ORIGINAL RESEARCH

Neonates with an Extremely Prolonged Length of Stay: An Analysis of Kids Inpatient Database

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Abstract

Background: With scientific and technological advances in intensive care, there is an increasing survival rate among neonates with complex medical problems who experience an extremely prolonged length of stay (EPLOS) of ≥180 days in the hospital. Little is known about the antecedents and characteristics of this particular group of neonates.

Aim: To characterize the risk factors associated with EPLOS in neonates.

Patients and methods: Retrospective study of neonates from the National Hospital Discharge Database for Children, Kids Inpatient Database 2012 (KIDS-2012), maintained by the Healthcare Cost and Utilization Project (HCUP), using data from 4,170 hospitals in 44 states in the US. All neonates with complicated births who were discharged from the hospital other than from the normal newborn nursey during the year 2012 were included. Newborns with uncomplicated hospital stays who were discharged from the normal newborn nursery were excluded. Diagnoses and procedures were retrieved using ICD-9 codes. Descriptive analyses were done to identify incidence and prevalence. Comparisons were made of neonates with EPLOS (LOS ≥180 days) and non-EPLOS (LOS ≤179 days) using univariate and multivariate analyses.

Results: A total of 1,314,066 neonates with complicated births discharged from US hospitals in 2012 were included in the analysis. The incidence of EPLOS was 6.2/10,000 (n = 812). On univariate analyses, neonates with EPLOS were more likely to have the following risk factors: Black race, Medicaid insurance, ZIP codes associated with lower median incomes, and born in the South and Midwest regions of the US. Most were neonates who had a surgical procedure done, especially tracheostomy and gastrostomy, being the most common procedures.

Conclusion: The occurrence of EPLOS is relatively uncommon among hospitalized neonates. The clinical and demographic characteristics of this subset of complicated neonates are distinct and can be anticipated using prediction models. Prediction models for EPLOS may be important for public policy issues and the proper allocation of healthcare resources.

Keywords: Hospital Length of Stay, Neonatal Intensive Care Unit, Pediatric Intensive Care Unit.

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Introduction

With advances in scientific knowledge and technology in intensive care units, there has been an increased survival of extremely sick neonates with conditions that would previously be considered lethal. Consequently, the need for ongoing advanced technological support in these infants has probably resulted in extremely prolonged hospital stays. Another reason for the prolonged hospitalization of neonates may be the increased societal and parental expectations for technology-assisted care for what may be considered futile care by nurses, physicians, and members of the healthcare team.[1] The length-of-stay for preterm birth is also increasing at a pace of 0.59% each year, probably related to the survival of extremely immature infants.[2] The use of advanced technologies in the hospital has also influenced the increased use of technology post-discharge, especially with the capability to provide respiratory and renal support at home for small children. It is reported that infants with prolonged initial hospitalization may also be at risk for increased morbidity and mortality post-discharge.[3] Given the changing landscape in this field of study, it is important to identify the risk factors for neonates who are likely to have extremely prolonged hospital lengths of stay. However, a current review of the literature shows a paucity of research and information on this subject. Therefore, we designed this study with the aim to evaluate the risk factors and clinical correlates of neonates with an EPLOS – defined as a hospital stay of ≥180 days.

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Patients and Methods

Definition of EPLOS: The use of an operational definition of extremely prolonged length of stay is derived from an extension of the concept of prolonged length of hospital stay. Prolonged

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length of hospital stay for neonates has been defined previously based on evidence, which suggests that the majority of extremely premature infants are discharged by 42 weeks post-menstrual age (PMA = gestational age at birth in weeks + weeks after birth); which for a 25-week GA infant would be about 120 days of hospital stay.[4,5] We extrapolated this to surmise that about 180 days of hospital stay, which constitutes almost half a year, would be an appropriate cut-off point for distinguishing an extremely prolonged length of hospital stay. For a 25-week GA infant, this would be about 50–51 weeks post-menstrual age (PMA).

