

Rehospitalization in the First Two Weeks After Discharge From the Neonatal Intensive Care Unit

Gabriel J. Escobar, MD*‡; Steven Joffe, MD, MPH*§; Marla N. Gardner, BA*; Mary Anne Armstrong, MA*; Bruce F. Folck*; and Diane M. Carpenter, MPH*

ABSTRACT. *Background.* High-risk newborns are known to have higher than average utilization of services after discharge from the neonatal intensive care unit (NICU). Most studies on this subject report aggregate data over periods ranging from 1 to 3 years postdischarge. Little is known about events that are temporally close to NICU discharge.

Objectives. To characterize rehospitalizations within the first 2 weeks after discharge from six community NICUs.

Methods. We scanned electronic databases and reviewed the charts of rehospitalized infants from six NICUs in the Kaiser Permanente Medical Care Program. We subdivided infants into five groups based on gestational age (GA) and birth hospitalization length of stay (LOS): 1) ≥ 37 weeks' GA with < 4 days LOS ($n = 2593$); 2) ≥ 37 weeks' GA with ≥ 4 days' LOS ($n = 1133$); 3) from 33 to 36 weeks' GA with < 4 days' LOS ($n = 545$); 4) from 33 to 36 weeks' GA with ≥ 4 days' LOS ($n = 1196$); and 5) < 33 weeks' GA ($n = 587$). We performed bivariate and multivariate analyses to identify predictors that might be useful for practitioners.

Results. There were 6054 newborns discharged alive from the six study NICUs between August 1, 1992 and December 31, 1995, and 99.5% of these infants remained in the health plan during the 2 weeks after NICU discharge. The overall rehospitalization rate was 2.72%, which is 20% higher than the rate among healthy term newborns in the Kaiser Permanente Medical Care Program (2.26%). The two most common reasons for rehospitalization were jaundice (62/165, 37.6%) and feeding difficulties (25/165, 15.2%). Infants with 33 to 36 weeks' GA and < 4 days' LOS were rehospitalized at a significantly higher rate than were all other infants (5.69%); 71% of infants in this group were rehospitalized for jaundice. The following variables predicted rehospitalization in multivariate models: < 33 weeks' GA (adjusted OR [AOR]: 1.88; 95% CI: 1.10–3.21), from 33 to 36 weeks' GA with < 96 hours' LOS (AOR: 2.94; 95% CI: 1.87–4.62), and birth at facility B, which had the highest rehospitalization rate of the six facilities (AOR: 1.92; 95% CI: 1.39–2.65).

Conclusions. The rate of rehospitalization among NICU graduates is higher than among healthy term infants. Most of the rehospitalizations among infants with

from 33 to 36 weeks' GA and < 4 days' LOS are for illnesses that are not life-threatening. Collaborative studies and new process and outcomes measures are needed to assess the effectiveness of follow-up strategies in high-risk newborns. *Pediatrics* 1999;104(1). URL: <http://www.pediatrics.org/cgi/content/full/104/1/e2>; neonatal intensive care, SNAP, assisted ventilation feeding difficulties, low birth weight, jaundice, prematurity rehospitalization, very low birth weight.

ABBREVIATIONS. LBW, low birth weight; VLBW, very low birth weight; NICU, neonatal intensive care unit; GA, gestational age; KPMCP, Kaiser Permanente Medical Care Program; NMDS; Neonatal Minimum Data Set; LOS, length of stay; SNAP, Score for Neonatal Acute Physiology; KFHP, Kaiser Foundation Health Plan, Inc; RSV, respiratory syncytial virus; AOR, adjusted OR.

Low birth weight (LBW; < 2500 g) newborns have excess morbidity and mortality, compared with newborns born at a normal weight. A large body of literature now documents increased mortality as well as morbidity among LBW infants.^{1–3} Within this group, the highest rates of adverse outcomes are experienced by infants who are of very low birth weight (VLBW; < 1500 g).^{4–8}

One important outcome of concern to clinicians is rehospitalization after discharge from the neonatal intensive care unit (NICU). A number of studies have documented increased postdischarge utilization of medical services by high-risk infants. Such increased utilization has been found using multiple definitions of a high-risk infant, eg, LBW, VLBW, prematurity, NICU graduate, or combinations thereof.^{6–15}

Knowing that NICU graduates experience excess overall rehospitalization is of limited use to clinicians. Neonatologists may have limited control over events that occur long after discharge from the NICU. For those individuals who are actually involved in the discharge planning of high-risk newborns, information on rehospitalization in the immediate postdischarge period would be highly desirable. Few studies have reported on such events.^{16,17} This differs from the literature on healthy term newborns in which a number of studies have reported on rehospitalization rates shortly after discharge from the birth hospitalization for different follow-up periods, eg, 2 weeks.^{18–21}

The purpose of our study was to characterize early rehospitalizations among infants discharged from the NICU. We focused on events occurring within 2 weeks of NICU discharge. Additionally, we sought

From the *Kaiser Permanente Medical Care Program, Division of Research, Oakland, California; ‡Department of Pediatrics, Kaiser Permanente Medical Center, Walnut Creek, California; and §Division of Hematology/Oncology, Children's Hospital, Boston, Massachusetts.

