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SERVICE EVALUATION

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Quality improvement intervention to stimulate early mobilization of critically ill children

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Abstract

Background: Immobility during hospital stay is associated with muscle weakness, delirium, and delayed neurocognitive recovery. Early mobilization of critically ill adults improves their physical functioning and shortens the duration of mechanical ventilation. However, comparable research in children is lacking.

Aims: To determine the effects of the implementation of an early mobilization (EM) program on mobility activities for critically ill children and to explore barriers and facilitators and clinical outcomes before and after implementation.

Study design: A prospective single-centre before-and-after study.

Methods: This study was conducted in a PICU of a large tertiary hospital. Children aged from 3 months to 18 years, with an expected stay of ≥3 days were eligible to participate. In the "before" phase, participants received usual care; in the "after" phase we implemented a multicomponent, multidisciplinary EM protocol. The primary outcome was a change in the process outcome "mobilization activities". Secondary outcomes were PICU staff opinions on mobilization (survey), safety, process measures, involvement of parents and physical therapist, and clinical outcomes (sedative use and prevalence of delirium).

Results: A total of 113 children were included; 55 before and 58 after, with a median age of 31 months (IQR: 10–103) and 35 months (IQR: 7–152), respectively. The number of mobilization activities (per patient per day) had significantly increased from 5 (IQR: 2–7) to 6 (IQR: 4–8) ($U = 272185.0$; $p < .001$). PT consultations for mobilization had significantly increased from 23.6% (13/55) to 46.5% (27/58) ($X^2 = 6.48$; $p = .011$). In both phases, no mobilization-related adverse events were documented. The survey showed that PICU staff found EM of critically ill children useful and feasible. In the after phase, PICU staff rated the perceived benefit of the support of the physical therapist during mobilization activities significantly higher than in the before phase ($X^2 = 34.80$; $p < .001$).

Conclusions: Implementation of a structured EM program for critically ill children is feasible and safe.

Relevance to clinical practice: It is suggested to start the implementation of a structed EM program with the idendentification of local barriers and facilitators by an interdisciplinary PICU team. Further, an increased presence of physiotherapists on the PICU would improve mobilisation levels, and facilitate mobilisation in critically ill children. Also, they can support and advice PICU nurses and parents in mobilising children.

KEYWORDS

critical care nursing, children, Early Mobilisation, PICU/ICU service delivery, physiotherapy, quality improvement

1 | INTRODUCTION

Many children receiving intensive care are sedated and immobilized (limited or absent motion of the body or a part of it) for the sake of safety, comfort, and haemodynamic stability. However, immobilization has negative effects such as loss of muscle mass and physical strength, adverse long-term functional outcome, and potentially higher risk of delirium and pressure ulcers.[1–4] Critically ill children admitted for more than 72 h in the PICU, were completely immobile in from 19% to 25% of the observations.[5–7]

Early mobilization is defined as appropriate rehabilitation exercises initiated within the first 48–72 h after admission on an ICU.[8,9] Early mobilization of critically ill adults has been proven effective, as it resulted in lesser muscle weakness, better physical function at discharge, fewer hospital costs, lesser use of sedatives, fewer cases of delirium, shorter duration of mechanical ventilation, and shorter hospital stay.[10–14] Evidence for the effectiveness of early mobilization in critically ill children is still lacking, although it has been found safe and feasible for this group.[15–17] PICU nurses and physicians generally find mobilization important, but perceive barriers; for example, lack of guidelines or protocols, risk of endotracheal tube and central venous catheter dislodgement, and lack of physical therapist involvement.[8,18–20] In view of these findings, we performed a study to evaluate mobility activities after implementation of an early mobilization protocol, and to explore barriers and facilitators before and after implementation. Further, we established clinical effects in terms of changes in the consumption of opioids and sedatives, and in the prevalence of delirium.

What is known about the topic

- Early mobilization of critically ill adults improved their physical functioning and shortened the duration of mechanical ventilation. However, comparable research in children is lacking.
- Immobility during hospital stay is associated with muscle weakness, delirium, and delayed neurocognitive recovery.
- Many PICU patients are sedated and immobilized because of safety reasons, comfort, and haemodynamic stability.

