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Improving Time to First Feeding for Preterm Infants: A Quality Improvement Approach

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ABSTRACT

Introduction: Early initiation of enteral feeding is reported to reduce sepsis and mortality in preterm infants. Less than half of stable infants born <35 weeks gestational age with birth weight <2,000 g are fed within 24 hours of birth at our center. **Methods:** The Specific, measureable, achievable, relevant, timely aim of this quality improvement project was to increase the initiation of enteral feeding within 24 hours of birth from 49% (baseline) to 75% among infants born <35 weeks gestational age with birth weight <2,000 g between November 2022 and December 2023. We identified the unavailability of a mother's own milk as a major barrier to early feeding initiation. Project interventions included antenatal lactation consultation, patient-dedicated breast pumps, standardized feeding orders, and multidisciplinary education. The outcome measure was the time to first enteral feeding, and the balancing measures were the diagnosis of necrotizing enterocolitis (NEC) and the use of formula for first feeding. **Results:** The proportion of infants with feeding initiated within 24 hours of birth increased from 49% to 80% during the project period. The incidence of NEC was unchanged (1.9% before and during the project period). Both before and during the project, feedings were most frequently initiated with pasteurized donor human milk (49.7% versus 58.7%), followed by mother's own milk (37.8% versus 35.6%) and formula (12.5% versus 5.8%). **Conclusions:** This quality improvement project increased the proportion of eligible infants fed within 24 hours of birth without a change in the incidence of NEC or an increase in formula use as first feeding. *(Pediatr Qual Saf 2025;10:e798; doi: 10.1097/pq9.0000000000000798; Published online February 20, 2025.)*

INTRODUCTION

Early initiation and advancement of enteral feeding in preterm infants reduce mortality and sepsis.[1–3] These effects may be mediated by supporting gut maturation, faster attainment of full enteral feeding, and reduction in central venous catheters duration for administering parenteral nutrition.[4–8] Meta-analyses of trials investigating different feeding regimens observed no increase in the risk of necrotizing enterocolitis (NEC) or feeding intolerance with early initiation of enteral feeding, historically a fear among clinicians when feeding premature infants.[1]

Despite the benefits and safety of early feeding initiation, enteral feeding is often delayed in preterm infants.[9,10] On evaluating enteral feeding practice at our center; we determined that although most medically stable preterm infants begin enteral feeding within 72 hours of birth, less than half were fed within 24 hours of birth. We identified reducing the time to first enteral feeding as an important nutritional goal. In November of 2022, we implemented a quality improvement (QI) project aimed at initiating enteral feeding ≤24 hours after birth among medically stable preterm infants. Our target population was infants born <35 weeks' gestation and as per medical center policy, these infants are admitted to and remain in the neonatal intensive care unit (NICU) until discharge.

In preparing for this project, we recognized the provider and family's desire to use the mother's own milk (MOM) as the first feed and its lack of availability in the first few days (**Supplemental Digital Content 1,** which describes the key driver diagram, **http://links.lww.com/**

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PQ9/A642). MOM is protective against gut microbiota alterations and associated with lower risk of NEC and feeding intolerance compared with other feed types, particularly in preterm infants.[11] Therefore, we were mindful of the importance of feeding preterm infants MOM, and the project developed measures to promote the availability of MOM.[8,12–14] Concern for NEC is often a driver of provider hesitation regarding preterm feeding. Hence, we chose the incidence of NEC and frequency of first feeding using formula as balancing measures.

METHODS

Study Setting

We conducted this project at Pennsylvania Hospital, a Magnet-certified urban tertiary-care center in Philadelphia, Pennsylvania, part of the University of Pennsylvania Health System. The hospital serves as the largest maternity center in the city, with ~5,000 annual deliveries and a 50-bed level III NICU. Neonatal care is provided by physicians, neonatal nurse practitioners, and physician assistants. Pasteurized donor human milk (PDHM) is offered to all NICU families as an alternate feeding when MOM is unavailable and used with the family's assent.