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Address correspondence to Gabriel J. Escobar, MD, Kaiser Permanente Medical Care Program, Division of Research, 3505 Broadway Ave, Oakland, CA 94611. E-mail: gabriel.escobar@nca.kaiperm.org
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to identify patterns that could be useful to practitioners making discharge and short-term follow-up decisions concerning NICU graduates of all birth weights and gestational ages (GAs).

METHODS

The setting for this study was the Kaiser Permanente Medical Care Program (KPMCP), a group-model managed care organization. The study sites consisted of all six northern California KPMCP level III NICUs. All these units are staffed by board-certified neonatologists. Infants requiring some form of specialized care, eg, complex cardiac surgery, or extracorporeal membrane oxygenation, are transported to several university centers in northern California but return to KPMCP facilities before discharge. Decisions regarding the timing of discharge and provision of follow-up services are made individually by neonatologists based on physiologic and facility-specific criteria. High-risk newborns discharged from these units receive follow-up services such as home visits from both the KPMCP and the state of California Children's Services.

Infants born at seven level I and II units are sometimes transported into these six units. The seven facilities include five KPMCP units and two contract facilities. None of these facilities routinely provide neonatal assisted ventilation.

We used the Kaiser Permanente Neonatal Minimum Data Set (NMDS) database²² to develop a retrospective cohort of NICU admissions. Inclusion criteria consisted of 1) membership in the NMDS, ie, admission to the NICU with a date of birth between August 1, 1992 and December 31, 1995; 2) birth at one of the six NMDS NICU facilities, ie, inborn status; and 3) discharge alive from the NICU. Because nurseries came on-line between July 1992 and January 1995, accrual to the NMDS accelerated over time. Currently, the NMDS database captures 95% to 100% of level III NICU admissions in a region of ~2.7 million members and 29 000 deliveries each year.²²

Key predictors such as birth weight and GA were obtained from the NMDS database²² or from other KPMCP databases. Length of stay (LOS) was calculated exactly in hours and includes time spent in non-Kaiser Permanente facilities. Beginning in December 1992, we measured 24-hour severity of illness using the Score for Neonatal Acute Physiology (SNAP),²³⁻²⁵ thus analyses involving the SNAP include only those newborns born after November 30, 1992. During the period of this study, no KPMCP database system consistently tracked home visits covered by the health plan. We did not have access to follow-up data for services provided by the state of California.

Infants born to women who are Kaiser Foundation Health Plan, Inc (KFHP) members are covered automatically for the first month of life. We determined which infants completed their automatic membership month during the period of the study, then scanned the KFHP length of enrollment database to identify which of these infants did not continue KFHP membership. We also searched KPMCP outpatient, inpatient, and out-of-plan utilization databases to determine who did not have utilization during the 21 days after NICU discharge, and therefore, who would be lost to follow-up. We found that 29 infants (0.5%) were lost to follow-up during the time period of the study. These infants were not included in our multivariate analyses.

We identified outpatient visits and rehospitalizations by scanning KPMCP clinical and administrative databases. Professional medical record analysts reviewed the charts of rehospitalized infants. Because infection with respiratory syncytial virus (RSV) is an important cause of neonatal morbidity, we assessed the influence of discharge date on rehospitalization. We defined the RSV season as beginning December 1 of each year and ending on March 31 of the following year (Joffe S, et al. Rehospitalization for respiratory syncytial virus among premature infants. Accepted for publication).

We also created two variables to incorporate birth weight and SNAP, both of which can be correlated highly with GA into multivariate analyses.

Smallest Quartile

The smallest quartile variable was scored as yes if an infant's birth weight was in the lowest 25th percentile for its GA. We created this variable, because it has been found that using birth

weight percentile ranges for a given GA can improve the power of predictive models for neonatal mortality.²⁶⁻²⁹

Sickest Quartile

The sickest quartile variable was scored as yes if an infant's SNAP was in the top 25th percentile for its GA. At present, the SNAP is considered experimental and scores are not routinely available to clinicians. However, we reasoned that experienced clinicians would be able to judge whether a given infant fell into the sickest quartile for its GA. Published data comparing clinician judgment to the SNAP support this assumption.³⁰

As part of our epidemiologic monitoring duties within the KPMCP, we use the sickest quartile and smallest quartile variables in models to predict LOS in LBW and/or premature infants admitted to the NICU. Threshold values used to define the sickest quartile and smallest quartile were determined using the moving average method (see "Statistical Methods"). The GA-specific SNAP and birth weight cutoffs that we used are provided in the Appendix.

