What are the non-technical skills used by scrub nurses? An integrated review

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Introduction

In 1999, the US Institute of Medicine released a report *To err is human: Building a safer health system*[1], which estimates that 44,000 and 98,000 patients die as a result of medical errors in the operating room (OR) annually. Despite dramatic improvements in surgical safety knowledge, at least half of the adverse events occur during surgical care[2]. Human failures (for example, miscommunication, teamwork breakdown, leadership and poor decision making) are not uncommon and often lead to errors in surgery[3-5]. Retained sponges, wrong site surgery, mismatched organ transplants, or blood transfusion can be the result of human errors resulting in many adverse incidents and accidents[6]. Analysis of adverse events in health care suggests that improvement of non-technical skills may reduce surgical errors and enhance patient outcomes[7]. The term 'non-technical skills' refers to "the cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance"[8(p. 376)]. Subsumed within non-technical skills are the domains of communication, leadership, teamwork, decision making and situation awareness.

The OR is a complex environment in which interdisciplinary groups of health professionals with a variety of skills work together interdependently to deliver optimum patient care[9]. The surgical team include the surgeon, anaesthetist, anaesthetic nurse, scrub and scout nurse. To date, formal training of non-technical skills has been developed within the medical field for surgeons[10] and anaesthetists[11], yet scrub nurses are also key members of the surgical team. The term 'scrub nurse' will be used throughout this paper. In Australia, the registered nurse undertakes the role of 'scrub nurse' and this position is also referred to as the instrument nurse. Scrub nurses are also referred to as 'scrub practitioner', 'operating department practitioner', 'operating department technician' or 'operating room technologist'

in other countries. Scrub nurses' roles and responsibilities encompass providing skilled assistance to the surgical team, ensuring that all items used within the surgical field are accounted for at the end of each procedure[12], and acting as advocate for patients while they are anaesthetised (for example, surveying and maintaining the sterile field, monitoring the status of the patient and responding to any intraoperative complication that may arise)[12,13]. In a previous literature review, Mitchell and Flin[9] identified that there is a gap in the understanding of the scrub nurse's non-technical skills. However, robust and rigorous review methods are essential when appraising the quality of studies to answer a research question. Therefore, a more focused identification and description of these specialist skills is required as they are essential for OR nurses' performance and, ultimately, safe practice.

Background

The scrub nurse assumed responsibility for all items used within the surgical field, ensuring that all instruments, sterile supplies and equipment required for procedures are available and functional[12]. Clearly, technical skills such as performing the surgical scrub, gowning, swab and instrument count are essential for effective scrub practice. Nonetheless non-technical skills (that is, cognitive and interpersonal skills) are also important as they enable scrub nurses to maintain a high level of performance and ensure patient safety and high-quality care[14].

Research on plane crashes has demonstrated that the majority of accidents and incidents are caused by human error, which could have been averted with an optimal human response[15]. Subsequently, training programs such as crew resource management (CRM) were developed to improve cockpit crews' non-technical skills[7] with the assumption that a cohesive team increases efficiency and reduces error in performance of a task[15]. Fostering a safety culture is recognised as a crucial element in reducing error and has provided the impetus for the introduction of CRM strategies that specifically focus on the development of non-technical skills in health care.

The safety culture of an organisation is the product of individual and group norms, beliefs, attitudes and values that determine the commitment of an organisation's management of critical safety issues[16]. Consequently, improvements in safety culture and attitudes across a range of specialty settings have provided the impetus for several health care disciplines to explore the use of this approach in the OR[17,18].

Non-technical skills are grouped according to: (1) cognitive or mental skills (for example, decision making, planning, situation awareness); and (2) social or interpersonal skills (for example, team-working, communication, leadership) that complement technical skills necessary for safe and effective practice in the OR environment[19,20]. In the context of the OR, *situational 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"[21 (p. 36)]. *Decision making* is described as "the process of reaching a judgement or choosing an option to meet the needs of a given situation"[20 (p. 41)]. *Teamwork, communication* and *leadership* skills are defined as "the skills required for working in a team context to ensure the team has an appropriate shared picture of the situation and can complete tasks effectively"[22 (p. 37)]. While it is widely recognised that these non-technical skills enhance the performance of all team members involved in surgery, there appears less clarity on exactly which skills are required for optimal performance in the scrub nurse's role. As an essential member of the OR team, an understanding of scrub nurses' non-technical skills is important to improve patient care, reduce adverse events and optimise patient outcomes.