What this paper adds

- Early mobilization was shown to be safe for PICU patients and feasible during daily care.
- The contribution of a physical therapist is recommended in complex cases
- Implementation of an early mobilization protocol lead to more mobilization activities per patient per day and more out-of-bed activities in ventilated patients.

2 | METHODS

2.1 | Design and setting

We performed this study as a structured intervention implementation project, and evaluated it using a before-and-after design. The setting was a tertiary 28-beds PICU of a children's Hospital in Rotterdam, the Netherlands. Patients in the age range 3 months to 18 years with an expected stay of 3 days or longer were eligible to participate. Excluded were those with an open chest, acute spinal cord or brain injuries, critical airway, or severe intellectual development disorder, as well as those in whom life-sustaining therapy was withheld. The intervention concerned the implementation of a multidisciplinary, nurse-driven protocol for early mobilization. The results of this study are reported using the Standards for Quality Improvement Reporting Excellence guidelines.[21] The study protocol was reviewed and approved by the Medical Ethics Review Board of the Erasmus MC—Erasmus University Medical Center, Rotterdam, the Netherlands (MEC-2017-1095). Patients were included after the parents had provided informed consent before the third day of admission. The study was registered at Dutch clinical trial registry (NL6719/NTR6898).

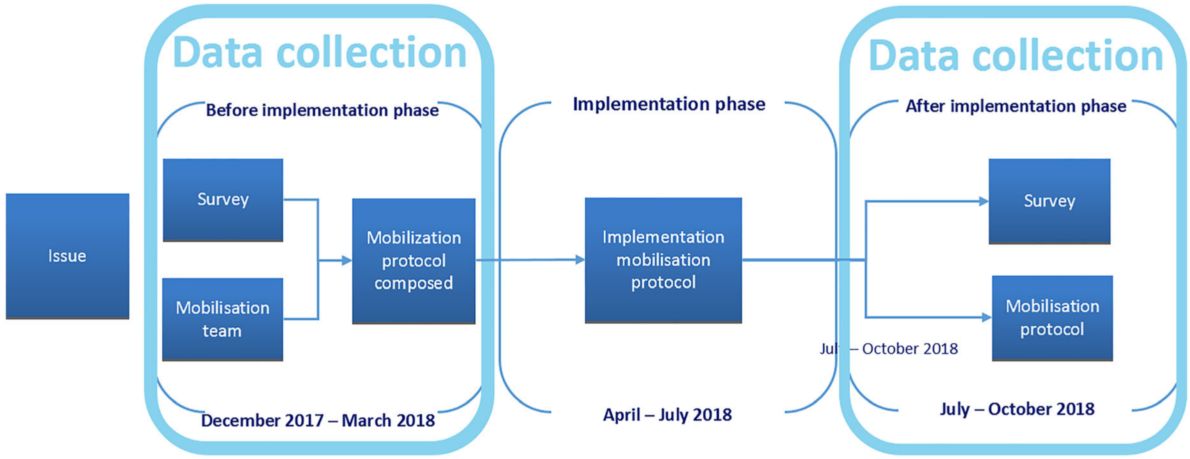

FIGURE 1 Study scheme

2.2 | Procedure

The study consisted of three phases from December 2017 to November 2018: two data collection phases and one implementation phase (Figure 1). The Implementation Model of Change of Grol and Wensing[22] was used to structure the implementation of an early mobilization protocol. This model proposes a seven steps approach, starting with identifying the problem and defining the aim of change, followed by identifying potential barriers and facilitators for implementation; developing an implementation plan based on these barriers and facilitators; and finally executing, evaluating, and sustaining the implementation plan.