Categorization of Rehospitalization Diagnoses

The results of our pilot work indicated that four diagnostic categories accounted for the majority of rehospitalizations in healthy term newborns in the KPMCP: jaundice, feeding difficulties, evaluation for suspected bacterial infection (rule-out sepsis), and confirmed urinary tract infections. We included all diagnosis codes assigned to a child on rehospitalization; in cases in which more than one diagnosis category applied, we counted the child as belonging to each category (eg, jaundice and urinary tract infections). For the purposes of this study, *International Classification of Diseases*, 9th Revision, Clinical Modification³¹ discharge diagnoses were grouped as follows. We considered an infant to have had a rehospitalization diagnosis of jaundice if the rehospitalization record contained the following ICD-9CM codes: 773.0, 773.1, 773.2, 773.4, 774.0, 774.1, 774.2, 774.30, 774.31, 774.39, 774.6, 774.7, 782.4, and/or procedure codes 99.83 and/or 99.01. The codes for feeding difficulties were any diagnosis beginning with 276, 775.5, 779.3, 785.50, and 785.59. The codes for rule-out sepsis were V29.0, V29.1, 079.9, 778.4, and 780.6. The codes for confirmed urinary tract infection were any diagnosis beginning with 590 and 599.

Statistical Methods

All statistical analyses were performed using SAS, Version 6 (SAS Institute, Inc, Cary, NC).³² Comparisons involving categorical variables were performed using the χ^2 test or Fisher's exact test as appropriate. Normally distributed continuous variables were compared using the Student's *t* test. Comparisons of nonnormally distributed continuous variables were performed using the Wilcoxon nonparametric test for comparing medians.

We used the moving average method³³ described by Arkin and Colton³⁴ to evaluate certain predictors for rehospitalization. The moving average smooths aberrations in a dataset to better represent trends. For example, to obtain the rehospitalization rate moving average for 34 weeks' GA, the mean of the three rehospitalization rates for 33, 34, and 35 weeks' GA was calculated.

We performed two sets of logistic regressions. The first set used any rehospitalization ($n = 165$) as the outcome variable. In the second set, the outcome variable was rehospitalization with a severe illness ($n = 47$) with all other rehospitalized infants excluded. We defined a severe illness as one in which any of the following occurred: 1) death, 2) assisted ventilation, and 3) >3 days' LOS.

Our preliminary analyses suggested that there was a significant difference in the rehospitalization rates within the GA ranges of 33 to 36 weeks and ≥ 37 weeks when stratified according to birth hospitalization <4 days' LOS and ≥ 4 days' LOS. Thus, we allocated infants to one of five groups for analysis based on GA and LOS: 1) ≥ 37 weeks' GA with <4 days' LOS ($n = 2593$); 2) ≥ 37 weeks' GA with ≥ 4 days' LOS ($n = 1133$); 3) from 33 to 36 weeks' GA with <4 days' LOS ($n = 545$); 4) from 33 to 36 weeks' GA with ≥ 4 days' LOS ($n = 1196$); and 5) <33 weeks' GA ($n = 587$). Infants with <33 weeks' GA were not divided according to LOS, because there were no infants with <4 days' LOS in this group.

We did not include length of assisted neonatal ventilation as a predictor variable in our multivariate analyses, because we found

that prolonged assisted ventilation was correlated highly with <33 weeks' GA ($r = 0.42$) as well as with LOS ($r = 0.83$).

Preliminary analyses indicated that one NICU, facility B, seemed to have a higher rehospitalization rate than did all other facilities combined, whereas another NICU, facility A, had the lowest rate. The predictive value of birth at each of these facilities was tested in multivariate models.

Ethical Considerations

This study was approved by the KPMCP Institutional Review Board for the Protection of Human Subjects.

RESULTS

During the study period, a total of 44 943 live births occurred at the six study hospitals. Of these infants, 6144 were admitted to the NICU and 6054 survived to discharge. These 6054 infants constitute the denominator for all analyses except the multivariate analyses, which do not include the 29 infants lost to follow-up and the analyses involving the SNAP. A total of 5734 of these 6054 survivors were born after November 30, 1992 and constitute the denominator for those analyses involving the SNAP. An additional 278 infants were transported into these six NICUs (outborn infants), and 260 of these infants survived to discharge. Because the neonatologists in the six level III NICUs were not in full control over decisions to admit or discharge these infants, we did not include these infants in this study.

Of the 6054 cohort members, 165 (2.72%) were rehospitalized within 14 days of their first discharge home. Of these infants, 2 were rehospitalized outside the health plan without first being rehospitalized at a KPMCP facility. Of the cohort infants, 4 were first rehospitalized at a KPMCP facility and then transported outside the health plan. Rehospitalization occurred within 3 days of discharge in 41.2% of the cases, within 4 to 7 days in 29.7% of the cases, and during the second week after discharge in 29.1% of the cases.

