Australian Critical Care 35 (2022) 159–166

Contents lists available at ScienceDirect

Australian Critical Care

journal homepage: www.elsevier.com/locate/aucc

Research paper

Professional Assessment Tool for Team Improvement: An assessment tool for paediatric intensive care unit nurses' technical and nontechnical skills

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ARTICLE INFORMATION

Article history:
Received 2 June 2020
Received in revised form
19 February 2021
Accepted 6 March 2021

Keywords:
Assessment
Development
Nurses' role
Resuscitation
Teamwork

ABSTRACT

Background: Cardiorespiratory arrests are rare in paediatric intensive care units, yet intensive care nurses must be able to initiate resuscitation before medical assistance is available. For resuscitation to be successful, instant decision-making, team communication, and the coordinating role of the first responsible nurse are crucial. In-house resuscitation training for nurses includes technical and nontechnical skills.

Objectives: The aim of this study was to develop a valid, reliable, and feasible assessment instrument, called the Professional Assessment Tool for Team Improvement, for the first responsible nurse's technical and nontechnical skills.

Methods: Instrument development followed the COnsensus-based Standards for the selection of health Measurement Instruments guidelines and professionals' expertise. To establish content validity, experts reached consensus via group discussions about the content and the operationalisation of this team role. The instrument was tested using two resuscitation assessment scenarios. Inter-rater reliability was established by assessing 71 nurses in live scenario sessions and videotaped sessions, using intraclass correlation coefficients and Cohen's kappa. Internal consistency for the total instrument was established using Cronbach's alpha. Construct validity was assessed by examining the associations between raters' assessments and nurses' self-assessment scores.

Results: The final instrument included 12 items, divided into four categories: Team role, Teamwork and communication, Technical skills, and Reporting. Intraclass correlation coefficients were good in both live and videotaped sessions (0.78–0.87). Cronbach's alpha was stable around 0.84. Feasibility was approved (assessment time reduced by >30%).

Conclusions: The Professional Assessment Tool for Team Improvement appears to be a promising valid and reliable instrument to assess both technical and nontechnical skills of the first responsible paediatric intensive care unit nurse. The ability of the instrument to detect change over time (i.e., improvement of skills after training) needs to be established.

1. Introduction

Resuscitations in paediatric settings are rare events for which time elapsed until start, and the quality of the resuscitation have a significant impact on clinical outcomes.[1–5] Healthcare professionals are rarely exposed to these events, and both development and

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https://doi.org/10.1016/j.aucc.2021.03.002

maintenance of effective resuscitation skills rely on training.[6–9] To ensure quality, every resuscitation event should have a designated team leader.[10] Effective team leadership requires specific skills, such as empowering the team to speak up, designating tasks, and keeping the overview of the resuscitation process also called situational awareness.[11] Healthcare professionals are familiar with technical skills being assessed, such as in basic life support or advanced (paediatric) life support (A(P)LS) training.[10,12] Teamwork skills, however, did not receive much attention during these training sessions.[13,14] Gilligan et al.[15] described in a prospective study the leadership role of ALS-trained nurses in simulated cardiac arrest situations as a good alternative when a doctor is not available. Lack of confidence and fear of litigation and of harming the patient are important factors that withhold nurses from successfully initiating resuscitation.[16–18] Greater confidence might help reduce feelings of helplessness, and educational programs should also address this.[19,20] Dwyer et al.[18] found that removing barriers to nurse-initiated resuscitation can be achieved by training and emphasising the individual contribution in achieving a favourable outcome. Aiken et al.[21] showed that the educational level of nurses is crucial, i.e., higher competence among nurses in hospital wards results in a reduced incidence of mortality, morbidity, and adverse events.

