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Actual and Potential Impact of a Home Nasogastric Tube Feeding Program for Infants Whose Neonatal Intensive Care Unit Discharge Is Affected by Delayed Oral Feedings

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Objective
To compare healthcare use and parent health-related quality of life (HRQL) in 3 groups of infants whose neonatal intensive care unit (NICU) discharge was delayed by oral feedings.

Study design
This was a prospective, single-center cohort of infants in the NICU from September 2018 to March 2020. After enrollment, weekly chart review determined eligibility for home nasogastric (NG) feeds based on predetermined criteria. Actual discharge feeding decisions were at clinical discretion. At 3 months' postdischarge, we compared acute healthcare use and parental HRQL, measured by the PedsQL Family Impact Module, among infants who were NG eligible but discharged with all oral feeds, discharged with NG feeds, and discharged with gastrostomy (G) tubes. We calculated NICU days saved by home NG discharges.

Results
Among 180 infants, 80 were orally fed, 35 used NG, and 65 used G tubes. Compared with infants who had NG-tube feedings, infants who had G-tube feedings had more gastrointestinal or tube-related readmissions and emergency encounters (unadjusted OR 3.97, 95% CI 1.3-12.7, P = .02), and orally-fed infants showed no difference in use (unadjusted OR 0.41, 95% CI 0.1-1.7, P = .225). Multivariable adjustment did not change these comparisons. Parent HRQL at 3 months did not differ between groups. Infants discharged home with NG tubes saved 1574 NICU days.

Conclusions
NICU discharge with NG feeds is associated with reduced NICU stay without increased postdischarge healthcare use or decreased parent HRQL, whereas G-tube feeding was associated with increased postdischarge healthcare use.

Key words
neonatal intensive care unit, feeding tubes, health-related quality of life, readmission

Abbreviations

COVID-19 Coronavirus disease 2019
G Gastrostomy
HRQL Health-related quality of life
NG Nasogastric
NICU Neonatal intensive care unit
PMA Postmenstrual age

Acquiring full oral skills is a major factor in determining discharge timing for infants in the neonatal intensive care unit (NICU).[1,2] Traditionally, infants remain in the NICU until full oral skills are achieved or a surgical gastrostomy (G) tube is placed. Both options carry risks. Remaining in the NICU carries the stress and cost of prolonged hospitalization and potential for iatrogenic harm; G-tube placement carries operative risks and complications with the tube itself.3, 4, 5, 6, 7 Recently there has been interest in the use of home nasogastric (NG)-tube feedings for neonates, with retrospective studies describing lower rates of readmission and tube-related complications compared with infants with G tubes.8, 9, 10, 11, 12

A home NG program may be an option for hospitals managing their NICU census, or for families who would prefer to attempt oral skill development at home before committing their infant to a surgical procedure. Although oral feeding impacts NICU discharge timing, it is unknown how many infants could be candidates for home NG feedings. For infants who could be discharged with NG feedings yet remain in the NICU to achieve full oral feedings, it is not known how their subsequent NICU length of stay, post-NICU healthcare use, and parent health-related quality of life (HRQL) compares with infants who were actually discharged with home NG feedings or to infants who were discharged with G tubes. For NICUs looking to offer or expand home NG-tube programs, this information would help balance the potential cost savings in NICU length of stay with the cost of designing appropriate outpatient follow-up.

In 2018, our institution began a clinic to centralize care for patients receiving home NG feeds. We sought to prospectively compare healthcare use and parent HRQL for infants who awaited full oral feeds in our NICU, those discharged with home NG feeds, and those discharged with home G-tube feeds and to test the impact of objective home NG eligibility guidelines on NICU days saved and duration of home NG feeds.

Methods

This was a prospective cohort study conducted in our level IV NICU from September 2018 to March 2020. Infants were assessed for eligibility if they had a NICU length of stay of at least 14 days. Infants were excluded if they would not be discharged home with their biological parent to provide study consent, if the parent did not speak English, if the infant had previously been home or was anticipating transfer to the cardiac intensive care unit, or if the infant's imminent death was anticipated. Two consents were signed, one for the infant and one for the parent. The study was approved by the institutional review board of the Children's Hospital of Wisconsin.

Determination of Feeding Group

Once an infant was enrolled, our research team reviewed the chart every week and determined an earliest date of theoretical home NG eligibility. We defined home NG eligibility as at least 36 weeks of postmenstrual age (PMA) and weight of 2 kg; 5 days free of apnea or bradycardia requiring nursing intervention after discontinuation of caffeine; 2 days of temperature stability in an open crib; receiving home respiratory support (either room air, or at or below 0.5 liters per minute nasal cannula); at least 25% of feedings by mouth; age-appropriate weight gain; and without anatomic anomalies precluding NG tube placement. This definition was based on literature and agreed on by a group of physicians, nurses, and advanced practice nurses from neonatology and gastroenterology to represent physiologic stability, reasonable anticipation of acquisition of oral feeding skills, and weight sufficient that the NG tube would be unlikely to obstruct breathing.[1] The research team did not share this theoretical NG eligibility with the clinical team; conversely, NICU practitioners were blinded to patient enrollment.

