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Bi-lingual content validation of the Non-Technical Skills for Operating Room Nurses (NOTSORN) tool: A Delphi study

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ABSTRACT

Background: The primary responsibility of the operating room nurse is to prevent adverse events and patient harm during surgery. Since most preventable adverse events are the result of breakdowns in communication and teamwork, or non-technical skills, training such skills should strengthen the operating room nurses' error prevention abilities. Behavioural marker systems operationalise non-technical skills; however, previous systems for operating room nurses do not cover the full extent of non-technical skills used by operating room nurses. Thus, the Non-technical Skills for Operating Room Nurses (NOTSORN) behavioural marker system was developed.

Objective: The objective of this study was to establish face and content validity of the Non-Technical Skills for Operating Room Nurses behavioural marker system. This multi-item scale measures individual non-technical skills in operating room nursing.

Participants: A purposive sample of operating room nursing researchers, educators, and senior clinicians from nine countries worldwide.

Methods: A two round, Delphi panel with international experts in operating room nursing. The survey was administered online. Content validity index (CVI) was used to measure agreement among panel members.

Results: 25 operating room nurse experts participated in the online Delphi study. After round 1, 56 items were accepted, 26 items were revised, and 1 item was dropped. Following round 2, all items (6 with minor revisions) were accepted. Thus, the Non-technical Skills for Operating Room Nurses tool comprise 81 items. The scale level CVI score for the final 81 item tool was 0.99. The individual item level CVI scores ranged from 0.9 to 1.0.

Conclusions: The Non-Technical Skills of Operating Room Nurses behavioural marker system is a nuanced tool with a myriad of non-technical skills operating room nurses need to undertake their work safely. The tool's intended use includes student/trainee supervision, supervision of novice operating room nurses, self-reflection for performance reports, and in operating room nursing education. Over time, use of the tool has the potential to contribute to patient safety in the operating room.

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Tweetable abstract: The NOTSORN tool provides a comprehensive and holistic evaluation of OR nurses' non-technical skills for safe surgical performance

What is already known

- Non-technical skills failures contribute to surgical adverse events
- Non-technical skills can be improved through systematic training
- Systematic non-technical skills training is underpinned by tools (behavioural marker systems) comprising descriptions of relevant non-technical skills supplemented by exemplar behaviours

What this paper adds

- A content validated behavioural marker system tool to assess operating room nurses' non-technical skills
- A description of a rigorous, transparent content validation process where validity was assessed by an international expert panel rather than by the developers of the behavioural marker system
- Preliminary evidence that the Non-Technical Skills for Operating Room Nurses tool may be relevant for translation into new languages to accommodate additional countries

1. Introduction

The global annual volume of surgical procedures is estimated at 313 million (Meara et al., 2015). Despite international patient safety programmes, a review found that the prevalence of surgery related adverse events was 20 % between years 2000 and 2019, of which, 50 % were considered preventable (Panagioti et al., 2019). More recent studies in Spain found that 13,3 % of all surgical patient experienced adverse events, while the prevalence for those having surgery was 15.8 % (Aranaz-Ostáriz et al., 2022; Valencia-Martín et al., 2022). Globally, approximately 7 million patients annually suffer from a significant surgery related injury, where 1 million of these patients die during, or immediately after, surgery (WHO, 2024). Safe surgery relies on the use of technical and non-technical skills, the latter often referred to as 'soft skills'. Research indicates that lack of non-technical skills is a major contributor to preventable adverse events, and that improvements in surgical team members' non-technical skills optimise the surgical team's performance (McCulloch et al., 2009; Nilsson et al., 2016). Adverse events may cause unnecessary bodily harm where the severity range from 'no treatment required' to 'death' (WHO, 2009). Furthermore, it is estimated that *preventable* adverse events impose a heavy financial burden of 8.7 % of health expenditure, and this does not include financial assistance or compensation (Slawomirski and Klazinga, 2022).

Non-technical skills are defined as 'the cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance' (p 1), that is, they are the skills needed to communicate, coordinate, prioritise tasks, take leadership, and make decisions in complex environments (Flin et al., 2008). This concept was first introduced in aviation through the crew resource management courses for improving the pilot's non-technical skills (CAP-737, 2014). These courses were later supplemented by behavioural marker systems, which are taxonomies of non-technical skills and their related observable actions, and rating tools for quantifying the pilots' performance level (Flin and Maran, 2004; Musson, 2017). Subsequently, non-technical skills training and assessment have transferred into other high-risk areas, including health care (Flin et al., 2008).

Several non-technical skills training and assessment tools have been developed for work in the operating room. The main principles for developing such systems are to first identify the non-technical skills and their related behaviour for the designated work setting, followed by refining the list and organising it into a structured taxonomy (Flin and Mitchell, 2017). Some tools provide whole-of-team assessment, exemplified by the Observational Teamwork Assessment for Surgery and the Oxford Non-Technical Skills II tools (Robertson et al., 2014; S. Undre et al., 2006), while others focus on the performance of sub-teams. The Anaesthetists' Non-Technical Skills tool was the first behavioural marker system to be developed for participants of the surgical team. Its development was rigorous, and this tool comprises four dimensions (Task Management, Team Working, Situation Awareness, and Decision Making) (Fletcher et al., 2004). In some contexts, nurse anaesthetists have an autonomous role in delivering anaesthesia, thus the Nurse Anaesthetists' Non-Technical Skills tool was developed with the same domains but with nurse specific behaviour markers (Flynn et al., 2021; Lyk-Jensen et al., 2016). Following the anaesthetists' initiative, the Non-Technical Skills for Surgeons tool was developed by surgeons for surgeons (Yule et al., 2006). Again, the domains are similar, but the surgeons replaced the domain of Task management with Leadership. Later, the Scrub Practitioners' List of Intraoperative Non-Technical Skills was developed for scrub practitioners (technician or instrument nurse), and comprises three domains of non-technical skills (Situation Awareness, Communication and Teamwork, and Task Management) (Flin et al., 2010).