Aims

This paper will present the results of an integrated review to identify and describe the non-technical skills used by scrub nurses in the OR in order to perform their role effectively. Further evaluation of the non-technical skills used by scrub nurses may also assist in the development of education programs for novice and experienced scrub nurses alike, and inform further research into this, as yet, largely unexplored area.

Methods

An integrative review method was used to enhance the rigour of evidence-based practice in nursing. Whittemore and Knafl's[23] theoretical framework was used to guide the review as this method enables a complete understanding of the phenomenon of interest. The framework provides a five-step method that incorporates problem identification, literature search, data evaluation, data analysis and presentation of data[23]. Whittemore and Knafl[23] ascertained that critical appraisal of the literature is not required when undertaking an integrative review; however, quality scores are often used to support data interpretation and study appraisal. The integrative review method has the potential to inform further research into the role of the scrub nurse, and will thus allow a more detailed examination of scrub nurses' non-technical skills.

Search strategies

A computerised search of the literature published between January 1980 and October 2013 was conducted using online sources including Cumulative Index for Nursing and Allied Health Literature (CINAHL), National Library of Medicine (MEDLINE), PROQUEST and the Cochrane library. The search terms used included a combination of keywords and MeSH terms, 'operating room/operating theatre', 'scrub nurse/practitioner/instrument/technician', 'non-technical skills', 'communication', 'situational awareness', 'teamwork' 'leadership' and 'decision-making'. Specific database functions such as "apply related words" and "explosion" were used to maximise the search. Despite setting broad inclusion criteria for scrub nurses' non-technical skills, care was taken to distinguish between non-technical skills and human factors. Human factors encompass the wider environment, organisational factors and individual characteristics that affect day-to-day working, and potentially health and safety, whereas 'non-technical skills' is one topic area that sits under the broad topic area of human factors[24].

Searches on scrub nurses' non-technical skills based on reference lists from articles were also conducted. Only studies that met the following inclusion criteria were included: (1) scrub nurse non-technical skill; (2) research-based papers; (3) full-text articles with abstracts published in English; and (4) methodological research conducted in "real time", naturalistic, clinical settings rather than simulated environments. Thus, for studies to be eligible for inclusion, authors had to describe examples where OR nurses used non-technical skills exclusively or in combination with OR nurses' behaviours, perceptions and attitudes of communication, teamwork, situational awareness, leadership or decision making.

Data extraction and synthesis

Specific information in relation to country, study design, sample and measures was extracted. The domains of scrub nurses described non-technical skills were thematically examined. Data extraction was performed by the first author and reviewed by a second team member, with discrepancies adjudicated by a third review author.

Quality assessment

The study methods and findings were critically appraised and summarised using the appraisal tool, *QualSyst*, which is based on the principles defined by Kmet, Lee and Cook[25]. In this review, study quality was assessed using two scoring tools specifically developed for the appraisal of diverse study design including qualitative and quantitative studies[25]. Two authors independently assessed the included qualitative and quantitative studies. Inter-rater agreement for papers eligible for inclusion from both quantitative and qualitative research papers was calculated. The proportion of inter-rater agreement was measured using the intraclass correlation coefficient (ICC) for included studies. A coefficient of >0.70 was considered acceptable[26].