This is a retrospective study using data available from the 2012 Health Care Utilization Project's (HCUP) Kids' Inpatient Database (KID-2012).[6] Kids' Inpatient Database is the largest publicly available pediatric database derived from 4,179 participating hospitals from 44 states in the United States, taking care of patients <20 years of age. This database is one in a family of databases and software tools developed as part of the HCUP. The project is coordinated through the Center for Organization and Delivery Studies, which is within the Agency for Healthcare Research and Quality (AHRQ). The database is derived from discharge abstracts and typically includes clinical and resource utilization information with >100 clinical and non-clinical variables for each hospital stay. There may be up to a maximum of 25 diagnoses and 15 procedures per hospitalization. The information in the database represents approximately 80% of complicated hospital births and 10% of uncomplicated hospital births per participating state. Hospital regions are classified as Northeast, Midwest, South, and West. The KID database was specifically designed to permit researchers to study a broad range of conditions and procedures related to child health issues. Researchers and policymakers can use the KID to identify, track, and analyze national trends in healthcare utilization, access, charges, quality, and outcomes. The KID contains clinical and resource use information included in a typical discharge abstract, with safeguards to protect the privacy of individual patients, physicians, and hospitals (as required by data sources). The KID excludes data elements that could directly or indirectly identify individuals. Healthcare Cost and Utilization Project publishes a new KID every 3 years.

We performed a retrospective review of the KID-2012 for neonatal (within 28 days of birth) admissions with complicated births (UNCBRTH = 0). Normal neonates were excluded from the analysis. All neonatal admissions with complicated births were included in the data analysis. We evaluated the prevalence, and clinical correlates of neonates with an EPLOS as defined by length of stay ≥180 days. We have compared the EPLOS group with the group having a length of stay ≤179 days (non-EPLOS) among infants who were considered complicated births. International Classification of Diseases, ninth revision (ICD-9) diagnosis and procedure codes were used to retrieve various diagnoses and procedures, respectively.

Statistical Analysis

The prevalence of EPLOS is reported per 10,000 discharges of neonates with complicated births. The mortality rate is reported per 100 neonates. All categorical variables [gender, race, patient location, median household income (MHI)] were analyzed with Chi-square tests. Healthcare Cost and Utilization Project defines MHI by the zip code in which the child resides. The zip codes are stratified by quartiles with quartile 1 representing the lowest and quartile 4 representing the highest income. Binomial data are presented as odds ratios with 95% confidence intervals and *p* values. *P*-values < 0.05 are considered statistically significant. All continuous variables (total charges, length of stay, number of procedures, and the number of diagnoses) were analyzed by the Mann-Whitney *U* test. Their analyses are presented as a median and interquartile range (IQR). All data were weighted according to HCUP recommendations prior to analysis to calculate national estimates. Demographic variables were compared between EPLOS and non-EPLOS groups. Univariate analyses were done to evaluate the variable associated with an extremely prolonged length of hospital stay. Binary logistic regression analysis was done to evaluate predictive variables for EPLOS. All variables with a frequency of at least 0.1% and a *p*-value < 0.05 on univariate analysis were included in the binary regression model. Then adjusted odds ratios were calculated after controlling for characteristics that were significant on univariate analysis including, birth weight, race, region of the country, socioeconomic ZIP code quartile, disease diagnoses, and procedures. Missing values were coded as a separate category for the variables of interest.

These data were analyzed with SPSS version 28 (IBM Corporation, Armonk, NY) or StatCalc of Epi Info™ (Centers for Disease Control and Prevention, Atlanta). This study was exempt from IRB review.

Results

Prevalence of EPLOS

From a total of 3,118,814 hospital discharges recorded in the KID-2012 database, there were a total of 1,314,066 neonates with complicated births. Out of these complicated births, 812 neonates (6.2/10,000) had an EPLOS. Although EPLOS neonates represented only 0.06% of all complicated birth admissions, these infants, because of their prolonged hospitalization, accounted for 2% of all occupied beds.