Although there were strictly defined research criteria for NG eligibility, actual discharge feeding decisions were made at family and clinical discretion. Our institution uses a bridle to secure NG tubes just before NICU discharge (Applied Medical Technology). The intent of the bridle is to decrease the risk of dislodged NG tubes and reduce the need for parent training in placement. There were no separate exclusion criteria for use of a bridled tube, because infants with congenital anomalies precluding NG or bridle placement were not considered NG eligible; however, 4 families who felt more comfortable with NG placement were allowed to elect discharge with NG tubes without a bridle per their preference. Similar to decisions regarding NG tubes, placement of G tubes was made at family and clinical discretion. Infants receiving G-tube placement at our institution generally have consistently <25% oral intake when other criteria for discharge have been met for at least 2 weeks. Patients discharged with either NG or G tubes receive outpatient follow-up in the gastroenterology clinic. Patients with G tubes or NG tubes are seen by a pediatric gastroenterology nurse practitioner with support from a dietitian and a speech and language pathologist. Discontinuing a bridled NG tube requires an outpatient clinic visit for the provider to remove the bridle.

NICU Data Collection

At enrollment, parents answered demographic questions about childcare plans after discharge, access to transportation, race, ethnicity, education, family income, adults living in the home or nearby to help with childcare, parent age, and time to travel from home to the hospital campus. We reviewed each infant's electronic health record for NICU clinical characteristics including gestational age, birth weight, multiple gestation, congenital or chromosomal anomaly, days of mechanical ventilation, surfactant, postnatal systemic steroids, positive blood cultures, vasopressor drips, treatment for seizures, treatment for hypoxic–ischemic encephalopathy, abnormal brain imaging (grade 3-4 intraventricular hemorrhage on cranial ultrasound scan, hydrocephalus, white matter injury or infarct on imaging), ventriculoperitoneal shunt or reservoir, age at discharge, number of medications and specialist appointments at discharge, and respiratory support at discharge. For infants designated home NG eligible, we recorded the proportion of feeds taken orally at the time of first NG eligibility and the days from first NG eligibility until NICU discharge. For the remainder of that infant's NICU stay, we recorded any inpatient management that would have resulted in readmission if that infant had been discharged

home. These included intravenous antibiotics, escalation of respiratory support above baseline, unplanned surgical procedures, or return to an isolette or radiant warmer.

Healthcare Use after NICU Discharge

For 3 months after NICU discharge, we used manual chart review to record each readmission, emergency department, and acute care encounter. We classified readmissions as scheduled (such as a planned surgical procedure) or unscheduled; we classified all encounters by whether they were primarily feeding/feeding-tube related. Feeding-related or feeding tube–related encounters included tube replacement, site bleeding or infection, failure to thrive, poor weight gain, or feeding difficulties. At 3 months after NICU discharge, we recorded each patient's feeding status: all oral feeds, still receiving NG feeds, or G tube placement. Due to the coronavirus disease 2019 (COVID-19) pandemic delaying nonemergent procedures toward the end of this study, we reviewed the charts of all patients still receiving NG feeds for an additional 3 months to determine whether plans were underway for G-tube placement and classified that infant's feeding status by what would have happened in a nonpandemic healthcare scenario. Parents were contacted 3 months after NICU discharge to confirm healthcare encounters within our system and to add additional healthcare encounters outside our system.

Parent-Reported Outcomes after NICU Discharge

Parents reported their HRQL using the PedsQL Family Impact Module, a validated 36-item measure assessing how a child's illness affects the parent's physical, emotional, social, and cognitive functioning, communication, worry, daily activities, and family relationships.[13] Scores are transformed to a 0-100 scale, with greater scores indicating greater HRQL. Subscores are reported on the same scale, so that greater subscores indicate less trouble with functioning, worry, or relationships. Parents of infants discharged with tube feedings, either NG or G tube, were asked to rate on a 5-point Likert scale the extent to which the following issues were a problem for them at home: tube coming out, wanting to discontinue use earlier than recommended, problems getting equipment, problems with a feeding pump, or skin issues. We asked all parents to rate on a 5-point Likert scale how prepared they felt for discharge, and to answer in an open-ended response what could have been done to better prepare them.

