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Contents lists available at ScienceDirect

Journal of Pediatric Nursing

journal homepage: www.pediatricnursing.org

Effectiveness of simulation training and assessment of PICU nurses' resuscitation skills: A mixed methods study from the Netherlands

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ARTICLE INFO

Article history:

Received 12 June 2020

Revised 29 January 2021

Accepted 29 January 2021

Available online xxxxx

Keywords:

Teamwork

Resuscitation

Nurses

Skills assessment

Pediatric intensive care

ABSTRACT

Purpose: The quality of resuscitation and effective leadership are decisive for the outcome of a resuscitation. Nurses are usually the first responders upon cardiac arrest. Therefore, we started the "proficiency check" project, which aims to improve nurses' resuscitation and teamwork skills. This article describes the effectiveness of the proficiency check and nurses' experiences with it.

Design and methods: This study was done among intensive care nurses working on a pediatric ICU (PICU) in the Netherlands. It was designed as a mixed-methods study combining a quantitative and a qualitative approach. Quantitative data were obtained through a pre-posttest comparison of nurses' resuscitation and teamwork skills, in a simulation setting. Qualitative data on nurses' experiences were collected through semi-structured individual interviews.

Results: Both resuscitation and teamwork skills improved significantly. In 39 nurses (32%), the improvement of both resuscitation and teamwork skills after the intervention was large (effect size >0.8). The experiences of nurses regarding the proficiency check were diverse: on the positive side, increased knowledge and confidence were reported, whereas negative experiences related, among other things, to stress and anxiety.

Conclusions: Resuscitation and teamwork skills of PICU nurses can be enhanced by the 'proficiency check' studied here. This simulation-based training can be further improved by incorporating the nurses' experiences.

Practice implications: A simulation-based assessment for resuscitation may play an important role in a PICU, and possibly for other skills and in other settings as well. Particular attention should be paid to the stress that many nurses experience due to skills assessment.

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Purpose

In healthcare, a considerable proportion of incidents, reportedly 22%–36%, are related to teamwork failures and communication breakdowns (Manser, 2009; Morey et al., 2002). An important reason may be that traditional classroom education of healthcare professionals pays little attention to teamwork. One of the changes proposed by Leape to achieve a culture of safety is a shift from reliance on independent, individual performance excellence to interdependent, collaborative, interprofessional teamwork (Leape, 2009). One way to achieve effective teamwork is crew resource management (CRM) training, which aims to prevent errors related to teamwork skills such as leadership, decision-making and communication skills (Haerkens et al., 2015;

Haerkens et al., 2012; Patterson et al., 2013). An important component of CRM is simulation based training (SBT), which is a tool to practice skills in a realistic and safe environment (Boet et al., 2014). It allows for training and assessing both teamwork skills and technical skills.

In the PICU setting, resuscitation after cardiac arrest is a typical domain in which not only teamwork, but also the leadership role is essential. Having someone take the lead is crucial, as time elapsed after the "no-signs-of-life" assessment is an important contributing factor to the patient's outcome (Meaney et al., 2013). The first responder in the PICU is most often the nurse, who is expected to take the team leadership role. However, nurses generally have not been trained to take this role and may lack confidence and be afraid to harm the patient (Coady, 1999; Heng et al., 2011). Another factor contributing to outcome is the quality of the resuscitation skills. However, research into the quality of resuscitation skills is scarce, because it is difficult to measure quality in an acute situation. Current research is mainly focused on

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patient outcomes. For example, Van Zelle and colleagues described children's long-term health status and health-related quality of life after cardiac arrest, but did not take into account the quality of the resuscitation (van Zelle et al., 2015).

Nurses working on the PICU of Erasmus MC-Sophia Children's Hospital are being trained in advanced pediatric life support skills (APLS) and in CRM, including SBT. This encompasses the training of teamwork skills, such as, leadership, communication, decision-making, and team situational awareness. However, the effectiveness of this training has never been evaluated. This evaluation is necessary to measure whether the quality of the resuscitation is improved. Moreover, little is known about nurses' experiences with SBT for resuscitation. This is an important knowledge gap, because experiences and emotions influence the way in which clinical information is perceived and interpreted during a critical situation. Therefore, experiences can have an impact on the effectiveness of SBT (McConnell & Eva, 2012). Thus, insight in the effectiveness of SBT and experiences of nurses during the learning process of SBT is highly valuable. Such insight can help to improve SBT, which in turn may take away obstacles for nurses to initiate resuscitation, as was documented by a study of Murphy (Murphy et al., 2016). Eventually, resuscitation outcomes and patient safety on the PICU may be improved.

In the present study, we aimed to evaluate the effectiveness of the so-called proficiency check, which is a SBT aimed at improving nurses' resuscitation and teamwork skills. Furthermore, we aimed to gain insight into the experiences of nurses during the proficiency check. We hypothesized that application of the proficiency check results in improved resuscitation skills and that nurses react positively to the proficiency check.

