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Impact of discharge criteria on the length of stay in preterm infants: A retrospective study in Japan and Finland

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ABSTRACT

Background: To shorten the hospital stay in preterm infants, it is important to understand the factors extending the length of stay.
Aims: To understand how different discharge criteria affect the length of stay in preterm infants.
Study design: A retrospective comparison study.
Subjects: Preterm infants born at 28 to 31 gestational weeks in 2020–2021 in a Level IV NICU in Japan ($n = 22$) and a Level III NICU in Finland ($n = 49$).
Outcome measures: We compared the most common last discharge criteria and the postmenstrual age (PMA) between the two NICUs. The potential extending effects of each discharge criterion on the length of stay were also evaluated. The discharge criteria were classified into six categories: temperature, respiration, feeding, examination, weight limit, and family readiness.
Results: The PMA at discharge was significantly higher in Japan than in Finland: median 40.7 (interquartile range 39.9–41.3) vs. 37.9 (36.9–39.0) weeks; $r = 0.58$; $p < 0.001$. The most common last discharge criterion was the family criterion in Japan ($n = 19$; 86 %) and the respiration criterion in Finland ($n = 43$; 88 %). In Japan, the length of stay was extended by 7.9 (standard deviation [SD] 7.0) days due to a lack of family readiness for discharge and 8.7 (SD 8.7) days due to not having discharged home with a feeding tube as a common practice.
Conclusions: The length of stay of preterm infants in Japan could be notably reduced by supporting the parents' earlier readiness for discharge and allowing tube feeding at home.

1. Introduction

Preterm infants require long hospital stays in neonatal intensive care units (NICUs). Long exposure to a hospital environment disrupts the normal development of the infant by inhibiting proper physical and emotional closeness between the infant and parents and by causing excessive exposure to chemicals and stimuli, such as noise and light [1–4]. In addition, a preterm infant's care in the NICU results in high hospital expenses [5,6]. Therefore, safely shortening the length of stay in NICUs is beneficial for the infants, their families, and neonatal care as a whole. To shorten the hospital stay in preterm infants, it is important to understand the factors extending the length of stay.

Most important background factors predicting the length of stay in preterm infants are gestational age at birth, birth weight, and sex [7,8]. Medical conditions, such as sepsis and surgical needs, can unexpectedly extend the hospital stay, making it difficult to predict the length of stay, especially with extremely preterm infants [7,9]. In addition, the discharge criteria vary between neonatal units and impact the length of stay differently. Commonly used discharge criteria include thermoregulation, control of breathing, feeding skills, specified postmenstrual age (PMA) and weight, and the parents' readiness [7,10,11].

There is a lack of national and international guidelines and criteria for determining when a preterm infant is ready for discharge from hospital [10,12–14]. Furthermore, it is unclear how much each discharge criterion affects the length of stay in preterm infants, or what the determinants of discharge are [10]. International comparison studies

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show that the length of stay differs between countries [12,13]. In a study of 11 neonatal networks including 12 countries, the length of stay was the shortest in Finland and the longest in Japan, with a 25-day difference in the mean length of stay [13]. We hypothesized that this variation in the length of stay was influenced by the differences in discharge criteria. Our study aimed to understand what is the last discharge criterion before discharge and how it affects the length of stay in preterm infants.

2. Methods

2.1. Study design and setting

Our retrospective study compared data from two NICUs: a level IV NICU in Japan and a level III NICU in Finland. Both NICUs are the only tertiary perinatal centers in their areas. The following data indicates that the study hospitals are representative for their countries.

The study site in Japan is one of about 100 level III/IV NICUs in Japan. It is one of three level III NICUs in the prefecture and the only level IV NICU. Of admissions of preterm infants born at 28–31 weeks of gestation, in the study hospital in 2020–21, 9 % of preterm infants were outborn compared to about 6 % in all NICUs participating in the neonatal research network database in Japan in 2020. Infants whose families live in other areas are usually transferred back to the level II NICU near their home after they have been weaned off from any respiratory support. The study hospital also functions as a level II NICU for the local patients. A total of 280 infants were admitted in 2021; about 25 % of them were preterm infants. The NICU had 24 intensive care beds and 18 step-down beds, and each hospital room accommodated 4 to 10 patients. One nurse cared for 3 infants in intensive care beds and 7 in step-down beds; this resource is determined by health care fees in Japan. Parents were allowed to visit the NICU 24/7 before the COVID-19 pandemic, but were limited to between 9 a.m. and 3 p.m. between March 2020 and the end of the study, except for hospitalized postpartum mothers who could access their infants 24/7.

