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Missed Oral Feeding Opportunities and Preterm Infants' Time to Achieve Full Oral Feedings and Neonatal Intensive Care Unit Discharge

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Abstract

Objective—To examine the association of missed oral feeding opportunities among preterm infants with achievement of full oral feedings and length of hospitalization.

Study Design—A secondary analysis of clinical trial data was conducted. Study infants included in the analysis ($N = 89$) were randomized to one of four standardized feeding progression approaches; detailed records on all feedings were maintained. The proportion of oral feeding opportunities reported as missed due to factors unrelated to the infant's clinical condition was calculated for each infant.

Results—The proportion of missed oral feeding opportunities per infant ranged from 0 to 0.12; 30 infants experienced one or more missed oral feeding opportunity. Each 1% increase in the proportion of missed oral feeding opportunities extended the time to achieve full oral feeding by 1.45 days ($p = 0.007$) and time to discharge by 1.36 days ($p = 0.047$).

Conclusion—Preterm infants' missed oral feeding opportunities may adversely affect feeding outcomes and extend hospitalization.

Keywords

standardized feeding protocol; prematurity; neonatal nursing care; NICU quality; missed care; gavage feedings

Preterm infants' oral feeding competence is a primary consideration for discharge to home from the neonatal intensive care unit (NICU),¹ and delayed transition from gavage to oral

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Conflict of Interest

The authors report no conflicts of interest related to the conduct or results of this research.

feeding is a contributing factor to prolonged NICU hospitalization.^{2–4} Physiological and developmental maturity is a prerequisite to the initiation of oral feedings^{4,5} and multiple studies have shown that oral feeding experience, or the opportunity to maximally orally feed during the transition from gavage to oral feedings, is associated with improved outcomes such as faster achievement of taking all feedings orally and earlier hospital discharge.^{3,6–8}

Oral feeding practices in NICUs are characterized by a high degree of variability^{9,10} and may not be aligned with current evidence that supports allowing infants to feed orally as early and as often as they exhibit signs of oral feeding readiness.^{3,6–8} Typically, oral feedings are scheduled every 2 to 3 hours or prescribed as cue-based when an infant exhibits signs of hunger (e.g., hands to mouth, rooting, lip smacking) or some combination of these two approaches. While physicians and other providers determine when to initiate oral feeds, nurses and parents are primarily responsible for the transition to full feedings by providing infants with increasing oral feeding opportunities until full oral feeding is achieved. In the absence of clinical instability or lack of wakefulness at a scheduled feeding, it is assumed that NICU nurses adhere to feeding schedules and advancement pathways without substituting gavage feedings for oral feedings. Research on this topic is limited, though a retrospective study shows inconsistency in the provision of oral feeding opportunities by nurses in the NICU.⁶ Thus, very little is known about the daily oral feeding experiences that nurses provide to infants during the feeding transition and even less about substitution of gavage feedings for oral feedings in infants who are physiologically stable and making feeding progress, which we refer to as missed oral feeding opportunities.

As part of a clinical trial of oral feeding readiness and progression, preterm infants were randomized to one of four feeding progression approaches; detailed records of all feedings during the entire NICU stay were kept. When these data were examined, the records revealed that some infants received gavage feedings instead of oral feedings in spite of the infant's assignment to a standardized oral feeding progression protocol. These missed oral feeding opportunities were documented by NICU nurses as unrelated to the infant's clinical condition or state of wakefulness at the time of the feeding and instead categorized as missed due to "time-management reasons" or "other reasons." The purpose of this analysis was to examine the association between preterm infants' missed oral feeding opportunities and two important clinical outcomes: the number of days to achieve full oral feedings and NICU discharge. We hypothesized that infants with a higher proportion of missed oral feeding opportunities during a hospitalization would take longer to achieve full oral feedings and have a longer length of stay following oral feeding initiation compared with infants with a lower proportion of missed oral feeding opportunities.

Subjects and Methods

We conducted a secondary analysis of data from a completed clinical trial (Preterms' Readiness and Outcomes at Bottle Feeding, [ClinicalTrials.gov](https://clinicaltrials.gov) no.) of oral feeding readiness and outcomes in preterm infants. The purpose of the trial was to prospectively test four approaches to the transition from gavage to full oral feedings in preterm infants. Within morbidity strata, infants were randomly assigned to one of four feeding approaches: (1) early start/slow progressing experience; (2) early start/maximum experience; (3) late start/

slow progressing experience; and (4) late start/maximum experience. Infants in the early start approaches began the transition to full oral feeding at 32 weeks postconceptional age (PCA) while infants in the late start approaches began the transition to full oral feeding at 34 weeks PCA. Infants in the slow progressing experience approaches had the number of oral feedings offered per day gradually increased in a set pattern over a 14-day period until they were offered eight of eight feedings orally per day. Infants in the maximum experience approaches were offered eight of eight feedings orally per day throughout the 14-day period. The study was reviewed and approved by the institutional review board and parents provided consent for their infant's participation.