2.2.1 | Phase 1: Before implementation phase—Usual care

In the 4-month before-implementation phase (December 2017—March 2018), children received usual care in the absence of an early mobilization protocol. A mobilization protocol for ventilated patients was in place, however, consisting of turning the patient every 4 h. This protocol was poorly adhered to, however, and adherence was highly dependent on the initiative of the nurse and doctor on duty that day. Physical therapist (PT) consultation and treatment were offered when ordered by a medical doctor. During this phase we assembled an early mobilization team consisting of PICU nurses (SH, MdH, JS), a medical doctor (SV), a researcher (EI), a child life specialist, and a PT (TZvdA). PICU nurses, nurse practitioners, and physicians were invited to fill out a questionnaire online via LimeSurvey. The content of the 15 items questionnaire is partially based on the questionnaire of Joyce et al.[23] dealing with perceptions and perceived barriers and facilitators of early mobilization. Identified barriers and facilitators were to form the basis for the selection of implementation strategies.

The team compiled an early mobilization protocol based on the members' expertise, recent research about early mobilization (e.g., PICU Up!) and the results of the questionnaire[1,15,17,19] Early mobilization was defined as the start of mobilization activities within 48–72 h after the patient's PICU admission.[8,9]

2.2.2 | Phase 2: Implementation phase

In the second phase we implemented the early mobilization protocol, which consisted of the following activities:

- Every day during the daily round, the physicians, supervising nurse, and bedside nurse discuss mobilization opportunities for all admitted patients, thereby considering each patient's medical status and age. Based on medical status, each patient is assigned to one of three safety levels (see supplementary file [Data S1]). Each safety level is associated with specific mobilization activities. Examples of mobilization activities are regular turning, passive motion, sitting in bed, sitting on the edge of bed, sitting in a chair or parents lap, standing, walking, and in-bed cycling.
- Twice a week, the PT and the supervising nurse discuss progress in mobilization of all admitted patients and decide which activities will be scheduled for eligible patients for the coming days and whether or not PT consultation is necessary to facilitate specific activities.

Based on the identified barriers and facilitators for adherence to the early mobilization protocol, we developed a tailored implementation program following the model of Grol and Wensing.[22] The implementation program consisted of different implementation strategies in accordance to Expert Recommendations for Implementing Change (ERIC) compilation, mainly on organizational and professionals' levels[24,25] (see details in Supplementary file—Table S1). Members of the mobilization team informed and instructed PICU nurses and PICU medical staff about the content and implementation of the early mobilization protocol in four 1-hours sessions. Furthermore, we developed an e-learning module which we sent to all PICU staff and made available on the computers of the units. In addition, we handed out a pocket card describing the safety levels with the associated mobility activities (see supplementary file [Data S1]). New equipment, such as extra bed cycle, adjustable mobilization chairs, fixation material for tubes, lines and drains was purchased to support the mobilization activities.

2.2.3 | Third phase: After implementation phase—Use of early mobilization protocol and evaluation, during 4 months

In this phase, the early mobilization protocol was applied to eligible patients. Nurses and physicians were invited to repeat the questionnaire about perceptions and barriers.

2.3 | Outcome measures

The primary outcome was the change in the process outcome "mobility activities", defined as the proportion of eligible children receiving either passive or active mobilization activities. The type and number of activities performed by PTs, nurses, physicians, nurse practitioners, and child life specialist were noted by the professionals in a "mobilization diary" during every shift.

The secondary outcome measures were: (1) Process measures: PT involvement (yes/no), participation of parents in mobility activities (yes/no), and barriers and facilitators perceived by nurses, physicians, nurse practitioners regarding early mobilization as surveyed; (2) Safety, reflected as the occurrences of adverse events related to mobility activities, such as tube dislocation, accidental removal of tube or lines, and circulatory and/or respiratory events (bradycardia or a decrease in oxygen saturation <88%) during or related to mobilization; and (3) clinical outcomes: sedatives and opioids consumption (mg/kg/day), duration of admission and of mechanical ventilation, incidence of delirium over the first 28 days. The incidence of delirium was assessed with the SOS-PD scale, a validated tool including 17 items that are scored as being present or absent.[26] Delirium was defined as a SOS-PD score of 4 or higher.