The system was developed to cater to the scrub technician who is responsible for the instrumentation towards the surgeon during surgery (Flin et al., 2010; Mitchell et al., 2011). However, operating room nurses have dual roles: the instrument nurse monitors and maintains asepsis throughout surgery and provide appropriate and timely instrumentation, while the circulating/floor nurse manages

the operating room, prevents patient positioning related nerve and/or pressure injuries, and is responsible for the well-being of the patient, while protecting their dignity (Gillespie et al., 2009; McGarvey et al., 2000). Operating room nursing is similar across countries with similar economies, although the formal requirements for employment as operating room nurse span from being a technician without nursing education to having a master's degree in operating room nursing (Willems, 2020). The most common requirement is being a registered nurse with additional operating room education and/or training. As the above-mentioned behavioural marker tool disregards the role of the circulating operating room nurse, it does not cover the range of non-technical skills areas that operating room nurses are expected to fulfil (I. Sirevåg et al., 2021; Sirevåg et al., 2023).

As the first step in developing the Non-Technical Skills for Operating Room Nurses, our team generated items through two preliminary studies (I. Sirevåg et al., 2021; Sirevåg et al., 2023). These items informed the second step of refining the list and organising it into a structured taxonomy. The aim of this paper was to establish content validity of the Non-Technical Skills for Operating Room Nurses (NOTSORN) behavioural marker system, a multi-item scale to assess operating room nurses' use of individual non-technical skills.

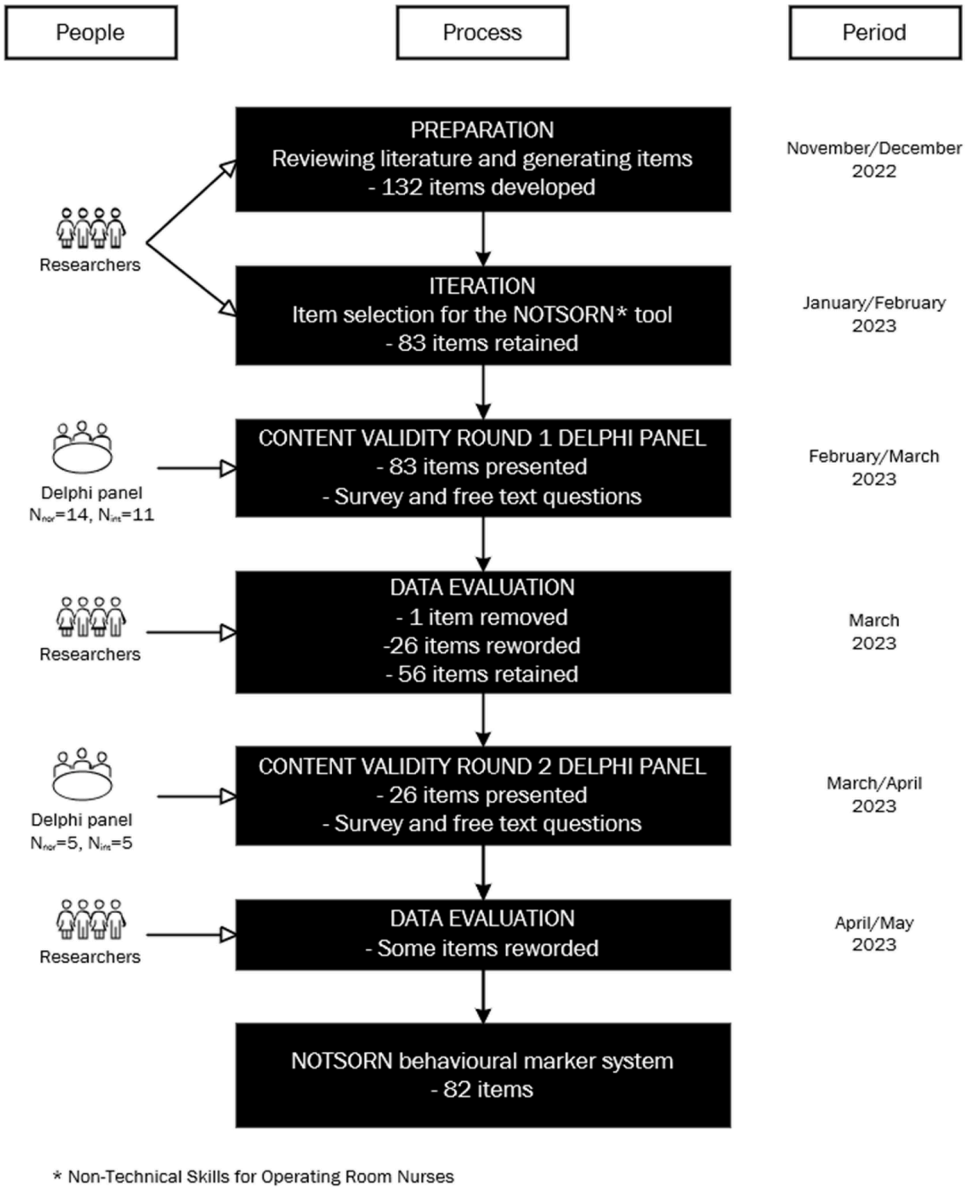

Fig. 1. Delphi process flowchart.