The study site in Finland is one of 5 level III/IV NICUs in Finland. It is the only level III NICU in the region. All very preterm deliveries from the region are centralized in this hospital. During the study period, 86/89 infants (96.6 %) born at 28–31 weeks of gestation were born in the level III NICU in this region, compared to 427/449 (95.1 %) in the whole country. The quality comparison data also shows comparable outcomes for all five level III/IV NICUs in Finland. The study hospital also functions as a level II NICU for the local patients. Infants whose families live in other areas are usually transferred back to the level II NICU near their home after they have been weaned off from any invasive respiratory support. A total of 443 infants were admitted in 2021; about 40 % of them were preterm infants. In 2021, the unit had 18 beds, including intensive care and step-down beds. The beds were mostly in single family rooms, accommodating two patients in the case of twins. The total number of rooms was 14. One nurse cared for 1–3 infants depending on the intensity of care. At least one parent could stay overnight in the same NICU room and the parents were allowed to visit 24/7 even during the COVID-19 pandemic.

2.2. Study population

Infants born between 28 and 31 weeks of gestation and discharged home from the study sites between January 2020 and December 2021 were eligible. However, infants were excluded if they had major anomalies at birth or required home oxygen therapy, tracheostomy, or gastrostomy at discharge. Our study only included infants born at 28–31 weeks of gestation because 1) we aimed to have comparable patient populations from the medical perspective, 2) we wanted to exclude the borderline viability infants to eliminate the confounding effects of possible differences in care approaches, and 3) different centralization strategies were applied in the countries after 31 weeks of gestation. Permission to carry out the study was given by the Ethics Committee of Nagano Children's Hospital and Turku Clinical Research Centre. Ethical approval with an opt-out approach was given by the Ethics Committee of Nagano Children's Hospital. This study was registered at www.clinicaltrials.gov (identifier: NCT06144190).

2.3. Data collection and definitions

The data were collected retrospectively from the medical record entries and/or progress notes made by the nurses at both study sites. The collected data included background information about the mother and infant, and the infants' clinical course. The infants' clinical course included the PMA when each discharge criterion was met and the infants' severe neonatal morbidities.

Severe bronchopulmonary dysplasia was defined according to the National Institute of Child Health and Human Development as a need for $\geq$30 % oxygen therapy, mechanical respiratory support, or non-invasive positive pressure ventilation at 36 weeks PMA [15]. Severe brain damage was defined as having grade III or IV intraventricular hemorrhage by Papile et al. [16] or cystic periventricular leukomalacia. Sepsis was defined as blood or cerebral fluid culture-positive infection.

2.4. Discharge criteria and outcome measures

We divided the discharge criteria into six categories: "temperature criterion" (no need for mechanical temperature control), "respiration criterion" (no need for respiratory support and observation), "feeding criterion" (no need for a feeding tube), "examination criterion" (completion of the necessary examinations), "weight criterion" (exceeding the weight limit), and "family criterion" (parents ready for caretaking at home). The "feeding criterion," "examination criterion" and "weight criterion" were not used in the NICU in Finland. The details of the discharge criteria in each study site are summarized in Table 1.

The primary outcomes of our study were the last discharge criterion before discharge and the potential extending effects of each discharge criterion on the length of stay. The secondary outcomes were the PMA when each discharge criterion was met.

2.4. Statistical analyses

No information related to outcome measures was missing. The potential extending effects of each discharge criterion on the length of stay were calculated as follows: We listed the days of postnatal age at which each discharge criterion was met, in the following order: temperature, respiration, (feeding, examination, and weight only in the NICU in Japan), and the family criterion. The discharge criteria were commonly met following this order. Next, we calculated the difference in days between each discharge criterion and the most recently met one. E.g. if the "weight criterion" was met at 30 days of age and the "family criterion" at 40 days, the extending effect of the "family criterion" was 10 days. The extending effect was determined to be 0 days if the discharge criterion was met earlier than the previous criteria. E.g. if the "respiration criterion" was met at 30 days and the "feeding criterion" at 25 days, the extending effect of the "feeding criterion" was 0 days. We calculated the mean and the standard deviation (SD) of each extending effect.