Statistical Analyses

We compared demographic and NICU illness characteristics of infants in 3 groups: NG eligible but discharged with full oral feeding (“oral feeding”), NG eligible and discharged with home NG (“home NG”), or G tube. Bivariable comparisons were made by χ^2 or Fisher exact tests for differences in proportions, or Kruskal–Wallis tests for differences in medians. For 3-month healthcare use and parent HRQL, we compared outcomes of infants discharged with NG and G tubes to infants discharged with oral feeding by logistic and linear regression analysis, both unadjusted and then adjusted for clinical characteristics which were significantly different between feeding groups at $P < .05$; for HRQL comparisons we also adjusted for unscheduled readmission or emergency department encounters. We omitted some variables from inclusion in regression models based on collinearity and chose similar covariates across all outcomes to facilitate comparisons. We compared parent-reported tube issues by grouping responses into 3 categories based on number of responses (not a problem, small–moderate problem, large–severe problem) and comparing differences in proportions by χ^2 or Fisher exact tests.

Finally, we estimated the NICU days saved by discharging patients with NG tubes, assuming that the days to oral feeding would be the same in the NICU as at home. Infants discharged with NGs who were not all orally fed by the end of the study were treated as 90 days of NG feeding, assuming a G tube was placed 3 months after discharge (G-tube placement timing was variable toward the end of the study period due to COVID-19 delaying elective surgeries). To estimate potential additional NICU days that could be saved by applying gestational age-based criteria for NG discharge, we again assumed that NG feeding days would be the same in the NICU and at home, and calculated the total number of NG feeding days from first theoretical home NG eligibility to home discharge for infants who were discharged with oral feeding. A *P* value of .05 was accepted for statistical significance.

Results

We enrolled 333 infants; 319 were eligible for follow-up (Figure 1); 80 infants were discharged with oral feeding, 35 infants were discharged with NG tubes, and 65 infants were discharged with G tubes; none met NG eligibility criteria due to proportion of oral feeding. Chart review was completed at 3 months on all 180 infants; parent-reported data were completed for 145 (81%). There were no differences in NICU illness severity between infants whose parents did versus did not complete 3-month follow-up.

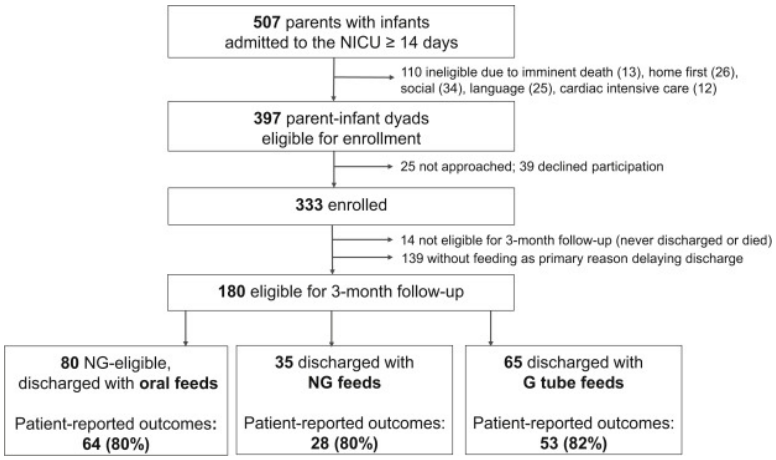

Figure 1. Study cohort.

Table I shows NICU illness differences between infants discharged with full oral intake, NG tubes, and G tubes. There were significant differences between groups, including the presence of a congenital or chromosomal anomaly, multiple consultants involved in the infant's care, days of mechanical ventilation, use of postnatal systemic steroids, use of vasopressors, abnormal brain imaging, and discharge support medications and appointments. Infants with G tubes had the greatest proportions of these illness measures, followed by infants with NG tubes. Infants discharged with NG feeds were older than those with full oral feeding by a median 4 weeks of corrected age and younger than those discharged with G tubes by a median 6 weeks of corrected age. Family demographic characteristics were similar between feeding groups (Table II; available at www.jpeds.com).