2. Methods

2.1. Design

The Delphi technique is a structured iterative approach for achieving consensus within an expert panel (Keeney et al., 2011). The technique is considered appropriate for providing evidence of content validity through computing a content validity index (CVI) which quantifies the level of consensus within the panel (Polit and Beck, 2006). Previously, the Delphi technique has been used in nursing research to measure content validity in a variety of instruments. Chang et al. (2010) used Delphi technique to validate an instrument for measuring advanced practice nursing role delineation, Bull et al. (2022) established content validity of a patient-reported experience measure for emergency departments through a Delphi study, while Latimer et al. (2023) used the Delphi technique to establish face and content validity of a screening tool for end-of-life wounds. These examples illustrate that CVI measurement through Delphi surveys can be used for content validation of various scales in nursing research.

The current study used a modified online reactive Delphi survey, which was conducted over two rounds, where round 1 was informed by the authors' previous research and drafted by the research team (Keeney et al., 2011; Polit and Yang, 2016). An overview of the Delphi process is presented in Fig. 1.

2.2. Iterative refinement of draft tool

As suggested by Polit and Yang (2016), the item pool from the preliminary study was complemented by items from previous research and existing non-technical skills tools. This ensured compatibility with existing tools catering to other surgical team members. Three clinical operating room nurses contributed along with the research team to reduce the number of items to 132, and to organise the items into a conceptual model (see supplementary material, Conceptual model) for the taxonomy (Flin and Mitchell, 2017). Through a subsequent iterative process, the authors reduced the number of items for domains/sub-domains from 18 to 16 and the number of behavioural markers from 114 to 67. Thus, the draft behavioural marker tool (see Supplementary material, Draft behavioural marker system) presented to the expert panel for assessment of content validity comprised 82 items across four domains, each with two to four sub-domains, and five to six behavioural markers operationalising each sub-domain.

Table 1
Participants recruitment and characteristics.

	Combined panel n(%)		International panel n(%)		Norwegian panel n(%)	
Recruitment Round 1 (20.02.2023–08.03.2023)						
Number invited	41		23		18	
Number responded	25	(61)	11	(48)	14	(78)
No reminders	8	(32)	3	(27)	5	(36)
One reminder (day 7)	12	(48)	8	(73)	4	(29)
Two reminders (day 7 and 14)	5	(20)	0	(0)	5	(36)
Recruitment Round 2 (16.03.2023–14.04.2023)						
Number invited	13		6		7	
Number responded	10	(77)	5	(83)	5	(71)
No reminders	6	(60)	2	(40)	4	(80)
One reminder (day 14)	4	(40)	3	(60)	1	(20)
Panel characteristics	***Combined panel*** *N = 25*		***International**** ***panel*** *N = 12*		***Norwegian panel*** *N = 13*	
Expert type n(%)						
Clinical ORN*	3	(12)	3	(25)	0	
Clinical research ORN	3	(12)	0		3	(23.1)
Lecturer	6	(24)	1	(8.3)	5	(38.5)
Researcher	5	(20)	5	(41.7)	0	
Other	2	(8)	1	(8.3)	1	(7.7)
Lecturer and researcher	3	(12)	1	(8.3)	2	(15.4)
Lecturer and clinical ORN	2	(8)	1	(8.3)	1	(7.7)
Lecturer and clinical research ORN	1	(4)	0		1	(7.7)
Highest degree/level of education						
Bachelor/Registered nurse	2	(8)	2	(16.7)	0	
Post registration ORN education	2	(8)	0		2	(15.4)
Master's degree, ORN	4	(16)	1	(8.3)	3	(23.1)
Master's degree, other	9	(36)	4	(33.3)	5	(38.5)
PhD	8	(32)	5	(41.7)	3	(23.1)
Sex						
Female	21	(84)	10	(83.3)	11	(84.6)
Male	4	(16)	2	(16.7)	2	(15.4)
Mean ORN experience in years		22.7		24.5		21.1

ORN=Operating room nurse.
* Australia (3), UK (2), Canada, Finland, France, Iceland, Sweden, USA.

2.3. Bilingual instrument development

The draft construction and iteration process was bilingual in Norwegian and English. One author is a native English speaker, while three authors are native Norwegian speakers with English as their second language. Through group discussions, construct equivalence between the two languages was ensured (Hawkins et al., 2020). The instrument was developed simultaneously in English and Norwegian. During this development, both versions were revised continuously as a measure to promote conceptual equality and avoid literal translations (Potaka and Cochrane, 2004). The English version will be considered the source language from which further translations will be made.