Results

Search outcome

The study flow chart used is based on the Preferred Reporting items for Systematic Reviews and Meta-Analyses (PRISMA) format[27]. Figure 1 displays the search strategy and details the number of publications identified using the database search.
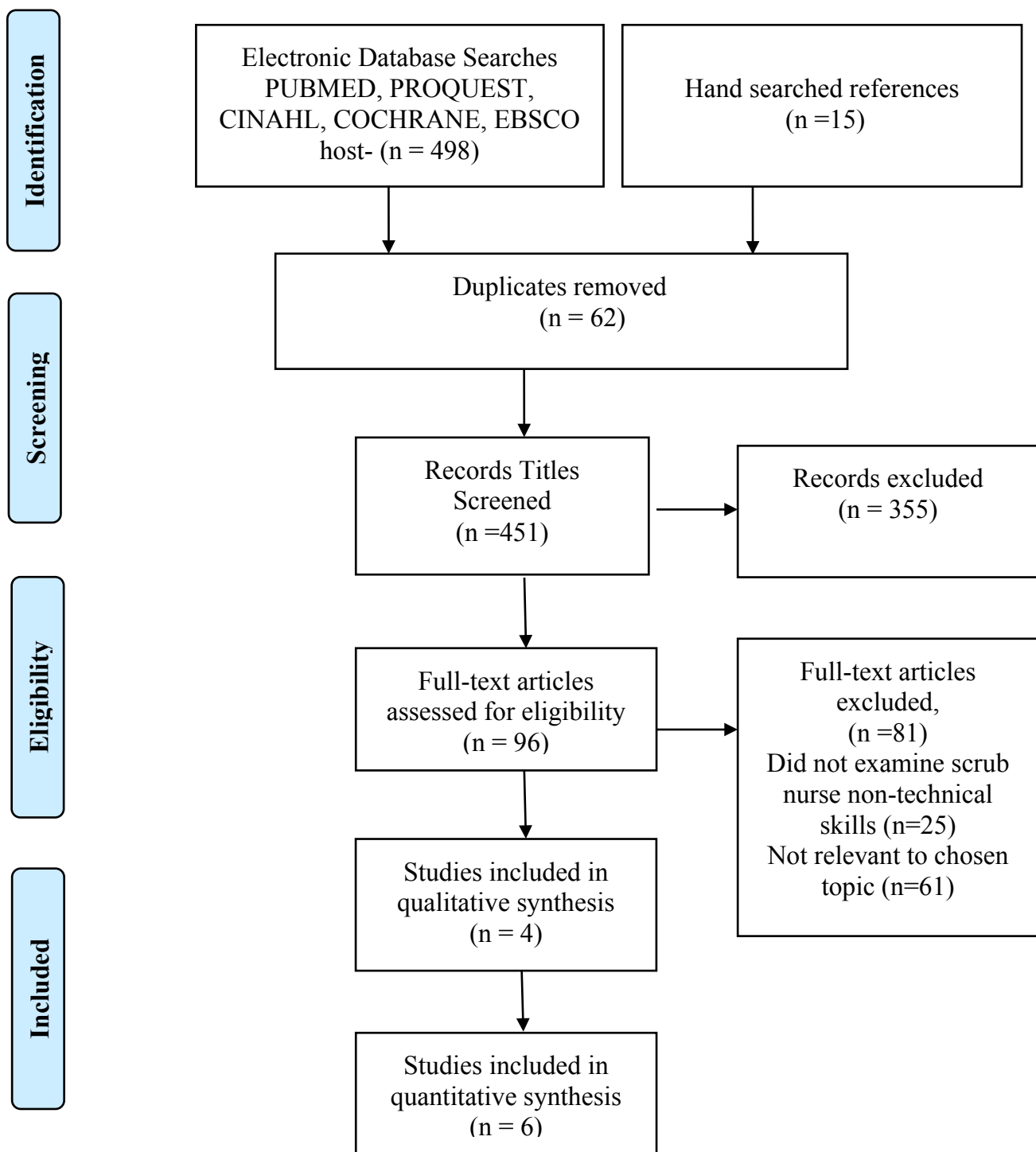
Figure 1. PRIMSA Diagram of the study flow
Adapted from: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA Statement

The initial search yielded 498 titles with 15 (3%) publications identified from secondary references; 62 duplicate articles were found using the searches in MEDLINE and were excluded. The titles and abstracts of 96 articles were retrieved and read as they reported on some aspect of non-technical skills in the OR. Of those 96 articles, 10 (10.4%) papers met the inclusion criteria. Nearly three-quarters of the original articles (n=86, 90%) reviewed were excluded for the following reasons: they focused on the non-technical skills of surgical team rather than the scrub nurses (n=25, 26%), or they were not relevant to chosen topic (n=61, 64%).