Study Population

Eligible infants were born with gestational age (GA) at birth <35 weeks and with birth weight <2,000 g. Exclusion criteria were outborn status, death or transfer at ≤24 hours of birth, hemodynamic instability ≤24 hours of birth defined as the need for >2 normal saline intravenous bolus administrations, and/or inotrope medication administration. This QI project was deemed exempt by the University of Pennsylvania institutional review board. The project adhered to the Standards for Quality Improvement Reporting Excellence (SQUIRE) 2.0 guidelines.[15]

Quality Project Design

The project used the Model For Improvement framework.[16] Before the project start, a division-wide feeding consensus guideline was presented in April 2022; this guideline advocated for feeding initiation within 24 hours of birth for medically stable preterm infants. Our local initiative started on November 1, 2022, when we presented the project goals and linked education to nursing and lactation staff. Approvals were obtained from the Women's Health nursing leadership and the NICU Medical Director, each of which served as executive sponsors of the project. The first plan-do-study-act cycles for the project began on February 1, 2023, and data review continued until December 31, 2023. Updates were provided after each process mapping and team meeting to the NICU quality team which consisted of the Medical Director, Women's Health QI Manager, and nurse managers of the NICU, labor and delivery (LD), and postpartum units (**Supplemental Digital Content 1, http://links.lww.com/PQ9/A642**). We considered study measures from January 2020 to October 2022 as the baseline period with November 2022 to December 2023 as the project period.

Measures

The *specific, measureable, achievable, relevant, timely aim* of this project was to increase the initiation of enteral feeding by 24 hours of birth from 49% (baseline) to 75% among eligible infants by December 2023. The outcome measure was the proportion of infants with time to first feeding (TTFF) ≤24 hours after birth. Enteral feeding was defined as a minimum of 10 mL/kg/d of human milk or formula; oral care or colostrum swabbing were not considered feeding. TTFF was obtained from nursing documentation in the electronic medical record. *Secondary outcome measures* included median CVC days and length of hospital stay. CVC days were defined as the number of days an umbilical venous catheter or peripherally inserted central catheter was present. Length of stay was defined as the number of hospital days until the infant was discharged to home or to another inpatient facility.

Process measures were the proportion of mothers of eligible infants who had an antenatal lactation consultation before birth and the placement of enteral feeding orders for the infant within 24 hours of birth. *Balancing measures* were the diagnosis of Stage II NEC or greater and formula use for first feeding. Disparities in exposure to MOM have been described by race and ethnicity.[17] We analyzed the type of first feeding by race/ethnicity.

Identifying Barriers and Facilitators of Early Feeding Initiation

Before the project (July 1–October 31, 2022), we held multidisciplinary sessions to understand current state and barriers to change. Participants included nurses and leaders from the LD and postpartum units, NICU, and lactation consultants. Root cause analyses identified lack of MOM as a main barrier to initiating feeding within 24 hours of birth (Fig. 1). Challenges to earlier initiation of feeding included: lack of timely ordering of feedings, milk room logistics, pasteurized human donor milk assent processes, and lack of availability of MOM at the first feeding. Barriers to MOM availability were identified as paucity of lactation support for patients in LD due to limited lactation consultant staffing and competing patient care priorities of LD staff.

Interventions

Antenatal Lactation Consultation

Hand expression of MOM in the first hour after birth and use of a breast pump in the 6 hours after birth aid in establishing and sustaining MOM supply.[10,14,18] Furthermore, family education can support breastfeeding intent and reduce anxiety.[18–20] We identified antenatal consults with