2.4. Sample and expert panel recruitment

The use of an online Delphi process allowed for international recruitment of experts (Polit and Yang, 2016). Professionals with relevant clinical or academic expertise are recommended for the judgement of the content validity of theoretical constructs such as the behavioural marker system (Polit and Yang, 2016). Thus, an expert was defined as a registered nurse with operating room nursing experience and/or education, and/or experience in teaching or researching operating room nursing. Potential participants were identified through published research on the topic of non-technical skills in operating room nursing and through networking. Thus, researchers, operating room nursing lecturers, clinical research nurses and operating room nurse point of care clinicians from 15 different high-income countries in Europe, North-America, and Australia were invited (Polit and Yang, 2016; World Bank, 2023). Finally, all experts were fluent in Norwegian or English.

Since the behavioural marker tool was simultaneously developed in Norwegian and English, two sub-panels were needed for the study. Polit and Yang (2016) recommends 8–12 expert panel members for the first round. Due to diversity, a sample size of 10–12 experts was planned for the international sub-panel, while 8–10 was considered sufficient for the more homogenous Norwegian sub-panel. Literature suggests that the average response rate for online surveys is 44 %, with better numbers for small, well defined samples (Wu et al., 2022). Thus, to allow for sufficient participation, 23 international and 18 Norwegian experts were invited to round 1. A round 2 panel size of four to six, comprising experts that provided substantial information in round 1 is recommended (Polit and Yang, 2016). Recruitment details are presented in Table 1.

2.5. Data collection

Data were collected from February to April 2023. To measure content validity of the English and the Norwegian behavioural marker tool, a bilingual, online survey, with quantitative and qualitative components, was developed and conducted using the software SurveyXact (SurveyXact 13; Ramboll Management Consulting, Copenhagen, Denmark). The round 1 survey was pre-tested with 6 experts from Australia and Norway meeting the inclusion criteria. Some minor adjustments were made based on qualitative feedback from the pre-test. Feedback from round 1 informed refinement of the items for the round 2 survey (Supplementary material, Surveys).

Two consecutive Delphi surveys, with one week between rounds, was distributed to potential participants of the Norwegian and the international expert panels. Based on the pre-testing, each survey was estimated to take 30–40 min to complete. Only those experts responding to the round 1 survey were eligible for an invitation for round 2. Round 1 was open for approximately two weeks, and two reminders were distributed to non-responders during that time. Round 2 was open for four weeks due to Easter holidays, and only one reminder was needed.

The Delphi panel members were asked to review domains, sub-scales, and behavioural markers. Quantitative data were collected using a four-point scale (not relevant (0) – somewhat relevant (0) – quite relevant (1) – highly relevant (1)) assessing the items relevance for operating room nursing (Polit and Yang, 2016). Qualitative feedback on the behavioural marker tool was collected through open ended questions in the form of 'Do you have any comments on clarity or suggestions to improve the relevance of the item […]?'. In round 1, demographic data were also collected.

2.6. Ethical considerations

This research study was conducted in accordance with the ethical principles of the Declaration of Helsinki (World Medical Association, 2013). All participants provided informed consent prior to the data collection. This research study was approved by the Norwegian Agency for Shared Services in Education and Research, reference number: 155,726.

3. Data analysis

3.1. Round 1

Content validity is defined by Polit and Yang (2016) p.169 as 'the extent to which an instrument's content adequately represents the focal construct'. The Content Validity Index (CVI) has several desirable qualities as a method for measuring content validity and is a recommended method for measuring agreement between expert panel members in a Delphi study (Polit and Beck, 2006; Polit et al., 2007). Importantly, the CVI measures consensus rather than consistency, is easily computed, and provides item and scale information. The CVI does not adjust for chance agreement between experts. However, an Item-CVI greater than 0.78 translates to a modified kappa greater than 0.75, thus providing evidence for adequate item relevance corrected for chance agreement (Polit et al., 2007). An

item-CVI greater than 0.78 is considered excellent regardless of number of experts, and an overall Scale-CVI value at or above 0.9 provides evidence of strong content validity (Polit et al., 2007).

The Item-CVI for relevance was calculated, and the given points of the CVI scale were binary coded where 'not relevant' and 'somewhat relevant' receives 0, and 'quite relevant' and 'highly relevant' receives 1. The Item-CVI score is the sum of scores for an item divided by the number of participants. The Scale-CVI/Average was computed by summing all Item-CVIs and dividing by number of items. To allow for comparison between languages, the combined scores for each item was supplemented by the scores for each language. The a priori conditions for consensus (Table 2) were applied to each item.

The qualitative feedback was grouped, and all suggested revisions were discussed among the research team. Suggestions improving clarity or promoting construct equivalence were applied, and alterations in one language entailed a consideration of alteration in the other language to ensure conceptual equality and construct equivalence (Hawkins et al., 2020; Potaka and Cochrane, 2004). Suggestions for addition of items were thoroughly considered to ensure conceptual relevance and prevent introducing redundancy of items.

Descriptive statistics were used to describe the panel members demographic characteristics. These data were analysed descriptively in SurveyXact, and CVI scores were calculated in Microsoft Excel.

3.2. Round 2

Analysis of the round 2 survey followed the format presented for round 1. Round 2 was comprised of only the revised items. Thus, when calculating the CVI/Average of the behavioural markers and the Scale CVI, the missing values of the items that were retained in round 1 were substituted by the Round 1 CVI score (Last observation carried forward) (Polit and Beck, 2017).