A summary of the included qualitative and quantitative research articles describing the non-technical skills of scrub nurses is presented in Tables 1 and 2. Survey designs were used in five of the quantitative studies[6,28-31] and quasi-experimental design was used in one study[32].

Of the 10 articles, two (20%) papers were from the United Kingdom[34,35] and three (30%) were from the United States[6,29,32]. Within the broad domain of non-technical skills, the following themes were identified: communication; teamwork; situational awareness; decision making; and leadership. Of the 10 papers examined, four (40%) studied communication[28,29,32,34], seven studies (70%) examined teamwork[6,28-31,35,36] and three (30%) described scrub nurses' situational awareness[28,33,34]. None of the papers described scrub nurses' leadership in the OR. Only one (10%) paper[33] examined the use of decision making by scrub nurses.

Of the 10 review papers, issues concerning study reliability, validity (quantitative) and rigour (qualitative) were assessed. Reliability and validity was not reported in three (30%) of the quantitative studies[6,28,32]. In five (50%) other review studies, a cross-sectional design was used to analyse perceptions of non-technical skills[6,28-31]. In two of the qualitative papers[35,36], strategies used to address rigour such as transferability, auditability and credibility were not identified.

Quality scores

Quality assessments were performed for the qualitative and quantitative papers using the *QualSyst* tool[25]. Quality scores for the studies ranged from 41% to 91% with the average being 74.0 (± = 14.0).The combined quality assessments of the studies by two independent reviewers were in good agreement (ICC=0.93, CI=95% [0.75–0.98], *p*<0.001).

Discussion

This integrative review aimed to identify the key non-technical skills specifically used by scrub nurses to perform their clinical roles effectively and enhance patient safety. This review highlights other skills such as decision making and leadership that may be less obvious, but highly relevant to the role of scrub nurses in addition to skills such as communication, teamwork and situational awareness with established link to safety in nursing. The following discussion details those non-technical skills that are widely recognised as important but vaguely understood in practice.

Communication

Surgical team members process multiple sources of information and use verbal and non-verbal communication process. Fundamental communication skills such as clarity of speech, being polite and courteous were deemed necessary for effective practice in the OR[19]. This review found OR nurses appeared generally dissatisfied with communication and felt constrained in their ability to communicate with surgeons in the OR[28,29,32,34,35]. To improve communication using medical team training among surgical team members, Awad and colleagues[32] demonstrated improvements in the perceptions of communication among surgeons and anaesthetists after CRM intervention. Paradoxically, in the same study, there was no significant improvement in communication among OR nurses after intervention training, although Awad and colleagues[32] suggest this may be due to the small number of nurses who participated in the

