Rehospitalization for Neonatal Dehydration

A Nested Case-Control Study

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Objectives: To determine the incidence of neonatal dehydration leading to rehospitalization, whether clinical and health services data could predict its occurrence, and the outcome of dehydrated infants.

Methods: We employed a retrospective case-control design nested within a cohort of 51,383 newborns weighing 2000 g or more, with a gestational age of 36 weeks or more born at 11 Kaiser Permanente hospitals during 1995 and 1996. Cases were 110 infants who were rehospitalized within 15 days of discharge with dehydration, and who either had 12% or greater weight loss or a serum sodium level of 150 mEq/L or greater. Controls were 402 randomly selected infants. We reviewed subjects' paper medical records and telephoned their families at 24 to 36 months of age to ascertain neurological outcomes.

Results: Rehospitalization for dehydration occurred in 2.1 per 1000 live births (95% confidence interval [CI], 1.8-2.6). Among vaginal births, the most important risk factors were being born of a first-time mother (adjusted odds ratio [AOR], 5.5; 95% CI, 3.1-9.6); exclusive breastfeeding (AOR, 11.2; 95% CI, 3.9-32.6); maternal age equal to or older than 35 years (AOR, 3.0; 95% CI, 1.5-6.0); and gestational age younger than 39 weeks (AOR, 2.0, 95% CI, 1.2-3.5). Among cesarean births, having a birth hospitalization length of stay less than 48 hours was associated with dehydration (odds ratio [OR], 14.8; 95% CI, 1.4-154.1). Adherence to the American Academy of Pediatrics follow-up guideline did not decrease risk of readmission. Among surviving infants, 1 of 110 cases and 12 of 400 controls had evidence of possible neurological problems 24 to 36 months after discharge (P=.3). No cases of limb gangrene, amputation, or intracranial infarction occurred.

Conclusions: In this population with good access to medical care, serious sequelae of neonatal dehydration are rare. Interventions to decrease the frequency of neonatal dehydration should focus on first-time mothers and those who breastfeed exclusively.

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In developed nations, feeding difficulties, failure to gain weight, and dehydration are among the most common reasons for rehospitalization in the immediate neonatal period. Many anecdotal reports about these conditions have been published. Concern about the outcome of newborns with short lengths of stay (LOS) during birth hospitalization increased significantly in the last few years. This concern led to passage of specific legislation in the United States. It also led to increased research attention, which has included population-based studies on neonatal rehospitalization. Although these studies provide some data on neonatal dehydration, they provide limited clinical information.

This study focused on dehydration occurring in newborn infants of birth weights and gestational ages likely to be cared for by general pediatricians. It aimed to determine (1) the incidence of severe dehydration leading to rehospitalization during the early neonatal period; (2) key demographic (eg, race/ethnicity), physiologic (eg, degree of weight loss at time of discharge), and health services (eg, timing of outpatient follow-up) correlates for this condition; and (3) postdischarge outcome.

RESULTS

Of 51,387 infants born alive at the 11 sites during the study period weighing 2000 g or more, and with 36 weeks or more gestation, 110 met our case definition, giving an overall incidence of 2.1 per 1000 live births (95% confidence interval [CI], 1.8-2.6). The incidence of rehospitalization for dehydration across hospitals ranged from 1.2 to 3.4 per 1000 live births.
SUBJECTS AND METHODS

STUDY DESIGN

The study is a nested case-control study. Nested case-control studies begin with an identified cohort, identify all instances of the outcome of interest, and then compare key predictors between these cases and a random sample of those in the cohort who did not develop the outcome—the controls. The study also included ascertainment of outcome by means of a review of later medical records and telephone interviews.

The study was approved by the Kaiser Permanente Medical Care Program (KPMCP) Institutional Review Board for the Protection of Human Subjects.

STUDY SITES

The setting for this study was the KPMCP, Northern California Region, a group-model managed care organization with integrated information systems. The study sites were the KPMCP hospitals in Hayward, Oakland, Redwood City, Sacramento, San Francisco, Santa Clara, Santa Rosa, Santa Teresa, South Sacramento, Vallejo, and Walnut Creek (Calif) and their associated outpatient clinics.