The PMA when each discharge criterion was met was compared between the data from Japan and Finland using the Wilcoxon rank sum test. The analysis was conducted using R [17], version 4.2.2 with the R packages of the Tidyverse [18]. The R package ggplot2 [19], version 3.4.0, was used for visualization. P values <0.05 were considered statistically significant.

3. Results

We identified a total of 73 preterm infants who were born at 28 to 31 weeks of gestation and discharged home in 2020–2021 from the NICU in Japan ($n = 23$) and the NICU in Finland ($n = 50$). We excluded one infant

Table 1
Discharge criteria and how they were used and defined at each study site.

Discharge criteria	NICU in Japan	NICU in Finland
Temperature	Definition: no mechanical temperature control (incubator, infant warmer, or heating mattress) The target body temperature was between 36.5 and 37.5 °C	
Respiration	Definition: no respiratory support (including oxygen, high-flow, or NCPAP) or respiratory monitoring • No apnea or other respiratory instability after 2 days of monitoring • Apnea definition: pause in breathing with bradycardia (<100/min) or requiring stimulation regardless of the duration of respiratory pause • The target SpO_2 was 88–94 % between 72 h after birth and 36 weeks PMA, and ≥ 95 % otherwise.	• No apnea after 7 days of monitoring • Apnea definition: pause in breathing with bradycardia (<80/min), excluding pauses during feeding • The target SpO_2 was ≥90 % until 40 weeks of PMA and ≥ 95 % after term age.
Feeding	Definition: feeding tube removed permanently • A feeding tube was only used at home if the infant needed it at the due date and the need was estimated to continue for several weeks	Not used • Infants were usually discharged despite having a feeding tube if the other discharge criteria were met
Examination	Definition: all necessary examinations completed, including a neurodevelopmental assessment • The necessary neurological examinations included brain MRI, a hearing test, Dubowitz and General Movements. They were conducted mostly between 36 and 40 weeks PMA.	Not used • All the necessary examinations could be conducted in the follow-up clinic after discharged home.
Weight	Definition: the infant's weight exceeds 2200 g	Not used
Family	Definition: the parents and the family are ready to take their infant home • In most cases, the parents felt ready after using the family room (there was only one in the NICU), where the parents stayed overnight with their infant. • In most cases, the staff used a checklist to ensure that parents had adequate skills in infant care. • In most cases, staff confirmed the readiness. • The other NICU beds were open-bay without the parents' bed next to them. The parents had no accommodation in the NICU. Parents' visits to the NICU were allowed 24/7 except for during the COVID-19 pandemic which limited the visit. The postpartum mothers had access to the NICU 24/7 even during the COVID-19 pandemic.	• In most cases, the exact date when the parents felt ready was difficult to confirm because they were usually ready long before the infant's condition met the discharge criteria. • In some cases, the staff and parents filled out a checklist together to ensure that parents were confident in caretaking and they had adequate skills in infant care. Using the checklist was not mandatory. • The parents and staff confirmed the readiness together. • Parents were allowed to stay with their infants 24/7, in most cases with at least one bed for a parent. Most NICU rooms were one or two-person private rooms.

MRI, magnetic resonance imaging; NCPAP, nasal continuous positive airway pressure; NICU, neonatal intensive care unit; PMA, postmenstrual age.

in the NICU in Japan due to a need for home oxygen therapy and one in Finland due to a need for a gastrostomy. The final number of infants included in the analyses was 22 for the NICU in Japan and 49 for the NICU in Finland. The demographics of the infants and their mothers are summarized in Table 2. The background information was comparable between the two countries, except that there were fewer male infants

Table 2
Characteristics of infants and mothers.