Characteristics of Rehospitalized Infants

Table 1 summarizes the characteristics of the 165 infants who were rehospitalized. Of the 165 infants, 2 died. Of these 2 infants, 1 had trisomy 18; and the other had multiple congenital and cardiac anomalies.

Of the 8 infants who experienced assisted ventilation during rehospitalization, 3 were ventilated for respiratory failure, and 5 had elective intubation and assisted ventilation for surgery.

Reasons for Rehospitalization

Table 2 summarizes the distribution of rehospitalizations among five groups of NICU survivors. The highest rate of rehospitalization (5.69%) was among infants with 33 to 36 weeks' GA and <4 days' LOS, which is significantly different from the rate of all other groups combined ($P = .001$). In all groups except <33 weeks' GA, jaundice and feeding difficulties were the most common rehospitalization diagnoses. A total of 62 (37.6%) infants had a rehospitalization diagnosis of jaundice, 25 (15.8%) had a rehospitalization diagnosis of feeding difficulty, 21 (12.8%) had a rehospitalization diagnosis of rule-out sepsis, and 4 (2.4%) had a rehospitalization diagnosis of urinary tract infection. Additionally, 9 (5.5%) of the infants had a rehospitalization diagnosis of apnea. Term infants with ≥ 4 days' LOS had the most heterogeneous group of diagnoses; this can be attributed to the presence of congenital anomalies in this group.

Among the 62 infants rehospitalized for jaundice, the median age at discharge from the birth hospitalization was 57.2 hours with a range of 17.1 to 896.4 hours. The majority of these infants (42/62, 67.7%) had a serum bilirubin measurement before discharge home. Among these 42 infants, the median serum indirect bilirubin before discharge home was 13.2 mg/dL (range: 5.2–20.3 mg/dL; mean \pm SD: 13.1 \pm 3.2 mg/dL). The majority (50/62, 81%) of these infants were treated with phototherapy during rehospitalization. Highest indirect serum bilirubin values among these 50 infants ranged from 11.0 to 24.6 mg/dL. The median peak serum bilirubin was 17.6 mg/dL (mean \pm SD: 17.3 \pm 2.9 mg/dL). No infant with jaundice experienced exchange transfusion during rehospitalization or was given a diagnosis of kernicterus.

Among the 25 infants rehospitalized with a diagnosis of a feeding difficulty, the median percent loss

TABLE 1. Characteristics of Rehospitalized Infants

	GA (Week)		
	<33	33–36	≥ 37
<i>n</i>	20	57	88
Mean BW \pm SD	1308 \pm 436	2469 \pm 495	3504 \pm 650
Median SNAP (range)*	15 (2–28)	4 (0–20)	3 (0–23)
Median LOS, in days (range)	52.6 (19.7–117.2)	3.6 (.7–73.1)	2.7 (.7–61.9)
% Male	70%	58%	64%
% Received oxygen in NICU	95%	23%	35%
% Ventilated in NICU	95%	11%	9%
% White	55%	51%	38%
% Black	15%	7%	7%
% Hispanic	30%	18%	28%
% Asian	0	19%	25%
Rehospitalization			
% Ventilated	30.0%	1.8%	1.1%
% Died	0	0	2.3%
Median LOS, in days (range)	2 (1–23)	2 (1–45)	2 (1–23)

* *n* For SNAP analyses is 157; *n* for all other analyses is 165.

TABLE 2. Distribution of Rehospitalization Rates and Diagnoses

Group	n	Number Rehospitalized (%)	Most Common Rehospitalization Diagnoses (% With This Diagnosis Within Group)
≥37 wk, LOS <96 h	2593	56 (2.2)	1. Jaundice (46%) 2. Rule-out sepsis (20%) 3. Feeding difficulties (13%)
≥37 wk, LOS ≥96 h	1133	32 (2.8)	1. Jaundice (25%) 2. Feeding difficulties (16%) 3. Congenital heart disease (9%)
33–36 wk, LOS <96 h	545	31 (5.7)*	1. Jaundice (71%) 2. Feeding difficulties (16%) 3. Rule-out sepsis (6%)
33–36 wk, LOS ≥96 h	1196	26 (2.2)	1. Dehydration (28%) 2. Jaundice (20%) 3. Rule-out sepsis (20%)
<32 wk, all LOS	587	20 (3.4)	1. Bronchiolitis (21%) 2. Gastroesophageal reflux (16%) 3. Hernia repair (10%)

* $\chi^2 P = .001$ when the rehospitalization rate for this group is compared with that of the other four groups combined.

from birth weight was 2.9% (range: 0%–16.7%), whereas the median percent loss from the discharge weight was 0% (range: 0%–8.4%; mean \pm SD: 2.0% \pm 2.8%). Only 4 of these infants lost >12% of their birth weight, an accepted definition of dehydration in the immediate neonatal period.³⁵ The majority (19/25, 76%) of these infants had serum sodium measured, and the median value was 140 mEq/L (mean \pm SD: 139 \pm 7 mEq/L). Only 1 infant had a serum sodium level >149 mEq/L.