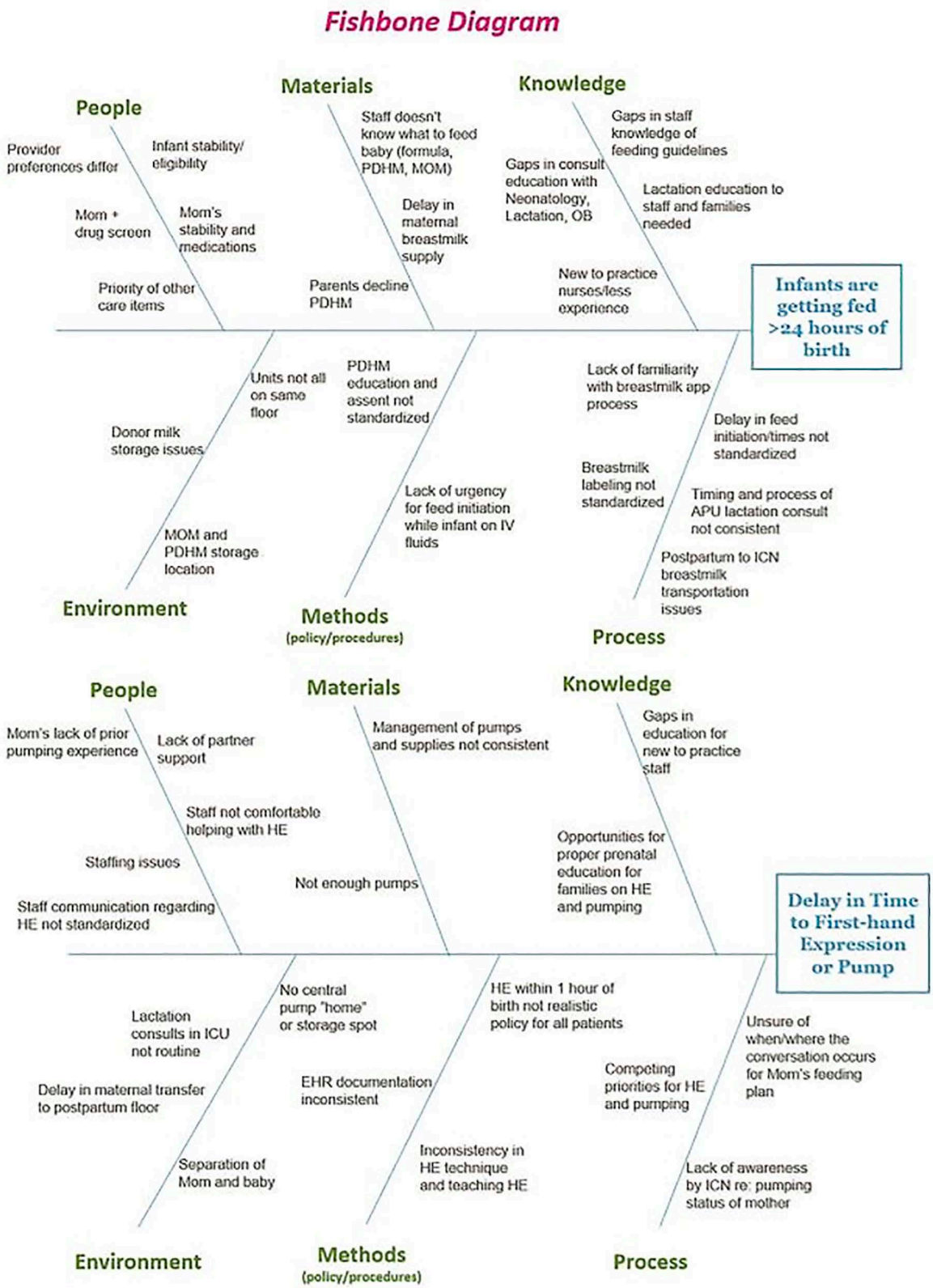

Fig. 1. Fishbone Diagrams. Problem statement listed on the right-hand side and potential root causes contributing to the problem listed in categories. APU: antepartum unit; EHR, electronic health record; ICN, intensive care nursery; ICU, intensive care unit; IV, intravenous; HE, hand expression; OB, obstetrics.

