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

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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.

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. Within this group, the highest rates of adverse outcomes are experienced by infants who are of very low birth weight (VLBW; <1500 g).

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, premature, NICU graduate, or combinations thereof.

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. 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.

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

Received for publication June 4, 1998; accepted Mar 1, 1999.
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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 (KP MCP), a group-model managed care organization. The study sites consisted of all six northern California KP MCP 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 KP MCP facilities before discharge. Decisions regarding the timing of discharge and provision of follow-up care 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 KP MCP 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 KP MCP 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; 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 KP MCP 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 included only those newborns born after November 30, 1992. During the period of this study, no KP MCP 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 KP MCP 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 KP MCP 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).

All statistical analyses were performed using SAS, Version 6 (SAS Institute, Inc, Cary, NC).26 Comparisons involving categorical variables were performed using the x2 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 method described by Arkin and Colton27 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 = 169) 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 = 2287). 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 44943 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 ± SD: 13.1 ± 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 ± SD: 17.3 ± 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>
<thead>
<tr>
<th>TABLE 1. Characteristics of Rehospitalized Infants</th>
<th>GA (Week)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;33</td>
</tr>
<tr>
<td>n</td>
<td>20</td>
</tr>
<tr>
<td>Mean BW ± SD</td>
<td>1308 ± 436</td>
</tr>
<tr>
<td>Median SNAP (range)*</td>
<td>15 (2–28)</td>
</tr>
<tr>
<td>Median LOS, in days (range)</td>
<td>52.6 (19.7–117.2)</td>
</tr>
<tr>
<td>% Male</td>
<td>70%</td>
</tr>
<tr>
<td>% Received oxygen in NICU</td>
<td>95%</td>
</tr>
<tr>
<td>% Ventilated in NICU</td>
<td>95%</td>
</tr>
<tr>
<td>% White</td>
<td>55%</td>
</tr>
<tr>
<td>% Black</td>
<td>15%</td>
</tr>
<tr>
<td>% Hispanic</td>
<td>30%</td>
</tr>
<tr>
<td>% Asian</td>
<td>0</td>
</tr>
<tr>
<td>Rehospitalization</td>
<td></td>
</tr>
<tr>
<td>% Ventilated</td>
<td>30.0%</td>
</tr>
<tr>
<td>% Died</td>
<td>0</td>
</tr>
<tr>
<td>Median LOS, in days (range)</td>
<td>2 (1–23)</td>
</tr>
</tbody>
</table>

*p For SNAP analyses is 157; n for all other analyses is 165.
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 ± SD: 2.0% ± 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 ± SD: 139 ± 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 facilities.

*χ² P = .001 when the rehospitalization rate for this group is compared with that of the other four groups combined.

Table 2. Distribution of Rehospitalization Rates and Diagnoses

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

*χ² P = .001 when the rehospitalization rate for this group is compared with that of the other four groups combined.