Table I. NICU clinical characteristics

Characteristics	**Oral feeds**	**NG tube**	**G tube**	**All**	***P* value**

n	80	35	65	180	
Gestational age, wk					
22-24	1 (1%)	3 (9%)	10 (15%)	14 (8%)	<.001
25-28	13 (16%)	4 (11%)	26 (17%)	34 (19%)	
29-33	42 (53%)	10 (29%)	6 (9%)	58 (32%)	
34+	24 (30%)	18 (51%)	32 (49%)	74 (41%)	
Birth weight, g	1795 (1250-2295)	2510 (990-3370)	1664 (820-2540)	1840 (1025-2648)	.057
Congenital anomaly					
Yes	12 (15%)	7 (20%)	30 (46%)	49 (27%)	<.001
Chromosomal anomaly					
Confirmed	2 (3%)	5 (14%)	19 (29%)	26 (14%)	<.001
Suspected	7 (9%)	3 (9%)	6 (9%)	16 (9%)	
Surgical procedure					
Yes	12 (15%)	9 (26%)	65 (100%)	86 (48%)	<.001
Multiple consultants					
Yes	35 (44%)	30 (86%)	65 (100%)	130 (72%)	<.001
Days of mechanical ventilation					
0	48 (60%)	16 (46%)	12 (18%)	76 (42%)	<.001
1-7	20 (25%)	7 (20%)	12 (18%)	39 (22%)	
8-30	8 (10%)	5 (14%)	10 (15%)	23 (13%)	
>30	4 (5%)	7 (20%)	31 (48%)	42 (23%)	
Abnormal brain imaging					
Yes	4 (5%)	7 (20%)	21 (32%)	32 (18%)	<.001
Age at discharge, d	39 (30-59)	52 (27-88)	108 (59-196)	57 (35-107)	<.001
Corrected gestational age at discharge, wk	38 (37-40)	42 (40-44)	48 (45-54)	42 (38-47)	<.001
Number of medications at discharge					
0	59 (74%)	17 (49%)	5 (8%)	81 (45%)	<.001
1-2	17 (21%)	9 (26%)	23 (35%)	49 (27%)	
3+	4 (5%)	9 (26%)	37 (57%)	50 (28%)	
Specialist appointments after discharge					
≤1	31 (39%)	0	1 (2%)	32 (18%)	<.001
2-3	32 (40%)	7 (20%)	5 (8%)	44 (24%)	
4+	17 (21%)	28 (80%)	59 (91%)	104 (58%)	
Respiratory support at discharge					
Room air	66 (83%)	28 (80%)	22 (34%)	116 (64%)	<.001
Home oxygen	14 (18%)	7 (20%)	21 (32%)	42 (23%)	
Tracheostomy	0	0	22 (34%)	22 (12%)	

HIE, hypoxic–ischemic encephalopathy.

Shown are clinical characteristics between infants who were discharged after awaiting full oral feeds and those who were discharged with NG and G tubes. *P* values indicate χ^2 or Fisher exact tests, or Kruskal–Wallis tests, as appropriate. Abnormal brain imaging refers to an infant with either grade 3-4 intraventricular hemorrhage, hydrocephalus, white matter injury, or infarct on ultrasound or magnetic resonance imaging scan. Data not shown include variables not different between discharge feeding groups at $P > 0.2$, including multiple gestation, surfactant, positive blood culture, and ventriculoperitoneal shunt placement.

On the day of first NG eligibility, infants discharged with oral feeding had a greater proportion of oral feeds (median 51%, IQR 36%-64%) than infants discharged with NG tubes (median 38%, IQR 25%-48%, *P* = .004). The number of days from first NG eligibility until discharge was clinically similar although statistically different (oral feeding discharge, median 9 days until discharge, IQR 7-14 days; NG discharge, median 8 days until discharge, IQR 3-10 days; *P* = .011). For the 115 infants who were eligible for NG, in the time between NG eligibility and discharge there were no surgeries or procedures, hypothermia requiring a warmer, apnea or bradycardia requiring positive pressure ventilation, or aspiration events. There were no issues with NG tubes or bridles obstructing breathing, causing skin breakdown, or needing replacement during this period of the NICU stay. There was one potential new diagnosis; an infant born late preterm on full ad lib oral feedings had an overnight abdominal radiograph taken for abdominal fullness the day before anticipated discharge, which was read as possible pneumatosis. There was one increase in respiratory support; an infant born preterm with bronchopulmonary dysplasia on home oxygen had an overnight increase in respiratory support, with negative infectious workup and no further issues.

Table III depicts infant acute healthcare use and parent HRQL 3 months after NICU discharge. Infants discharged with G tubes had the greatest proportion of unscheduled readmissions and emergency department encounters. Infants with NG tubes did not have significantly greater proportions of these encounters than infants discharged with oral feedings, either in unadjusted or adjusted comparisons. There were relatively few feeding or tube-related encounters in the oral and NG-tube feeding groups. Among the infants discharged with oral feeding, there was 1 patient with multiple encounters for failure to thrive and 3 patients with encounters for constipation or vomiting. Among infants discharged with NG tubes, there was one emergency encounter for bridle-related issues that did not result in admission, 2 emergency encounters for reflux symptoms, and 1 infant with complex gastroschisis receiving an exploratory laparotomy. Among infants discharged with G tubes, 22 had acute encounters, 19 of which were directly related to G-tube dislodgement, bleeding, or complications. Among parents of infants discharged with NG tubes, there was no significant difference in HRQL compared with parents of infants discharged with oral feeding or G tubes. Feeding type was associated with significant differences in parent worry at 3 months, but the statistical significance disappeared after multivariable adjustment.