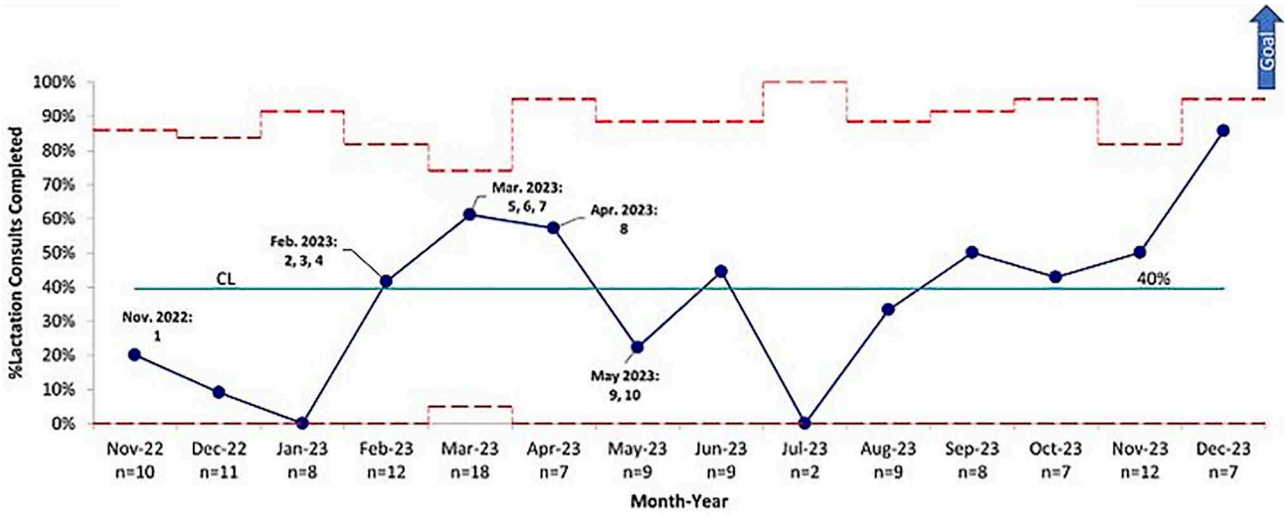

Fig. 2. Percentage lactation consults completed before delivery p chart. The y-axis represents the percentage of lactation consults that were completed before delivery. The x-axis shows the date and number of antenatal consults completed for patients <35 weeks at consult.

a neonatologist as an opportunity to discuss the importance of early human milk feeding for preterm infants with families and initiate antenatal lactation consultation. To remind providers to order antenatal lactation consultation, we modified the antenatal consult note template with a prompt to discuss feeding preferences and place the order if the mother was planning on providing milk. Patients considered appropriate for this were those where delivery was not imminent and in whom it was anticipated that the infant would require intensive care due to prematurity. Additionally, at routine staff huddles, the roles of hand expression within an hour of delivery and first breast pump within six hours were reviewed with LD and postpartum nurses. Each month, project leadership reviewed documentation compliance and shared results with staff.

Breast Pump Accessibility

We identified limited availability of breast pumps and pump supplies as a barrier to initiation of pumping. As the project began, the hospital had about 30 pumps; exact numbers were difficult to ascertain since pumps frequently were missing and were not dedicated to each room. An additional 24 breast pumps were purchased to ensure a dedicated hospital-grade electric pump was present in each (private) postpartum room. Pump supplies were relocated to a central supply closet on each floor.

NICU Standardized Feeding Protocols

Root cause analysis identified knowledge gaps among NICU nurses and providers regarding time to enteral feeding initiation and identified standardized feeding start times as a remedial measure (Fig. 1). We observed that feeding orders placed close to 24 hours of age resulted in delays due to the need to obtain MOM and/or assent for and defrost PDHM. We selected a standardized feeding start time of 6 AM or 6 PM to focus feeding decisions. Birth time reminders were added to the provider sign out sheets when an infant was born. We reinforced guidance] via staff huddles, staff meetings, and email blasts among clinicians and nurses.

Statistical Analysis

Common cause variation was established with preproject data from January 2020 to October 2022. Changes in proportion of infants fed by 24 hours of birth were assessed using statistical process control methods. Provost and Murray[21]'s rules of a shift (8 or more in a row above or below the mean) was used to identify special cause variation. For monthly progress analysis during the project period, run charts and P charts were used to display the TTFF. We wanted to examine the effect of our intervention and therefore chose to change the centerline only after the intervention was active (November 2022). A P chart was used to trend the proportion of eligible neonatology consults (<35 wk gestation) with completed antenatal lactation consults during the project period (Fig. 2). We also compared infant characteristics and other study measures between infants admitted in the preproject period and project period using standard statistical tests and QI Macros software. Finally, we conducted an exploratory analysis of characteristics associated with delayed initiation of feedings in the project period. All statistical tests were done in SAS 9.4 (NC).