Rehospitalized Versus Nonrehospitalized Patients

Table 3 presents a univariate comparison of rehospitalized versus nonrehospitalized NICU survivors. Male infants, infants ventilated >6 days, Hispanic infants, and infants with anomalies were more likely to be rehospitalized, whereas white and black infants were less likely to be rehospitalized. The median SNAP did not differ between rehospitalized and nonrehospitalized infants.

Predictive Factors for Rehospitalization

Figures 1 through 4 show rehospitalization rates as a function of individual predictors using the moving average method. An elevated rehospitalization rate is apparent at 34 to 36 weeks (Fig 1), which is consistent with the distribution described in Table 2. Figure 2 shows that a birth weight of <1000 g seems to be associated with markedly increased rates of rehospitalization, whereas Fig 3 shows that the SNAP only has predictive value at very high values (>20). A length of assisted ventilation that is >6 days is also associated with increased rehospitalization rates (Fig 4).

Interfacility Variation

Facility-specific rehospitalization rates among all survivors ranged from 1.55% (facility A) to 4.09% (facility B). The rehospitalization rate for facility B differed significantly from the rate of all other facil-

TABLE 3. Comparison of Rehospitalized Versus Non-rehospitalized NICU Survivors

	Not Rehospitalized	Rehospitalized	P
GA			
<33 wk	N = 567 (9.6%)	N = 20 (12.1%)	—
33–36 wk	N = 1684 (28.6%)	N = 57 (34.6%)	—
37+ wk	N = 3638 (61.8%)	N = 88 (53.3%)	—
Median BW*	3055 (430–5770)	2952 (601–4990)	.30
Median SNAP* (range)	3 (0–48)	4 (0–28)	.21
Male sex	3180 (54%)	102 (62%)	.041
Respiratory support			
Received oxygen in NICU	2179 (37%)	55 (33%)	.63
With oxygen at 28 d	1884 (32%)	55 (33%)	.86
Ever ventilated in NICU	942 (16%)	31 (20%)	.15
% Ventilated >6 d in NICU	259 (4.4%)	16 (9.7%)	.001
Congenital heart disease	35 (.58%)	4 (2.42%)	.003
Other anomaly	398 (6.76%)	17 (10.3%)	.076
Race†			
White	3357 (57%)	73 (44%)	.002
Black	648 (11%)	14 (8%)	.254
Hispanic	883 (15%)	41 (25%)	.001
Asian	824 (14%)	31 (20%)	.03
Median LOS (range)*	3.82 (.3–301)	3.51 (.7–117.2)	.58
Had nonemergency department visit within 72 h of NICU discharge	1000 (17.0%)	68 (41.2%)	.04
Postdates (>40 wk)	848 (14.4%)	26 (15.8%)	.625

* Non-Gaussian distribution, nonparametric comparison conducted.

† Comparison is between selected racial group versus all other races combined.

Rehospitalization Rate by Gestational Age

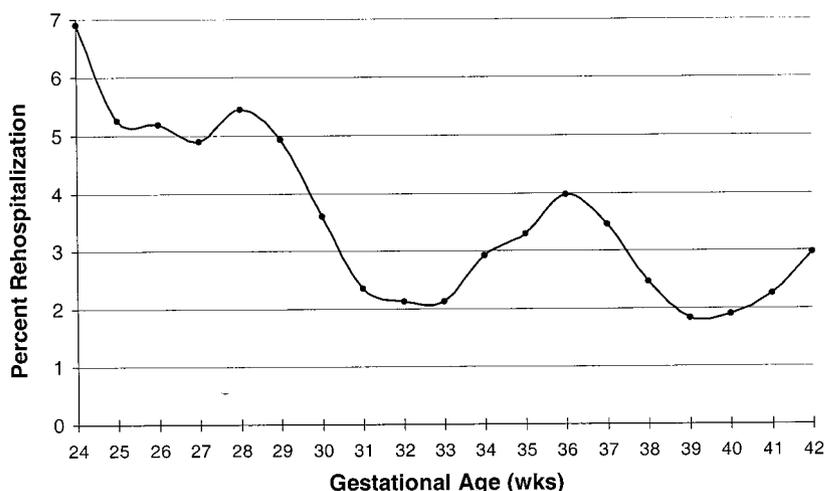


Fig 1. Rehospitalization rate as a function of GA among NICU survivors using the moving average technique. Note curve elevation between 33 and 37 weeks' GA.