	Japan (n = 22)	Finland (n = 49)
Infant		
Gestational age, mean (SD), weeks	30.1 (1.0)	30.2 (1.2)
Birth weight, mean (SD)	1220 (306)	1351 (328)
Small for gestational age [a], n (%)	6 (27)	15 (31)
Male sex, n (%)	8 (36)	30 (61)
Apgar score < 7 at 5 min., n (%)	4 (18)	6 (13)
Mother		
Age, mean (SD), years old	29.1 (4.5)	31.4 (4.8)
Age < 20 years of, n (%)	0 (0)	1 (2)
Singleton, n (%)	10 (45)	33 (67)
Antenatal steroid, n (%)	13 (59)	31 (63)
Outborn, n (%)	2 (9)	1 (2)
Cesarean delivery, n (%)	17 (77)	37 (76)
Primipara, n (%)	17 (77)	36 (73)
Fluent in official languages, n (%)	22 (100)	43 (88)
Distance between hospital and home, mean (SD), km	27.4 (18.1)	21.5 (26.6)

SD, standard deviation.
[a] Whose birth weight z-score below 10 percentile.

(36 % vs. 61 %) and more singleton infants (55 % vs. 33 %) in the NICU in Japan than in Finland. The severe neonatal morbidities and rehospitalizations up to 6 months of corrected age were comparable between the countries (Table 3).

The most common last discharge criterion in the NICU in Japan was the "family criterion" (n = 19; 86 %), followed by the "feeding criterion" (n = 2; 9 %) and the "weight criterion" (n = 1; 5 %). In Finland, the most common last discharge criterion was the "respiration criterion" (n = 43; 88 %), followed by the "family criterion" (n = 5; 10 %) and the "temperature criterion" (n = 1; 2 %). In Finland, the "family criterion" included four infants waiting for their twin or triplet siblings to be ready, and one waiting for the recovery of the mother.

Fig. 1 shows how much each discharge criterion contributed to the hospital stay in each infant. The temperature and respiration criteria (gray area) were dominant in the NICU in Finland, whereas other infant criteria and the "family criterion" (colored area) had a significant contribution to the hospital stay in Japan. We calculated the potential extending effect of each discharge criterion on the length of stay. In the NICU in Japan, the length of stay was extended by 7.9 (SD 7.0) days due to a lack of family readiness for discharge ("family criterion") and 8.7 (SD 8.7) days due to not having discharged home with a feeding tube as a common practice ("feeding criterion"). The effect of the "examination" and "weight" criteria would be small: mean 0.4 days (SD 1.0) and 1.2 days (SD 7.0), respectively. In the NICU in Finland, on the other hand, the length of stay was extended by 1.6 days (SD 5.2) due to a lack of family readiness for discharge ("family criterion"). The mean duration of the hospital stay after the infant and the family met all the discharge criteria was 1.0 day (SD 1.8) in the NICU in Japan and 0.2 days (SD 0.6)

Table 3
Neonatal morbidities.

n (%)	Japan (n = 22)	Finland (n = 49)
Severe bronchopulmonary dysplasia	0 (0)	1 (2)
Patent ductus arteriosus operation	0 (0)	1 (2)
Abdominal operation	0 (0)	1 (2)
Severe brain damage [a]	2 (9)	3 (6)
Sepsis	0 (0)	4 (8)
Treatment for retinopathy of prematurity	0 (0)	4 (8)
Any rehospitalization up to 6 months of corrected age	2 (9)	8 (16)

Fisher's exact test was used to compare the two groups.
[a] Grade 3 or 4 intraventricular hemorrhage or cystic periventricular leukomalacia.

