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RESEARCH

Home Visiting Program for NICU Graduates: Feasibility and Potential for Impact

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Neonatal intensive care unit (NICU) admissions have been increasing. Home visiting services are an integral part of caring for high-risk children with limited resources. The effectiveness of physician-led home visiting programs on post-NICU health outcomes is not well studied. The Pediatric Visiting Doctors (PVD) program provides home-based primary care for high-risk children including NICU graduates, for 6 months after discharge. The team consisted of a pediatrician, and care coordinator or social worker. The study compares the characteristics and care utilization of PVD program participants with a hospital-based pediatric clinic population.

A retrospective cohort study of PVD infants born from 2013–2016, who were enrolled after referral during their NICU admission, was conducted. Data were also obtained on infants who were hospital clinic patients born during the same time frame, with parents residing in the PVD catchment area, and had a minimum 72-hour NICU stay. Between group differences were assessed; and logistic regression and generalized linear models were used to adjust for uneven group characteristics.

Forty-six PVD participants completed the program, and 91 comparison infants had at least 6 months of post-NICU clinic visits. PVD program completers received a median of 5 home visits. There were no differences in emergency care use or hospitalization. PVD program participants were more likely to attend development clinic compared to the non-PVD group (59% vs 12%, $p = 0.002$).

Physician-led home visiting services is a feasible way of providing clinical care to this population. Additional research is needed to assess patient-centered outcomes of these programs.

Keywords: NICU; home visiting program; care utilization; high risk newborns; high risk infants

Background

The number of infants admitted to the neonatal intensive care unit (NICU) has been steadily increasing in all birth weight categories [1]. Prematurity and low birth weight (<2500 grams) are common reasons for NICU admission and need for higher level of care, however, there are numerous other medical indications for NICU admission [2]. Regardless of indication for NICU admission, many parents experience stress around discharge; and effective discharge planning includes assessing both the psychosocial and physical home environments [3, 4]. Previous literature has examined NICU cohort birth weight (BW) and gestational age (GA) outcomes and their impact on: hospitalization rates, development, and long-term cognitive function [5]. Despite current healthcare advances, infants requiring NICU services are often sicker; and remain at risk of neurodevelopmental delays and having chronic medical conditions after discharge [6].

Home-visiting services have been an integral part of caring for high-risk children of low-resourced families, who often have difficulty accessing healthcare services. One study demonstrated a decrease in infant mortality among home visit participants [7]. Another study demonstrated improved childhood development for families who participate in programs with postpartum home visits [8]. A 2017 Cochrane Review of home-visiting program maternal and child outcomes found that postnatal home visits may promote infant health and maternal satisfaction when the visit schedule is individualized to meet specific patient needs [9]. However, the majority of home visiting programs are led by either nurses or community health workers [10–12]. There is little data on physician-led home visiting programs for NICU graduates within the first year of life. The purpose of this study is to examine the care utilization outcomes of a pilot, physician-led, home visiting program that serves high-risk NICU graduates.

Methods

Setting

The Pediatric Visiting Doctors (PVD) program was started in 2013 to care for high-risk children, including NICU graduates. The program is situated within a larger medical clinic at an academic institution, and provides multidisciplinary, home-based primary care for 6 months, post NICU discharge. Each home visit is made by a team consisting of a pediatrician and social worker or care coordinator. During the home visits, patients receive their routine well child screening and physical exam, a home assessment, psychosocial screening, and vaccinations. In addition, acute medical concerns are addressed. They are seen in accordance with the standard well child visit schedule, with additional visits as needed depending on medical needs. Patients are referred to the program during their NICU admission or shortly thereafter for prematurity of <34 weeks gestational age—a risk factor for increased length of stay and co-morbidity; having a chronic medical condition requiring specialized care; or discharge to a high-risk social environment. Families in the program receive assistance with care coordination and connection to support services as needed, in addition to routine clinical care. Individuals are followed in the program for six months post-NICU, since many issues of prematurity and parental anxiety are highest in the first few months of discharge.

Data Analysis

The investigators compared patients receiving PVD services with a group of patients who were born in the same time period, in the same NICU with a minimum stay of 72 hours, lived in the same zip codes, and were primary care patients of the larger clinic in which the PVD program was housed. A 72-hour minimum length of stay was chosen to exclude infants who were admitted to the NICU for routine newborn issues such as hypoglycemia, delayed respiratory transitioning after birth, and monitoring for neonatal sepsis. Our main outcomes were: acute care service utilization during the six months of program participation, overall outpatient clinic no-show rate, and use of development clinic. Clinic no-show rate was calculated using the number of outpatient clinic visits and the number of no-show visits recorded in the electronic medical record regardless of service date. Both sick and well outpatient pediatric visits, inclusive of the PVD home visits were included in the denominator for our analyses. Use of development clinic was defined as attending at least one scheduled appointment in the clinic.