Rehospitalization Rate by Birth Weight

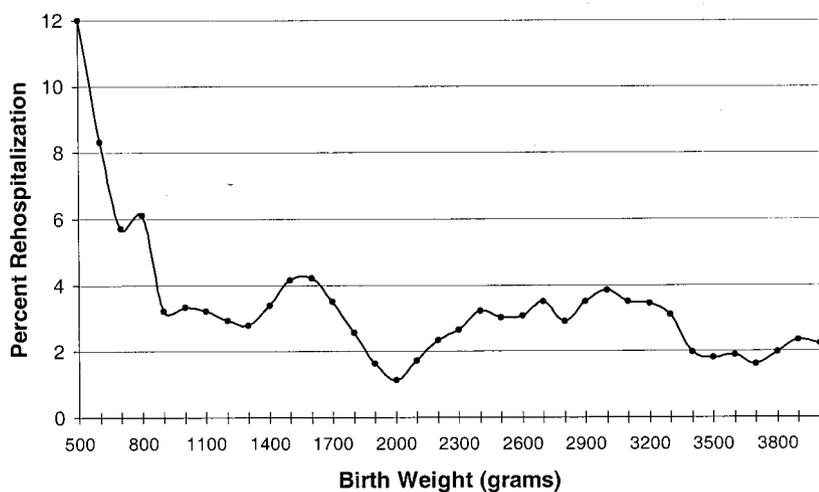


Fig 2. Rehospitalization rate as a function of birth weight among NICU survivors using the moving average technique. Note the consistent rise in curve at <1000 g birth weight.

ities combined (2.24%; $P = .001$); the rate for facility A also differed significantly from the rate of all other facilities combined (2.95%; $P = .02$). Sample size and database limitations, such as the inability to adjust for predictors such as socioeconomic status or breastfeeding, precluded a detailed analysis of the factor that might account for such variation. However, the increased rehospitalization rates for infants <33 weeks and from 33 to 36 weeks with <4 days' LOS still held within individual facilities.

Multivariate Analyses

Table 4 presents results of a logistic regression model using any rehospitalization ($n = 165$) as the outcome variable. It shows that three predictors are significant: <33 weeks' GA, from 33 to 36 weeks' GA with <4 days' LOS (both vs term gestation with <4 days' LOS), and birth at facility B (vs all other facil-

ities), which had the highest rehospitalization rate. If rehospitalization with a severe illness ($N = 47$) was the outcome, two predictors were significant: <33 weeks' GA (adjusted OR [AOR]: 3.74; 95% CI: 1.43–9.80) and term gestation with ≥ 96 hours' LOS (AOR: 3.41; 95% CI: 1.50–7.77; both vs term gestation with <96 hours LOS). Birth at facility B was not associated with rehospitalization with a severe illness.

We also tested a more complex model that included 1) the predictors listed in Table 4, 2) discharge during the California RSV season, 3) a nonemergency department visit within 72 hours of NICU discharge, and 4) an emergency department visit within 72 hours of NICU discharge. In this model <33 weeks' GA, from 33 to 36 weeks' GA with <4 days' LOS, and birth at facility B remained significant. Discharge during the California RSV season was not significant. A nonemergency department

Rehospitalization Rate by SNAP

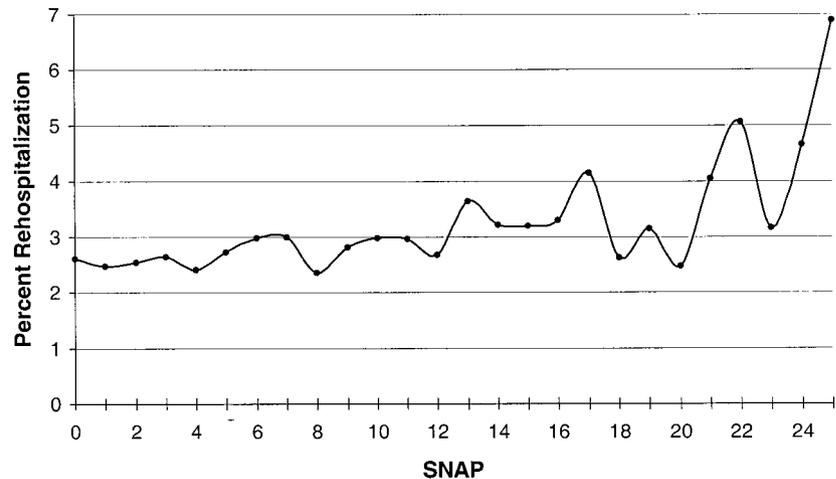


Fig 3. Rehospitalization rate as a function of 24-hour SNAP among NICU survivors using the moving average technique. Note that curve drifts upward as SNAP increases with sharpest rise beginning at SNAP of 20.