Methods

Study design

This was a mixed methods evaluation study, combining a quantitative and a qualitative approach. Quantitative data were obtained through assessment of nurses' resuscitation and teamwork skills in a simulation setting before and after application of the proficiency check, using the newly developed and validated instrument named the Professional Assessment Tool for Team Improvement (PATTI©; see further below). Qualitative data were obtained through semi-structured individual interviews with selected nurses.

Setting and participants

The setting of this study was the 28-beds level 3–4 PICU at the Erasmus MC-Sophia Children's Hospital in Rotterdam, the Netherlands, which admits children between 0 and 18 years treated for, among other things, congenital anomalies, trauma, and neonatal, cardiac and craniofacial surgery. The PICU is staffed by 125 PICU nurses, 12 pediatric intensivists, and 6 fellows. Each year about 40 to 50 resuscitations are performed. The quantitative part of the study included 61 of the 71 nurses who had voluntarily participated in the validation study of the PATTI© (Fig. 1). For the qualitative part of the study, nineteen nurses were interviewed. For this part of the study, inclusion criteria were participation in the proficiency check program and availability during dayshifts.

A project team was formed consisting of simulation trainers (doctors $n = 5$ and nurses $n = 5$), a methodologist, a nurse manager specialized in nurses' training, a management assistant, and a planner (to schedule the training and assessment sessions). This team was responsible for the development, evaluation and assessment of the "Proficiency Check". Only the simulation trainers were trained in using the PATTI©.

Ethical considerations

For this study permission was requested from the Medical Ethics Review Committee of our institution. The committee concluded that the investigation was not subject to the Dutch Medical Research Involving Human Subjects Act (WMO) so further review was waived.

Intervention: "the proficiency check"

The proficiency check is based on Miller's pyramid of competence (Miller, 1990) (Fig. 2). The first layer represents cognition; the second layer technical skills; the third layer attitudes or teamwork skills; and the fourth layer performance at the workplace.

The proficiency check encompasses three phases.

Phase 1: E-learning module and online theoretical assessment of APLS skills. The subject must pass this phase before proceeding to phase 2.

Phase 2: APLS skills assessment in practice: nurses individually demonstrate their technical APLS skills on a manikin. The nurse must pass this phase before proceeding to phase 3.

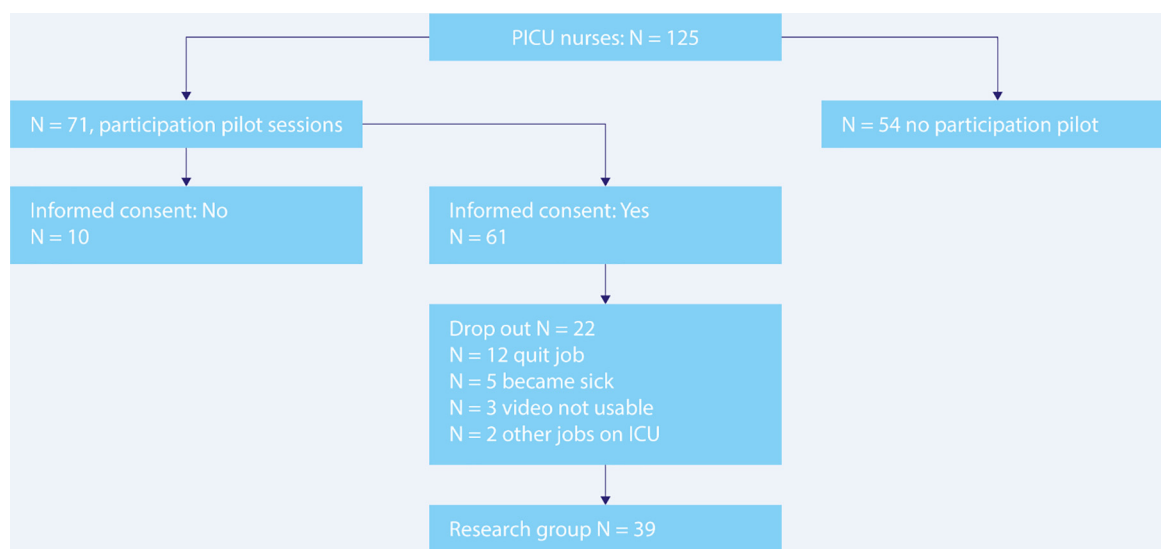


Fig. 1. Flowchart of participants selection and drop out.