A convenience sample was recruited from a 34-bed level III NICU located in an urban academic medical center in the Southeastern United States. Infants were included if (1) the infant's gestational age at birth was less than 32 weeks; (2) the infant was receiving enteral feedings every 3 hours; (3) the infant was medically able to feed orally by 32 weeks PCA; and (4) the parents gave consent for the infant's participation. Infants were excluded if (1) they were unable to begin oral feeding at 32 weeks PCA due to gastrointestinal, craniofacial, cardiovascular, neuromuscular, and/or genetic defects; (2) had surgical necrotizing enterocolitis; or (3) needed ventilator support including nasal continuous positive airway pressure beyond 32 weeks PCA. Infants receiving oxygen by cannula were included. A total of 109 infants were enrolled and 107 were randomized to the four treatment groups. Overall 18 infants were excluded following randomization due to medical condition ($n = 15$) or parent request unrelated to the study ($n = 3$), resulting in data from 89 infants available for analysis. Characteristics of infants included in the analysis are shown in Table 1.

Once oral feedings were initiated, data were collected at each scheduled feeding (generally eight feedings per day) using a paper-and-pencil data collection form with time of feeding noted. These data, collected daily from the day of the first oral feedings until the infant's NICU discharge, included a field for the infant's assigned nurse to record a reason why an oral feeding was not offered according to the study protocol. Infant-related reasons for not offering an oral feeding included respiratory instability, lack of wakefulness, and infant stress/irritability at the time of a feeding. Noninfant reasons for not offering an oral feeding included nurse time management issues or other reasons such as the infant being placed on nil per os (nothing by mouth) status preparatory to a test or procedure, or the infant leaving the unit for a short period of time. However, the nurse was instructed to note such reasons on the data collection form and these feedings were not coded in the database as oral feeding opportunities.

All infants in the study were offered oral feedings with bottles. A small number of infants received some pumped maternal breast milk; there was no donor milk program in the NICU at the time of the study. Some infants were also fed at breast when their mothers were present; this number was very small. In this analysis we focus on protocol-based oral feedings that were not given orally but were rather substituted with a gavage feeding due to time management or other reasons unrelated to the clinical condition of the infant at the time of the feeding. We define these particular feedings as missed oral feeding opportunities because the decision to substitute an oral feeding with a gavage feeding was due primarily to noninfant factors. We determined the total number of missed oral feeding opportunities per

infant by summing the number of feedings coded as not given due to these reasons. We then calculated the proportion of missed feeding opportunities (the primary predictor variable) by dividing the total number of feeding opportunities that were missed by the total number of opportunities (total number of missed opportunities plus oral feedings given). Oral feedings that were substituted due to infant reasons were not counted as oral feeding opportunities because the infant was not considered clinically able to take an oral feeding at that time.

The number of days to achieve full oral feeding was calculated by subtracting PCA at first oral feeding from PCA at full oral feeding. The number of days to NICU discharge from first oral feeding was calculated by subtracting PCA at first oral feeding from PCA at discharge. We controlled for other factors relevant to the outcomes of interest including study group assignment (which accounted for PCA at oral feeding initiation and the number of feedings offered per day according to the progression protocol), PCA at birth (measured in weeks and days), and infant morbidity at the time of study enrollment as measured by neonatal morbidity index (NMI).¹¹ The NMI summarizes infants' medical condition with classifications ranging from 1 for infants born weighing $\geq 1,000$ g and without major complications to 5 for infants born $< 1,000$ g and with very serious complications.

Data were analyzed descriptively using means, standard deviations, medians, and ranges. Univariable regression models were tested to determine associations between individual variables and infant outcomes. Next, we ran standard multivariable linear regression models testing the effects of (1) whether an infant had any missed oral feeding opportunities (0/1 measure) and (2) the proportion of missed opportunities (continuous measure) on outcomes while adjusting for other clinically relevant variables. We conducted posthoc examinations of influential data points. Due to a small number of infants with high proportions of missed oral feeding opportunities, we reran the fully adjusted models using robust linear regression, which weighted all values for their leverage potential and dropped infants with values above a cut point. We present the results of the robust regression models in this article. All analyses were performed using Stata 11.0 (STATA Corp., College Station, TX) and results were considered statistically significant at $p < 0.05$.