4. Results

4.1. Demographics

Twenty-five operating room nursing experts practising in clinical, research and/or education roles were recruited for participation in the round 1 Delphi panel. Both sub-panels were within the recommended panel size (Table 1) (Polit and Yang, 2016). Participant characteristics are presented in Table 1. The expert panel had a mean operating room nursing experience of 22.7 (SD 9.19) years. Forty-four percent of the experts worked at educational institutions, 36 % were employed at hospitals, and the remaining 20 % worked clinical and education roles.

4.2. Round 1

Round 1 had a 61 % response rate (N_{eng}=11, N_{nor}=14). The experts spent a median time of 29 (IQR= 59.5) minutes completing the survey. In Round 1 the difference between the Item-CVI scores of the languages were minimal and the qualitative feedback was similar in both languages. The Item-CVI of the four domains were all at 1.0. The Sub-Dimensions Item-CVI's varied from 0.93 to 1.00, while the behavioural markers were scored between 0.81 and 1.0. The Scale-CVI of the combined language panel was 0.99 (Scale-CVI_{eng} =0.98, Scale-CVI_{nor}=0.99). All CVI scores and subsequent actions are presented in Table 3.

Since all 82 items received an Item-CVI above 0.78, the qualitative free-text suggestions received a greater emphasis in decisions about which items to accept and which to reword. The 17 open ended questions received an average of 7 responses each. The application of the a priori judgement strategy led to 55 items being accepted for the English version of the tool while 52 items met the criteria for acceptance in the Norwegian version. One behavioural marker received an Item-CVI score of 0.96. However, the qualitative feedback revealed that item application across contexts was unobtainable, thus the item was dropped. The remaining items received constructive feedback which led to their rewording and inclusion in Round 2.

The nature of the qualitative feedback followed three patterns: Some experts provided suggestions for improvement of clarity or relevance. Others gave recommendations for improving the universality of the behavioural marker tool to enhance usability across contexts/countries. The final area of feedback was the identification of redundancy. Examples of the content of the feedback are presented in supplementary material (Qualitative feedback and rewording), while the complete iteration process with Item-CVI scores of individual behavioural markers is provided in supplementary material (CVI scores and Delphi iteration).

Table 2
A priori conditions for consensus and consideration of qualitative feedback.

CVI criteria	Qualitative feedback	Consensus	Action
Item CVI≥0.78	None	yes	Accepted for final NOTSORN
Item CVI≥0.78	Revision needed	no	Revised and included in round 2
Item CVI≥0.78	Contradicts relevance	no	Dropped
Item CVI<0.78	N/A	yes	Dropped

Qualitative suggestions are considered regarding conceptual relevance and contribution to clarity.
Note: Excellent Scale content validity is demonstrated by every item measured at Item-CVI > 0.78, and a Scale-CVI/Average > 0.9 (Polit and Beck, 2006; Polit et al., 2007). N/A= not applicable. NOTSORN=Non-Technical Skils for Operating Room Nurses

Table 3
Quantitative results Round 1 and Round 2.

	ROUND 1			Action	ROUND 2			Action
	Total N = 25	Eng N = 11	Nor N = 14	Accepted(A), Reworded(R), Dropped(D) Eng(Nor)*	Total N = 10	Eng N = 5	Nor N = 5	Accepted(A), Reworded(R), Dropped(D) Eng (Nor)
Professionalism	1.00	1.00	1.00	R	1.00	1.00	1.00	A(*R*)
Ethical care	1.00	1.00	1.00	A	1.00	1.00	1.00	A
BM† (5), CVI/Average‡	0.97	0.94	0.99	2A/3R	0.98	1.00	0.96	5 A
Professional accountability	0.96	1.00	0.93	R	1.00	1.00	1.00	A
BM (5), CVI/Average	0.98	0.96	1.00	4A/1R	0.98	0.96	1.00	4A/1R
Situation awareness and decision making	1.00	1.00	1.00	A (*R)*	1.00	1.00	1.00	A
Surveillance	0.96	1.00	0.93	R	1.00	1.00	1.00	A
BM (5), CVI/Average	0.98	0.96	0.99	4A/1R	0.98	0.96	0.99	4A/1R
Comprehension	1.00	1.00	1.00	A (*R*)	1.00	1.00	1.00	A(R)
BM (5), CVI/Average	0.98	0.96	0.99	3A/2R	0.96	0.98	0.95	5A
Anticipation	1.00	1.00	1.00	A (*R*)	1.00	1.00	1.00	A
BM (5), CVI/Average	1.00	1.00	1.00	5A	1.00	1.00	1.00	5A
Clinical care decisions	1.00	1.00	1.00	A	1.00	1.00	1.00	A
BM (5), CVI/Average	1.00	1.00	1.00	3A/2R	1.00	1.00	1.00	4A/1R
Teamwork and communication	1.00	1.00	1.00	R	0.90	0.80	1.00	R
Exchanging information	1.00	1.00	1.00	A	1.00	1.00	1.00	A
BM (6), CVI/Ave	0.99	0.98	1.00	4A/2R	0.97	0.93	1.00	6A
Co-ordinating activities	1.00	1.00	1.00	R	1.00	1.00	1.00	A
BM (6), CVI/Ave	0.99	0.97	1.00	5A/1D	0.99	0.98	1.00	5A
Supporting others	1.00	1.00	1.00	R	1.00	1.00	1.00	A
BM (6), CVI/Ave	0.99	0.98	0.99	3A/3R	0.98	0.98	1.00	5A/1R
Leadership and task management	1.00	1.00	1.00	R	1.00	1.00	1.00	A(R)
Promoting and maintaining standards	1.00	1.00	1.00	R	1.00	1.00	1.00	R(A)
BM (6), CVI/Ave	1.00	1.00	1.00	6A	1.00	1.00	1.00	6A
Prioritising, planning, and preparing	1.00	1.00	1.00	R	1.00	1.00	1.00	A
BM (6), CVI/Ave	0.99	0.98	1.00	6A	0.99	0.98	1.00	6A
Coping with pressure	1.00	1.00	1.00	R	1.00	1.00	1.00	A
BM (6), CVI/Ave	0.99	0.98	0.99	4A/2R	0.98	0.97	0.99	6A
Scale CVI/Ave	0.99	0.98	0.99		0.99	0.99	0.99	