RESULTS

From January 2020 to December 2023, 577 infants were born <35 weeks GA with birth weight <2,000 g. Of these, 416 (72%) infants met inclusion criteria; 312 were born before the project period and 104 infants during the project period. The characteristics of the

Table 1. Study Population Characteristics before and after Start of Feeding Initiative

Characteristics*	Before Initiative (January 2020–October 2022)	After Initiative (November 2022–December 2023)	
Maternal Characteristics	**n = 274**	**n = 92**	***P***
Maternal age, y	33 (30, 37)	31 (27, 35.5)	0.02
Maternal race			0.62
Black	138 (50.4)	48 (52.2)	
White	86 (31.4)	23 (25.0)	
Asian	20 (7.3)	9 (9.8)	
Other/more than one race	30 (11.0)	12 (13.0)	
Maternal ethnicity			1.0
Hispanic	30 (11.0)	10 (10.9)	
Non-Hispanic	242 (88.3)	82 (89.1)	
Unknown/missing	2 (0.7)	0 (0)	
Maternal BMI, kg/m^2†			0.16
<25	94 (36.0)	20 (36.4)	
25–29.9	77 (29.5)	10 (18.2)	
≥30	90 (34.5)	25 (45.5)	
Gravidity			0.68
1	86 (31.4)	31 (33.7)	
2 or more	188 (68.6)	61 (66.3)	
Parity			0.88
0	142 (51.8)	45 (48.9)	
1	63 (23.0)	23 (25.0)	
2 or more	69 (25.2)	24 (26.1)	
Preferred language			0.18
English	260 (94.9)	84 (91.3)	
Spanish	13 (4.7)	6 (6.5)	
Other	1 (0.4)	2 (2.2)	
Infant characteristics	n = 312	n = 104	
Delivery mode			0.81
Cesarean	211 (67.6)	69 (66.4)	
Vaginal	101 (32.4)	35 (33.7)	
Time of birth			0.19
Day shift (7 AM–7 PM)	169 (54.2)	64 (61.5)	
Night shift (7 PM–7 AM)	143 (45.8)	40 (38.5)	
Birth weight, g	1,575.0 (1,292.5, 1,780.0)	1,515.0 (1,155.0, 1,762.5)	0.16
Gestational age, wk†	31.9 (30.1, 33.3)	31.6 (29.6, 33.4)	0.40
Female sex	160 (51.3)	56 (53.9)	0.65

*All variables are shown as n (%) or as median (Q2, Q3).

†The outcomes reported exclude 50 patients (13 before treatment and 37 after treatment) who did not have a prepregnancy value BMI available. There were several sets of twins, accounting for the difference in number of mothers vs infants in the study. *P* values obtained from chi-square test, Fisher's exact test or from Kruskall–Wallis test as appropriate.

BMI, body mass index.

population were comparable except a lower mean maternal age during the project period (33 versus 31 y, p 0.02) (Table 1).

Outcome Measures

Proportion of infants with TTFF <24 hours and the average time to first feeding in the statistical process control chart showed special cause variation in the project period (Fig. 3B). Preproject improvement was noted following division-wide nutrition recommendations (April 2022); however, this improvement was increased and sustained during the intervention period. The proportion of infants with TTFF <24 hours increased from 49% to 80% by the end of the project period, exceeding the project aim of 75% (Table 2). The median time to first feeding decreased from 24.2 to 20.3 hours ($P < 0.001$) (Table 2). There was no change in CVC days or length of hospital stay.

Process Measure

Before the QI initiative, antenatal lactation consultation was not routinely sought. During the project period, 40% (51/129) of eligible pregnant patients had lactation consultations completed before delivery. The proportion varied during the project, but in aggregate there was no change (Fig. 2). Median time to first enteral feeding order decreased from 19.4 to 14.1 hours (Table 2).

Balancing Measure

The incidence of NEC Bell Stage II or higher did not change when comparing the periods (Table 2). The overall distribution of feeding type for the first feeding was similar before the project and during the project period with PDHM being the most common feeding type, follow by MOM and formula (Table 2). Formula feeding did not increase in the project period. Among infants fed MOM as their first feed, there was a higher proportion of mothers who identified as White (48.5%) compared with Black (34.2%) and Asian (22.7%) (**Supplemental Digital Content 2,** which describes first feed type in infants by maternal race and ethnicity, **http://links.lww.com/PQ9/A643**). In the postproject period, distribution of race did not change significantly: White (51.7%), Black (29.6%), and Asian (11.1%).