Results and Discussion

Descriptive Findings

The analysis was completed on 89 infants who constituted 76% of the original study sample; data were collected on 14,352 oral and gavage feedings starting with the first oral feeding and continuing until discharge. Gavage feedings provided before the initiation of oral feedings were not included in the analysis; no infants were fed orally before their enrollment in the study. Infants' demographic and clinical characteristics were evenly distributed across the four study assignment groups. The median number of days to achieve full oral feedings across the study groups was 13 (range: 0–45 days), and the median number of days to discharge after the initiation of oral feedings was 17 (range: 4–56 days). Of the 13,322 oral feeding opportunities (oral feedings given plus missed oral feeding opportunities), only 90 ($< 0.01\%$) were categorized as missed feeding opportunities and two-thirds of infants ($n = 59$) did not have any missed oral feeding opportunities. The proportion of missed oral feeding opportunities among all infants ranged from 0 to 0.12. We observed no significant

differences in mean gestational age at birth, birth weight, and distribution by sex, group assignment, or morbidity score between infants who experienced missed feeding opportunities and those who did not.

Regression Results

Univariable regression results are shown in Table 2. All variables had significant or near-significant unadjusted effects on both outcomes, and all effects were in the expected direction. We retained all variables except birth weight in the final multivariable linear regression models, which was removed due to collinearity with PCA at birth.

Multivariable regression results of the fully adjusted models examining effects of any missed oral feeding opportunities on outcomes (Table 3) were generally consistent with unadjusted results in effect size and direction. In these models, infants who missed any oral feeding opportunities took 2.86 days longer to achieve full oral feedings ($p = 0.045$) and were hospitalized an additional 5.36 days ($p = 0.003$) compared with infants who had no missed feeding opportunities.

Effects of the proportion of missed oral feeding opportunities as a predictor of preterm infants' days to achieve full oral feedings and days to discharge remained significant in the full model. The final regression coefficients shown in Table 4 indicate that a 1% increase in the proportion of missed oral feeding opportunities extended the time to achieve full oral feeding by 1.45 days ($p = 0.007$), or almost a day and a half after adjusting for important clinical covariates. Similarly, a 1% increase in the proportion of missed feeding opportunities prolonged the time to discharge by 1.36 days ($p = 0.047$). Thus, as the proportion of missed oral feeding opportunities increased, infants took significantly longer to achieve full oral feedings and experienced prolonged hospitalizations.

Discussion

In this analysis, we found that a higher proportion of missed oral feeding opportunities for preterm infants who were progressing on a standardized oral feeding pathway resulted in significant prolongation in the time to achieve full oral feeding and in the time from the initiation of oral feedings to NICU discharge. These findings are generally consistent with existing research demonstrating the importance of maximizing preterm infants' oral feeding opportunities and experiences to achieve desired feeding outcomes^{6,12,13} and are striking given the infrequency of missed opportunities among sample infants. Missed oral feedings represent the loss of opportunity for the infant to master the coordination of feeding responses and behaviors, such as suck-swallow-breathe patterning and intake regulation. Moreover, research has increasingly demonstrated that a predictable approach to common caregiving activities, such as feeding, supports neurological development.^{14,15} Appropriate experiences, including opportunities to feed orally during the critical periods of "learning" may help organize the developing brain and encourage neurological maturation.¹⁶

Feeding care in the NICU is largely the role of registered nurses, who routinely make decisions about the mode of feeding (oral vs. gavage) at the bedside even after oral feeding orders have been initiated by the medical team.¹⁷ While we expect that most real-time decisions about feeding mode are driven by infant condition, our data show that nurses also

make feeding decisions based on noninfant factors such as time management concerns. This is not surprising; orally feeding a preterm infant can take up to 20 to 30 minutes per feeding and requires the nurse to suspend all other patient care activities while holding and feeding the baby. Given that a typical patient assignment in a NICU is two to three infants (who each feed every 3 hours) a nurse could spend between 4 to 6 hours of a 12-hour shift on oral feedings alone, particularly on night shifts when parents are often not present. In contrast, a gavage feeding requires the nurse to remain at the infant's bedside to either initiate a feeding that is administered over a period of time by an infusion pump or to administer the feeding as a gravity bolus. In both gavage approaches, the time required by the nurse to attend the feeding is significantly less than the time needed for an oral feeding, and the nurse can continue other work activities because the feeding can be delivered without the infant being held.