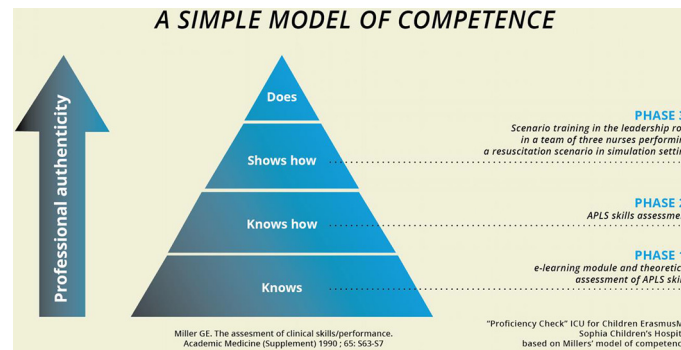


Fig. 2. Theoretical framework proficiency check based on Millers Model: Left side Millers model of competence / right side phases of the “Proficiency Check” integrated in Millers model.

Phase 3: SBT which encompasses scenario training in which one of a team of three nurses – the first responsible nurse – takes the leadership role and secures the quality of the resuscitation. The skills, both technical and non-technical, of this nurse are assessed with the PATTI©.

The proficiency check may be considered a combination of formative and summative evaluation, as it both aims to monitor nurses' learning (to provide ongoing feedback and to improve their learning) and to assess nurses' learning after completing the proficiency check. To give them the opportunity to learn and improve, the nurses were provided feedback both in phase 2 and phase 3.

Implementation of the intervention

To implement the proficiency check, a comprehensive, structured implementation strategy was used, which may briefly be described as follows.

The first phase of the proficiency check (E-learning module and on-line assessment) could be planned and managed by the nurses themselves. The second phase was already embedded in the training program of the PICU. Therefore, these two phases were rather easy to implement. The third phase of the proficiency check was the most challenging part because of the manpower needed to train and assess the PICU nurses. To ensure the effective implementation of the intervention, pilot sessions were run. These pilot sessions were videotaped. Using the Plan Do Study Act (PDSA) principle, several actions could be taken prior to and during the intervention, referring to: barriers and facilitators, the

logistics around the simulation (i.e., manageability, planning of the nurses, assessors, reservation of simulation rooms and assessment materials), the materials in the scenario, the time frame, preparation beforehand, and completeness and reliability of data (see appendix A).

Data collection and outcome assessment

Given the heterogeneity of healthcare teams, assessment instruments should be tailored to specific healthcare teams (Havyer et al., 2014). As an existing assessment tool fulfilling our requirements was not available, we set out to develop a valid and reliable tool to assess the nurses' resuscitation and teamwork skills. This resulted in the Professional Assessment Tool for Team Improvement (PATTI©). It encompasses 12 items divided into four categories: Team role, 6 items; Teamwork and communication, 3 items; Technical skills, 2 items; and Reporting, 1 item. The response categories range from 1 (very poor performance) to 4 (very good performance) (See Table 1). Because scores were based on videotaped scenarios, the last item of the PATTI© about reporting after the resuscitation outside the room could not be included in the study. In a later phase we asked the participants to report inside the room, so we could also record this item.

The PATTI© was applied before and after the intervention, from December 2014 till September 2017. The before measurement was rated by two assessors using the videotaped pilot sessions, after inter rater agreement was sufficient. The after measurement was done after nurses completed the three phases of the proficiency check. Nurses worked

Table 1 Professional Assessment Tool for Team Improvement score sheet.

Professional Assessment Tool for Team Improvement (PATTI©)		Scenario type: Ventricle Fibrillation/Asystole (delete if not applicable)				Date:
Candidate:						Date:
Assessor 1: (the one filling out the form)		Assessor 2:				Result:
		1	2	3	4	Notes
a. Role in the team						
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. Collaboration and communication						
7. Has helicopter view on process and product and evaluates joint actions						
8. Acts pro-actively in bringing in expertise and shows assertive behavior						
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)						

Legend: Subscale A: 6 items; Subscale B: 3 items; Subscale C: 2 items; Subscale D: 1 items; Total scale: 12 items.

through the scenario of phase 3 of the proficiency check in teams of three. They took turns in having the role of first nurse and, as such, were assessed successively. During both the before and after measurement, one of two scenarios were assessed: a child with ventricular fibrillation or a child with an asystole. The nurses knew both scenarios and could also prepare themselves with the PATTI© for the teamwork skills. Both during the before and after measurement, nurses were briefed about the child before the start of the scenario and debriefed afterwards. Two assessors rated the nurses on all items. These were doctors and nurses of the project team (so, colleagues of the nurses who were being assessed). The sum of all items resulted in the total score (ranging from 11 to 44). Depending on this score, the nurses could receive an advice for study or could be required to follow a training. The nurses themselves were responsible for working on the areas for improvement and discuss with their manager what they need to improve. We also asked nurses to rate themselves on the 12 items of the PATTI© – but with only two response categories: sufficient (score = 1) or insufficient (score = 0). Accordingly, the total self-assessment score ranged from 0 to 12.