Demographic Variables

Demographic variables were compared within EPLOS and non-EPLOS neonates and the results are shown in Table 1. There were no significant differences in the sex distribution of neonates between the two groups. Significantly lower proportions of neonates were born in the hospital they were cared for in the EPLOS group [47.7% vs 84.9%, $p < 0.0001$; OR: 0.16 (95% CI: 0.14–0.19)]. Neonates from the South and Midwest were more highly represented in the EPLOS group compared to neonates from the Northeast and the West [76.1% vs 59.7%, $p < 0.0001$; OR: 2.2 (95% CI: 1.8–2.5)]. The proportion of neonates with Medicaid insurance was higher and private insurance was lower in the EPLOS group [72.3% vs 53.6%, $p < 0.0001$; OR: 2.3 (95% CI: 1.9–2.7)]. Similarly, the proportion of Blacks was higher [33.5% vs 16.5%, $p < 0.0001$; OR: 2.6 (95% CI: 2.2–3.0)] and Whites was lower (37.0% vs 51.3%; $p < 0.0001$) in EPLOS group. A significantly higher proportion of neonates were residents from ZIP codes that were classified in the lower half of median income in the EPLOS group [66.3% vs 54.2%, $p < 0.0001$; OR: 1.7 (95% CI: 1.4–1.9)].

Complications and Interventions

A comparison of clinical correlates of neonates in the two groups is presented in Table 2. Overall, medical complications and the need for procedural interventions were higher in the EPLOS group. A major operating procedure was performed in 87.4% of neonates in the EPLOS group compared to 26% in the non-EPLOS group [$p < 0.0001$; OR: 19.8; (95% CI: 16.1-21.4)]. Tracheostomy and gastrostomy procedures were the most common procedures performed in neonates with EPLOS. The median hospital day on which tracheostomy was performed was 135 days (IQR: 90–161).

Table 1: The differences in demographic variables in neonates with extremely prolonged length of stay and non-extremely prolonged length of stay

Variable	*EPLOS group*	*Non-EPLOS group*	*p-value; (OR; 95% CI)*
Male (%)	56.0	54.6	$p = 0.42$; (1.06; 0.92–1.22)
Gestational age <27 weeks (%)	37.2	1.6	$p = 0.000$; (37.2; 32.3–43.0)
Birth weight <1000 gm (%)	51.1	2.08	$p = 0.000$; (49.3; 42.9–56.6)
Race and ethnicity			
White (%)	37.0	51.3	$p = 0.000$; (2.6; 2.2–3.0); Black vs all others
Black (%)	33.5	16.5	
Hispanic (%)	17.5	19.1	
Asian (%)	3.2	5.1	
Insurance			
Medicaid (%)	72.3	53.6	$p = 0.000$; (2.3; 1.9–2.7); Medicaid vs private insurance
Private (%)	27.7	46.4	
In-born (%)	47.7	84.9	$p = 0.000$; (0.16; 0.14–0.19)
Children's hospital (%)	36.5	4.8	$p = 0.000$; (11.5; 10.0–13.2)
U.S. region			
South and Midwest (%)	76.1	59.7	$p = 0.000$; (2.2; 1.8–2.5)
Northeast and West (%)	23.9	40.3	
ZIP codes with median income quartiles			
Quartile 1 (%)	38.5	29.8	$p = 0.000$
Quartile 2 (%)	27.8	24.4	
Quartile 3 (%)	21.8	23.9	
Quartile 4 (%)	11.9	21.9	

Table 2: Comorbid conditions and complications in neonates with extremely prolonged length of stay and non-extremely prolonged length of stay

Variable	*EPLOS group*	*Non-EPLOS group*	*p-value; (OR; 95% CI)*
Birth weight <1000 gm (%)	51.1	2.1	$p < 0.0001$; (49.3; 42.9–56.6)
RDS (%)	53.6	7.1	$p < 0.0001$; (15.0; 13.1–17.2)
Pulmonary air leaks (%)	17.4	1.5	$p < 0.0001$; (13.5; 11.2–16.2)
Pulmonary hemorrhage (%)	5.6	0.2	$p < 0.0001$; (34.4; 25.4–46.6)
Atelectasis (%)	18.0	0.7	$p < 0.0001$; (31.0; 25.9–37.1)
BPD (%)	46.1	0.8	$p < 0.0001$; (109.9; 95.6–126.3)
Mechanical ventilation (%)	68.9	10.9	$p < 0.0001$; (18.1; 15.6–21.0)
Tracheostomy (%)	28.1	0.05	$p < 0.0001$; (733; (618–869)
PDA (%)	55.4	4.4	$p < 0.0001$; (26.7; 23.3–30.7)
Cardiopulmonary arrest (%)	6.3	0.12	$p < 0.0001$; (55.9; 41.9–74.5)
NEC – any stage (%)	22.3	0.4	$p < 0.0001$; (65.3; 55.3–77.2)
Gastrostomy (%)	30.4	0.28	$p < 0.0001$; (157; 134–183)
Ileostomy (%)	12.0	0.1	$p < 0.0001$; (125; 100–155)
Colostomy (%)	7.9	0.1	$p < 0.0001$; (84.0; 64.7–109)
Retinopathy of prematurity (%)	24.0	1.4	$p < 0.0001$; (22.0; 18.7–25.9)
Intraventricular hemorrhage – any grade (%)	30.2	1.2	$p < 0.0001$; (34.9; 30.1–40.6)
Ventricular shunt (%)	7.5	0.1	$p < 0.0001$; (73.6; 56.4–96.1)
Major operating room procedure (%)	87.4	26.0	$p < 0.0001$; (19.8; 16.1–24.4)
Phototherapy (%)	20.2	14.1	$p < 0.0001$; (1.6; 1.3–1.8)
ECMO (%)	5.7	0.1	$p < 0.0001$; (67.7; 50.0–91.7)