Table III. Acute healthcare use and parent HRQL 3 months after discharge

Healthcare use outcome (n = 180)	**Feeding type**	**n (%)**	***P* value**	**OR (unadjusted)**	***P* value**	**OR (adjusted)**	***P* value**
Unscheduled readmission or emergency department	Oral	4 (5%)	**<.001**	0.41 (0.10-1.73)	.225	0.43 (0.09-2.15)	.306

encounter – GI or tube related							
	NG tube	4 (11%)		REF		REF	
	G tube	22 (34%)		**3.97 (1.24-12.7)**	**.020**	**4.65 (1.20-18.1)**	**.027**
Unscheduled readmission – GI or tube-related	Oral	1 (1%)	.138	0.21 (0.03-2.38)	.207	0.39 (0.02-7.78)	.540
	NG tube	2 (6%)		REF		REF	
	G tube	5 (8%)		1.38 (0.25-7.48)	.713	1.02 (0.11-9.63)	.989
Emergency department encounter – GI or tube-related	Oral	4 (5%)	**<.001**	.56 (0.12-2.65)	.466	0.47 (0.09-2.59)	.385
	NG tube	3 (9%)		REF		REF	
	G tube	19 (29%)		**4.41 (1.20-16.1)**	**.025**	**5.68 (1.17-27.6)**	**.031**
Unscheduled readmission or emergency department encounter – all causes	Oral	23 (29%)	**.001**	0.61 (0.26-1.39)	.237	0.71 (0.27-1.88)	.490
	NG tube	14 (40%)		REF		REF	
	G tube	38 (58%)		2.11 (0.92-4.88)	.080	0.80 (0.27-2.33)	.680

HRQL outcome (n = 143)	**Feeding type**	**Median (IQR)**	***P* value**	**HRQL difference (unadjusted)**	***P* value**	**HRQL difference (adjusted)**	***P* value**
Total score	Oral	77 (65-86)	**.038**	+5 (−4 to +13)	.273	+5 (−4 to +15)	.251
	NG tube	69 (55-87)		REF	REF	REF	
	G tube	68 (49-81)		−5 (−13 to +4)	.285	−1 (−12 to +10)	.888
Worry subscore	Oral	90 (70-100)	**<.001**	**+11 (+1 to +21)**	**.028**	+8 (−2 to +18)	.105
	NG tube	80 (63-95)		REF	REF	REF	
	G tube	60 (48-80)		**−14 (−23 to −4)**	**.009**	−3 (−14 to +9)	.685
Social functioning subscore	Oral	75 (56-100)	**.049**	+3 (−9 to +14)	.641	+1 (−12 to +14)	.865
	NG tube	69 (56-94)		REF		REF	

	G tube	63 (35-88)		−10 (−22 to +2)	.094	−8 (−23 to +8)	.322

GI, gastrointestinal.

Shown are readmissions, emergency department encounters, and parent HRQL by 3 months after discharge, by discharge feeding type. N (%) shows proportions, with *P* values indicating χ^2 tests across all 3 groups. For healthcare use outcomes, the aOR reports results after adjustment for gestational age, ventilator days, presence of congenital or chromosomal anomalies, abnormal neuroimaging, discharge respiratory support, and day of life at discharge. For parent quality of life, the HRQL difference reports linear regression results before and after adjustment for the same illness covariates as well as whether that infant had an unscheduled readmission. Numbers in bold highlight results with $P < .05$. Parent HRQL was measured by the PedsQL Family Impact Module; total and subdomain scores are transformed to a 0-100 scale, with greater values indicating higher quality of life.

Table IV (available at www.jpeds.com) shows parent responses to questions about feeding difficulties 3 months after discharge. In response to "How prepared did you feel leaving the NICU?" parents of infants discharged with G tubes were less likely to report feeling moderately or very well prepared, compared with parents of infants discharged with oral feeding or NG tubes. When asked "What more could have been done to help you feel more prepared?" all parents of infants discharged with oral feeding said that they felt very well prepared; one said her infant still needed a lot of assistance feeding. Similarly, almost all parents of infants discharged with NG feeds said they felt very well prepared; one would have preferred to adapt the infant's feeding schedule a little bit more before discharge. Twelve parents of infants discharged with G tubes commented that they would have appreciated more organization and setup with tube feeding supplies before discharge. Table IV also shows parent-reported tube feeding issues in the 3 months after discharge. Parents of infants with NG tubes were less likely to report skin issues than parents of infants with G tubes; otherwise, there were no significant differences between groups reporting problems with tube dislodgement, pump, or equipment issues. For parents of infants with NG tubes, other concerns included one misplaced NG tube (which did not result in an acute event), one complaint of the infant having irritation and discomfort with the tube, and one report of difficulty with breathing and eating with upper respiratory tract infections. For parents of infants with G tubes, there were 4 reports of leaking around the tube site, 2 complaints of problems securing the tube, and 1 complaint of pain around the tube site.