Rehospitalization Rate by Length of Ventilation

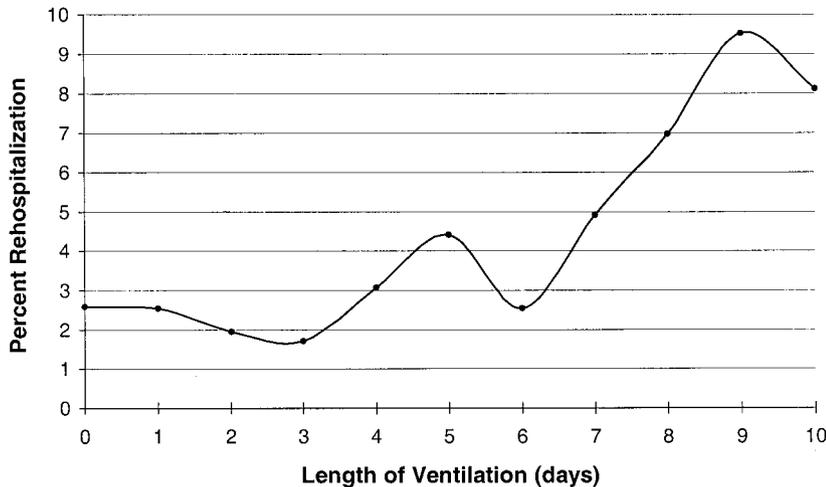


Fig 4. Rehospitalization rate as a function of the length of assisted ventilation among NICU survivors using the moving average technique. Curve rises consistently when length of assisted ventilation is ≥ 6 days.

visit within 72 hours of discharge was significant (AOR: 3.06; 95% CI: 2.21–4.24), and an emergency department visit was significant (AOR: 4.08; 95% CI: 1.75–9.49). Term gestation with ≥ 4 days' LOS (AOR: 3.46; 95% CI: 1.52–7.90), <33 weeks' GA (AOR: 3.90; 95% CI: 1.49–10.23), and an emergency visit (AOR: 8.24; 95% CI: 2.38–28.58) remained predictive of rehospitalization with a severe illness.

We also tested birth at facility A, which had the lowest rehospitalization rate, versus all other facilities, as a predictor in the simple and complex multivariate models. Birth at facility A proved to be protective against rehospitalization in both models (AOR: 0.51; 95% CI: 0.30–0.89), but not against rehospitalization with a severe illness.

DISCUSSION

The overall rehospitalization rate in the first 2 weeks after NICU discharge (165/6054, 2.72%) is higher than the rehospitalization rate we found in

our monitoring of healthy term newborns in the KPMCP in 1995 (158/7154, 2.26%; $P = .06$). We also found that the rehospitalization rate with a severe illness is much higher among the NICU graduates. We found that none of the healthy term newborns required assisted ventilation or interhospital transport when rehospitalized, and there were no deaths.

We found two groups with elevated rehospitalization rates. High rates among infants with <33 weeks' GA are consistent with what is known about very premature infants. The fact that <33 weeks' GA is correlated highly with prolonged assisted ventilation (>6 days) suggests that the sequelae of lung immaturity may be responsible for the increased risk of rehospitalization among these infants.

The second group, infants from 33 to 36 weeks' GA with <4 days' LOS, has not been described previously. This population comprises 9% of NICU discharges, but 19% of NICU rehospitalizations. In this

TABLE 4. Multivariate Analysis for Predictors of Rehospitalization

Predictor	OR	95% CI
Term gestation, LOS <96 h	—Reference group for gestational age comparisons—	
Gestation <33 wk, all LOS	1.88	1.10–3.21
Gestation 33–36 wk, LOS <96 h	2.94	1.87–4.62
Gestation 33–36 wk, LOS ≥96 h	1.13	.69–1.84
Term gestation, LOS ≥96 h	1.31	.83–2.05
Smallest quartile*	.73	.44–1.22
Sickest quartile†	1.26	.90–1.77
Birth at facility B‡	1.92	1.39–2.65

Denominator, 6025 NICU survivors (29 infants lost to follow-up excluded). Numerator, 165 rehospitalized infants.

* Compared with infants who were not in lowest 25th weight percentile for GA.

† Compared with infants who were not in highest 25th SNAP percentile for GA.

‡ Compared with infants born at all other five facilities.

group, 71% of infants were rehospitalized because of jaundice. These findings are not surprising, because clinical experience suggests that these infants often do well during the first 2 days of life and then experience fatigue on days 3 and 4. Strict adherence to purely physiologic criteria could lead to the discharge of asymptomatic infants who may, in fact, be at risk of developing feeding difficulties and/or jaundice later.

In our multivariate models, we found that being in the lowest weight quartile and being in the lowest SNAP quartile for a given GA do not predict rehospitalization. However, the results found when using the moving average technique suggest that the SNAP might become significant in analyses involving larger datasets.