Given the substantial time difference between oral and gavage feeding modes, we posit that oral feedings in the NICU may be substituted with gavage feedings due to nurses' workloads and competing patient priorities at the time of a scheduled feeding. An emerging body of literature supports this view; Hall et al¹⁸ describe the time pressures faced by NICU nurses while providing patient care and the prioritization of "instrumental" tasks over observation of infants and talking to parents. Rochefort and Clark¹⁹ found that NICU nurses ration care, or fail to carry out necessary nursing care activities, such as discharge planning and comfort care when time and staffing resources are limited. Pillay et al²⁰ observed significant reductions in time spent on clinical care per baby in British nurseries when nursing workloads are high, with approximately 17% of essential tasks (including feeding) delayed or missed when workloads exceeded national standards. At last, Kalisch found that nurses' workloads and staffing levels influenced the occurrence of missed care, or necessary nursing that this is omitted either in part or in whole.²¹ Importantly, the amount of time required for a particular task influenced nurses' prioritization of the task, with lengthier tasks assigned a lower prioritization.²¹ We recognize that substitution of an oral feeding with a gavage feeding may be necessary in some situations, and that the time saved is often rationally allocated to another infant whose needs receive higher nursing prioritization (e.g., an infant experiencing clinical deterioration). More research is needed to understand the range of factors associated with nurses' decisions to substitute oral feedings with gavage feedings for infants who are physiologically stable and on the pathway to achieving full oral feedings, including when missed oral feeding opportunities are most likely to occur and under which patient and NICU conditions (e.g., rising unit census).

Reducing variation in feeding practices across NICUs is increasingly recognized as a potential mechanism for reducing NICU length of stay and overall hospitalization costs related to prematurity.¹⁰ The average daily cost of a NICU hospitalization in the United States exceeds \$3,500 per infant.²² Based on our findings, we estimate that missed oral feeding opportunities could have contributed up to \$57,120 (12% of oral feeding opportunities missed, the maximum in our sample) in excess costs per infant due to extended length of stay. This estimate, while gross, provides a starting point for discussions of potential cost savings related to reliable oral feeding care for the thousands of infants born prematurely in this country each year.

There were several limitations to the study. Although, nurses provided a reason for substitution of an oral feeding with a gavage feeding by checking a box on data collection form, we do not fully understand what nurses meant when they selected “time management” or “other” reasons on the data collection form and thus, our hypothesis of nurse workload as a driver of missed oral feedings is speculative until confirmed by further research. The data collection process may have been biased by having nurses complete the data collection form, which can be viewed as self-reported data about the feeding care that was delivered to the baby during a shift. Although, nurses were trained to use the tools,, we are unable to confirm the accuracy of nurses’ reasons for missed oral feedings due to the way data were collected. We were also limited in this analysis by the infrequency of missed oral feeding opportunities; missed opportunities constituted an extremely small proportion of all feedings delivered over the course of the trial and approximately two-thirds of infants had no missed oral feeding opportunities, though it is possible that oral feeding opportunities categorized as missed due to nurse reasons are under reported in our data. Finally, we acknowledge that length of stay can be influenced by other noninfant characteristics such as individual neonatologist discharge practices, the effects of which are unmeasured in the analyses we have presented.

To our knowledge, this study is the first to explicitly examine missed oral feeding opportunities and their relationship to preterm infant outcomes. Further research is needed to understand why preterm infants who are transitioning from gavage to oral feeding are not offered oral feeding opportunities in the absence of physiological or behavioral indicators of nonreadiness to feed, a practice that is incongruent with current evidence. If missed feeding opportunities are related to nurse workloads, then system- level interventions such as staffing patterns that account for the time-intensive nature of oral feedings (e.g., creating staffing assignments based on staggered oral feeding times) and/or NICU policies and environments that promote continuous parental presence and involvement may be useful to maximize infants’ oral feeding experiences for the duration of a hospitalization.

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Table 1

Sample characteristics (*n* = 89)

Infant characteristic	N (%)
Morbidity (NMI) at enrollment	1 (most well)
	20 (22.5)
	2
	16 (18.0)
	3
Study group assignment	30 (33.7)
	4
	8 (9.0)
	5 (least well)
	15 (16.9)
Sex (male)	32 wk/slow progressing
	19 (21.4)
	32 wk/fast progressing
	26 (29.2)
PCA at birth (wk, d)	34 wk/slow progressing
	24 (27.0)
	34 wk/fast progressing
	20 (22.5)
Median (range)	
47 (52.8)	
PCA at birth (wk, d)	
30.5 (24–32)	
Total NICU length of stay (d)	
38 (15–107)	
Days from first oral feeding to achievement of full feeds	
13 (0–45)	
Days from first oral feeding to NICU discharge	
17 (4–56)	
Number of oral feedings received	
115 (35–382)	
Number of missed oral feeding opportunities	
0 (0–19)	
Number of gavage substitutions due to infant reasons	
0 (0–55)	
Proportion of missed oral feeding opportunities	
0 (0–0.12)	
Proportion of missed oral feeding opportunities among infants with at least one missed opportunity (<i>n</i> = 30)	
0.01 (0–0.12)	

Abbreviations: NMI, neonatal morbidity index; PCA, postconceptual age; NICU, neonatal intensive care unit.