Next to this, teamwork failures and communication breakdowns are substantial contributing factors to adverse incidents in health care.[22,23] Through team training, teams may be able to prevent most of these incidents.[22,24,25] Other high-risk industries, such as aviation, have invested in crew resource management (CRM) and subsequently achieved better performance to manage error.[26,27] CRM training has since been successfully implemented in the healthcare sector.[28–30] Assessments of team performance can give insight into issues that need improvement.[31,32] Teamwork skills such as communication, leadership, decision-making, and team interaction have proven to be as important as technical skills, as reflected by the availability of many tools to assess health professionals' teamwork skills.[33,34] One published tool, the Imperial Paediatric Emergency Training Toolkit, aims to assess technical and teamwork skills in a paediatric intensive care setting and focuses on general nontechnical skills, mainly of physicians.[35] As the Imperial Paediatric Emergency Training Toolkit was not used to assess nurses' skills, we set out to develop a new tool that would allow us to assess the technical and nontechnical skills of nurses.[35]

1.1. Background

In our paediatric intensive care unit (PICU), between 40 and 50 resuscitations per year (approximately 2% of annually admitted patients) are carried out, which is comparable with other PICUs.[36,37] In our facility, a physician fulfils the role of a team leader in the resuscitation setting. In practice, intensive care nurses are often the first present in the case of cardiorespiratory arrest;[8,16] then, it is crucial that one nurse, the “first responsible nurse”, takes the lead in the resuscitation process and instructs other nurses and monitors the quality of the resuscitation, before physician arrival.[38]

Using simulation sessions, we have been training our nurses and doctors in technical and teamwork skills since 2005, as part of the patient safety management system. The literature confirms that simulation is an effective method of training resuscitation teams in teamwork skills.[39–41] During the debriefing in the team training sessions, our nursing staff suggested that technical and teamwork skills should be regularly assessed. They indicated the discrepancies between regular assessment during their formal training and the lack thereof after finishing education. Next to the yearly mandatory APLS training,[42] the PICU nurses made clear that regular assessments in teamwork training would make them feel confident about their technical and nontechnical skills.

To address nurses' leadership role during resuscitations, it was decided to focus on resuscitation procedures first because these require exceptional technical and teamwork skills, especially from the “first responsible nurse”.

1.2. Research objective

We aimed to develop and test the validity, reliability, and internal consistency of the Professional Assessment Tool for Team Improvement (PATTI©) that assesses technical and nontechnical skills of nurses in the PICU.

2. Methods

2.1. Design

This is a prospective psychometric evaluation of the skill assessment tool named the PATTI©, following the COnsensus-based Standards for the selection of health Measurement Instruments (COSMIN) guidelines and the assessment guidelines from CITO, the Dutch Institute for Educational Measurement.[43]

2.2. Setting

Our PICU has four units with 28 beds and staff consisting of 125 paediatric intensive care nurses, 11 intensivists (pediatricians and anaesthesiologists), five paediatric intensive care fellows, and 10 junior doctors. There is a 24/7 presence of both a consultant and fellow in the hospital. Yearly, 1700 children are admitted between the ages of 0 and 18 years, who are treated for a variety of issues including congenital anomalies, trauma, neonatal surgery, and craniofacial surgery. The PICU also serves as one of the two extracorporeal membrane oxygenation centres for the Netherlands. A blueprint for effective teamwork, developed in our facility, has been in use for both resuscitations and other procedures wherein teamwork is critical. This blueprint defines teamwork roles and tasks (Fig. 1).

2.3. Participants

An expert panel consisted of 11 simulation experts working in the PICU (four doctors and seven nurses), both of whom served as developers and raters and received rater training before the start of the project. The simulation training experts all have been trained in technical and nontechnical skills and are now working as teamwork trainers next to being simulation experts, which makes them best equipped to determine the criteria for technical and nontechnical skills. An assessment specialist guided the experts in successive stages of the development and test phases of the PATTI©.

All 125 PICU nurses were invited to participate in pilot simulation training sessions to test the PATTI© in the successive stages, and 71 (56.8%) participated.

2.4. Development of the PATTI©

An iterative approach was used to develop the PATTI©. First, the 11 simulation experts and the assessment specialist formulated the criteria the tool had to meet to achieve content validity (the degree to which the content is an adequate reflection of the construct to be measured), based on teamwork tasks and responsibilities as per the