The investigators excluded from analysis: infants with less than 6 months of pediatric clinic visits in the comparison group; and those who did not complete the 6 month PVD program, post NICU discharge. Between-group differences in both demographic characteristics and care utilization measures were assessed using the Wilcoxon rank-sum test for continuous measures, and the Chi-square and Fisher Exact tests as appropriate for categorical measures. Multicollinearity was assessed using variance inflation factors to identify highly correlated variables. Multivariable logistic regression and generalized linear models were used to adjust for birthweight, NICU length of stay, teen parent status, diagnosis of respiratory distress syndrome, and whether they required ventilator support greater than a nasal cannula when comparing care utilization outcomes. Gestational age was excluded from the final adjusted analyses due to high correlation with birthweight in the assessment of collinearity. Term infant was not included as it was clinically redundant with gestational age. All statistical analyses were conducted in SAS version 9.4 (SAS Institute, Cary, North Carolina).

Results

Data from 46 PVD and 91 hospital-based clinic (non-PVD) NICU graduates were analyzed. Mean maternal age was 26.1 and 27.6 in the PVD and non-PVD group ($p = 0.15$). The majority of the patients: were Black/African American race or Latino/Hispanic ethnicity; received public health insurance; and were children of first time mothers (**Table 1**). Median BW was 1703 g in PVD and 2965 g in the non-PVD group. About 80% of PVD participants were born prematurely compared to only half of the non-PVD group ($p < 0.001$).

PVD program completers received a median of 5 home visits over a 6 month period. We adjusted for the following unbalanced patient characteristics: birthweight (BW), NICU length of stay, teen motherhood, ventilator requirement (inclusive of continuous positive airway pressure therapy), and respiratory distress syndrome diagnosis (RDS). After adjustment, more PVD participants: had at least one hospitalization in the 6 months post NICU discharge (26.1% vs 8.8% $p = 0.11$) compared to the non-PVD group but the difference was not statistically significant. There were no differences in emergency department (ED) visits, ICU admissions, or clinic no-show rate as outlined in **Table 2**. PVD program participants were more likely to attend development clinic compared to the non-PVD group (58.7% vs 12.1%, $p = 0.002$).

Discussion

The study found that PVD group participants were of lower GA and BW; had a higher prevalence of respiratory sequelae and longer NICU stay than non-PVD group participants; and were more likely to attend a development clinic appointment. There were no statistically significant differences in ED use, hospitalization and ICU care after adjusting for BW and other unbalanced factors, when comparing the two groups.

The longer NICU length of stay among PVD participants is consistent with a higher level of patient acuity and potentially more post-discharge care needs. The higher prevalence of development clinic attendance highlights the ability of our program to provide care coordination for patients with specialty care needs. As the cost of healthcare

Table 1: Summary of patient characteristics in PVD and hospital clinic patients.

	Hospital Clinic* (N = 91)		Pediatric Visiting Doctors Program* (N = 46)		p-value+
	No. Observed	n (%) or Median [IQR]	No. Observed	n (%) or Median [IQR]	
Sex (M)	91	47 (51.6)	46	27 (58.7)	0.43
Race	91		46		0.17
White		2 (2.2)		4 (8.7)	
Black		38 (41.8)		18 (39.1)	
Asian		3 (3.3)		0 (0.0)	
Native American		2 (2.2)		1 (2.2)	
Other		44 (48.4)		19 (41.3)	
Unknown		2 (2.2)		4 (8.7)	
Ethnicity	91		46		0.07
Hispanic		34 (37.4)		10 (21.7)	
Non-Hispanic		45 (49.5)		24 (52.2)	
Unknown		12 (13.2)		12 (26.1)	
Public Insurance (Y)	91	82 (90.1)	44	42 (95.5)	0.50
Gestational Age (days)	91	261 [237, 280]	42	235 [208, 250]	<0.001
Birthweight (g)	91	2965 [2015, 3430]	42	1702.5 [1210, 2470]	<0.001
NICU LOS (days)	91	6 [3, 15]	45	23 [11, 66]	<0.001
Maternal Age (years)	91	27.6 [22.8, 33.5]	42	26.1 [21.5, 30.9]	0.15
Discharge Weight (g)	91	3035 [2230, 3430]	43	2690 [2135, 3295]	0.21
Teen Parent (Y)	86	1 (1.2)	38	4 (10.5)	0.03
First Child (Y)	91	73 (80.2)	42	36 (85.7)	0.44
Term Infant (Y)	91	49 (53.8)	42	9 (21.4)	<0.001
RDS Diagnosis (Y)	91	12 (13.2)	46	19 (41.3)	<0.001
Required Vent (Y)	91	34 (37.4)	46	31 (67.4)	<0.001

* Patients who attended either outpatient pediatrics clinic or Pediatric Visiting Doctors Program for at least 6 months were included.
+ P-values represent results of Chi-square, Fishers' exact, Wilcoxon rank-sum analyses as is appropriate for the variable type and data distribution.

Table 2: Comparison of care utilization between PVD and hospital clinic patients.