By 3 months after NICU discharge, 27 of 35 (77%) infants discharged with NG tubes had progressed to full oral feeds; of the remaining 8 infants, 3 received G tubes during the study period, and an additional 3 were scheduled to receive a G tube although the surgery itself was delayed. The median duration of NG use was 29 days. Figure 2 displays reductions in NICU days, first for infants actually in our home NG program, and then the potential impact of theoretical gestational-age-based criteria for NG discharge. Patients discharged with NGs in our program saved 1574 NICU days. Had we theoretically discharged all eligible infants at 40 weeks of PMA in addition to our actual patients receiving NG feedings at home, 1679 NICU days would have been saved; theoretically discharging all eligible infants at 36 weeks of PMA increased the NICU days saved to 2454. No infants who were ultimately discharged with G tubes were included in this theoretical analysis, since they had not been initially considered NG eligible due to either anatomical reasons or low proportion of oral feeds. Allowing theoretically eligible infants to be discharged with NG feeds would reduce home NG feeding duration from 29 to 12 days.

Patients discharged, n	35	45	59	115
Home NG days, median (IQR)	29 (26-87)	29 (10-63)	19 (9-43)	12 (7-26)

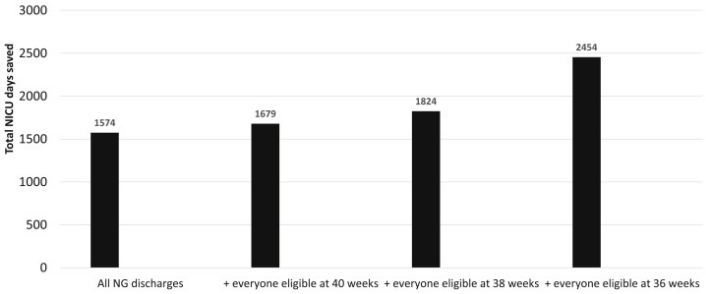

Figure 2. Actual and potential reductions in NICU stay by use of a home NG program.

Discussion

We found that although infants with G tubes had greater proportions of acute healthcare encounters, infants discharged with NG tubes did not have greater proportions of acute healthcare encounters than infants discharged from the NICU on full oral feeds. Similarly, we found that parents of infants with NG tubes did not report different HRQL than parents of infants discharged on full oral feeding. Parents of infants with NG tubes reported feeling well prepared to care for their infant after NICU discharge, without more tube-specific issues, than parents of infants with G tubes. We estimate that our center's home NG program saved 1574 NICU days, with potential for further reductions based on objective criteria.

One difficulty in beginning a home NG program is trying to determine eligibility. All NICU discharge planning requires a combination of physiologic stability, appropriate outpatient supports in place, and parent readiness.[1] When describing home NG discharge criteria, previous studies describe physiologic stability and provider consensus that the infant is appropriate for discharge.[11,14] By testing a set of explicit NG criteria apart from the clinical team, we found that one-third of infants enrolled in our study could have been home NG eligible. In practice, most infants discharged with NG tubes were discharged about a week after they met discharge criteria, likely due to a combination of provider hesitancy or unfamiliarity with a novel program, coordinating discharge care needs, and continued progress with oral skills. Reassuringly, infants who met our research criteria had almost no issues that would have required readmission had they been at home. This finding adds support both for our own providers and for other centers considering their own inclusion criteria.

Infants requiring feeding tubes after NICU discharge have been shown to have more emergency encounters and inpatient readmissions than infants discharged with oral feeding.[3,14,15] Although widely variable, most infants receiving feeding assistance after the NICU are discharged with G tubes.[16,17] Like other studies, we noted that infants receiving feeding assistance at discharge were mostly infants born late preterm and full-term with anomalies, or infants born extremely preterm with complications from prematurity itself.[3,14] Traditionally, there have been concerns about discharging infants from the NICU with NG tubes due to the risks of malposition with replacement.[18] However, Khalil et al found that compared with infants with G tubes, infants discharged with NG tubes were less likely to experience tube-related admissions or emergency department visits.[9] More programs are now reporting positive experiences with home NG programs.9, 10, 11, 12,[19] Our study adds to this growing literature by

comparing outcomes for infants discharged with G tubes and NG tubes to a unique reference group of infants who could have been discharged with home NG feeds but who instead remained in the NICU until achieving full oral feeding. Another unique feature of our study was the inclusion of patient-reported outcomes. Because parent well-being can be negatively impacted by infants' healthcare use needs after NICU discharge, our findings add confidence that home NG programs can be a reasonable alternative to prolonged NICU length of stay from a family perspective.[20]