Table 1. Characteristics of quantitative studies

Lead Author, (Year) Location	Design & Sampling	Non-technical skills domain & Aim	Measures	Key Findings	Limitations	Quality score (Avg %)
Wauben et al. (2011)[28] Netherlands	Cross-sectional survey 5 Hospital sites OR* Team (N=235) 66 Surgeons 97 Nurses 18 AN* 40 Anaesthetists	Communication Teamwork Situation awareness Assess surgical team members' perception of their non-technical skills.	NOTSS* ANTS* OTAS* Reliability measures not reported.	Response rate 39% with 235 questionnaires returned. OR nurses rated communication of the planned procedure & actions by anaesthetist as inadequate (61-62%). OR nurses reported teamwork among team members lower compared to the rest of team members, especially surgeons (mean 3.06). 72% of OR nurses were dissatisfied with communication & teamwork in the OR. OR nurses rated projecting & anticipating future states (situation awareness) as adequate (mean 3.74).	Only 5 hospitals participated of the 90 hospitals in the Netherlands (6%). Other non-technical skills such as leadership, decision making were not measured. Last page of survey was not distributed to surgeons due to human error, causing unreliable answers for surgeon's situation awareness.	79.5%
Mills et al. (2008)[29] United States	Cross sectional study 6 Hospitals N=309 (OR staffs & administrators)	Communication Teamwork Assess the safety climate and reveal differences in perceptions of non-technical skills between professional groups in surgical team.	MTT* Questionnaire Organisational culture α= 0.786 Communication α=0.819 Teamwork 0.858 Human factors awareness α=0.842	Response rate 80% with 309 surveys returned. Nurses & anaesthetists perceived their environment of teamwork, communication effectiveness & organisational culture similarly, and differ significantly from surgeon's perceptions. Nurses' perceptions of teamwork & communication less favourable compared to surgeons. Nurses less likely to report their agreement with surgeons on communication & collaborations. Nurses less likely to report higher rating on teamwork effectiveness. Nurses rated overall teamwork lower than surgeon working in the same OR.	Most questionnaires answered by nurses (45%). No follow-up information on patient outcomes. Staff behaviours not observed.	61.5%
Makary et al. (2006)[6] United States	Cross sectional study 60 Hospitals OR Team (N=2135) 1058 OR nurses 564 surgical technicians 170 anaesthetists 121 CRNA*	Teamwork Compare ratings of teamwork within OR team members.	SAQ* Reliability measures not reported.	Response rate of 77% with 2135 surveys returned. OR nurses given the highest rating on teamwork compared to physicians and anaesthetists (4.2/5.0). Surgeons rated OR nurse's teamwork as high (4.4/5.0).	Staff perceptions of communication vary over time & can be influenced by acute events within the OR. Study designed as a baseline assessment, but many of the hospitals had already implemented specific interventions aimed at improving patient safety.	82.0%
Flin et al. (2006)[30] Scotland	Cross sectional survey 17 Hospitals OR Team (N=352) 138 consultant surgeons 93 trainee surgeons 121 OR nurses	Teamwork Assess surgical team members' attitudes to safety & teamwork in the OR.	ORMAQ* All themes between α=0.1-0.75	Response rates :- Consultant surgeons - 48% Trainee surgeons – 27% OR nurses – 19% Nurses' favoured regular debriefing post-operatively more than consultant surgeons (78% vs. 44%). Nurses rated teamwork with surgeons low (2.6 / 5.0).	Results of study presented at an item level due to the absence of an established factor structure for the ORMAQ. No response bias due to low response rates.	75.0%

Table 1 (continued). Characteristics of quantitative studies

Study	Design	Sample	Aim	Tool	Results	Limitations	%
Prati & Pietrantoni (2013)[31] Italy	Cross sectional survey	1 Hospital OR Team (N=103) 55 surgeons 48 OR nurses	Teamwork Assess differences in attitudes toward safety & Teamwork between surgical team members in the OR.	ORMAQ	Response rates :- Consultant surgeons - 89% OR nurses – 67% Discrepancies on aspects in attitude to teamwork and safety between surgeons & OR nurses. OR nurses less likely to agree that leadership should rest with medical staff & more likely to favour flatten team structure with shared responsibilities for leadership. OR nurse reported more problems in teamwork as compared to surgeons.	Results cannot be generalized to other hospitals due to single site & small sample size. Results presented at an item level due to the absence of an established factor structure for the ORMAQ as the literature failed to demonstrate it.	88.5%
Awad et al. (2005)[32] United States	Quasi-experimental study OR Team N not reported	Communication Determine if communication in the OR could be improved using medical team training.	Survey Pre/ post Medical team training Reliability measures not reported.	Response rate: not reported. No significant improvement in communication among OR nurses (p=.7) after implementation of prebriefing. Disconnection in the perceptions of teamwork between the 3 professions.	Did not report response rate of surveys pre and post training. Single site study, limited ability to generalise beyond the sample surveyed. Sample size unknown.	43.5%

Abbreviation and Acronyms*

AN = Anaesthetic Nurse; ANTS = Anaesthetists' Non-Technical Skills; CRNA = Certified Registered Nurse Anaesthetist; MTT = Medical Team Training; NOTSS = Non-technical Skills for Surgeons; OR = Operating Room; ORMAQ = Operating Room Management Attitude Questionnaire; OTAS = Observational Teamwork Assessment for Surgery; SAQ = Safety Attitude Questionnaire

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new briefing process. Clearly, communication skills are a fundamental element for scrub nurses to perform their role effectively.