ECMO, extracorporeal membrane oxygenation; NEC, necrotizing enterocolitis; PDA, patent ductus arteriosus; RDS, respiratory distress syndrome

Outcome

Overall, approximately 80% of all neonatal deaths occur within 10 days of admission for a complicated birth. The mortality rate was significantly higher in the EPLOS group (10.9% vs 1.1%; $p = 0.000$; OR: 11.0 (95% CI: 8.8–13.7). Only 0.6% of all deaths in neonates occurred with EPLOS. The median [IQR] length of hospital stay was longer [214 (193–247) days vs 2 (2–3) days; $p = 0.000$] and the hospital charges were higher [$1,859,847 (1,334,863–2,537,870) vs $3,211 (2,115–5,623)] in EPLOS group compared to the non-EPLOS group. In the EPLOS group, the disposition at discharge from the hospital was

Table 3: Summary of binary regression analysis for variables predicting extremely prolonged length of stay in neonates

				95% CI for Odds ratio	
Independent variable	*β*	*Significance*	*Odds ratio*	*Lower*	*Upper*
Birth weight <1000 gm	1.643	0.000	5.171	4.043	6.614
African American race	0.421	0.000	1.523	1.269	1.828
Hospital: South or Midwest	0.397	0.000	1.487	1.238	1.786
Born in the same hospital	–0.373	0.001	0.688	0.555	0.854
Children's hospital	0.958	0.000	2.606	2.084	3.260
Insurance: Medicaid	0.475	0.000	1.609	1.351	1.916
Major operating procedure	1.927	0.000	6.867	5.461	8.633
Extracorporeal membrane oxygenation	2.354	0.000	10.532	7.206	15.392
Dialysis	0.825	0.044	2.281	1.022	5.091
Patent ductus arteriosus	0.630	0.000	1.878	1.557	2.265
Transient tachypnea of newborn	–1.178	0.000	0.308	0.164	0.579
Respiratory distress syndrome	0.407	0.000	1.503	1.217	1.855
Pulmonary air leaks	0.366	0.001	1.442	1.151	1.807
Atelectasis	0.345	0.003	1.413	1.125	1.774
Bronchopulmonary dysplasia	1.191	0.000	3.292	2.666	4.064
Tracheostomy	3.606	0.000	36.810	29.046	46.650
Necrotizing enterocolitis	0.976	0.000	2.654	2.108	3.340
Gastrostomy	1.765	0.000	5.840	4.756	7.172
Ileostomy	0.703	0.000	2.019	1.493	2.731
Colostomy	1.459	0.000	4.302	3.058	6.054
Intraventricular hemorrhage	0.379	0.000	1.461	1.194	1.788
Constant	–10.268	0.000			

Income levels, mechanical ventilation, pulmonary hemorrhage, and cardiopulmonary resuscitation were included in the regression model but were not reached statistical significance

to a home destination in only 47.8% of neonates compared to 88.9% in the non-EPLOS group ($p < 0.0001$). A significantly high proportion of EPLOS (31.0%) were discharged to skilled nursing homes or with provisions for home health care compared to a small minority (4.7%) needing such arrangements in the non-EPLOS group ($p < 0.0001$).