Prior to the study, the PATTI© was validated. This was done in collaboration with the Dutch Institute for Educational Measurement (CITO). Content validity was established in 62 pilot sessions. The interrater reliability between assessors varied from an intraclass correlation coefficient of 0.78 to 0.87. Furthermore, the use of the PATTI© proved feasible; the assessment time could be shortened from 120 min to 60 min for three consecutive simulation sessions. Further details about the validity and feasibility of the PATTI© will be published separately.

The semi-structured, individual interviews were held by the second author, who was not in a working relationship (hierarchical or otherwise) with the interviewees, in March and April 2018. During the interviews, 'what' and 'how' questions were used to obtain data. According to Pope et al., this design is appropriate when the aim is to explore experiences and attitudes of individuals (Pope et al., 2002). The interviews were guided by a topic list (see Appendix B) to cover all important subjects during the interview (Mason, 2002). The topic list was based on conversations with experts on patient safety on a PICU, conversations with the developers of the proficiency check, and literature. It was slightly adapted after the first three interviews, based on information obtained from participants. Individual face-to-face interviews lasted approximately 20 min and were conducted in a quiet room during nurses' working hours.

Statistical analysis

Sample size calculation

An earlier study of Kurosawa (Kurosawa et al., 2014) showed a large effect of the training on APLS skills (that is, an effect size of 1.5). To be on the conservative side, the sample size calculation was based on a moderate effect size of 0.50. Using an alpha level of 0.05 and a power of 0.80, this resulted in a required sample size for a paired *t*-test of 34.

Effect evaluation

Data of the pre-and post-measurement were entered into IBM SPSS 24.0 and stored in a secured database.

Table 2

Mean (SD) on all subscales and total PATTI© score.

Subscale	Score range	Before <i>N</i> = 39 Total score (SD)	After <i>N</i> = 39 Total score (SD)	Effect size
A: Role in the team	6–24	18.1 (1.7)	21.0 (1.7)	1.7
B: Collaboration and Communication	3–12	7 (1.5)	10 (1.1)	2.3
C: Technical skills	2–8	4.5 (0.8)	6.6 (0.8)	2.6
Total score	11–44	32.8(3.4)	41.4(3.1)	2.6

Pre- and post-intervention subscales and total PATTI© scores were assessed using the absolute standardized mean difference (Cohen's *d*) and compared with a paired sample *t*-test. A Cohen's *d* of 0.20 represents a small effect; a value of 0.50 a moderate effect; and a value of 0.80 and higher a large effect (Cohen, 1988). A *p*-value < 0.05 was considered statistically significant. Furthermore, for each PATTI© item, the percentage passed was calculated as items scored 3 or 4.

Qualitative data analysis

Interviews were digitally recorded – with consent from the participant – and transcribed verbatim. One participant did not give consent to record the interview. During this interview, notes were made instead and used for the analysis. The interview data were subjected to inductive qualitative content analysis (Elo & Kyngas, 2008; Kolb, 1984). This method was considered appropriate for this study, considering the lack of qualitative data into this subject. Moreover, this method is often used in analyzing multifaceted and sensitive data from nurses (Elo & Kyngas, 2008). Data were analyzed through three phases: preparation, organizing and reporting phase. In the preparation phase, the unit of analysis was determined. In this study, this were 19 transcripts of interviews. Sub categories were derived from the transcripts using open coding in the organizing phase. Phrases from the interviews were assigned a code. A code represented a sub category and phrases from all interviews representing the same sub category were given the same code. The open coding process was repeated to make sure all data was correctly analyzed. Then, similar sub categories were merged into larger categories. Lastly, in the reporting phase, findings were reported by giving an overview of the different categories. As a result, five different themes emerged from the data (Elo & Kyngas, 2008).

Results

Quantitative analysis

Thirty-nine of the 61 nurses who had provided informed consent to use their simulation video sessions in the current study completed a pre- and post-measurement. The flowchart gives the reasons for drop-out of the other 22 nurses (Fig. 1). The mean age of these 39 nurses was 42 (SD 9.2), the vast majority (*n* = 37) were female.

Table 2 presents the mean (SD) subscale scores and the total PATTI© score. All scores statistically significantly improved between the pre- and post-measurement (paired *t*-test, *p* < 0.001), with effect sizes ranging from 1.7 to 2.6.

Fig. 3 presents the items of the PATTI© and the percentage of nurses that passed for each item before and after "the proficiency check". All items on the subscales improved apart from two that already scored 100% before the intervention. The score of reporting after the resuscitation outside the room (item 12) was not based on the videotaped scenario, but considering the sufficient reporting of all nurses, everyone scored "passed". Two items improved most prominently; item 7: "Checks whether the tasks have been performed" from 7.7% to 79.5% and item 10: "Follows the right protocol and executes it correctly based on readings of vital parameters" from 20.5% to 94.9%.

