16**, 235–239.
- Flin R., O'Connor P. & Crichton M. (2008) *Safety at the Sharp End. A Guide to Non-Technical Skills*. Ashgate, Aldershot.
- Green S. & Higgins J. (eds) (2005) *Cochrane Handbook for Systematic Reviews of Interventions 4.2.5*. Retrieved from <http://www.cochrane.org/resources/handbook/> on 14 April 2008.
- Helmreich R.L. & Schaefer H.G. (1994) Team performance in the operating room. In *Human Error in Medicine* (Bogner M., ed.), Lawrence Erlbaum Associates, Mahwah, NJ, pp. 225–253.
- Hind M. (1997) Surgeons' assistants: a new role for operating theatre nurses? *British Journal of Nursing* **6**(22), 1298–1300.
- Hughes D. (1988) When nurse knows best: some aspects of nurse/doctor interaction in a casualty department. *Sociology of Health and Illness* **10**, 1–21.
- Kennedy I. (2001) *Bristol Royal Infirmary Inquiry*. Retrieved from http://www.bristol-inquiry.org.uk/final_report/index.htm on 12 March 2007.
- Kenyon L. (1997) Cost and benefit of the trained laparoscopic team. *Surgical Endoscopy* **11**, 812–814.
- Lingard L., Espin S., Whyte S., Regehr G., Baker G. & Reznick R. (2004) Communication failures in the operating room: an observational classification of recurrent types and effects. *Quality and Safety in Healthcare* **13**, 330–334.
- Lingard L., Espin S., Rubin B., Whyte S., Colmenares M. & Baker G.R. (2005) Getting teams to talk: development and pilot implementation of a checklist to promote interprofessional communication in the OR. *Quality and Safety in Healthcare* **14**, 340–346.
- Mackay L. (1993) *Conflicts in Care. Medicine and Nursing*. Chapman & Hall, London.
- McGarvey H.E., Chambers M.G.A. & Boore J.R.P. (2000) Development and definition of the role of the operating department nurse: a review. *Journal of Advanced Nursing* **32**(5), 1092–1100.

- Militello L. & Lim L. (2006) Patient assessment skills: assessing early cues of necrotizing enterocolitis. *Journal of Perinatal and Neonatal Nursing* 9, 42–52.
- Nembhard I.M. & Edmondson A.C. (2006) Making it safe: the effects of leader inclusiveness and professional status on psychological safety and improvement efforts in health care teams. *Journal of Organizational Behavior* 27, 941–966.
- Nestel D. & Kidd J. (2006) Nurses' perceptions and experiences of communication in the operating theatre: a focus group interview. *BMC Nursing* 5(1) doi: 10.1186/1472-6955-5-1.
- O'Connor P., Hörmann H.J., Flinn R., Lodge M., Goeters K.M., The JARTEL Group (2002) Developing a method for evaluating CRM skills: a European perspective. *The International Journal of Aviation Psychology* 12, 263–285.
- Plowes D. (ed.) (2000) *Back to Basics: Perioperative Practice Principles*. National Association of Theatre Nurses, Harrogate.
- Porter S. (1991) A participant observation study of power relations between nurses and doctors in a general hospital. *Journal of Advanced Nursing* 16, 728–735.
- Reader T., Flin R., Lauche K. & Cuthbertson B.H. (2006) Non-technical skills in the intensive care unit. *British Journal of Anaesthesia* 5, 551–559.
- Reilly D. & Oermann M.H. (1985) *The Clinical Field, its use in Nursing Education*. Appleton-Century-Croft, Norwalk, CT.
- Riley R.G. & Manias E. (2006) Governance in operating room nursing: nurses' knowledge of individual surgeons. *Social Science and Medicine* 62, 1541–1551.
- Saunders S. (2004) Why good communication skills are important for theatre nurses. *Nursing Times* 100(14), 42–44.
- Sevdalis N., Healey A.N. & Vincent C.A. (2007) Distracting communications in the operating theatre. *Journal of Evaluation in Clinical Practice* 13, 390–394.
- Sexton J.B., Thomas E.J. & Helmreich R.L. (2000) Error, stress, and teamwork in medicine and aviation: cross sectional surveys. *British Medical Journal* 320, 745–749.
- Silen-Lipponen M., Tossavainen K., Turunen H. & Smith A. (2005) Potential errors and their prevention in operating room teamwork as experienced by Finnish, British and American nurses. *International Journal of Nursing Practice* 11, 21–32.
- Sneddon A., Mearns K. & Flin R. (2006) Safety and situation awareness in offshore crews. *Cognition, Technology and Work* 8, 255–267.
- Stein L.I. (1967) The doctor–nurse game. *Archives of General Psychiatry* 16, 699–703.
- Stein L.I., Watts D.T. & Howell T. (1990) The doctor–nurse game revisited. *New England Journal of Medicine* 322, 546–549.
- Svensson R. (1996) The interplay between doctors and nurses: a negotiated order perspective. *Sociology of Health and Illness* 18, 379–398.
- Tanner J. & Timmons S. (2000) Backstage in the theatre. *Journal of Advanced Nursing* 32(4), 975–980.
- Taylor M. & Campbell C. (2000a) Communication skills in the operating department. In *Back to Basics: Perioperative Practice Principles* (Plowes D., ed.), National Association of Theatre Nurses, Harrogate, pp. 50–53.
- Taylor M. & Campbell C. (2000b) The multi-disciplinary team in the operating department. In *Back to Basics: Perioperative Practice Principles* (Plowes D., ed.), National Association of Theatre Nurses, Harrogate, pp. 44–48.
- Thomas E.J., Sexton J.B. & Helmreich R.L. (2004) Translating teamwork behaviours from aviation to healthcare: development of behavioural markers for neonatal resuscitation. *Quality and Safety in Healthcare* 13, 57–64.
- Timmons S. & Reynolds A. (2005) The doctor–nurse relationship in the operating theatre. *British Journal of Perioperative Nursing* 15(3), 110–115.
- Undre S., Healey A.H., Darzi A. & Vincent C.A. (2006) Observational assessment of surgical teamwork: a feasibility study. *World Journal of Surgery* 30, 1774–1783.
- Ward K. (2002) A vision for tomorrow: transformational nursing leaders. *Nursing Outlook* 50, 121–126.
- Way L.W., Stewart L., Gantert W., Liu K., Lee C.M., Whang K. & Hunter J.G. (2003) Causes and prevention of laparoscopic bile duct injuries. *Annals of Surgery* 237, 460–469.
- Wiener E., Kanki B. & Helmreich R. (eds) (1993) *Cockpit Resource Management*. Academic Press, San Diego, CA.
- Woodhead K. (1995) Assisting the surgeon: the dilemma for nurses. *Nursing Standard* 10(3), 53–54.
- Yule S., Flin R., Paterson-Brown S. & Maran N. (2006a) Non-technical skills for surgeons: a review of the literature. *Surgery* 139, 140–149.
- Yule S., Flin R., Paterson-Brown S., Maran N. & Rowley D. (2006b) Development of a rating system for surgeons' non-technical skills. *Medical Education* 40, 1098–1104.