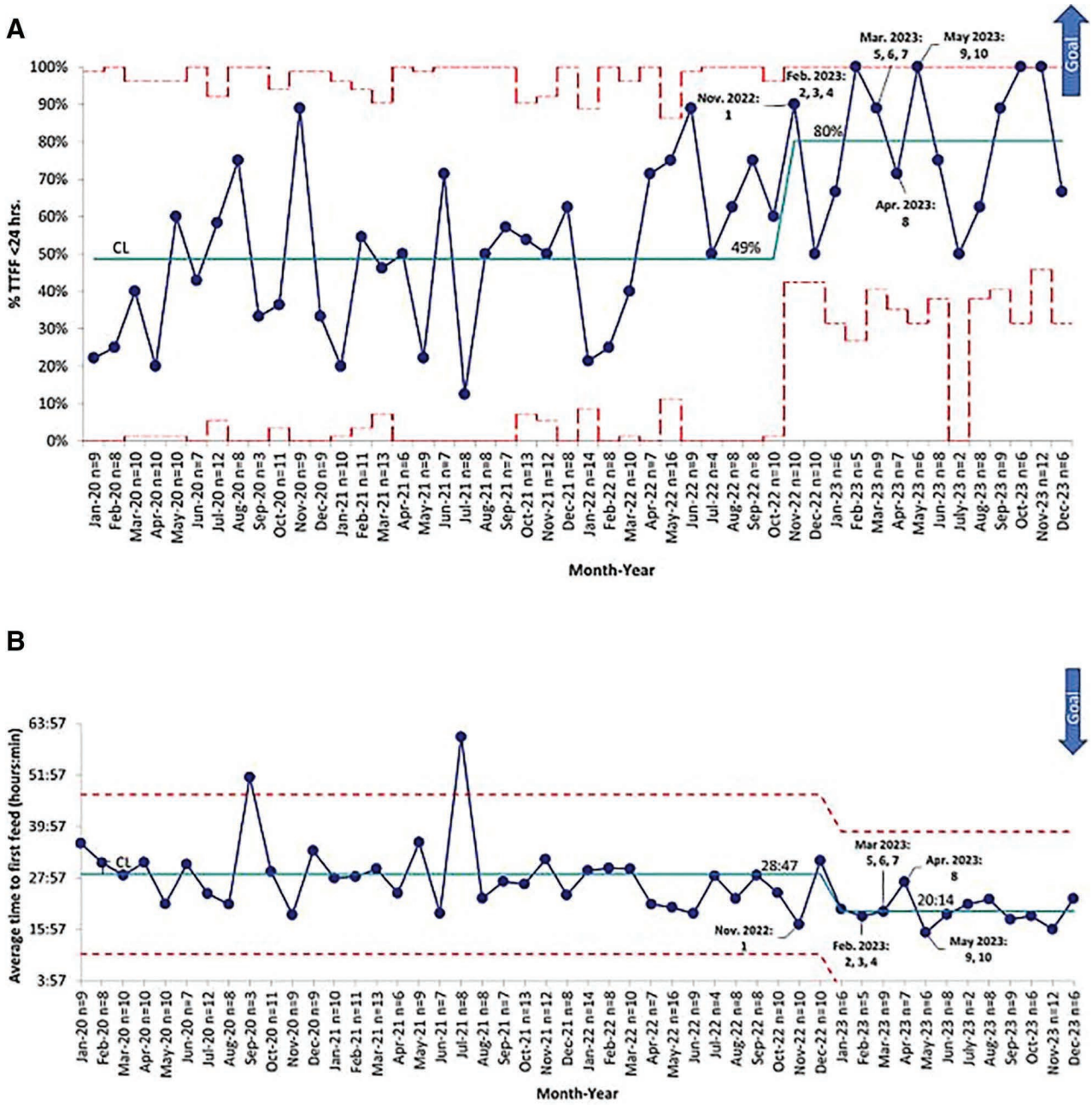

Fig. 3. Statistical process control charts. A, Percentage time to first feeding less than 24 hours p Chart. The y-axis represents the percentage of infants in the cohort that were fed within 24 hours of birth. The x-axis shows the date and number of infants. B, Average time to first feeding by month X chart. The y-axis represents the average time in hours:minutes. The x-axis shows the date and number of infants.