Teamwork

Key elements of team working include supporting other team members through sharing of workload, accepting individual responsibility, maintaining good working relationships, conflict resolution, and effective exchange of information[19]. Of the 10 papers reviewed, teamwork or attitudes and perceptions of teamwork were explored in six papers[6,29-31,35,36]. Surgeons were rated less favourably in relation to teamwork; these findings have been reported previously[38]. Recent increases in the expansion of the delivery of surgical services mean that OR staff are now more likely to work in fragmented and unstable teams, compared to the past when individuals have a shared work history, and know each other in terms of their strengths and weakness[39]. Silen-Lipponen et al.[36] argue that familiarity with team members and the stability of teams helped to combine team members' skills and fostered advanced planning and promote patient safety. During interviews, nurses expressed dissatisfaction as a result of team changes as these prevented them from preparing or participating in the adequate planning and preparation for the procedure[9,36]. Conceivably a lack of familiarity in teams has the potential to diminish individual and team performance, and thus has implications for patient safety[40].

Situational awareness

Perceptual and anticipatory cognitive skills are critical for scrub nurses to gain information from cues in the OR to understand a patient's condition or anticipate a surgeon's requirements. Gillespie et al.[33] observed and interviewed OR nurses and found behaviour of 'overhearing' conservations at the operating table heightened OR nurses' situational awareness and enabled them to pre-empt surgeons' needs and 'think ahead' to ensure the operation progressed smoothly. Mitchell et al.[34] also identified scrub nurses' ability to identify and cope with different surgeons' personalities and changing preferences. In earlier research the importance of knowing surgeons' behaviours enabled nurses to predict case needs well ahead of time[41]. This knowledge referred to as 'judicial wisdom'[41] allowed scrub nurses to modify their own performance to assist the surgeons more effectively. Although the impact of these skills may not be apparent when surgery is progressing smoothly, the ability of scrub nurses to modify their behaviours during stressful moments of surgery may have a 'calming' effect on the surgeon's demeanour.

Leadership and decision making

Scrub nurses' leadership skills during surgery were not examined in any of the studies reviewed; yet in two of the research studies[31,42], the Operating Room Management Attitude Questionnaire (ORMAQ) tool was used to evaluate attitudes of the surgical team towards teamwork and safety. One of the domains in the ORMAQ focused on the leadership structure of the medical staff rather than OR nurses. In both studies, leadership as a non-technical skill was not explored. This finding may be attributed to the fact that leadership skills were not viewed as an essential element of the scrub nurse's scope of practice as the role of leadership is often perceived to lie with the medical staff[37]. Findings from an earlier literature review[43] suggest that there has been increasing acknowledgement of the role of leadership