The 39 participating nurses also assessed themselves. Due to the gradual implementation of the PATTI© over time, only eleven nurses

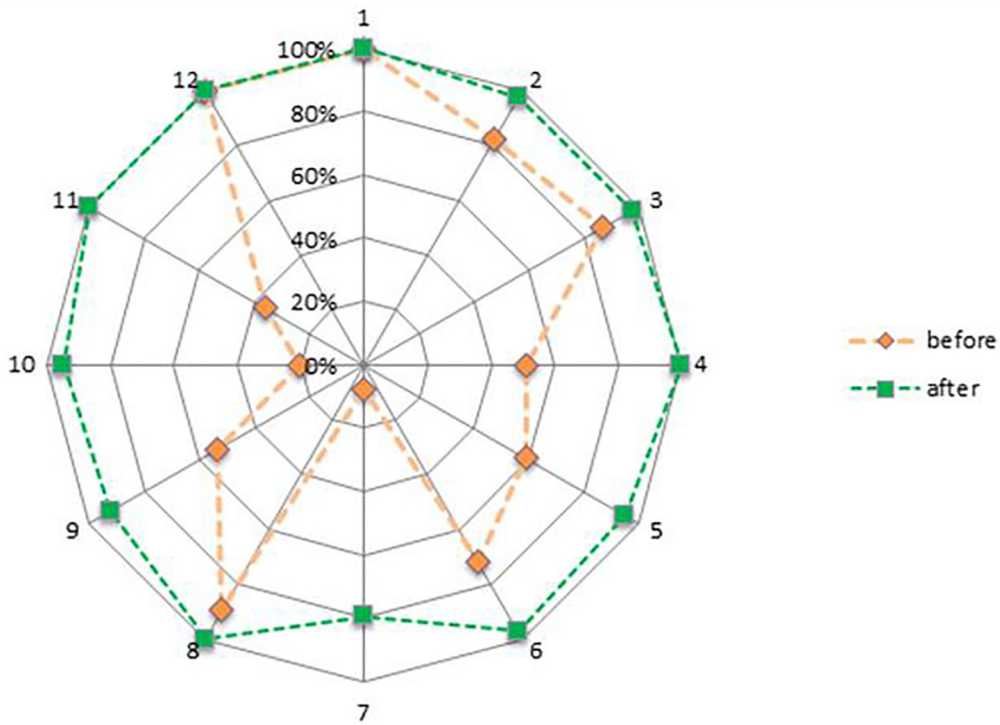


Fig. 3. Pre- and post item scores, numbers related to the items of the PATTI©, see Table 1.

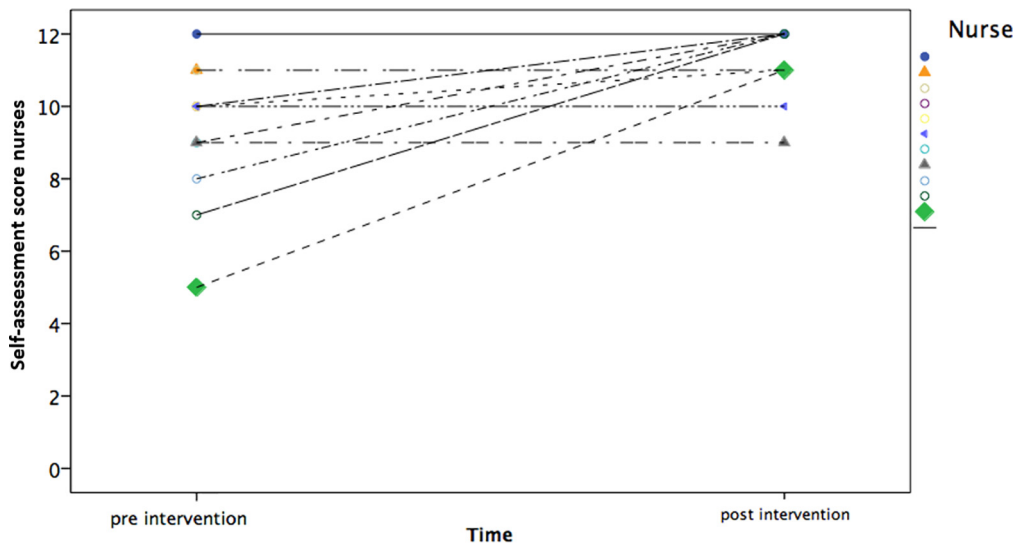


Fig. 4. Nurses' self-assessment scores.

provided both a pre and post self-assessment score. Seven nurses found themselves improved, ranging from 0 to 5 points improvement, while 4 nurses scored the same (Fig. 4).

Qualitative

The nurses who participated in the interviews were predominantly female (89%), with an average age of 49 years. All participants were specialized as pediatric ICU nurse. On average, participants had 29 years (range 11–39) of experience as a nurse. The majority of participants had performed 6 to 19 resuscitations in their career as a nurse.