* Eng(Nor)= When actions differ between languages, the action for the Norwegian version is presented within brackets.
† BM = Behavioural marker (number of items).
‡ =CVI/Average(sum of item CVI's divided by number of items.

4.3. Round 2

Ten first round participants who provided qualitative feedback were recruited to participate in the second round (Table 1). The experts used a median of 24 (IQR=26) minutes to complete the survey. In Round 2, the experts scored 29 reworded items and had the opportunity to further comment on these items in 16 open ended questions.

The quantitative scoring of items translated into Item-CVI scores ranging from 0.8 to 1 for separate language panels, where a 0.8 Item-CVI score means that one of the five panel members found the item not/somewhat relevant. The combined panel of both languages yielded Item-CVI scores between 0.9 and 1.0. Thus, no items received more than one not/somewhat relevant judgement. The Round 2 Item-CVI and Scale-CVI/Average scores are presented in Table 2.

Each of the 16 open ended questions averaged three responses. The research team discussed all feedback and made minor changes to 6 items. Some suggestions were dismissed due to a clear lack of relevance, and some suggestions represented items dropped in previous iterations.

The final version of the Non-Technical Skills for Operating Room Nurses -NOTSORN behavioural marker tool comprises 4 domains and 12 subdomains (Fig. 2). Each subdomain is operationalised with five to six (total 65) behavioural markers (supplementary material, NOTSORN).

5. Discussion

The aim of this study was to assess the content validity of the 82 items of the Non-Technical Skills for Operating Room Nurses tool. A two-stage consensus process was used. All items, except one behaviour marker, was assessed by expert operating room nurses to have excellent content validity regardless of round or sub-panel. Furthermore, this study refined the tool; one behavioural marker was removed because universality across contexts could not be achieved; 26 items (round 1) and 6 items (round 2) were modified to

NON-TECHNICAL SKILLS FOR OPERATING ROOM NURSES - NORSORN
PROFESSIONALISM Optimising the patient journey through performing evidence based operating room nursing within national legislation, professional standards, and the Code of Ethics for Nurses. The category of professional conduct is overarching the other categories, directing the performance of all non-technical skills.
Ethical care – being the patients advocate: Showing respect for human rights, including cultural rights, the right to life and choice, and the right to dignity (ICN, 2021). Treating *all* patients with respect and having the patients' best interest as main objective throughout the surgical trajectory.
Professional accountability – upholding the professional standards of practice of operating room nursing: Maintaining high professional standards according to local, national, and international guidelines, new research, and developments of the profession. Promoting the role and integrity of the operating room nursing profession in actions and words (EORNA, 2019).
SITUATION AWARENESS AND DECISION MAKING Situation awareness is knowing what is going on around you (Endsley, 2021), and is achieved by actively gathering information from the environment (patient, medical records, team, and equipment). By using your situation awareness, knowledge, and experience, you can make appropriate clinical care decisions.
Surveillance – becoming aware that something is happening: Using all senses (seeing, hearing, smelling, feeling, sensing) to collect information from the surgical field, equipment, patient, and team members.
Comprehension – understanding what is happening: Using knowledge and experience to interpret the information gathered from the environment to understand its meaning or significance in relation to your OR nursing goals. Detecting and analysing changes in the environment or the patient's condition.
Anticipation – predicting what may happen next: Using knowledge and experience to think beyond the current situation and predict how the situation may develop. This enables proactive decision making, rather than just reacting to current situations (Endsley, 2021).
Clinical care decisions – making the appropriate decisions: Making the appropriate decisions for the current or emerging challenges based on your situation awareness. Considering risks, benefits, and cost of the option when choosing the best approach to rectify the situation. Completing the chosen course of action and reviewing the outcome.
TEAMWORK AND COMMUNICATION Using communication and teamworking skills to ensure that the operating room nurses (scrub and circulating) and the surgical team have a shared understanding of the situation and can cooperate to complete tasks effectively.
Exchanging information – sharing your information and observation: Contributing to shared situation awareness. Using communication techniques appropriate to the situation when sharing relevant information with the team.
Co-ordinating activities – planning your work in the team: Coordinating patient positioning, equipment, and infection control with other team members to promote patient safety, efficiency, and sustainable use of resources. Working interdependently within the team to coordinate care.
Supporting others – teaching, supervising, and providing physical and emotional support: Supporting colleagues experiencing emotional or physical distress. Contributing towards mutual respect and understanding between team-members. Taking responsibility for teaching new team members.
LEADERSHIP AND TASK MANAGEMENT The skill of leading oneself, operating room nurses, and the surgical team. Managing own tasks and maintaining standards. Participating in organising procedures and schedules according to resources. Taking leadership of the team in situations where other team-members are occupied or need assistance.
Promoting and maintaining standards: Promoting quality and safety of patients and staff by adhering to standards of clinical practice, and ensuring relevant standards are maintained by all members of the team.
Prioritising, planning, and preparing – facilitating single procedures and schedules: Prioritising one's work assignments. Planning one's next procedure according to the patient, guidelines, and surgeons' requests. Preparing all necessary technical equipment, operating table, positioning aids, and instruments.
Coping with pressure – dealing with stressful or exhausting situations: Remaining calm and focused on immediate tasks when under pressure. Recognising when feeling overwhelmed and ask for assistance.
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(caption on next page)