2.4 | Data collection

The following data were prospectively collected during the four-month phases before and after the early mobilization protocol implementation phase: (1) Patient clinical characteristics; for example, reason for admission, Paediatric Risk of Mortality Score (PRISM) III, pre-admission physical function categorized by the Paediatric Cerebral Performance Score (PCPC),[27] type of respiratory support; (2) Outcomes; for example, duration of mechanical ventilation, length of PICU stay, dosages of continuous sedatives and opiates, and; (3) Mobility characteristics; number and type of mobility activities, mobility-related adverse events, and PT consultation. The mobility characteristics were documented by the caregiving nurse or parents in the "mobilization diary" and were classified as in-bed activities (e.g., passive motion, sitting in bed) and out-of-bed activities (e.g., transfer from bed to chair, being held by family of staff, mat play, standing, or walking). Furthermore, the presence of parents at the bedside and their involvement in mobility activities were registered. Data of individual patients were collected during the first 28 days of the PICU admission.

2.5 | Statistical analysis

Categorical data are presented as numbers and percentages. Non-normally distributed data variables were summarized as median (interquartile range) and normally distributed data as mean (standard deviation). Normal distribution of data was determined with the Kolmogorov–Smirnov test. Demographics, clinical characteristics, and mobilization characteristics were compared between the before and after implementation phases with chi-square tests or Fisher's exact tests for dichotomous or categorical variables and either independent samples *t*-tests or Mann–Whitney *U* tests for normally and non-normally distributed continuous variables, respectively. Differences in perceived barriers between both phases were tested by unpaired t-tests. Linear mixed models for repeated measurements served to explore the differences in the number of mobilization activities per patient per day performed before and after implementation. In a second model, we assessed the effect on the number mobilization activities for the type of respiratory support and corrected for covariates (i.e., age, severity of illness, and PCPC). Day of admission was coded as a categorical variable with categories: day 1, day 2, days 3 through 7, days 8–14, and days 15 or more. A random intercept and a random slope of day of sadmission (as a continuous variable) were included to account for the within-subject correlations. Parents' involvement in mobilization was expressed, as the number of days a parent was involved in mobilization divided by the number of days a parent was present at the bedside. A p value of <.05 was considered to indicate statistical significance. Data were analysed using IBM SPSS Statistics version 25.0.

3 | RESULTS

3.1 | Characteristics of patients and professionals

148 patients were screened for eligibility: respectively for 70 patients in the before-implementation phase and 78 patients in the after-implementation phase (see Supplementary file—Figure S1). In total, 113 children were included; 55 in the before-implementation phase and 58 in the after-implementation phase, with a median age of 31 months (IQR: 7–106) and 35 months (IQR: 8–147) ($U = 1722.5$: $p = .4$), respectively. Patient characteristics (e.g., age, gender, reason for admission, ventilation, length of PICU stay) did not statistically differ between the two groups (Table 1).

Ninety-four (59.1%) and 71 (48.6%) PICU staff members completed the survey, respectively before and after implementation; 80% and 87% of respondents were nurses. Table S2 presents the demographic characteristics of the respondents.

TABLE 1 Demographics and clinical characteristics of included children

	Before implementation phase ($n = 55$)	After implementation phase ($n = 58$)	Test statistic	*p* value
Gender m/f, *n* (%)	35/20 (64/36)	31/27 (53/47)	$\chi^2_{df=1} = 1.21^a$	.27[a]
Age, months[c]	31 (7–106)	35 (8–147)	$U = 1722.50^b$	.47 [b]
Age category, *n* (%)			$\chi^2_{df=5} = 5.69^a$	.34 [a]
<6 months	12 (21.8)	9 (15.5)		
6–12 months	6 (10.9)	10 (17.2)		
1–3 years	10 (18.2)	11 (19.0)		
3–6 years	7 (12.7)	4 (6.9)		
6–12 years	12 (21.8)	8 (13.8)		
>12 years	8 (14.5)	16 (27.6)		
Reason for admission, n (%)			$\chi^2_{df=6} = 11.55^a$	.07 [a]
Respiratory	21 (38.2)	12 (20.7)		
Postoperative	2 (3.6)	8 (13.8)		
Post-cardiac surgery	5 (9.1)	13 (22.4)		
Neurologic	6 (10.9)	7 (12.1)		
Cardiac	10 (18.2)	9 (15.5)		
Congenital abnormalities	2 (3.6)	0 (0)		
Others	9 (16.4)	9 (15.5)		
Length of PICU stay, days[c]	8 (5–19)	11 (5–20)	$U = 1642.0^b$	.79[b]
Ventilated, yes (%)	41 (74.5)	42 (72)	$\chi^2_{df=1} = 0.07^a$	.80[a]
Duration MV, days[c]	3 (0–7)	3 (0–9)	$U = 1602.50^b$	.97[b]
PRISM (%)[c]	13 (8–20)	11.5 (6.8–18.3)	$U = 1368.50^b$	.19[b]
Baseline PCPC, *n* (%)			$\chi^2_{df=4} = 1.82^a$	.77[a]
No	20 (36.4)	18 (31.0)		
Mild disability	15 (29.1)	17 (29.3)		
Moderate	13 (25.5)	19 (32.8)		
Severe	4 (7.3)	4 (6.9)		
Coma/vegetative status	1 (1.8)	0		