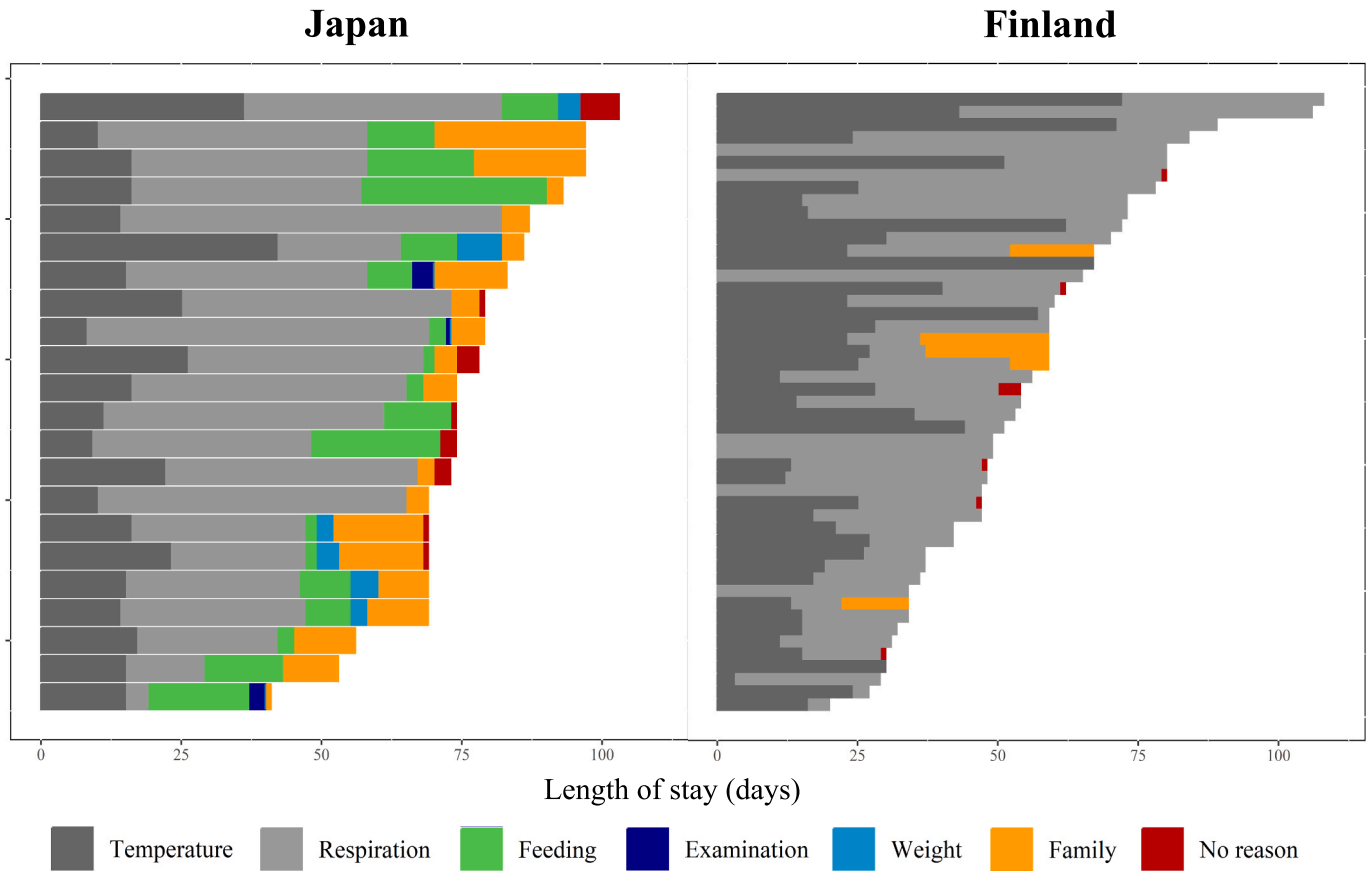

Fig. 1. How much each discharge criterion contributed to the hospital stay of each infant participating in the study.

in Finland.

The discharge to home happened significantly later in the NICU in Japan than in Finland: the median PMA was 40.7 weeks (interquartile range [IQR], 39.9–41.3) in Japan and 37.9 weeks (36.9–39.0) in Finland ($r = 0.58$; $p < 0.001$). The PMA for each discharge criterion was compared between the two countries (Table 4, Fig. 2). The "temperature criterion" was met significantly earlier in the NICU in Japan than in Finland: the median PMA was 32.7 weeks (IQR 31.7–33.8) in Japan and 33.9 weeks (33.3–34.8) in Finland ($r = 0.41$; $p = 0.001$). The PMA for the "respiration criterion" showed no significant difference between the two study sites (median 37.9 vs. 37.0 weeks; $r = 0.18$; $p = 0.13$). The PMA for the "family criterion" was 40.6 weeks (IQR 39.5–41.5) in the NICU in Japan. In most cases in Finland, it was not possible to determine the exact time when the families had met the family criterion, as it had often already been met at some point before the other criteria. In the NICU in Japan, the PMA for the "feeding criterion" was 38.6 weeks (IQR 37.9–39.7), for the "examination criterion" 38.3 weeks (37.6–39.2), and for the "weight criterion" 36.8 weeks (35.8–38.4). These were not used as discharge criteria in Finland.