We estimate that our home NG program saved more than 1500 NICU days in the first 18 months after its inception. Implementing a home enteral feeding transition program in one center increased the use of NG tubes and reduced NICU length of stay.[10] In that study, as with our clinical practice, inpatient care and discharge decisions were guided by a protocol but left to clinician and family discretion. Our study extends those findings by examining the potential for additional reductions in NICU stay. Reducing a NICU stay has positive and negative potential consequences for families and healthcare systems. For families, having their infant at home takes away the comfort of an experienced bedside nurse and daily access to speech therapists but can also enable them to provide more consistent feeding and therefore quicker weaning from NG tubes.[12] To ensure a successful home NG program, expectations for hospital discharge need to match the structure of appropriate outpatient follow-up. We found that infants discharged with home NG feedings had a median time to achieving full oral feeds of 29 days; this timeline is similar to other programs.[8,12] As centers like ours shift to more liberal use of home NG at discharge, we will need to maintain responsive outpatient follow-up and support for parents and clinicians caring for these infants in the community setting. Since beginning our home NG program, our institution has increased our access to enteral feeding providers 24/7 for troubleshooting, hoping to centralize tube-related care and reduce the number of emergency room visits for NG- or G tube–related issues. A subset of our population achieved full oral intake 9-10 days after becoming NG eligible; this cohort will benefit from being able to make quicker appointments for NG removal, because the bridle requires removal by an experienced healthcare provider. We also continue to anticipate the needs of more complex patients discharged with NG feeds, like those reported in programs for medically complex infants, infants with BPD, and infants whose families or specialist providers choose to defer G tube placement for a variety of reasons.[10,19,21] A team from Cincinnati found that most infants attaining full oral feeds had done so by 60 days of age; more complex infants may be less likely progress to full oral feeds and will need consideration of G tube placement.[12] One issue hopefully unique to our study is that 3 infants who needed G tubes toward the end of the study period were unable to receive them in a timely fashion due to COVID-19 delaying elective procedures. Regardless of the pandemic-related delay, a sustainable home NG program needs a streamlined approach to obtaining G tubes for infants who need them. Our next steps are to consolidate the teams caring for tube-fed patients into one program to increase outpatient access for all families, and lessen the steps between home NG feeds and G-tube placement for infants who do not progress to oral skills.

Strengths of this study include prospective data collection, including all infants theoretically eligible for a NG program, inclusion of healthcare use and parent-reported outcomes, and the high degree of follow-up. We acknowledge several limitations. We used a bridle to secure the NG tube, so our parent training and outpatient needs may differ from a center who does not use such a device. We did not enroll non–English-speaking families due to limitations in our ability to collect patient-reported

outcomes data; future studies need to include non–English-speaking families, especially regarding complex home health needs, as the potential for language barriers limiting access to healthcare is an important consideration. Although we had a reasonable degree of 3-month follow-up, we are missing parent-reported data for 20% of infants in this study. Although we obtained chart review on all patients and confirmed 80% of visits by phone or electronic follow-up, and our health system is the only regional location for pediatric subspecialty care for tube feeding related issues, we still may have missed some encounters at locations outside of our health system. We chose 3-month follow-up to match the timeline for anticipated G-tube placement in our clinical guidelines, but because most infants who had NG-tube feedings had progressed to oral feeding by this point, a shorter HRQL follow-up time frame may have captured additional differences in HRQL. In addition, a longer follow-up period beyond 3 months would have allowed us to capture more detail, especially on infants with home NG feedings who did not progress to full oral feeds by 3 months. Nonemergent encounters may have been lower toward the end of the study due to the COVID-19 pandemic. We assumed that the pace of acquiring full oral skills would be the same in the hospital as at home, which may not be the case. Single-center studies are unlikely to provide definitive safety evidence when harms are thankfully rare events; rather, they highlight the opportunity for a multicenter prospective evaluation of home NG feedings.

In conclusion, infants discharged from a level IV NICU using home NG-tube feedings had similar healthcare use and parent HRQL as infants who were theoretically eligible for home NG feeds but awaited full oral feeds in the NICU. Increasing use of home NG feeds to facilitate NICU discharge has the potential to further reduce NICU length of stay while also attending to parental HRQL. These benefits need to be balanced against outpatient follow-up needs in eligible patients.