Abbreviations: df, degrees of freedom; MV, mechanical ventilation; PCPC, Paediatric Cerebral Performance Score; PRISM, paediatric risk of mortality score.
[a]Statistical tests used for analysis: chi-square test.
[b]Statistical tests used for analysis: Mann–Whitney *U* test.
[c]Median (IQR).

3.2 | Mobilization activities

Overall, the median number of mobilization activities per child had increased from 5 (IQR: 2–7) to 6 (IQR: 4–8) ($U = 272185.0$; $p < .001$) after implementation of the early mobilization protocol. The median number of out-of-bed activities had increased from 0 (IQR: 0–1) to 1 (IQR: 0–2) per day ($U = 257.451.0$; $p < .001$). The linear mixed model, accounting for repeated measurements, showed that the number of mobility activities after implementation had increased by 0.93 (95% CI: 0.17–1.70) activity per child per day (model 1, Table 2). The effects of covariates on the numbers of mobilization activities are shown in model 2 (Table 2). In this model, the increase in number of mobilization activities was slightly lower, but still significant. There was no significant effect on the PCPC score, and receiving mechanical ventilation had a negative effect on mobilization activities compared to the reference (no mechanical ventilation).

After implementation of the mobilization protocol a significantly higher proportion of patients had received out-of-bed activities than before (76% vs. 95%; $X^2 = 5.87$; $p < .011$) (Table 3). The proportion of ventilated children mobilized into a chair increased from 29.4% to 55.6% ($X^2 = 5.31$; $p = .028$).

3.3 | Secondary outcomes

3.3.1 | Involvement of PT and parents

The proportion of children for whom PT consultations for mobilization was sought had increased significantly from 23.6% (13/55) before to 46.5% (27/58) after implementation ($X^2 = 6.48$; $p = .011$). Parents were significantly more often involved in mobilization of their child than before implementation of early

TABLE 2 Linear mixed model analyses for the number of mobilization activities per patient per day

	Model 1 (unadjusted)[a]			Model 2 (adjusted for covariables)[a]		
Variables	*B* (SE)	95% CI	*p* value	*B* (SE)	95% CI	*p* value
Intercept	2.42 (0.36)	1.72–3.12	<.001	3.81 (0.47)	2.89–4.73	<.001
After implementation[b]	0.93 (0.39)	0.17–1.70	.018	0.80 (0.36)	0.1–1.52	.03
Day category						
Day 1	(Reference)	-	-	-(Reference)	-	-
Day 2	1.68 (0.35)	2.32–3.89	<.001	1.65 (0.34)	0.98–2.33	<.001
Day 3–7	2.47 (0.28)	2.37–3.57	<.001	2.32 (0.28)	1.78–2.87	<.001
Day 8–14	2.97 (0.30)	1.92–3.02	<.001	2.65 (0.31)	2.03–3.26	<.001
Day 15 or more	3.11 (0.40)	1.01–2.36	<.001	2.66 (0.41)	1.86–3.47	<.001
Type of respiratory support						
None	-			-(Reference)	-	-
Nasal cannula or face mask				−0.62 (0.37)	−1.26-0.01	.055
Heated high-flow nasal cannula				0.13 (0.35)	−0.56-0.82	.712
CPAP				−5.11 (1.86)	−8.76- -1.45	.006
Mechanical ventilation				−1.43 (0.26)	−1.94 - -0.91	<.001
PCPC						
PCPC < 3 (good to mild)				−0.66 (0.37)	−1.40-0.80	.08
PCPC ≥ 3 (moderate to severe)				-(Reference)		

Abbreviations: CPAP, continuous positive airway pressure; PCPC, Paediatric Cerebral Performance Score.
[a]Statistical tests used for analysis: Linear mixed models for repeated measurement; adjustment for covariables: age, severity of illness and PCPC.
[b]Before implementation reference.