Table 4
Postmenstrual age at the time when each discharge criterion was met.

Median (interquartile range), weeks	Japan (n = 22)	Finland (n = 49)	r [a]	*P*=
Temperature (No need for mechanical temperature control)	**32.7 (31.7–33.8)**	33.9 (33.3–34.8)	0.43	**<0.001**
Respiration (No need for respiratory support and observation)	37.9 (37.1–39.8)	37.0 (36.4–38.9)	0.18	0.13
Feeding (No need for a feeding tube)	38.6 (37.9–39.7)	NA [b]	NA	NA
Examination (Completion of the neurological evaluation)	38.3 (37.6–39.2)	NA [b]	NA	NA
Weight (> 2200 g)	36.8 (35.8–38.4)	NA [b]	NA	NA
Family (The parents' readiness for caretaking at home)	40.6 (39.5–41.0)	NA [c]	NA	NA
Discharged home	40.7 (39.9–41.3)	**37.9 (36.9–39.0)**	0.58	**<0.001**

[a] The effect size of the Wilcoxon rank sum test.
[b] The feeding, examination, and weight criteria were not used in Finland.
[c] In most cases in Finland, it was not possible to determine when the families had met the "family criterion."

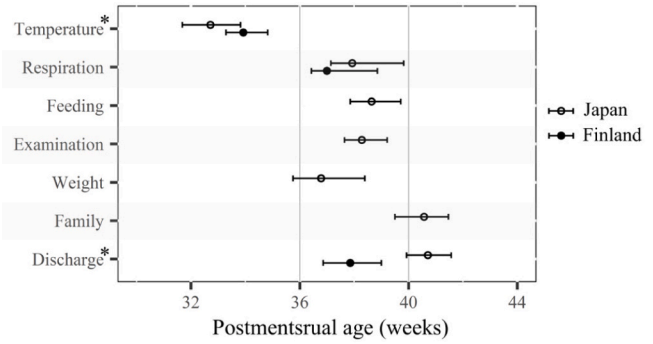

Fig. 2. Postmenstrual age at the time when each discharge criterion was met. The circles and bars indicate medians and interquartile ranges.
* $P < 0.05$ by the Wilcoxon rank sum test.

4. Discussion

To our knowledge, this is the first study comparing the details of discharge criteria applied to preterm infants and their impact on the length of stay. It showed that the longer hospital stay among very preterm infants in the NICU in Japan compared to Finland was mostly related to the lack of parents' readiness and differences in feeding management. Thus, improving the parents' readiness and allowing tube feeding at home would have a remarkable potential to reduce the length of stay in preterm infants.

The three-week difference in the PMA at discharge was consistent with the findings of the previously mentioned international comparison study on preterm infants born below 29 weeks of gestation in 11 networks: the longest length of stay was in Japan and the shortest in Finland [13]. Therefore, we compared the last reason to stay in the NICU in one hospital in each of these two countries and assessed the impact of different criteria on the length of stay.

The lack of the parents' readiness was the most common last reason to stay in the hospital in Japan. One factor extending the length of stay in the NICU in Japan was the practice of having the parents stay at least one night in the family room with their infant shortly before discharge to home to complete their preparation. The parents sometimes had to wait for the opportunity to use the family room. On the other hand, the exact time point when the readiness was reached in the NICU in Finland was not known, as the parents were competent in infant care before the infants met physiological stability requirements. If this had also been the case in the NICU in Japan, the length of stay would have been eight days shorter. This difference between the NICUs in Japan and Finland can be explained by the differences in the NICU environment and the way the parents are prepared for discharge. In the NICU in Finland, most patient rooms accommodated one or two infants, and there was at least one bed for a parent. Recent studies have associated this type of NICU environment with increased parental presence and involvement in infant care [20,21]. The parents' readiness can also be promoted by implementing family-centered care interventions, some of which have been shown to reduce the length of stay in preterm infants [22–27]. Our study suggests that the mechanism through which family-centered care interventions shorten the length of stay is by preparing the parents for discharge. The NICU in Finland has implemented the Close Collaboration with Parents intervention to improve the skills the staff need to collaborate with the parents. This intervention was shown to shorten the length of stay and decrease later unscheduled visits in preterm infants [27]. One of the components of the training focuses on how to support parents to get ready for discharge from the early phase of NICU admission [28]. In this way, the need for support after discharge can be decreased with in-hospital preparation. In addition, the shortening effect on the length of stay was also possibly mediated by the increased presence of the parents [29], which may facilitate the parents' readiness for discharge as they learn to know their infant better and start practicing infant care earlier.