Differences in rehospitalization rates among the six facilities could be driven by practice variation in two areas. The first area is the management of jaundice, an area in which clinicians differ in perception of risk as well as optimum management.³⁶ The bilirubin values in our cohort indicate that, as among other pediatricians, there is no consensus among KPMCP neonatologists as to what constitutes a safe bilirubin. The second area is infant feeding, for which a tool comparable to the SNAP to assess feeding competency on the day of discharge does not exist. Differences in maternal socioeconomic status may be associated with variations in rehospitalization rates; however, we were not able to adjust for this factor.

Despite the prominence of feeding difficulties as a reason for rehospitalization among NICU graduates, these occurrences do not seem associated with severe dehydration, which is a problem that is receiving increasing research attention.^{36,37} In our surveillance of healthy term infants born in 1995, 13 of 33 infants who were rehospitalized with a diagnosis of feeding difficulty and/or dehydration had a high serum sodium level (>149 mEq/L), whereas among the NICU graduates, only 1 of 25 infants with similar diagnoses had a high serum sodium. This suggests that dehydration may be detected earlier in NICU graduates or that there may be a lower threshold for rehospitalizing them.

The relationship between outpatient events and rehospitalization was unclear because of the absence of useful process and outcomes measures and inadequate data. Electronic scanning of existing data-

bases could not distinguish among preventive, palliative, and urgent visits. Moreover, we did not have access to data on home visits provided to KPMCP by California Children's Services.

Other studies on healthy term newborns also report rehospitalization rates in the 2% range.^{18–21,36} Two studies report rehospitalizations among NICU graduates within 2 weeks after discharge. The first, by Kotagal et al,¹⁶ reports on 257 NICU survivors who were discharged from the University of Cincinnati, of whom, 1 was rehospitalized within 2 weeks. Kotagal et al do not report outcomes of all infants >1500 g, thus we cannot compare our data with their results for such infants. Our rehospitalization rates for infants 500 to 1500 g are not significantly different from the rates reported by Kotagal (0/58 at Cincinnati; 13/362 at the KPMCP; *P* = .23).

The second study by Gray et al¹⁷ reported a 1.2% rehospitalization rate among infants ≥2500 g admitted to the Boston Brigham and Women's Hospital NICU. This rehospitalization rate is significantly different from our rate (6/521 at Boston; 111/4106 at the KPMCP; *P* = .03). Their methodology differs from our methodology because not all infants who were treated expectantly with antibiotics (rule-out sepsis) were admitted to the Boston unit; all such newborns are admitted to KPMCP NICU's. This difference underscores the fact that there are no standard criteria for admission to the NICU. Additionally, Gray et al used maternal recall to quantify rehospitalizations, whereas we used encounter data. However, like us, Gray et al found no significant association between the SNAP and rehospitalization. Also, among the infants with early rehospitalizations in the study by Gray et al, the most common diagnoses were feeding difficulties (2/6) and jaundice (2/6).

CONCLUSIONS

We have found that the short-term rehospitalization rate among NICU graduates is somewhat higher than the rate of healthy term infants. Also, serious events shortly after discharge are more common among the NICU graduates. When compared with other NICU graduates, infants with <33 weeks' GA and infants with 33 to 36 weeks' GA and <4 days' LOS have higher rehospitalization rates. However, in the latter group, most of the rehospitalizations are

not associated with serious or life-threatening illnesses.

Because few studies have reported on early rehospitalization after discharge from the NICU, our analyses were performed for the purpose of description and hypothesis generation rather than hypothesis testing. Our results highlight important gaps in our knowledge regarding high-risk infants. One gap is the ability to predict outcomes over the short-term. In the absence of reliable risk-assessment instruments and outcomes measures, it is difficult to conclude what optimum NICU follow-up should be. Two other areas requiring research attention relate to practice variation; we must define standards for feeding competency and hyperbilirubinemia and determine the correlation between physician perception of risk and biologic risk, an area that is beginning to be explored in neonatology.³⁰

Finally, researchers in this area must develop and validate better measurement tools. Instruments should be applicable to individual infants (eg, a 28-day feeding SNAP score) or their mothers (eg, a discharge comfort with breastfeeding score) and should permit risk-adjustment using birth weight, gestation, and LOS. It is also essential to develop tools that measure a given neonatal unit's compliance with guidelines. Collaborative cohort studies including these data elements could begin to define optimum follow-up strategies.

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APPENDIX. Weight and SNAP Thresholds

GA (Weeks)	Smallest Quartile Birth Weight in Grams	Sickest Quartile SNAP
24	<645	≥17
25	<675	≥16
26	<705	≥16
27	<870	≥15
28	<1020	≥15
29	<1120	≥14
30	<1190	≥13
31	<1390	≥12
32	<1590	≥11
33	<1775	≥8
34	<1995	≥6
35	<2148	≥6
36	<2295	≥5
≥37	<2500	≥5

The information in this appendix will be provided to interested readers on request.

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