Binary Logistic Regression

Binary logistic regression was performed to assess the effects of the independent variable listed in Table 3 on the likelihood that neonates have EPLOS. The logistic regression analysis was statistically significant at χ^2 (25) = 6541, $p < 0.0001$. A regression model based on this analysis explained 48.2% (Nagelkerke R^2) of the variance in extremely prolonged length of stay and correctly classified 99.9% of neonates with EPLOS. Neonates requiring tracheostomy procedures are 36.8 times more likely to have EPLOS. The effect of clinical variables (diagnoses or procedures) on EPLOS is presented in Table 3. The tests of the assumption of independence of independent variables showed no collinearity. Pearson bivariate correlation showed a correlation of <0.4 among all independent variables. The Variance in Inflation Factor was <3 for all independent variables in the collinearity diagnostics of linear regression analysis.

Predicted_Logit = –10.268 + (1.643*BW_LessThan1000) + (0.475*Medicaid insurance) + (0.421*Race_Black) + (0.958*Childrens hospital) + (0.397*Region_South or Midwest) + (1.926*Major operating procedure) + (.630*PDA) + (0.407*RDS) + (0.366*Air leaks) + (0.345*Atelectasis) + (.379*IVH_Any) + (1.191*BPD) + (2.354*ECMO) + (3.606*Tracheostomy) + (0.976*NEC_Any) + (1.765*Gastrostomy) + (0.703*Ileostomy) + (1.459*Colostomy) + (0.825*Dialysis) – (0.373*Born in same hospital) – (1.178*Transient tachypnea of newborn)

Predicted_Probability = (2.718281828^Predicted_Logit)/(1 + 2.718281828^Predicted_Logit) [^ is exponent sign]

Discussion

This study describes the prevalence of EPLOS (6.2 per 10,000 discharges) in non-uncomplicated neonatal births in the US for the year 2012 based on data from HCUP's KID database. In this study, we were also able to describe for the first time, the clinical correlates and risk factors in neonates with a hospital stay ≥180 days versus neonates who had a shorter length of stay. Based on the data available for analysis, we derived a predictive model that would predict EPLOS.

The length of hospital stay for neonates is primarily dependent on the maturity of the infant at birth, with more immature infants needing longer hospital stays.[7] The average duration of the length of stay of extremely premature babies (23–28 weeks of gestation) during 1977 to 1986 was 95 days and was inversely proportional to gestational age.[8] A recent large multicenter study of infants, born ≤28 weeks gestation and admitted to one of 12 tertiary US centers between January 1998 and October 2001 showed that 18% of infants had a prolonged length of stay defined as discharge at >42 weeks post-menstrual age.[4] An audit of hospital admissions to children's hospital groups in Ireland showed that of all infants that needed a hospital stay of >1 month, there were 4.4% (19/436) that needed a hospital stay of >6 months with an average stay of 331 days.[9] They also showed a temporal trend towards longer hospital stays but no details of demographics or clinical correlates were

provided.[9] The only study published to date relating to extremely long hospitalization of neonates identified 680 infants from the KID-2003 data, that needed hospitalization of about 6 months (≥180 days) or longer.[1] In this study, no denominator was provided to estimate prevalence. Our results in this study based on KID-2012 data using the same definition (≥180 days) identified 812 neonates. The difference in patient number may not be due to a real change in prevalence but may be due to several factors such as changes in nature, number, or characteristics of hospitals contributing to the KID data. However, the prevalence rate of 6.2 per 10,000 neonates with non-uncomplicated births has not been reported heretofore and needs to be corroborated with data from other large databases such as the Vermont-Oxford Network.

Investigation of hospital length of stay to mortality has shown that the majority of neonatal mortality is within the first 1–2 weeks of birth.[8,10] A study by Catlin et al. using the KID 2003 data of 680 neonates who stayed ≥180 days reported a mortality rate of 16%.[1] In the present study, 812 neonates stayed for ≥180 days with a mortality rate of 10.9%. Although the mortality rate is high in babies with EPOLS, the total number of children dying after EPLOS is relatively small compared to all neonatal deaths. However, this small proportion of patients with EPLOS does occupy a significant proportion of ICU or hospital beds.[9,11]

In our study, the following factors were associated with at least a 2.5-fold or more increase in the unadjusted odds ratio for EPLOS – birth-weight <1000 gm (extremely low birth weight – ELBW); diagnosis of BPD, NEC or cardiopulmonary arrest; the need for a major surgical procedure, especially procedures for placement of colostomy, gastrostomy or tracheostomy. The highest unadjusted odds ratio was for tracheostomy (>36-fold increase). Other factors with lower than 2-fold increase in unadjusted odds ratios were black race, births in South or Midwest regions of the US, Medicaid insurance, diagnosis of PDA, diagnosis of respiratory problems such as RDS, pulmonary air-leaks or atelectasis, or the need for ileostomy surgical procedure.