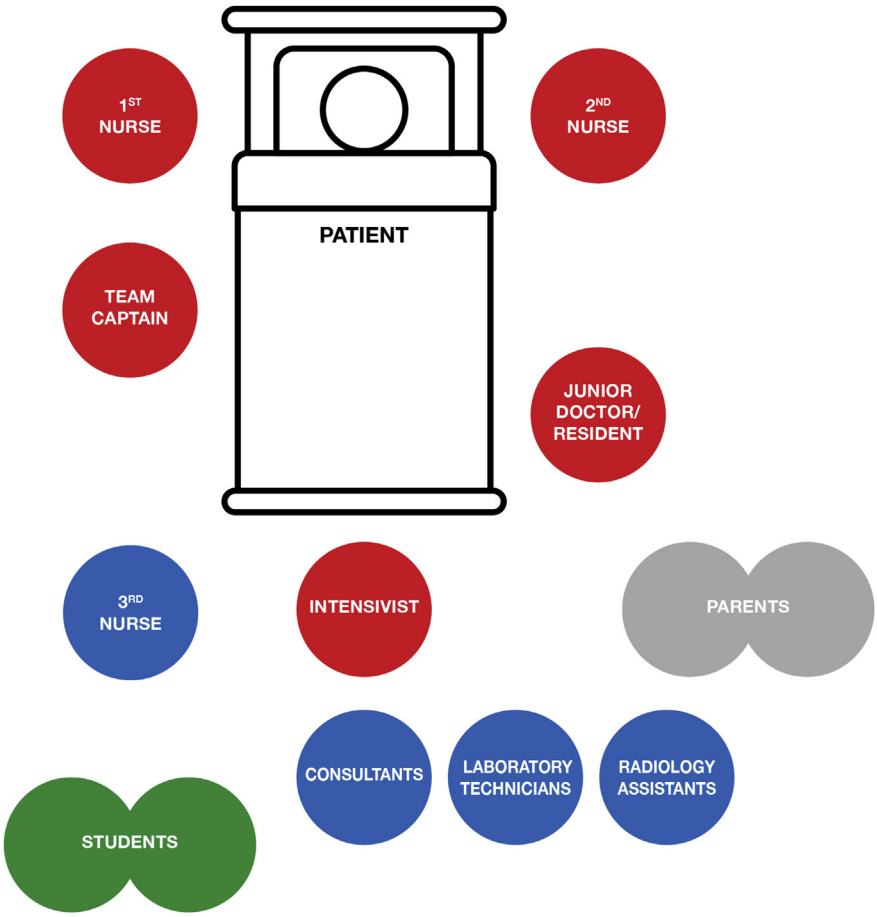

Fig. 1. Bird's-eye view of team members' positions, tasks, and roles in a PICU acute care situation. Red circles: first nurse at the headboard, right-hand side of the patient, team captain (usually paediatric intensive care fellow), intensivist at the footboard, junior doctor/resident, second nurse at the headboard, left-hand side of the patient. Blue circles: third nurse, consultants (e.g., cardiologist, anaesthesiologist), laboratory technicians, radiology assistants. Grey circles: Parents may be at a close distance, but if necessary, they will be asked to step back. Green circles: Two students (medical or nursing) allowed in the context of training. PICU = paediatric intensive care unit. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article).

CRM principles.[44,45] The technical skill content was based on the guidelines for APLS.[46] The measurement properties were selected using the COSMIN guidelines (Fig. 2).[47]

Second, we drafted a preliminary version, on which we reached consensus via group discussions during three 8-h sessions with our simulation experts and the assessment specialist. The deliberations resulted in a version consisting of 16 items divided into four categories: Team role, Teamwork and communication, Technical skills, and Reporting. The response categories ranged from 1 (very poor) to 4 (very good).

Third, content validity was further established through 62 pilot simulation training sessions as this triggered the most debate. To support uniformity of assessment, we chose to use two simulation scenarios that are highly standardised and that nurses are expected to master: the shockable and nonshockable resuscitation protocol. To maintain equivalence, the age of the child was the same in both scenarios.

Fourth, the items in the PATTI© were evaluated and reworded by the simulation experts and assessment specialist, based on the simulation pilot sessions, and a list with detailed descriptions of the response categories was drawn up to ensure good inter-rater reliability.

Fifth, the resulting version was evaluated again and tested for feasibility (time needed to complete) in the simulation pilot sessions.

As a sixth step, several items were removed or integrated with other items that in the fifth step proved difficult to score. The result was a 12-item version containing four subscales: subscale A, Team role (six items); subscale B, Teamwork and communication (three items); subscale C, Technical skills (two items); and subscale D, Reporting (one item).