	Hospital Clinic* (N = 91)	Pediatric Visiting Doctors Program* (N = 46)	Adjusted p-value+
	n (%) or Median [IQR]	n (%) or Median [IQR]	
6 months post NICU discharge			
At least one ED Visit (Y)	45 (49.5)	22 (47.8)	0.48
At least one Hospitalization (Y)	8 (8.8)	12 (26.1)	0.11
*At least one ICU Stay (Y)***	5 (5.6)	6 (13.0)	0.89
First year of life			
At least one ED Visit (Y)	61 (67.0)	27 (58.7)	0.65
At least one Hospitalization (Y)	12 (13.2)	13 (28.3)	0.35
At least one ICU Stay (Y)	3 (3.3)	6 (13.0)	0.12
Clinic No-Show Rate	17% [10%, 27%]	18% [8%, 28%]	0.13
Attendance in Development Clinic	11 (12.1)	27 (58.7)	0.002
Median # of Home Visits	N/A	5 [4, 7]	N/A

* Patients who attended either Pediatric Associates clinic or Pediatric Visiting Doctors Program for at least 6 months were included.
+ Adjusted p-value comes from generalized linear model results (for continuous outcomes) and logistic regression model results (for categorical outcomes) adjusting for unbalanced patient characteristics Birthweight, NICU LOS, Teen Parent, RDS Diagnosis and Required Vent.
** One missing value among the infants who had at least six months of pediatric associates visits.

rises, care coordination for medically complex children has become more important. Studies have found that care coordination reduces use of inpatient care and the emergency department for children with complex medical needs [13, 14, 15, 16]. NICU graduates are a group of infants that is at risk for developmental delay since many of them are born prematurely and have low birth weight. In addition, our particular cohort of NICU graduates was of lower socio-economic status which also contributes to their risk, and this is consistent with the literature [17, 18]. Studies show that early intervention in premature infants improves cognition, and this benefit extends throughout preschool [19]. The program's ability to successfully connect patients to this critical resource via referral to development clinic serves as an important first step in connecting participating families to resources that promote healthy child development.

The results did not demonstrate a significant change in ED and inpatient care use. However, this may be explained by differences in the medical complexity of our population that were not accounted for. Future studies with an acuity-matched cohort may provide insight into the impact of home-visiting programs on acute care utilization when taking into consideration the level of medical comorbidity.

The study did not examine between-group differences in severity of ED clinical presentation, which is a major determining factor in the need for hospitalization; and as result our ability to assess the true program's impact on acute care measures may have been limited. Since the PVD NICU graduates were of lower GA and had more respiratory co-morbidity compared to their non-PVD counterparts, it is possible that they presented to the ED more acutely ill, thus requiring a higher level of care including hospitalization. This is consistent with current literature that suggests that preterm infants are more likely to be hospitalized post NICU discharge after adjustment for co-morbidity [20, 21]. Research with a larger sample size may help further characterize reasons for emergency care visits in this population; and identify preventable ED visits types with implementation of clinic-based home visiting programs. Additionally, data were only available for care received at the study's home institution; and as a result, healthcare utilization at other institutions was not accounted for.

This study is among the first to assess acute care utilization among NICU graduates receiving home-based primary care services in an academic medical center. The study's home-based care was also physician-led which is unique among which are typically nurse or community health worker based. Also, the primary outcomes of these studies focus on aspects of child development, including better parent-children interaction, higher levels of cognitive development, and reductions in child abuse or neglect [10–12]. Data from studies of national nurse-based home visiting programs show improvements in preventable infant mortality, however these studies do not address acute care utilization [22]. Other nursing-based home visiting programs highlight a reduction in acute care utilization within the first year of life, but do not address these outcomes in a population of NICU graduates [23–25].

The pilot study demonstrates the feasibility of providing home-based physician services for this vulnerable population. PVD participants received an average of 5–6 home visits in a 6-month period, including both preventive and sick visits, which is comparable to the visit frequency expected as part of routine child care in the first 6 months of life [26].

The study design has several limitations. First, the investigators did not track individuals' reasons for program referral, or data on eligible mothers who declined to participate; nor did they abstract information on medical comorbidities other than RDS. These factors may have impacted the ability to obtain a cohort from the hospital-based clinic for analysis that was comparable in acuity. The impact of number of home visits on our primary outcomes was also not explored. Additional studies should look at the dose response between number of home visits and acute care outcomes. Nevertheless, the study highlighted the overall higher need for medical interventions in the home-based clinic population as well as areas for further study.

Conclusions

NICU graduates are a vulnerable population of infants with greater medical needs and increased risk of poorer long term health outcomes. The PVD population was higher risk compared to the non-PVD NICU graduates, which may highlight a need for more intensive post-discharge services. Physician-led, home visiting services are a feasible way of providing clinical care to this population. Additional research is needed on medical and psychosocial risk factors that impact the efficacy of these programs on reducing acute care utilization among low-income families.

Ethics and Consent

This project was approved by and conducted in accordance with the policies of the institutional review board.

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Competing Interests

The authors have no competing interests to declare.

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