The following themes emerged from the interviews: (1) usefulness of the proficiency check to improve quality of resuscitation;

(2) emotional experience of undergoing the proficiency check; (3) effectiveness of assessing resuscitation skills, (4) self-reported improvement in resuscitation and teamwork skills; and (5) self-confidence of nurses after the proficiency check. The main results are presented below.

Usefulness of the proficiency check to improve resuscitation

All nurses found a program to improve resuscitation skills useful. They mentioned that they do not often perform resuscitation and that it is important to keep skills up to date.

“But resuscitation (...), if I have performed it four times in the past twenty years, it would be a lot.”

[(Interview 12)]

Emotional experience of undergoing the proficiency check

The reported general emotions about the proficiency check were stress, anxiety and nervousness. All nurses felt some anxiety and were nervous before the proficiency check. Eight out of the 19 nurses described their nervousness as unhealthy: sleepless nights, headaches and two weeks of stress before the proficiency check.

"I was nervous beforehand, but when the moment [of the proficiency check] came, I really had the feeling I could pass out on the spot! That was how nervous I felt."

[(Interview 15)]

Other nurses reported positive feelings after completing the proficiency check. They experienced some nerves but had positive feelings after completing the proficiency check.

"No I did not dread it, but I am not easily shaken. I told my colleagues, like what can happen, when you fail? You get fired? I don't think so, as long as I'm not fired, I'm fine."

[(Interview 13)]

The stress and nervousness experienced before the proficiency check were mainly due to the realization that people would be watching and assessing their skills. Other triggers mentioned were the feeling of doing an examination, insecurity during an examination and fear of failure. Moreover, the simulation setting was experienced as stressful and intense.

"You are pushed in a simulation box with a headset on your face, like a workout class at the gym. You are aware of everything being filmed, people are watching you while you do your thing. I do not like it."

[(Interview 11)]

Effectiveness of assessing resuscitation skills

Twelve out of the 19 nurses found the resuscitation skills assessment effective in improving these skills. However, the majority of the 12 nurses were not happy with the procedure because the skills assessment predominated over the possibility to improve resuscitation skills.

"I think, you have to train people and not assess people. If you include an assessment in a training, you do not have to emphasize this. You should not put that much pressure on the assessment."

[(Interview 14)]

Seven of the 19 nurses found the skills assessment unnecessary – and too stressful – and would like to focus more on only training resuscitation skills.

"Just practicing, without an assessment, pass, fail. And people who fail are upset for three weeks. That is too big of a negative impact. (...) If you practice regularly and repeat, it will have just as much of an effect."

[(Interview 16)]

Nevertheless, other nurses were more positive and recognized the importance of an assessment to master a crucial skill like resuscitation.

"You know, you do not have to get rid of the assessment completely, because I think that you have to master certain skills."

[(Interview 12)]

The learning process of nurses was sometimes hindered by the skills assessment and resulting negative emotions. Half of the nurses claimed that they learned more from the training ahead of the proficiency check than from the proficiency check itself.

"I do not see the advantage in assessing skills, since it is such a pressured situation which leads to the loss of the learning element, in my opinion."

[(Interview 17)]

Self-reported improvement in resuscitation and teamwork skills

Seventeen of the 19 nurses reported improvement in their technical skills; more up-to-date knowledge about medication and technical skills like compressions. They also felt more knowledgeable about the resuscitation procedures and highlighted the importance of refreshing their knowledge. This also held true for those who were more negative towards the skills assessment during the proficiency check.

"It [technical skills] is in your system now, and it is good to refresh knowledge. What I learned from it is that when something like that happens now, it is fresh in my memory, like I am going to start to induce adrenaline."

[(Interview 11)]

Half of the nurses reported improvements in their communication skills, such as smoother communication.

"Regarding communication skills, you are becoming more aware. You name people by their first name and indicating what you are doing. (...) I think it is good that it is trained."

[(Interview 16)]

In contrast, the others claimed no change in communication skills and not having learned new communication skills. They stated that communication was already very good due to the yearly CRM training. Less than half of the nurses saw improvement in teamwork after the proficiency check. Again, a lot of nurses mentioned that teamwork was already good, due to the yearly CRM training. Improvements in leadership skills were rarely reported; leadership is rather seen as a physician's job.

Self-confidence of nurses after the proficiency check

Self-confidence about their resuscitation skills increased in the majority of nurses, even though the proficiency check was not always considered the perfect method. Confidence increased due to the proficiency check, but also as a result of practice beforehand.

"Well, I felt safer because you had the feeling that you know things better. Yes, you know what to do, but also that you feel a little safer."

[(Interview 16)]

The proficiency check increased nurses' confidence and decreased dependency on the physician. In turn, this empowered nurses to initiate resuscitation immediately after a child's collapse. The majority of nurses thought that time to initiation of resuscitation has decreased.