Table 2. Characteristics of qualitative studies

Lead Author, (Year) Location	Design & Sampling	Non-technical skills domain/ Aim	Rigour	Key Findings	Limitations	Quality Appraisal (Avg %)
Mitchell et al. (2011)34 United Kingdom	Interview (semi-structured format) 9 surgeons (Consultants) 25 OR nurses	Situation awareness Communication Task management Identify the non-technical skills required for safe and effective performance as a scrub nurse.	Inter rater reliability	Non-technical skills of situation awareness, communication, teamwork, task management and managing stress were identified as important non-technical skills for scrub nurses. Communication with surgeons included verbal, subtle and non-verbal methods. No clear consensus among the interviewed scrub nurses as to which member of the OR team is the leader. Efficient scrub nurses develop these non-technical skills implicitly with experience.	Deductive approach to analysis may have limited the types of non-technical skills identified. Other aspect of rigour such as transferability & auditability not addressed. Limited ability to generalise study as it is a single site study.	77.5%
Gillespie et al. (2013)33 Australia	Observational and semi-structured interviews 160 procedures observed with OR Teams comprising 63 nurses, 39 surgeons, 26 anaesthetists and 15 ancillary staffs 16 individuals and three group interviews were conducted with 24 participants	Situation Awareness Decision making Identify strategies that may help team members build situational awareness.	Elements of rigour i.e., triangulation, transferability, auditability, & credibility addressed.	Three themes described: 1) 'Synchronizing actions and strategizing to adapt', 2) 'sharing local knowledge' & 3) 'planning contingency decisions based on priority'. Scrub nurses' behaviour of "overhearing" conversations at the operating table heightened their situational awareness & enabled them to anticipate. OR nurses actively participated in decision-making around coordination of personnel & equipment needs on selected occasions. OR nurses became the 'gatekeeper' to the surgeon, vetting information flow based on their assessment of the status of the procedure.	Findings of this study cannot be generalised as staff working in this hospital may be different in some ways. Observer might have influenced the outcome of the interview as an OR nurse. Different methods used for some of the OR nurse participants might have led to different dynamics during interviews.	90.0%
Silen-Lipponen et al. (2004)36 Finland	Phenomenological Critical incident technique 10 Finnish nurse 10 American nurses 10 British nurses	Teamwork Identify the threats of errors experienced by Finnish, American & British nurses.	Investigator triangulation used during analysis phase	Some potential sources of errors & ways of prevention in OR teamwork identified. Categories identified: 'demanding teamwork practice,' 'shared responsibility in teams' & 'organised teamwork'. Emotional distress caused by errors in the OR compromised team cohesion as nurses feared disciplinary procedures.	Aspects of rigour such as transferability, auditability, and credibility not described / addressed. Researcher's role in one of the study hospitals as a teacher may have influenced participants' responses during interviews. Data collected in three countries by the same Finnish researcher who was not a native English speaker and was unable to understand the nuances of the verbal data.	67.5%
Nestel & Kidd (2006)35 United Kingdom	One focus group interview with 7 nurses 1 OR department	Communication Teamwork Report nurses' perceptions and experiences of communication in the OR.	Aspects of rigour not reported	Effective communication in the OR includes verbal & non-verbal skills. Active listening identified as an important interpersonal skills. Confusion in relation to the perception of technical & non-technical aspects of perioperative roles. Nurses appeared to be frustrated by the expectations others have of their roles. Roles of team members significantly influenced the quality of communication and were foremost in the nurse's minds. Nurses responses in interview suggested management styles & team functioning were ineffective.	The numbers of participants in this study were small & only one focus group interview was conducted. Additional focus group interviews may have gleaned further information. One hospital site was used, therefore limited ability to generalise. Elements of rigour such as triangulation, transferability, auditability, & credibility not addressed.	55.0%

in perioperative nursing, though this is largely unexplored. At times, experienced scrub nurses are expected to undertake leadership roles when working with an inexperienced surgeon or a less experienced circulating nurse. While not directly related to scrub nurses, OR nurses' leadership is often manifested in more subtle ways, for instance, in the coordination and triage of semi-urgent cases after hours[44]. The lack of description of scrub nurses' leadership skills used before, during and immediately following surgery warrants further research.

In this integrated review, decision-making skills required by OR nurses were identified by Gillespie *et al.*[33] who demonstrated that nurses tended to make intuitive decisions based on experiential knowledge. OR nurses used decision making and acted as a 'gatekeeper' by vetting information that reached the surgeon, thus permitting surgeons to remain disconnected and remain focused 'on the act of surgery'[44]. Nursing practice in the OR includes a myriad of potential environmental hazards and scrub nurses are often expected to make timely, anticipatory decisions in life-threatening, emergency situations[43]; however, decision-making skills as a non-technical skill in the OR remains largely unexplored.

Assessment of tools and behavioural marker systems

A range of different tools were used to measure non-technical skills needed for safe and effective practice for the role of scrub nurses. Some of the tools used included self-reported questionnaires, interviews or observation. Flin *et al.*[19] recommended that combinations of two or more tools should be used to identify domains and behavioural markers of non-technical skills as no single tool on its own provides a full picture of the relevant non-technical skills.

Behavioural rating systems used in these review studies for evaluating non-technical skills have demonstrated value for understanding of surgical team performance and safety culture. Assessment of non-technical skills of participants was carried out using various valid and reliable tools such as ORMAQ, Non-technical Skills for Surgeons (NOTSS), Anaesthetists' Non-Technical Skills (ANTS), Observational Teamwork Assessment for Surgery (OTAS) and Safety Attitudes Questionnaire (SAQ). A significant problem of the studies reviewed was the lack of internal and external validity of the behavioural tools used to measure the non-technical skills of OR nurses. While it is important to maintain the validity and reliability of measures used, the lack of consensus among measurement techniques decrease the comparability of study results and limit confidence in the validity of the findings. Despite this, there was significant concordance on the particular skill set domains of the non-technical skills that scrub nurses either required or used. This review has contributed to the topic area by clarifying those non-technical skills which are imperative for scrub nurses' optimal performance. However, non-technical skills have not been explored sufficiently in the literature to enable a comprehensive understanding of non-technical skills used by scrub nurses. The importance of teamwork, situational awareness and communication were identified in this review, while leadership and decision making are less frequently described. This supports previous findings drawn from one earlier review exploring scrub nurses' non-technical skills in the OR[9].