Table 2

Univariate regression models for days to full oral feeds and days to discharge after first oral feeding

	Days to full oral feeds		Days to discharge	
	Coefficient (SE)	p-Value	Coefficient (SE)	p-Value
Any missed oral feeding opportunities (0/1)	6.38 (1.80)	0.001	8.54 (2.30)	0.000
Proportion missed oral feeding opportunities	1.51 (0.73)	0.042	1.91 (0.94)	0.045
Morbidity				
Strata 1 (lowest/most well)	reference	–	reference	–
Strata 2	1.48 (2.70)	0.58	0.53 (3.34)	0.87
Strata 3	3.42 (2.33)	0.15	5.39 (2.88)	0.065
Strata 4	6.17 (3.35)	0.069	10.66 (4.15)	0.012
Strata 5 (highest/least well)	8.57 (2.86)	0.004	12.23 (3.54)	0.001
Study group assignment				
32 wk/slow	reference	–	reference	–
32 wk/max	–0.19 (2.33)	0.94	–2.04 (3.00)	0.50
34 wk/slow	–5.01 (2.35)	0.036	–8.74 (3.03)	0.005
34 wk/max	–9.13 (2.48)	0.000	–11.70 (3.20)	0.000
PCA at birth	–1.00 (0.37)	0.009	–1.74 (0.46)	0.000

Abbreviations: PCA, postconceptional age; SE, standard error.

Table 3
Fully adjusted robust regression models testing effects of any missed oral feeding opportunities

	Days to full oral feeds		Days to discharge from first oral feeding	
	Coefficient (SE)	p-Value	Coefficient (SE)	p-Value
Any missed oral feeding opportunities (0/1)	2.86 (1.40)	0.045	5.36 (1.77)	0.003
Morbidity				
Strata 1 (lowest/most well)	reference	–	reference	–
Strata 2	0.65 (1.98)	0.97	0.10 (2.49)	0.97
Strata 3	1.76 (1.91)	0.36	6.04 (2.40)	0.014
Strata 4	4.45 (3.23)	0.17	8.52 (4.07)	0.040
Strata 5 (highest/least well)	1.92 (3.90)	0.62	13.98 (4.91)	0.006
Study group assignment				
32 wk/slow	reference	–	reference	–
32 wk/max	0.97 (1.81)	0.59	–2.02 (2.28)	0.38
34 wk/slow	–2.63 (1.85)	0.16	–6.65 (2.33)	0.006
34 wk/max	–8.96 (1.93)	0.000	–9.77 (2.43)	0.000
PCA at birth	–0.08 (0.57)	0.90	–0.30 (0.72)	0.68

Abbreviations: PCA, postconceptional age; SE, standard error.

Fully adjusted robust regression models testing effects of the proportion of missed oral feeding opportunities

Table 4

	Days to full oral feeds		Days to discharge from first oral feeding	
	Coefficient (SE)	p-Value	Coefficient (SE)	p-Value
Proportion of missed oral feeding opportunities	1.45 (0.52)	0.007	1.36 (0.67)	0.047
Morbidity				
Strata 1 (lowest/most well)	reference	–	reference	–
Strata 2	–0.02 (1.91)	0.99	–0.16 (2.47)	0.95
Strata 3	1.98 (1.85)	0.29	5.39 (2.39)	0.027
Strata 4	4.93 (3.12)	0.12	8.98 (4.03)	0.029
Strata 5 (highest/least well)	1.58 (3.77)	0.68	12.24 (4.88)	0.014
Study group assignment				
32 wk/slow	reference	–	reference	–
32 wk/max	0.74 (1.75)	0.67	–1.93 (2.26)	0.40
34 wk/slow	–2.90 (1.75)	0.10	–7.39 (2.26)	0.002
34 wk/max	–9.59 (1.85)	0.000	–10.25 (2.39)	0.000
PCA at birth	–0.12 (0.55)	0.82	–0.50 (0.71)	0.48

Abbreviations: PCA, postconceptional age; SE, standard error.