TABLE 3 Number of patients participating in mobilization activities

Mobilization activities (Number of children participating in that activity during admission)	Before implementation phase (*n* = 55)	After implementation phase (*n* = 58)	Test statistic[a]	*p* value
In-bed activities, *n* (%)				
Passive motion	42 (76)	56 (97)	$\chi^2_{df=1} = 9.99$	.002
Turning	54 (98)	57 (98)	$\chi^2_{df=1} = 0.001$	1.00
HOB in 30°	49 (89)	52 (91)	$\chi^2_{df=1} = 1.68$	.758
Sitting in bed	38 (69)	46 (79)	$\chi^2_{df=1} = 1.55$	.282
In-bed cycling	4 (7)	4 (7)	$\chi^2_{df=1} = 0.006$	1.00
Out-of-bed activities, *n* (%)				
Sitting on edge of bed	21 (38)	29 (50)	$\chi^2_{df=1} = 1.60$	.256
Sitting on chair/baby swing chair	21 (38)	36 (62)	$\chi^2_{df=1} = 6.44$	.015
On lap of parents	34 (62)	35 (60)	$\chi^2_{df=1} < 0.001$	1.00
On play mat	7 (12)	5 (9)	$\chi^2_{df=1} = 0.51$	.551
Walk	11 (20)	18 (33)	$\chi^2_{df=1} = 2.36$	.141

Abbreviations: df, degrees of freedom; HOB, head of bed.
[a]Statistical tests used for analysis: chi-square test.

mobilization (before: 50% [IQR: 33–75] vs. after: 80% [IQR: 60–100] ($U = 2110.50$; $p < .001$).

3.4 | Safety

No mobilization-related adverse events were documented after implementation of the early mobilization program.

3.5 | Perceived barriers and facilitators for early mobilization

During both phases, all respondents were of the opinion that early mobilization is beneficial for critically ill children. The largest perceived benefits ranged from 80% to 100% for shorter durations of ventilation and PICU stay, lesser use of sedatives, and improved day-night cycle (Figure 2a). We found no differences in this respect