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

<table>
<thead>
<tr>
<th>GA</th>
<th>Not Rehospitalized</th>
<th>Rehospitalized</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;33 wk</td>
<td>N = 567 (9.6%)</td>
<td>N = 20 (12.1%)</td>
<td>—</td>
</tr>
<tr>
<td>33–36 wk</td>
<td>N = 1684 (28.6%)</td>
<td>N = 57 (34.6%)</td>
<td>—</td>
</tr>
<tr>
<td>37+ wk</td>
<td>N = 3638 (61.8%)</td>
<td>N = 88 (53.3%)</td>
<td>—</td>
</tr>
<tr>
<td>Median BW*</td>
<td>3055 (430–5771)</td>
<td>2952 (601–1490)</td>
<td>.30</td>
</tr>
<tr>
<td>Median SNAP* (range)</td>
<td>3 (0–48)</td>
<td>4 (0–28)</td>
<td>.21</td>
</tr>
<tr>
<td>Male sex</td>
<td>3180 (54%)</td>
<td>102 (62%)</td>
<td>.041</td>
</tr>
<tr>
<td>Respiratory support</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Received oxygen in NICU</td>
<td>2179 (37%)</td>
<td>55 (33%)</td>
<td>.63</td>
</tr>
<tr>
<td>With oxygen at 28 d</td>
<td>1884 (32%)</td>
<td>55 (33%)</td>
<td>.86</td>
</tr>
<tr>
<td>Ever ventilated in NICU</td>
<td>942 (16%)</td>
<td>31 (20%)</td>
<td>.15</td>
</tr>
<tr>
<td>% Ventilated &gt; 6 d in NICU</td>
<td>259 (4.4%)</td>
<td>16 (9.7%)</td>
<td>.001</td>
</tr>
<tr>
<td>Congenital heart disease</td>
<td>35 (5.8%)</td>
<td>4 (2.4%)</td>
<td>.003</td>
</tr>
<tr>
<td>Other anomaly</td>
<td>398 (6.7%)</td>
<td>17 (10.3%)</td>
<td>.076</td>
</tr>
<tr>
<td>Race*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>3357 (57%)</td>
<td>73 (44%)</td>
<td>.002</td>
</tr>
<tr>
<td>Black</td>
<td>648 (11%)</td>
<td>14 (8%)</td>
<td>.254</td>
</tr>
<tr>
<td>Hispanic</td>
<td>883 (15%)</td>
<td>41 (25%)</td>
<td>.001</td>
</tr>
<tr>
<td>Asian</td>
<td>824 (14%)</td>
<td>31 (20%)</td>
<td>.03</td>
</tr>
<tr>
<td>Median LOS (range)*</td>
<td>3.82 (3.3–3.87)</td>
<td>3.51 (7.17–11.7)</td>
<td>.58</td>
</tr>
<tr>
<td>Had nonemergency department visit within 72 h of NICU discharge</td>
<td>1000 (17.0%)</td>
<td>68 (41.2%)</td>
<td>.04</td>
</tr>
<tr>
<td>Postdates (&gt;40 wk)</td>
<td>848 (14.4%)</td>
<td>26 (15.8%)</td>
<td>.625</td>
</tr>
</tbody>
</table>

* 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 facilities), 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
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
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. 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. 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 databases 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. Two studies report rehospitalizations among NICU graduates within 2 weeks after discharge. The first, by Kotagal et al, 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 al 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
EARLY REHOSPITALIZATION AFTER NICU DISCHARGE

Richardson for reviewing the manuscript.

MPH, for assistance with programming, Veronica Gonzales for

Group, Inc.

Permanente Medical Group, Inc. Funding for the Neonatal Mini-

optimum follow-up strategies.

including these data elements could begin to 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.\textsuperscript{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.

ACKNOWLEDGMENTS

This project was supported by the Kaiser Foundation Health

Plan, Inc, Community Service Program Grant 115-9851 and by The

Permanente Medical Group, Inc. Funding for the Neonatal Mini-

mum Data Set database was provided by the Kaiser Foundation Health

Plan, Inc Grant 115-6137 and by The Permanente Medical

Group, Inc.

We thank Berwick Chan, Wesley Hawkins, and Blong Xiong,

MPH, for assistance with programming, Veronica Gonzales for

assistance with graphics, and Joan E. Verdi, MBA, and Mamie

Ford for record abstraction. We also thank Drs Gary D. Friedman,

Joseph V. Selby, Allen Fischer, Tracy A. Lieu, and Douglas K.

Richardson for reviewing the manuscript.

APPENDIX. Weight and SNAP Thresholds

<table>
<thead>
<tr>
<th>GA (Weeks)</th>
<th>Smallest Quartile Birth Weight in Grams</th>
<th>Seventh Quartile SNAP</th>
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<tr>
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<td>≥37</td>
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<td>≥5</td>
</tr>
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</table>

The information in this appendix will be provided to interested

readers on request.

REFERENCES


Rehospitalization in the First Two Weeks After Discharge From the Neonatal Intensive Care Unit
Gabriel J. Escobar, Steven Joffe, Marla N. Gardner, Mary Anne Armstrong, Bruce F. Folck and Diane M. Carpenter

Pediatrics 1999;104:e2

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