2.5. Validity and reliability testing

Bearing in mind that a gold standard to establish criterion validity does not exist, we sought to determine the construct validity of the PATTI©. Other studies have shown that nurses are able to assess their own skill;[48–50] therefore, we compared the experts' assessments with nurses' self-assessment scores of the PATTI©. We hypothesised that a correlation of 0.60 or higher between the PATTI© scores of the assessors and the nurses' self-report assessments would indicate sufficient construct validity.

Then, we set out to test the reliability of the PATTI©. To support inter-rater reliability, the simulation training experts attended an in-house assessor training program delivered by the assessment specialist. Next, two infant resuscitation assessment scenarios were performed: asystole and ventricular fibrillation. Inter-rater reliability was established in live pilot sessions and sessions in which videotaped scenarios were assessed by multiple pairs of assessors.

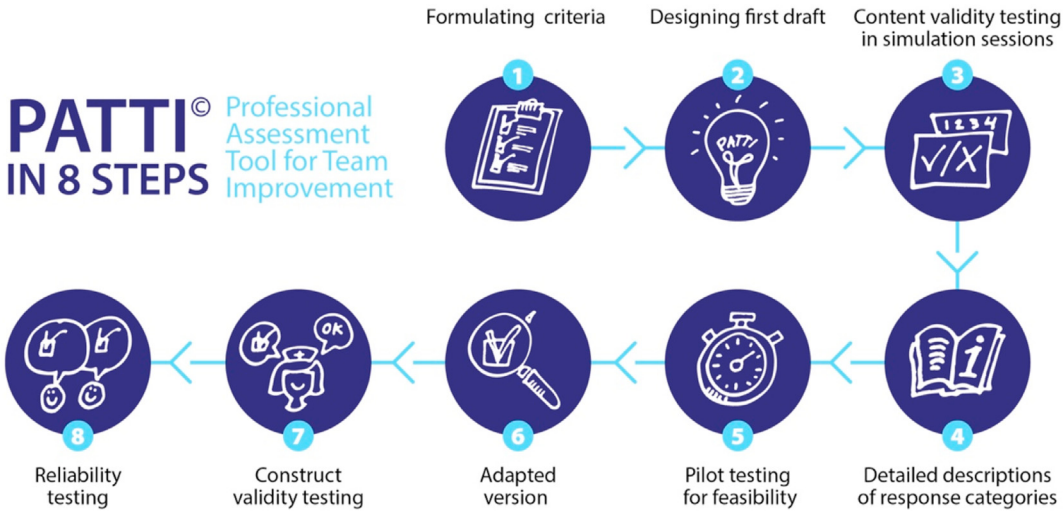

Fig. 2. Development of the Professional Assessment Tool for Team Improvement (PATTI©). (Permission has been granted for this figure "PATTI© in 8 steps" to be reproduced in this article.)

Pairs of assessors were used because we had noted that assessing teamwork skills proved difficult for a single observer.

The inter-rater reliability of the 12-item PATTI© was iteratively tested in four phases by the 11 assessors:

Phase 1. In 32 live simulation sessions with one pair of assessors per session, the agreement between assessors' individual scores was determined. The live sessions were videotaped.
Phase 2. The four videotaped scenarios performed in phase 1 for which the PATTI© score ranged most widely between two assessors were scored again with multiple pairs of assessors. Finally, the consensus scores of all pairs were compared, and inter-rater reliability was calculated. This yielded a lower intraclass correlation coefficient (ICC) than that in the first phase. We were not yet satisfied with the results.
Phase 3. Therefore, in phase 3, we continued with the assessment of 48 live simulation sessions comparing the consensus scores of two or more pairs of assessors assigned during live sessions. This yielded a higher ICC than in the previous step.
Phase 4. The ICC scores of individual assessors in 136 live simulation sessions with two assessors per session were again compared. In each phase, the assessors discussed any differences in scoring to reach consensus and improve the inter-rater reliability.

2.6. Statistical analysis

To examine construct validity, correlation between assessors' and nurses' self-assessment scores was calculated using the Spearman rank-order correlation coefficient. As there is no gold standard test, we applied hypothesis testing beforehand as per the COSMIN guidelines. This implies that we do not look at the p-value of a correlation or a rule of thumb for effect size, but in this case at the preferred value of the correlation of 0.60 to support construct validity.