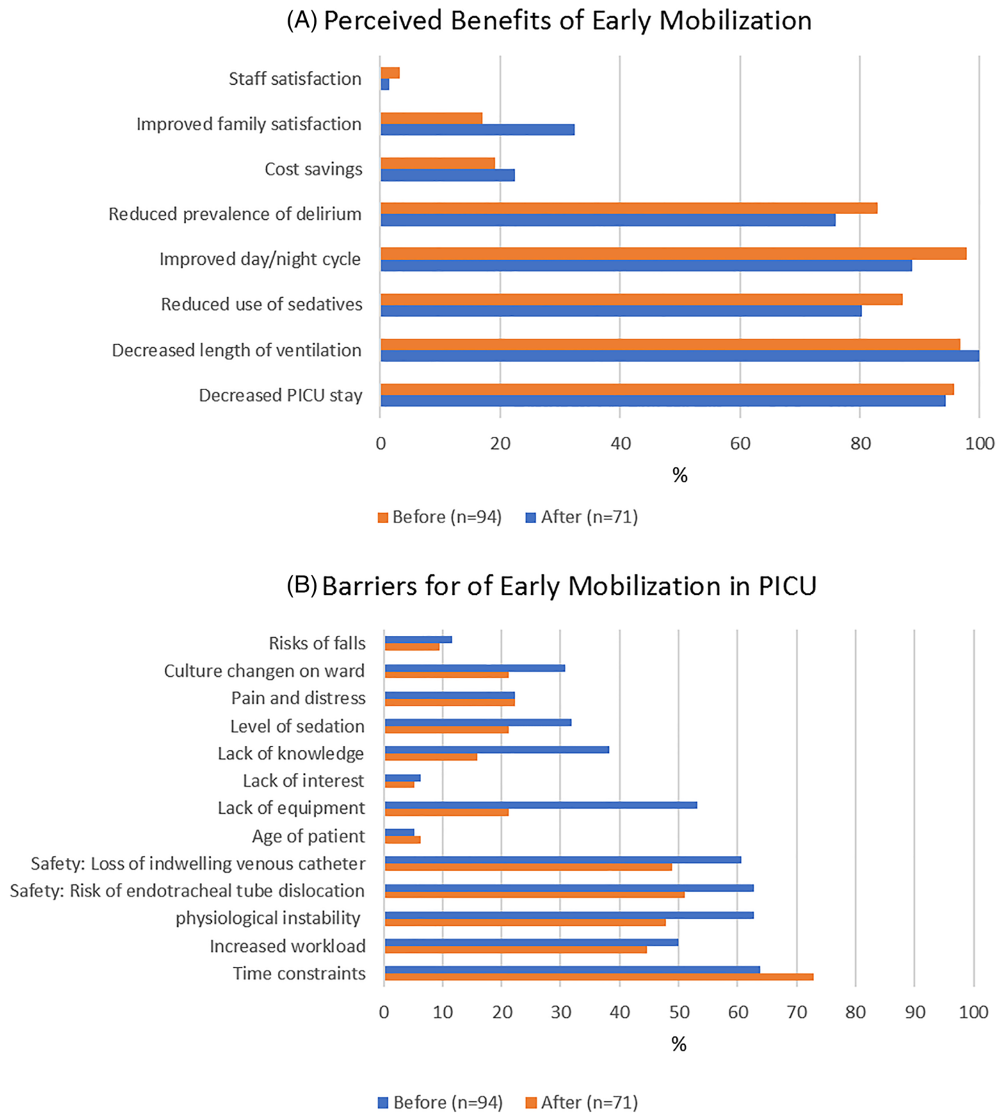

FIGURE 2 (a, b) Result survey: barriers and facilitators of PICU staff (nurses, NPs and physicians)

between the before- and after implementation responses. Respondents' perception about patients' family satisfaction with mobilization increased from 17% before to 32% after implementation (Figure 2a).

Before implementation, PICU staff ranked the following aspects as important barriers to early mobilization: time constraint (64%), physiological instability (63%), risk of endotracheal tube dislocation (63%), loss of indwelling central venous catheter (60%), lack of equipment (53%), and increased workload (51%). After implementation, only time constraint (73%) was the most important perceived barrier. Involvement of PTs for early mobilization was perceived as significantly higher after implementation: 76% versus 33% before ($X^2 = 34.80$; $p < .001$) (Figure 2b).

3.6 | Clinical outcomes

There were no statistically significant differences in the administered midazolam day doses (median 2.9 [IQR: 0.8–5.1] vs. 2.9 [IQR: 1.1–4.7] mg/kg; $U = 583.0$; $p = .47$) and morphine doses (median 0.19 [IQR: 0.13–0.38] vs. 0.24 [IQR: 0.16–0.31] mg/kg; $U = 535.0$; $p = .71$) between the before and after implementation phases. The delirium rate was not statistically significantly different between the before and after implementation phases (16.4% vs. 29.0%; $X^2 = 2.67$; $p = .12$).

4 | DISCUSSION

The implementation of an early mobilization protocol in the PICU of our hospital proved to be safe and feasible. It led to a significant increase of mobilization activities, in particular out-of-bed mobilization activities. We noted that the physical therapist became significantly more involved in mobilization activities. The average number of mobilization activities per patient per day had risen from five before to six after implementation. The absolute difference seems only modest, but the difference was clinically relevant because it specifically involved more out of bed mobilization activities.