"Well, because you are overruled by physicians. This is what happened. I would start when something happens, but there are also people who are looking at the situation before they will start. And they will make a call and do not start resuscitation until the physician arrives, and that happened a couple of times. That is a shame. If that continues for three minutes for example. I think this improved and now you are seen as a team member by physicians. There is a strong hierarchy between physicians and nurses which can get in the way of things like this. However, within resuscitation, this has improved [after the proficiency check]."

[(Interview 5)]

Discussion

This study examined the effectiveness of "the Proficiency check", which aimed to improve PICU nurses' resuscitation and teamwork skills, and explored the nurses' experiences with it. Assessment with the PATTI© tool showed improvement in the resuscitation and teamwork skills of all nurses after the proficiency check – notably communication, collaboration and technical skills. These quantitative results were, in a way, confirmed by the qualitative data: the nurses generally felt more

confident to start a resuscitation and felt they had improved their resuscitation skills. We were surprised to find that most nurses beforehand were very anxious about the assessment; some even reported sleep problems and 'unhealthy' stress. Apparently, anxiety and stress due to the assessment could not be taken away by low-threshold practicing and tailor-made coaching, which the nurses were offered when needed. The simulation room and patient simulation during SBT were labeled as realistic but were experienced as intense and stressful by some nurses.

The largest improvements as measured by the PATTI© instrument concerned the subscales teamwork and communication and technical skills. Less improvement was found for team role, which may be explained by the relatively high pre-intervention score possibly as a result of frequent CRM training. This is supported by a study of Costello et al. In this study, healthcare profession students after interprofessional team simulation had increased awareness of professionals' roles and felt more confident during resuscitation, which may improve patient outcomes (Costello et al., 2018). Although this study was done in a different setting, we could compare healthcare profession students and the nurses in this study, as they both were participating in a learning experience.

The improvements in teamwork and communication may be due to the fact that in the scenario training nurses have to show leadership in the scenario. Gilligan et al. supports the notion that nurses can show good team leadership in a resuscitation scenario setting, but must be supported on how to lead a team (Gilligan et al., 2005).

Nurses indicated during interviews that their technical resuscitation skills improved, rather than teamwork skills such as communication. Communication skills were already felt to be good due to the annual CRM training sessions. Still, the quantitative data show great improvements in communication skills. This discrepancy might be explained by the different types of communication addressed in the quantitative and the qualitative parts of the study. During the interviews, the nurses possibly referred to closed loop communication, since this is the type of communication addressed in the CRM training. The proficiency check, however, dealt with leadership communication; for example summarizing what is said during resuscitation and empowering the team to create situational awareness. The type of communication the nurses talked about is incorporated in the team role, like 'checking medication' and 'gives clear commands'.

The improvements on the subscales teamwork and communication and technical skills can be explained by the low pre-intervention scores due to the fact that PICU nurses were not used to taking the lead during resuscitation. The interviews support this suggestion. Nurses stated that after a child's cardiac arrest, the physician is always present within a short period of time. The physician, then, is to be in charge and attending nurses follow the physician's orders, which is related to traditional physician-nurse hierarchy. This is confirmed by a study which holds the idea that nurses have a supportive role during resuscitation (Meaney et al., 2013). However, Heng et al., 2011 have proposed that nurses, physicians and managers should realize that nurse-led resuscitation will lead to improved patient outcomes, as it can decrease the time interval between the child's collapse and the start of resuscitation. This is confirmed by Gilligan et al., who found that ALS trained nurses perform as good as ALS trained junior physicians do in resuscitation (Gilligan et al., 2005). Thus, the leadership role can easily be performed by other healthcare professionals as long as they are well trained. Keogh et al. suggest another approach to change the nurse's role from supportive to leading; nurses may also benefit from awareness of different behavioral leadership styles (Keogh et al., 2019). This will help them to increase self-esteem and to identify individual nurses' skills, which in turn can increase quality of resuscitation.

A strength of this study is the use of standardized scenarios and a reliable, validated measurement tool to measure the pre- to post-intervention change in resuscitation skills. Furthermore, the nurses'

experiences were adequately studied through the semi-structured interviews exploring individual opinions and experiences. Moreover, a rigorous qualitative data analysis technique, appropriate for the study setting, was applied, and the number of participants (19) was high compared to other qualitative studies in this field.

Practice implications

A simulation-based assessment for resuscitation may play an important role in a PICU. Although this was a single-center study done in one PICU in the Netherlands, we feel that in other settings – in the Netherlands and abroad – trainings comparable to our "Proficiency check" may be expected to lead to similar improvements in quality of care regarding resuscitations (or even other areas) as well. After all, in these settings, nurses also carry out patient-related procedures (related or unrelated to resuscitation) that they do not often perform, showing the potential benefits of training and assessments. However, no firm conclusions can be drawn about the generalizability of our results to other settings, which may be limited due to, among other things, selection bias (see further below). Furthermore, this study implies that particular attention should be paid to the stress that many nurses experience due to skills assessment. Another consideration should be how to support nurses to take up the leadership role, as this may further contribute to higher quality of resuscitations.