Inter-rater reliability among pairs of assessors for the total score and for the subscales A, B, and C of the PATTI© was evaluated using the ICC. Values between 0.75 and 0.9 indicate good reliability.[51] The ICC was calculated using IBM SPSS Statistics for Windows, version 25.0 (IBM Corp; Armonk, NY) using the two-way mixed model, type absolute agreement and single measures (with 95% confidence intervals). For the single item subscale D, we calculated the percentage agreement between the pairs of assessors because the raters had used only response categories 3 and 4.

Internal consistency for the total scale was established using Cronbach's alpha, aiming for values between 0.70 and 0.90. We chose Cronbach's alpha to determine if the items of the PATTI© are sufficiently correlated to justify the use of a total and subscale score. Structural validity was not tested with factor analysis because the subscales were theory driven. A p-value <0.05 was considered to reflect statistical significance.

2.7. Ethical considerations

Permission for this study was requested from the medical ethics review board of our institution. The board concluded that the investigation was not subject to the Medical Research Involving Human Subjects Acts, and further review was waived. Through anonymising collected data, participants' privacy is guaranteed, and research data are stored in accordance with Good Clinical Practice guidelines.[52]

3. Results

Content validity for the PATTI© was established in 62 pilot rounds: the expert panel reduced the 16-item draft version to 12 items, each with four response categories (Table 1).

One of the adjusted items was “provides adequate monitoring of vital signs”, which was integrated into item 10, “follows the guidelines by degree of (in)stability of the vital signs”, because that is one of the criteria in the resuscitation protocol. The item “acts safely and effectively under stress” was removed because the level of stress proved difficult to assess. The item “always mentions all findings of relevant interventions” and the item “observes and evaluates joint actions, maintains situational awareness of process and product” were integrated into one item “has situational awareness on process and product and evaluates joint actions”.

Use of the PATTI© proved feasible, especially because the assessment time for three simulation sessions could be shortened from 120 min to 60–90 min.

The Spearman rank-order correlation coefficient between 32 paired assessors' PATTI© consensus scores and the self-report scores was 0.343 (95% confidence interval = 0.006 to 0.617). Nevertheless, one outlier deflates the correlation between the two

Table 1
Professional assessment tool for team improvement (PATTI©).

Professional Assessment Tool for Team Improvement (PATTI©)	Scenario type: Ventricle Fibrillation/ Asystole (delete if not applicable)
Candidate:	Date:
Assessor 1: (the one filling out the form)	Assessor 2: Result:
	1 2 3 4 Notes
A. Team role in first responsible nurse	
1. Stays on the patients right side	
2. Coordinates and assigns tasks to the second and third nurse	
3.Gives clear commands	
4. Checks whether the tasks have been performed	
5. Gives medication and fluid in time to the patient or delegates this to the second or third nurse	
6. Ensures that a colleague attends to the parents/caretakers	
B. Teamwork and communication	
7. Has situational awareness on process and product and evaluates joint actions	
8. Acts pro-actively in bringing in expertise and shows assertive behaviour	
9. Invites team members to think about the problem, listens, contemplates aloud and achieve an adequate solution	
C. Technical skills	
10. Follows the right protocol and executes it correctly based on readings of vital parameters.	
11. Recognizes the complexity of the situation and asks for the right expertise	
D. Reporting	
12. Reports all interventions during the scenario (defibrillation, medication, amounts/doses and frequency)	

Subscale A: six items; subscale B: three items; subscale C: two items; subscale D: one item; total scale: 12 items.

scales (Fig. 3). Without this outlier, the Spearman rank-order correlation coefficient improved to 0.445 (95% confidence interval = 0.108 to 0.690), which is still lower than an r value of 0.60. Therefore, the hypothesis was rejected, and construct validity was insufficient.

The ICC, used as a measure of inter-rater reliability, between the assessors varied from 0.78 to 0.87 in four different phases (Table 2).

Phase 1. The ICC between assessors' individual scores during these sessions of the total PATTI© sum score was 0.87. The lowest ICC of 0.63 was seen for subscale C (technical skill items).
Phase 2. The four videotaped scenarios resulted in an ICC of 0.78 for the total score again, with a lower ICC for subscale C.
Phase 3. The assessment of 48 live sessions yielded an ICC of 0.79 for the total PATTI© score between pairs of assessors. The ICCs for subscale C (0.65) and subscale A (0.66) were lower than for subscale B (0.82).