Appendix

Table II. Demographic characteristics of the cohort

Variables	**Oral feeds**	**NG tube**	**G tube**	**All**	***P* value**
n	80	35	65	180	
Responding parent					
Mom	78 (98%)	33 (95%)	64 (98%)	175 (97%)	.430
Preferred mode of contact					
Phone	21 (26%)	11 (31%)	23 (35%)	55 (31%)	.466
Email	56 (70%)	24 (69%)	38 (58%)	118 (65%)	
Mail	2 (3%)	0 (0%)	4 (6%)	6 (3%)	
Race of mother					
Black	20 (25%)	4 (12%)	23 (35%)	47 (26%)	.102
White	51 (64%)	29 (85%)	37 (57%)	117 (65%)	
Asian	2 (3%)	0	3 (5%)	5 (3%)	
American Indian	1 (1%)	0	0	1 (0.6%)	
Mixed/other	6 (8%)	1 (3%)	2 (3%)	9 (5%)	
Ethnicity of mother					
Hispanic	8 (10%)	3 (9%)	7 (11%)	18 (10%)	1.000
Highest level of education					

Less than high school	4 (5%)	1 (3%)	5 (8%)	10 (6%)	.575
High school graduate	15 (19%)	4 (11%)	14 (22%)	33 (18%)	
Some college	18 (23%)	10 (29%)	20 (31%)	48 (27%)	
College graduate	33 (41%)	18 (51%)	22 (34%)	73 (41%)	
Graduate school	10 (13%)	2 (6%)	4 (6%)	16 (9%)	
Transportation access					
Drive own car	67 (84%)	31 (89%)	50 (77%)	148 (82%)	.515
Get a ride	9 (11%)	4 (11%)	12 (18%)	25 (14%)	
Bus or taxi	4 (5%)	0	3 (5%)	7 (4%)	
Adults living in the home					
Single parent	10 (13%)	3 (9%)	4 (6%)	17 (9%)	.729
Parent + 1	65 (81%)	30 (86%)	55 (85%)	150 (83%)	
>2 adults	5 (6%)	2 (6%)	6 (9%)	13 (7%)	
Adults nearby to help					
No help	6 (8%)	3 (9%)	9 (14%)	18 (10%)	.772
1-2 adults	25 (31%)	11 (31%)	21 (32%)	57 (32%)	
>2 adults	49 (61%)	21 (60%)	35 (54%)	105 (58%)	
Other children living at home					
First child	34 (43%)	10 (29%)	23 (36%)	67 (37%)	.656
1 other	22 (28%)	9 (26%)	17 (27%)	48 (27%)	
2+ other kids	24 (30%)	18 (46%)	24 (37%)	64 (36%)	
Child care plans after maternity leave					
One parent at home	33 (41%)	13 (37%)	41 (63%)	87 (48%)	**.017**
Extended family	27 (34%)	13 (37%)	13 (20%)	53 (29%)	
Day care	16 (20%)	9 (26%)	5 (8%)	17 (30%)	
In-home nanny	1 (1%)	0	3 (5%)	4 (2%)	
Parent age, y	31 (26-34)	30 (27-32)	30 (25-34)	30 (26-34)	.821
Minutes from home to hospital	30 (20-60)	45 (20-70)	40 (20-80)	35 (20-60)	.302
Insurance type					
Public	40 (50%)	17 (39%)	48 (74%)	105 (58%)	**.006**

Shown are the demographic characteristics of the cohort. *P* values indicate χ^2 or Fisher exact for differences between proportions, or Kruskal–Wallis test for differences in medians. Demographic characteristics were reported by the parent at enrollment, except for insurance type which was abstracted from the electronic health record. Not included in the tables are the 1 person requesting follow-up in person at clinic rather than by email, mail or phone; the 6 people who did not yet know their child care plans. Bolded *P* values indicate statistical significance at $P < .05$.

Table IV. Parent-reported issues with tube feedings

Variables	**Oral feeds**	**NG tube**	**G tube**	***P* value**
n	64	28	53	
How prepared did you feel to care for your child after coming home from the NICU?				
Very well	88%	79%	70%	**.016**

Moderately	11%	21%	13%	
Somewhat	2%	0	15%	
Very little	0	0	2%	
How big of an issue was this for you/your child…				
Tube kept coming out				
Not an issue		79%	77%	.352
Small-moderate issue		21%	15%	
Big-severe issue		0	8%	
Stopped using earlier than recommended				
Not an issue		89%	94%	.526
Small–moderate issue		4%	4%	
Big–severe issue		7%	2%	
Skin issues				
Not an issue		68%	25%	**.001**
Small–moderate issue		18%	55%	
Big–severe issue		11%	21%	
Problems getting equipment				
Not an issue		89%	75%	.254
Small–moderate issue		7%	21%	
Big–severe issue		4%	4%	
Problems with pump				
Not an issue		83%	60%	.122
Small–moderate issue		14%	36%	
Big–severe issue		4%	4%	

Shown are the differences in parent responses to questions about tube feeding issues 3 months after discharge, as reported on a Likert scale. *P* values indicate χ^2 or Fisher exact tests. Bolded *P* values indicate statistical significance at $P < .05$.

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