Nevertheless, parents' readiness and the timing of discharge to home are also influenced by the support from society and the medical care after discharge. One study about an early discharge program indicated that support from primary care pediatricians was one of the important factors to stabilize parents' psychological status.[30] Cooperation with organizations inside or outside hospitals that support parents is also essential to successfully promote parents' readiness in NICUs. The follow-up system in these two countries is comparable. We need further research to understand how the socioeconomic and educational background of parents and support from society would affect parents' readiness for discharge from NICUs.

Another notable difference between the NICUs in Japan and Finland was observed in feeding management. In the NICU in Finland, many preterm infants continued tube feeding at home after discharge, whereas in Japan it was not a common practice. In our study, the impact of this difference on the length of stay was nine days. Early discharge with a feeding tube has been encouraged in hospitals in Sweden and Denmark. In both countries, this has resulted in shorter hospital stays [31,32]. A recent survey showed that in the Nordic countries, 86 % of NICUs discharged very preterm infants despite them having a feeding tube [10]. This practice is consistent with the parents' wishes [33]. Some studies have associated early discharge with a feeding tube with fewer respiratory infections and a higher rate of breastfeeding among preterm infants, without causing safety issues [31–34]. It is also important to note that, for early discharge with a feeding tube, the parents need to be confident in their skills related to tube feeding. The NICU staff should appropriately support the development of the parents' skills, which is also part of the family-centered care philosophy.

To evaluate the impact of the different discharge criteria, we need to know when each discharge criterion was met during hospitalization. We found large differences in reaching temperature control, preparing the parents for discharge, and managing feeding support between the NICUs in Japan and Finland. The need for mechanical temperature control continued for longer in the NICU in Finland than in Japan. Preterm infants are usually bundled by several layers of blankets in the NICU in Japan after incubator care, whereas a heating mattress is used in addition to a blanket in Finland. We speculate that this explains the difference in the PMA for the "temperature criterion".

The main strength of our study is that the two cohorts were homogeneous and comparable. This allowed an accurate comparison of the impact of the discharge criteria on the length of stay. In addition, the difference in the length of stay between the two countries in our study was similar to what was reported in an international comparison study[13] even though our study targeted more mature infants. On the other hand, our study did also have some limitations. Our study was conducted in only two NICUs with a limited gestational age group, which may not represent all of the existing variations in discharge practices in each country and at each gestational age. In addition, our study analyzed only those who did not have special medical needs at discharge. Nevertheless, our study offers valuable information since there was a robust effect of discharge practices on the length of stay. This was one of the first studies comparing the details of discharge criteria applied to preterm infants and the impact these criteria have on the length of stay. Therefore, our study is likely to promote a change in Japan so that parents will be prepared earlier to shorten the hospital stay.

5. Conclusion

Our study comparing two NICUs with a three-week difference in the length of stay showed that discharge preparation and practices had a major impact on the length of stay. The length of stay of preterm infants in Japan, and similar neonatal contexts, may be notably reduced by earlier promotion of parents' readiness for discharge and continuing tube feeding at home. Family-centered care interventions, including NICUs with single-family rooms and staff education, could offer effective ways to shorten the length of stay in preterm infants. Further studies are awaited to understand the factors affecting the parents' readiness for discharge from NICUs so that parents can be offered better support.

CRediT authorship contribution statement

Ryo Itoshima: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Venla Ojasalo:** Writing – original draft, Resources, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Liisa Lehtonen:** Writing – review & editing, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors have no potential conflicts of interest to disclose.

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