Fig. 2. The non-technical skills for operating room nurses: NOTSORN.

improve clarity and universality across contexts. The Non-Technical Skills for Operating Room Nurses tool now consist of 4 domains, 12 subdomains, and 65 behavioural markers.

Face validity of the Non-Technical Skills for Operating Room Nurses tool can be claimed based on the following study characteristics (Keeney et al., 2011). Three of the researchers are operating room nurses with extensive clinical experience, the items included in the instrument were developed by experienced operating room nursing clinicians, and finally, the iterative process of this Delphi study allowed the expert panel of mainly operating room nursing researchers and educators to generate, review and judge the appropriateness of the items.

To facilitate training and assessment of operating room nurses' non-technical skills, we need robust and validated tools. This paper reports a rigorously conducted bi-lingual and cross-cultural sensitive draft tool refinement and validation. We argue that this bilingual process is a necessary preliminary step of the content validation, and for further testing of the tool. The similarities in CVI scores between the Norwegian and the international expert panel supports the relevance of the tool in both languages, and across the nine participating countries. Furthermore, the qualitative feedback on the content corresponded between the panels, although some linguistic suggestions were language specific. Thus, in line with the assumption that study findings are not unique to the original context (people, places, or circumstances) (Polit and Beck, 2010), it is assumed that the non-technical skills collected from Norwegian operating room nurses would most likely be transferable to high income contexts where the operating room is staffed by nurses. However, the content validation process revealed that some items were not transferrable from a Norwegian context (public health care system and master's degree level operating room nurses). Thus, to maximise adequacy and ensure transferability between operating room nursing cultures, and conceptual equivalence, these items were either removed or edited in both languages (Harkness et al., 2003; Potaka and Cochrane, 2004). Furthermore, the simultaneous tool refinement eliminated issues regarding referential meaning and structural needs which are limitations in a standard forward back translation (Harkness, 2003).

Some authors of non-technical skills behavioural marker systems intended for the operating room claim content validity through using the tool for assessment of non-technical skills in simulation (Beard et al., 2011; Fletcher et al., 2004; Jepsen et al., 2016; Mitchell et al., 2012). However, we have only identified measurement of content validity for the Asian adaptation of the Scrub Practitioners List of Intraoperative Non-Technical Skills (Loh et al., 2019). The overall scale-CVI scores measured by Loh et al. (2019) are comparable to the scale-CVI scores in our study. However, the lack of sub-scale- and item-CVI's hinders further comparison of the relevance to operating room nursing between the two behavioural marker systems. As there are few rigorous examples of content validation of non-technical skills behavioural marker systems intended for the operating room, the current study can be used to inform future content validations.

The Non-Technical Skills for Operating Room Nurses tool differ from previous behaviour marker system developed to cater to the scrub practitioners (Flin et al., 2010; Mitchell et al., 2011) in several areas. Namely, the intended users, the intended practice, and the included domains of non-technical skills.

The first distinction between the tools is the qualification of the intended users. Our tool caters to *nurses* with specific operating room education and/or training. In addition to the traditional personal resource non-technical skills (i.e. coping with fatigue and coping with stress), nurses also have a strong sense of professionalism and a deeply rooted professional ethics (Hanssen et al., 2020; Sirevåg et al., 2023). The novel domain of 'Professionalism' received positive feedback from the experts, particularly on how this domain is intertwined with the other domains. They recognised a link between the operating room nurses' ethical awareness and their moral decision making and actions. Research on operating room nurses competence highlights their 'aesthetic' knowledge and human factors skills (teamwork, communication, leadership and clinical coordination) as the demarcation contrasting operating room nurses and the non-nursing technically oriented scrub technicians (Gillespie and Hamlin, 2009; Gillespie and Pearson, 2013).

The second distinction is made around which practice is covered by the tools. Our tool caters to the intra-operative phase as defined by the operating room nursing profession. That is, from the arrival of the patient to the operating department until transfer of care to the recovery unit (Kelvered et al., 2012). This contrasts the definition 'knife-to-skin to close' (p. 826) used when developing the previous tool (Mitchell et al., 2011). While technicians have training for the singular task of passing instruments to the surgeon, the operating room nurses have dual roles: the instrument nurse monitors and maintains asepsis throughout surgery and provide appropriate and timely instrumentation, while the circulating nurse manages the operating room, prevents patient positioning related nerve and/or pressure injuries, and is responsible for the well-being of the patient while protecting their dignity (Gillespie et al., 2009; Gillespie and Pearson, 2013; McGarvey et al., 2000; Sirevåg et al., 2023). By using the broader definition of the intra-operative phase, we include the circulating nurse's non-technical skills in addition to the skills of the instrument nurse.