In an exploratory analysis, we compared characteristics of infants with and without feeding initiation within 24 hours of birth (**Supplemental Digital Content 3**, which describes characteristics associated with time to first feed initiation in 24 hours, before and after initiative, http://links.lww.com/PQ9/A644). During the project period, infants with delayed initiation were more frequently (95%) born in day shift (7 AM to 7 PM) compared with those with initiation within 24 hours (54%, $P < 0.001$). Infants with delayed feeding initiation were more frequently born to patients with Spanish as their primary language (15.8%) compared those with initiation within 24 hours of birth (6%, $P = 0.08$).

DISCUSSION

In this single-center QI initiative, we achieved early feeding initiation ≤24 hours after birth in 80% of medically stable preterm infants without significantly impacting use of MOM as first feeding. We recognized the lack of MOM availability as the main barrier to timely feeding initiation and addressed this in each of our intervention

Table 2. Comparison of Outcomes by before and after Initiative

	Before Initiative (January 2020–October 2022), n = 312	After Initiative (November 2022–December 2023), n = 104	*P*
Time to first enteral feed, hours from birth*†	24.2 (19.7–31.6)	20.3 (15.7–22.7)	<0.001
Feed type at first enteral feed (any time)†			0.10
MOM	118 (37.8)	37 (35.6)	
PHDM	155 (49.7)	61 (58.7)	
Formula	39 (12.5)	6 (5.8)	
Infants with time to first feed <24 h	153 (49.0)	84 (80.8)	<0.001
Feed type at first enteral feed when TTFF<24 h			0.11
MOM	51 (33.3)	28 (33.3)	
PHDM	82 (53.6)	52 (61.9)	
Formula	20 (13.1)	4 (4.8)	
First enteral feed order entered, hours from birth	19.4 (12.9, 24.5)	14.1 (9.0, 18.9)	<0.001
CVL (UVC or PICC) line days‡	7 (6-8)	7 (5-9)	0.72
Need for >1 CVL, n (%)	40 (12.8)	15 (14.4)	0.74
NEC§	6 (1.9)	2 (1.9)	1
Length of stay, days	35.0 (20.0–56.0)	34 (19.0–57.0)	0.55

*All variables are shown as n (%) or as median (Q2, Q3).
†Variable not normally distributed. Median and IQR reported. *P* value from Kruskall–Wallis test. This was a post hoc test to determine significance when there are more than 2 variables; none of the *P* values for the individual feed type were significant so individual *P* values were not included.
‡The outcomes reported exclude 197 infants (149 before treatment and 48 after treatment) who did not need CVL.
§NEC was defined as infant having an ICD-10 diagnosis code of NEC Stage II or greater.
CVL, central venous line; ICD-10; NEC, necrotizing enterocolitis; PICC, peripherally inserted central catheter; UVC.

components: increasing the likelihood of MOM availability (antenatal lactation consultation and provision of patient-specific breast pumps), emphasizing the benefits of human milk and early enteral feeding in preterm infants (staff and provider education), and establishing processes for timely administration to eligible infants (standardized unit guidelines on feeding initiation times).

Early initiation of low-volume feeding improves release of gastroenteric hormones, supports gut mucosal nutrition and promotes gut motility.[5–8,21] A systematic review and meta-analysis of 14 randomized control trials comparing early (<72 h) versus delayed feeding found reduction in mortality and infection, and no increase in risk of NEC or feeding intolerance with early feeding.[1] Similarly, in a large cohort study of more than 2,500 very preterm infants, initiation by 24 hours after birth compared with later initiation was associated with reduced rates of infection, feeding intolerance, and postnatal growth retardation and was not associated with the risk of NEC.[22] Given these benefits, early initiation of enteral feedings is often part of nutrition bundles to improve the outcomes of infants admitted to the NICU.[9,23–26] While the recommended timing for initiation varies from "as close to birth as possible" to initiation by day 3, most recommend initiation on day 1.[9,23,24]