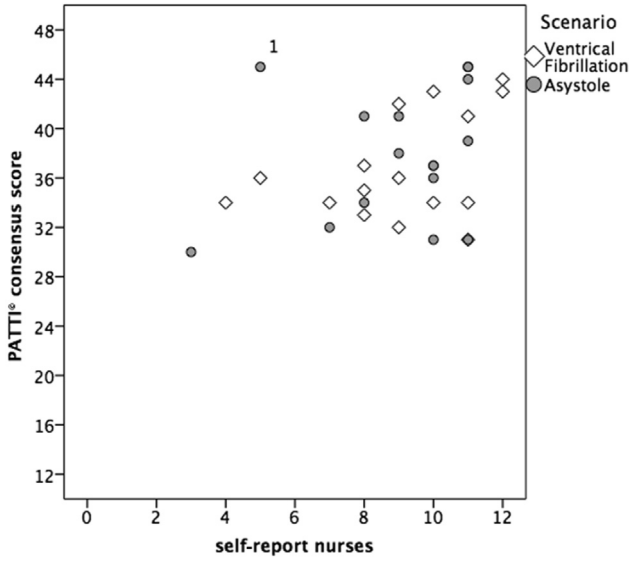

Fig. 3. Correlation between the assessors' PATTI© consensus score and nurses' self-report-score. PATTI© = Professional Assessment Tool for Team Improvement.

Phase 4. The ICC score of 136 live sessions was 0.88. In addition, the ICC of all subscales was between 0.78 and 0.84. Data on subscale D are missing for phase 2 because the participants' report was given outside of the simulation room and thus could not be reviewed by the assessors.

As demonstrated by Cronbach's alpha (0.83), internal consistency was established (Table 2).[53]

4. Discussion

We developed a tool that seems able to assess both technical and nontechnical skills of PICU nurses in a simulation setting. We found adequate inter-rater reliability, good internal consistency, and content validity of the PATTI© tool. Construct validity, however, in terms of the correlation between the PATTI© and the self-reported skill assessment of the nurses, was lower than that hypothesised beforehand. Three explanations may account for this. First, the variation in scores on both scales is relatively low (no scores in the lower left quadrant in Fig. 3), which deflates the correlation. Second, for each PATTI© item, the self-report options were “fail” and “pass”, and in hindsight, this might have stimulated them to score “pass” more often. Third, the difference in scores by the assessors and the self-assessments may be explained by the fact that the self-assessment was carried out by a small group of nurses with little to no experience in using the PATTI©. In follow-up studies, we should use the same response categories for both the observers and the self-report options to improve the correlation. Another option to test criterion validity is to ask an independent expert panel to judge the videos and give an expert opinion that could be compared with the PATTI© total score.

The literature describes several assessment tools for teamwork skills.[34] Most of them focus on physicians, not on nurses or other healthcare professionals.[34,54,55] In the study by Carr et al.,[56] junior doctors were assessed not only on teamwork skills but also on general clinical management skills. Pugh et al.[57] studied internal medicine residents and assessed critical team errors, individual team member contributions, task performance, and overall team performance. In a study on nurses' and respiratory therapists' APLS skills, the teamwork skills were not assessed.[58,59] The lack of assessment tools for our Dutch PICU context necessitated

Table 2
Inter-rater reliability coefficients between individual and consensus scores between pairs of assessors.

Phase	1	2	3	4
Comparison	Individual scores	Consensus scores between pairs of assessors	Consensus scores between pairs of assessors	Individual scores
Scenario	32 pilot life	Four videotaped	48 real-life	136 real-life
ICC sum score, total	0.87	0.78	0.79	0.88
ICC sum score, subscale A	0.80	0.75	0.66	0.82
ICC sum score, subscale B	0.80	0.65	0.82	0.84
ICC sum score, subscale C	0.63	0.55	0.65	0.78
Percentage agreement: subscale D	69%	NA	85.4%	96.6%
Cronbach's alpha, total scale	0.83	NA	0.85	0.82

NA = not applicable, ICC = intraclass correlation coefficient, using the two-way mixed model, type absolute agreement and single measures.
Subscale A: six items; subscale B: three items; subscale C: two items; subscale D: one item; total scale: 12 items.

developing the PATTI©. Our assessment tool expands on this work as it focuses on leadership, communication, and other teamwork skills as well as on technical skills.