Incorporating non-technical skills into training and assessment may improve nurses' attitudes towards understanding of human factors and non-technical skills, with the aim of reducing the risk of the potential for adverse events and therefore improve patient care[19]. In recent years, nurses' non-technical skills have been studied in other areas of nursing such as intensive care nursing[45] and emergency department teams[46]. Each clinical environment adapts its own, unique non-technical skills requirements that are crucial for safe practice. Given the integral role of the scrub nurse to ensure patient safety during surgery, it is surprising that scant attention has been paid to the assessment of these skills in the OR. In perioperative contexts, skill taxonomies and rating systems for surgeons and anaesthetists have been developed to measure non-technical skills. Currently, taxonomy of non-technical skills for scrub nurses such as the SPLINTS (Scrub Practitioner List of Intraoperative Non-Technical Skills) has been developed. However, this tool has only been piloted in a video-recorded simulation scenario and not been used in the OR setting in real time.

Limitations

While rigorous methods were used for this review, there are limitations. Firstly, while the search was exhaustive and robust, other articles not uploaded online might have been missed and, as such, this review may not be representative of all relevant work in the field. Secondly, only 10 studies were reviewed; however, these were the most recent in this field. Thirdly, studies included were assessed using a validated quality assessment tool. While the *QualSyst* tool[25] has established validity, it may introduce bias as checklists are subjective and may reflect individual perceptions of the key components of study quality[25]. To address the potential for bias, two reviewers completed quality assessments, with a third review author adjudicating where appropriate. Fourthly, in the majority of the studies, cross-sectional surveys were used and as surveys are collected at a single point in time, it is difficult to measure changes over time in the perceptions of the scrub nurses. Finally, key limitations of the review studies involved limited sample sizes (quantitative studies), single hospital site locations and lacked statistical rigour that limit generalisability of the findings. Although a number of the studies demonstrated these weaknesses, these were still included in the review as they were judged to be of adequate quality.

This review has several strengths. Whittemore and Knafl's[23] revised integrative review framework has provided a transparent and rigorous method for identifying and evaluating available studies to arrive at the synthesis of non-technical skills required by scrub nurses to perform their role effectively. Despite some methodological limitations noted in this review, this is the first integrative review to offer a foundation on which future education programs on non-technical skills for perioperative nurses may be developed.

Implications for education

It is argued that non-technical skills are required for scrub nurses to perform their role in the surgical team effectively. For the scrub nurses, skills not taught in the nursing curriculum become essential in meeting the many challenges of the OR. Many of the skills identified within this review could form the basis of an education program specifically to develop scrub nurse non-technical skills in

the creation of team training policies and protocols. We recommend that education programs for scrub nurses be developed based on crew resource management techniques. Annual performance evaluations may help reinforce work behaviour after team training. This would maintain behaviour over time and embed integration of teamwork into the organisational culture, improving patient care and outcomes[47].

Implications for nursing research

The findings of this integrative review highlights the need for further high-quality research that employs rigorous study designs, and uses valid and reliable methodologies and methods. Only one[33] of the review studies used fieldwork methods to capture the behaviours of scrub nurses in the OR. While observational research to examine the behaviours of the OR team does have some limitations, triangulating observational methods with self-report and interviews would strengthen research efforts.

Conclusion

Through this review, it has been identified that assessment of scrub nurses' non-technical skills is still in its infancy. Although imperfect, researchers have sought to identify scrub nurses' non-technical skills and developed important groundwork in this area. Better understanding of these skills could guide educators in future instructional design that would improve the non-technical skills of scrub nurses and, ultimately, enhance surgical patient care.

Authors' declarations

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