We prioritized initiating feedings ≤24 hours to ensure the greatest number of infants benefitted from early enteral feeding, setting them on a path for timely attainment of subsequent nutritional milestones. Similar to a previous QI study, we found that initiating feeding ≤24 hours is feasible for most medically stable infants (80%) without an increase in adverse outcomes.[10] Stefanescu et al[26] reported lower rates (17%) after implementing a nutrition bundle that included initiation in 24 hours along with other recommendations. This may have been due to different patient populations or due to a lack of emphasis on targeting early feeding initiation processes beyond education. Similarly, in a process improvement study at a referral NICU, initiation was recommended within 3 days of birth. The median days to feeding initiation remained unchanged at ~day 3, suggesting that improving time to initiation may be more successful when targeting medically stable infants using day 1 as the target and with implementation of processes dedicated to supporting early feeding initiation.[9]

Type of feeding at initiation is an important consideration, with most guidelines recommending first feeding with human milk and some guidelines explicitly recommend delaying initiation if human milk is unavailable.[23,27] We and others have found that clinicians and families share these views and may be hesitant to initiate if a human milk alternate is not available (Fig. 1).[13] The availability of PDHM has improved options for early initiation; however, reliance on PDHM may reduce total exposure to MOM.[12,13] We therefore tracked type of feeding at as a balancing measure. Previous work shows that improving availability of MOM requires supporting families before birth.[14,28] Despite this, many nutrition guidelines target only measures after birth.

Although not all preterm births afford the time or circumstances for this intervention, when possible, supporting families antenatally can be a key driver to improving MOM availability. In devising explicit strategies to enable this we encountered several challenges. The first hurdle was poor compliance among neonatologists placing lactation consult orders during antenatal neonatology consults. This was initially offset by the project leader monitoring the LD and antepartum unit census and ordering lactation consults when appropriate. She also provided feedback to attendings if an eligible order was missed. To serve as a nudge, we added a hard stop smart phrase to the neonatal consult note stating "a lactation consult was/was not placed after this consult," which improved compliance.

A second hurdle was the increase in requests for lactation consultations. Although buy-in from the lactation group was instrumental in overcoming this hurdle, we were unable to address this challenge completely. The need to prioritize postpartum consultation for mothers of well and NICU infants led to delays in antenatal consultation that remain at this time. Finally, we discovered neither breast pump instructions nor PHDM assent information existed in languages other than English. Culturally tailoring breastfeeding information and support may help reduce breast milk and breastfeeding disparities.[29] In studies prioritizing antenatal education, use of leaflets with pictograms, videos and other non-written material were successful in improving MOM availability and remains a modality we will explore in the future.[19,30]

We identified baseline disparities in provision of MOM similar to that reported at a national level.[14] Although initiation with formula remained low during the project period and the initiative did not increase health inequities, we observed continued differences in both MOM and PDHM by race/ethnicity and primary language like that described by others.[13] These early disparities may contribute to differences in MOM availability at time of discharge. An important next step to equitably improving feeding initiation at our center is to support better written and non-written communication regarding provision of MOM or acceptance of PDHM across all race/ethnicity and language groups.

We identified NEC as a balancing measure and observed no change comparing the preproject period and project period. There is no single factor that accounts for the risk for developing NEC, but low GA, growth restriction and lack of MOM availability are identified risk factors.[31] Future studies could address whether a decrease in NEC might follow efforts to support early feeding initiation specifically with MOM.

Project Limitations

We did not obtain provider feedback when feeding was not initiated within 24 hours or obtain maternal perspectives on the initiative. The relationships between race/ethnicity, GA, maternal age and co-morbidities and provision of MOM are complex and we were unable to perform multivariate analyses to identify independent contributions.

Implications for Practice

This project provides evidence that early feeding is achievable and safe among medically stable preterm infants. The project highlights the importance of dedicated antenatal lactation consultation for high-risk pregnancies; a practice that is not the standard of care at most delivery hospitals. We found that antepartum lactation consultations were key to preparing families, connecting them to resources, and raising awareness of the importance of MOM for preterm infants. Lastly, we recognized that such an initiative demands a cross-unit, multidisciplinary teamwork involving antepartum, lactation, LD, postpartum units and the NICU.

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