The use of the PATTI© enables professionals to identify shortcomings in specific areas. For example, a nurse who has good technical skills may not think aloud and instruct others and might score less well on the teamwork item "Has situational awareness on process and product and evaluates joint actions". In addition, self-assessment of nurses' competencies can raise awareness of individual educational gaps and address teamwork skills as in the aforementioned example.[60] Item-level feedback such as "checks whether the tasks have been performed" will encourage nurses to create better closed loop communication. Thus, team situational awareness may improve and lead to better performance in resuscitation events and promote better patient outcome.[6] Obtaining evidence of improved patient outcomes after resuscitation will be difficult: (i) owing to the low incidence of resuscitation events in the PICU and (ii) because of the many confounding factors influencing outcomes of PICU patients such as, for example, illness severity, underlying disorders, and age range.

A strength of our measurement property study is that many end users were involved in developing and testing of the tool. The ICC above the threshold of 0.7 shows we effectively reduced the interpretive bias by thoroughly practicing and discussing rater outcomes via pilot sessions. For example, when a nurse fails to take the lead in the simulation setting as required, and the assessor knows he/she does that very well in real situations, the assessor may be inclined to consider this. The potential bias caused by the assessors knowing most of the participants was resolved by instructing the assessors to base their scores only on the observed behaviour. The simulation training scenarios were standardised so that results could be compared, especially over time.

Several limitations of this study should be addressed. First, the PATTI© was developed in a high-quality simulation setting, but not yet applied in clinical practice. Live resuscitations are more chaotic, with many healthcare professionals attending, and can provide many learning opportunities. Thus, it would be of great didactic value to film such a live resuscitation and have "the first responsible nurse" afterwards assessed by trained assessors using the PATTI©. Second, this was a single-centre study, and it would add value to test this tool in other centers/units as that would increase the tool's generalisability. Third, the PATTI© has been tested only for the PICU environment, and its usability in other critical care areas cannot be determined. Another issue is the time-consuming, iterative approach that was used in the development process of the PATTI©. As the assessments were executed by coworkers of the nurses, this necessitated time and effort put in achieving the highest possible inter-rater reliability. But, although scenario training and skill assessments are time-consuming, they provide an opportunity to increase healthcare professionals' confidence in their skills and therefore better teamwork, which may lead to improved patient outcomes.[61]

4.1. Future perspectives

We have started to use the PATTI© before and after a training program for PICU nurses to assess their teamwork and resuscitation skills. Comparison of the outcomes before and after the program will provide evidence of the responsiveness of the scale and will be published at a later stage. Next, intensive care physicians will be assessed on their technical and teamwork skills. We set up a training program to improve their resuscitation skills and will use the PATTI© to evaluate the progress of individual candidates. It will be interesting to explore if our educational program not only improves resuscitation skills but can also enhance nurses' confidence. However, increased confidence may be hard to assess. The self-assessment with the PATTI© for "the first responsible nurse" should have the same response categories as the PATTI© for educators, and the correlation should be tested again to determine if the correlation will improve. As the PATTI© has been developed based on international guidelines on technical and nontechnical skills, it will be interesting to test the generalisability internationally.

5. Conclusion

These are the first findings on the psychometric properties of the PATTI©. The results of this study on reliability and validity are a starting point for more research on this topic. Educators and managers can use the PATTI© to assess PICU nurses' technical and nontechnical skills and if needed can provide additional training. The discrepancy between the self-assessments of nurses and the assessor's assessments can provide a starting point for a discussion on how to better train and assess resuscitation and teamwork skills. By synchronising the scoring options for self-assessment with those for the raters' assessment, better reflection on the individual nurses' skills can be facilitated, thus increasing the potential for learning in technical and nontechnical skills.

CRediT authorship contribution statement

Ada van den Bos-Boon: Supervision, Conceptualisation, Data curation, Investigation, Methodology, Project administration, Resources, Roles / Writing – original draft, Writing – review & editing. **Monique van Dijk:** Formal analysis, Methodology, Writing – review & editing. **Jan Adema:** Process evaluation, review & editing. **Saskia Gischler:** Conceptualisation, Investigation, Resources, Writing – review & editing. **Cynthia van der Starre:** Supervision, Conceptualisation, Investigation, Resources, Writing – review & editing.

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