Many morbidities have been shown to be higher in black neonates, but the issue of prolonged hospital length of stay has not been adequately studied in this population.[12] Higher hospital stays for conditions such as surgery for congenital heart disease have been noted in the black race compared to other racial groups in the US.[13] Therefore, the finding of increased EPLOS in blacks in this study was not unexpected. However, this finding needs to be interpreted with caution as the black race is highly correlated with other risk factors such as lower socioeconomic status and Medicaid insurance status.[13] Therefore in an analysis adjusted for these two variables, we found that black neonates have 1.5 times the odds of EPLOS than other neonates.

In our study, EPLOS was associated with multiple procedures and other neonatal comorbidities. In a study evaluating clinical correlates of prolonged length of stay (>42 week post-menstrual age), development of chronic lung disease, necrotizing enterocolitis requiring surgery, and two or more episodes of sepsis were found to be the major risk factors.[4]

Extreme prematurity or very low birth weight (VLBW, <1000 gm birth weight) are known to be associated with prolonged length of stay.[4] In most of these infants, the length of stay is a factor of the time needed for full maturity of physiological functions. For example, a 23-week gestational age infant needs 119 days (17 weeks) just to reach full maturity of 40 weeks. However, even within this group, some infants have other major morbidities that may prolong hospital stay by another 2 months or more. Among the respiratory morbidities that contribute to EPLOS, we found that BPD has the most impact (OR-3.4) with relatively minor effects of the need for mechanical ventilation (OR-1.3), RDS (OR-1.6), and pulmonary air leaks (OR-1.4) or atelectasis (OR-1.5). The effect of respiratory morbidities on prolonging hospital stay (>42 PMA) has been previously reported but their impact on EPLOS has not been previously described.[4] It is well recognized that the need for tracheostomy represents the highest level of intervention for the continuing care of neonates with respiratory compromise.[14,15] Therefore, it is not surprising that tracheostomy, in our study, had the highest unadjusted OR (36.8) for EPLOS. The median age of tracheostomy in our study cohort was 135 days, which is similar to the previous reports.[14,15]

Another contributor to prolonged length of stay that has been previously reported is complications resulting from NEC, especially the need for surgical procedures.[4,16] Even though the diagnosis of NEC increased the adjusted odds for EPLOS by 2.7-fold, the need for major surgical intervention of any kind (OR-6.8) or specific procedures such as ileostomy (OR-2.0), colostomy (OR-4.3) or gastrostomy (OR-5.8) made EPLOS even more likely. Other studies focused on outcomes of neonates with NEC have shown that the need for surgery and the type of surgery affect hospital length of stay; but there are no published reports on the impact of NEC on EPLOS.[17]

Although the proportion of neonates receiving cardiopulmonary resuscitation in the EPLOS group was significantly higher in univariate analysis, the adjusted odds ratio in regression analysis was not significantly different between both groups.

There are several limitations of our study and analyses. The use of a large administrative database, while providing a large sample size, also limits the availability of detailed clinical information. The accuracy and completeness of coding may vary, but the errors can be mitigated by the extensive sampling of data. Birthweight category was used as a proxy for the degree of immaturity of the neonate. Additionally, the temporal sequence of the clinical factors studied is lacking; therefore, we can only comment on the association but cannot infer whether the given factor was the cause or the result of EPLOS. Despite these limitations, the available data and the conducted analyses provide information that has significant implications for policy, planning, and practice of healthcare in the United States.

Conclusion

In conclusion, we have shown that neonates with EPLOS, though relatively few, have important implications for provisions of healthcare within NICUs and PICUs. Our study is one of the first attempts at characterizing the clinical correlates of this population of patients. More studies using other data sources need to be done to further define this group of neonates and develop strategies for their optimal management.

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