The following directions for future research may be suggested. First, this study did not measure the effect on patient outcomes related to the proficiency check. Although it is difficult to measure this effect, due to many confounding factors, such as improved possibilities to treat patients, more complex diseases, and a changing environment, it would be useful to know whether improved resuscitation skills actually result in better patient outcomes.

Second, the fact that the interviewed nurses had mixed feelings about the necessity of skills assessment may be an argument to abolish it and rather focus on practicing resuscitation skills. Nevertheless, Mahajan and co-workers recommended that training and assessment should be mandatory in a postgraduate program to support lifelong learning and to give insight in performance gaps (Mahajan et al., 2017). We support the idea that skills assessments should not be left out in a training intervention like ours. Further research is necessary to understand whether nurses experience less stress and negative emotions when they are more used to these assessments. Although stress related to assessments may be unavoidable to some extent, it may be recommended, when proficiency checks or similar trainings are held in the future, to inform nurses more extensively about the assessment part and to explain that no consequences are attached to poor performance on it.

Limitations

The following limitations may have introduced bias into the results of the quantitative part of the study. First, the results are susceptible to the Hawthorne effect, which implies that professionals are more motivated to do well when they know they are being observed (McCambridge et al., 2014). Second, the results could have been influenced by the fact that most nurses practiced the scenarios during the course of this project, of which the frequency was not registered, but differed per person. The fact that nurses knew which scenarios were used during the proficiency check was not considered as a limitation. The goal of "the Proficiency check" is improvement of quality of resuscitation. Preparation and knowing which scenarios may have contributed to improved quality of resuscitation, but did not bias it, because the scenarios are recognized earlier in real work practice and dealt with more quickly and thus better for patient safety. Ultimately, the point is that this is a quality improvement in the recognition of an acute situation

where leadership, teamwork is required and with the proficiency check trained and assessed. Third, selection bias is possible: the nurses who participated in this study were volunteering, and these may either be the nurses who already feel confident in resuscitation events or those who know they have knowledge gaps to overcome. The reasons for nurses to participate or not were not registered in this study, so we cannot be sure about the degree of bias.

Fourth, this study was done in a simulation setting, whereas in clinical practice the situation is probably more chaotic, with many healthcare professionals attending and every acute situation being unique. It is hard to tell whether in a real-life setting similar improvements in resuscitation skills and teamwork skills would have been found. In the future, it would be worthwhile to evaluate real-life resuscitations through debriefings using the PATTI© as a checklist.

Regarding the qualitative part of the study, it may be considered a limitation that the interviews were conducted by one and the same researcher, as was the data analysis. Participants for the interviews were selected on the basis of their availability during day shifts. Selective non-response may have occurred, because nurses with negative attitudes towards the proficiency check might be less interested in an interview. On the other hand, nurses with negative attitudes towards the proficiency check might be more willing to be interviewed since they want their opinion to be heard.

Conclusion

This study shows encouraging improvement of nurses' resuscitation- and teamwork skills in a simulation setting following a proficiency check for resuscitation. We may not automatically assume that this effect can be translated to the real-life setting, and this should be explored in future research. The participating nurses saw the benefit of the proficiency check, acknowledging the relative rareness of cardiac arrest on a PICU. Nonetheless, experiences with the proficiency check were both negative and positive. Negative emotions of nurses included stress, anxiety, nerves, fear of failure and insecurity during the proficiency check. On the contrary, increased knowledge regarding resuscitation, improved resuscitation skills and improved confidence regarding resuscitation skills contributed to the positive experiences of nurses.

CRediT authorship contribution statement

Ada van den Bos-Boon: Supervision, Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Writing - original draft, Writing - review & editing. **Susan Hekman:** Supervision, Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing - original draft, Writing - review & editing. **Robert-Jan Houmes:** Conceptualization, Resources, Writing - review & editing. **R.N. Lilian Vloet:** Investigation, Methodology, Writing - review & editing. **Saskia Gischler:** Investigation, Resources, Writing - review & editing. **Cynthia van der Starre:** Conceptualization, Resources, Writing - review & editing. **Monique van Dijk:** Formal analysis, Methodology, Writing - review & editing. **Marten J. Poley:** Conceptualization, Supervision, Writing - review & editing.

Acknowledgments

Thanks to the project team and all the nurses who gave permission to use their data for the study and thus made it possible to do research on this topic.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial or non-profit sectors.

Declaration of Competing Interest

None of the authors has any conflict of interest to disclose. No external funding has been received.

All authors have approved the manuscript and agree with its submission to the Journal of Pediatric Nursing.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pedn.2021.01.029>.

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