Besides PICU staff, parents play an important role in mobilization. We found that parents were more involved in mobilization after implementation of the early mobilization protocol. As identified in the PARK-PICU USA, European, and Canadian studies, family presence and involvement are independently associated with out-of-bed mobility of PICU patients.[5–7] Parents have a supportive role that helps to decrease the child's anxiety, which facilitates mobility activities.[17,28]

We found no significant effects on clinical outcome measures such as sedatives and opioids consumption, duration of admission and of mechanical ventilation, and prevalence of delirium. To be able to pronounce on the effect of early mobilization on clinical outcome measures, a study in a larger cohort is needed, and if possible, a randomized study design with a control group. In adult ICU patients, early mobilization proved to have a positive effect on length of ICU stay, length of hospital stay, length of mechanical ventilation, incidence of delirium and ICU-acquired weakness.[29] Two ongoing studies on early mobilization in children by research groups in Canada[30] and the USA[31] will show if the findings in adult ICU patients on clinical outcomes (e.g., length of ventilation, length of PICU stay), and morbidities such as delirium, iatrogenic withdrawal, pressure ulcers, or ICU acquired weakness can be replicated in critically ill children.

To our knowledge, this is the first quality improvement intervention to promote early mobilization in the PICU setting in Europe. Comparable research has only been done in the USA and Canada.[5,8,15,17,32] In those studies, with setting and the patient category similar to those in our study, the implementation of a mobilization protocol in a tertiary PICU was safe and feasible, too, and led to an increase of mobilization activities and more consultation of PTs.

This protocol was assembled through a structured implementation process and contained an interdisciplinary, nurse-driven intervention because nurses are at the patient's bedside all day and can thus apply the activities during daily care. For optimal realization of early mobilization in the PICU, dedicated PT staff needs to be available during the whole week. However, extension of PT staff in the PICU could be limited by cost considerations. Besides that, PTs support the PICU nurses, they have an important role in view of their expertise in assessing patient's capabilities, best ways to mobilize the patient and, if necessary, to adjust the environment to make the mobilization comfortable for the patient. Previous studies confirmed that PTs are the very ones to provide key interventions to advance infants' and toddlers' gross and fine motor skills, sensory stimulation, and cognition during critical illness.[33,34]

In line with adult literature, key factors that fostered a culture of mobility after implementation in this study included (1) standardization of workflow; (2) consideration of patient safety based on patient's medical status during morning rounds; and, (3) identification of mobility goals based on the patient's safety level. To facilitate early mobility in the long term, a consistent focus on staff buy-in and interprofessional leadership remains important. Moreover, after successful implementation of EM, attention should be paid to any remaining barriers—specifically related to resource management, sedation decisions, and patient heterogeneity.[35]

This study has several strengths and limitations. The mobilization protocol was built on the knowledge and experience of the mobilization team as well as on the results of a survey. The survey indicated that the PICU staff members lacked sufficient knowledge on this issue, and that appropriate equipment to mobilize patients was lacking. With this information we have been able to turn barriers into facilitators by means of education and purchasing equipment.

Several limitations may be of relevance. First, the design of the study was a single-centre before-after study, limiting the generalizability. Second, a control setting was lacking, which also weakens the strength of the evidence. Third, the two study phases were during different seasons. During the before phase (winter), more children with pulmonary problems were admitted than in the after phase.

5 | CONCLUSION

In this study, we showed that implementation of an early mobilization protocol for critically ill children is safe and feasible, as it resulted in more mobilization activities per patient without any adverse events related to mobilization. To determine best practice for paediatric critical care, the short-term and long-term impacts of early mobilization and rehabilitation programs should be evaluated in a large multicentre cohort of critically ill children.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

The authors have made substantial contributions to the conception and design of the study (**Erwin Ista**, **Monique van Dijk**, **Sascha Verbruggen**), acquisition of data (**Erwin Ista**, **Mariska de Heer**, **Sjoukje Hoekstra**, **Judith Steenhorst**), analysis (**Erwin Ista**, **Tabitha Zanen-van den Adel**, **Joost van Rosmalen**) and interpretation (**Erwin Ista**, **Monique van Dijk**, **Tabitha Zanen-van den Adel**, **Joost van Rosmalen**) of data. All authors discussed the results, commented on the manuscript, and approved the final version to be submitted.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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