The final distinction between the tools is the included domains of non-technical skills. In contrast to our tool, Flin et al. (2010) did not identify decision making or leadership skills during their item generation. This may be a result of their emphasis on the scrub practitioners as decision making and leadership non-technical skills are previously identified for the circulating operating room nurse (Gillespie et al., 2009; Gillespie et al., 2013; Redaelli, 2018; Sirevåg et al., 2021). The responses from the expert panel in this study confirms that a designated non-technical skills tool for operating room *nurses* is warranted.

Various non-technical skills tools for members of the surgical teams have near identical domains with user specific behavioural markers. This facilitates a common language for non-technical skills within the team, regardless of chosen behavioural marker system. Thus, each sub-team can train and be assessed according to their professional qualifications and responsibilities using sub-team tools with appropriate behaviour markers, while the team dynamics can be assessed through a team-based tool (McMullan et al., 2020). This approach can accommodate the lack of cohesiveness observed in operating room teams (Gillespie et al., 2018; Undre et al., 2006).

Since each sub-team needs to train their own non-technical skills using a tool customised to their profession before the team can train or be assessed, we argue that these tools are complementary, rather than competitive.

5.1. Strengths and limitations

While rigorously undertaken, we acknowledge that this study has some limitations. First, the recruitment process of self-inclusion following an e-mailed invitation contributed to the international panel being smaller than intended due to expired addresses and the invitation being identified as spam. Despite these issues, the response rate of the international experts was 44 % which has been identified as an average survey response rate (Wu et al., 2022). The Norwegian operating room nursing community involved in research and education is relatively small, and a high response rate of 78 % led to a larger sub-panel than intended. However, the sample size of 13 Norwegian and 12 international experts falls within, or close to, the recommended panel size for CVI measurements (Polit and Yang, 2016).

Second, the high CVI scores on item and scale level may suggest a tendency to a ceiling effect (Polit and Yang, 2016). Alternatively, the high score reflects that the researchers' selection of items for the behavioural marker system accurately captures the non-technical skills of operating room nurses. Furthermore, the dichotomisation of responses dictates that a judgement of 'quite relevant' qualifies for a '1′ measure. The likelihood of the items being 'quite relevant' should be considered as an explanation for the high CVI scores. This explanation is feasible as the item generation was informed by operating room nurses. Furthermore, three of the authors are operating room nurses, and thus possess a deep understanding of the profession's responsibilities and the organisational frameworks under which they perform.

Third, a classical translation/back translation was not chosen for this study. However, the rigorous bilingual refinement of items ensured conceptual equivalence and maximised adequacy between two languages and multiple cultures. The Delphi panel comprised subject experts from nine countries worldwide. Their diverse expertise prevented a myopic perspective and contributed to establishing the content- and face validity of the Non-Technical Skills for Operating Room Nurses tool for both languages (Keeney et al., 2011; Polit and Yang, 2016). The Delphi technique established consensus by experts engaged in clinical care, academia, and research, thus increasing the tools relevance and applicability in clinical and educational settings.

5.2. Recommendations

Previous research has shown that using behavioural marker systems in student supervision is beneficial (Flynn et al., 2021; Sirevåg et al., 2021). Thus, the Non-Technical Skills for Operating Room Nurses tool may be used as a support in education and, for life-long learning, and as a framework for non-technical skills in operating room nursing. By identifying the student/trainee's areas of strengths as well as areas needed for improvement, the tool may be used by preceptors/mentors to inform reflections and formative feedback. When a planned psychometric testing of the tool is completed, we will also provide a normative rating scale. To accommodate work sites requiring periodical performance reports, an adaptation of the tool into a self-reporting tool will be made. Recommended further research also includes psychometric analyses and invariance testing based on country and years of experience across high-, middle-, and low-income countries.

6. Conclusions

Lack of non-technical skills is a substantial contributor to adverse events in the operating room. Traditionally, the non-technical skills of operating room nurses have developed over time. However, this development can be accelerated through purposeful training and subsequent assessment, using a non-technical skills development tool. We have measured the content validity of the Non-Technical Skills for Operating Room Nurses tool and, based on international expert guidance, confirm that the new tool captures the myriad of non-technical skills needed in operating room nursing. The Non-Technical Skills of Operating Room Nurses tool offers an operationalisation of cognitive and social skills which benefits the development of non-technical skills of trainee/student and novice operating room nurses. The tool's intended use includes education of operating room nurses, supervision, training, and formative assessment of operating room nursing students and trainees, in addition to training and assessment of the non-technical skills of operating room nurses. The tool may also guide reflections over own performance during formal and informal debrief. Over time, the use of this tool, may reduce the time gap where novice operating room nurses master the technical skills but have not yet acquired the non-technical skills necessary for safe performance.

CRediT authorship contribution statement

Irene Sirevåg: Conceptualization, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – original draft. **Britt Sætre Hansen:** Conceptualization, Writing – review & editing. **Ingrid Tjoflåt:** Conceptualization, Writing – review & editing. **Brigid M. Gillespie:** Conceptualization, Writing – review & editing.

Declaration of competing interest

None of the authors have any conflict of interest.

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Supplementary materials

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