INCLUSION CRITERIA

Infants were eligible for this study as cases if they (1) weighed at least 2000 g at birth; (2) were born at 36 weeks gestation or more; (3) were discharged alive after birth hospitalization at one of the study sites; (4) were born vaginally and had a birth hospitalization LOS of less than 72 hours; (5) were born by cesarean delivery and had a birth hospitalization LOS of less than 120 hours; (6) were rehospitalized within 15 days following discharge from birth hospitalization; and (7) met the study dehydration definition. Randomly selected controls had to meet criteria 1 through 5 as listed here.

For the purposes of this study, the following International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes were considered to be “dehydration diagnoses”: 276.0 (hyperosmolality and/or hypernatremia), 276.5 (volume depletion), 775.5 (other transitory neonatal electrolyte disturbances), 778.4 (other disturbances of temperature regulation of newborn, which includes dehydration fever in newborns), 779.3 (feeding problems in newborn), 783.2 (abnormal loss of weight), 783.4 (lack of expected normal physiologic development), 785.30 (shock without mention of trauma), and 785.59 (other forms of shock, including hypovolemic shock). We defined dehydration as having one of these diagnoses on readmission, and either (1) a serum sodium level of 130 mEq/L or greater, which has been suggested as placing infants at risk for neurological sequelae and/or (2) a 12% or higher loss of birth weight, which has been proposed as the upper limit of normal weight loss in newborns.

SUBJECT IDENTIFICATION

We scanned KPMCP databases to identify potential study subjects; we then performed medical record review to ensure that case or control criteria were met. Controls were selected at random. The KPMCP’s information systems use a common medical record number and clinical data repository. These information systems permit multiple linkages (eg, downloading all neonatal serum sodium results and linking these to hospitalization records). The methods we

in this birth weight and gestational age range. Of 428 controls initially sampled, one infant’s initial birth hospitalization medical record could not be located, 3 were ineligible due to birth weight or gestational age, and 22 did not meet LOS criteria, leaving 402 controls.

Among the cases, rehospitalization occurred when infants were between 42 and 349 hours (14.5 days) old. Rehospitalization occurred within 0 to 47.9 hours after discharge in 45% of cases, within 48 to 71.9 hours in 25%, and within 72 to 96 hours in 14%. Most rehospitalizations (70 [64%] of 110 cases) occurred between 24 and 72 hours after discharge. Few hospitalizations occurred after 96 hours: there were 12 between 96 hours and 168 hours (11%), and only 5 in the second week after discharge (5%).

The most common clinical presentation at the time of rehospitalization was parent-reported feeding difficulty, which was present in 44% of the dehydrated infants. Seizures were uncommon (present in only 3%), but lethargy was more common (17%). Serum bilirubin levels were measured in 80% of the dehydrated infants, and the median highest total serum bilirubin measurement was 17.0 mg/dL, with 34 infants (31%) having a total serum bilirubin level of 20.0 mg/dL or greater, and 7 infants (6%) with a level of 25.0 mg/dL or greater. Phototherapy was employed in 39%. Serum sodium values were obtained from 82% of the cases, with serum sodium levels ranging between 137 and 188 mEq/L, with a median value of 151 mEq/L. Most rehospitalizations lasted 2 to 3 days and involved admission to a pediatric ward (69%) rather than an intensive care setting. Few differences existed among subgroups of dehydrated infants (eg, between those who met the sodium criterion as compared with the weight loss criterion). The most important of these differences was that infants who met both sodium and weight criteria were more likely to be readmitted to an intensive care nursery and more likely to receive intravenous fluids.

BIVARIATE COMPARISONS

Table 1 presents key predictors among cases and controls. Cases were much more likely than controls to have been exclusively breastfed at the time of discharge, to have a gestational age less than 39 weeks, and to have been their mothers’ first live birth. They were less likely to be either born by cesarean delivery or to be African American. Median length of rupture of membranes was more than twice as high in cases than in controls; this difference was significant (P < .001). Median maternal age and percent weight loss per day were also higher among cases than among controls. There were no significant differences with respect to mean birth weight, mean gesta-
employed for subject identification, data abstraction, and electronic linkage have been described elsewhere.23-29

DATA COLLECTION

Professional medical record analysts reviewed paper records to verify eligibility and abstract study data for cases and controls. We attempted to contact study families by phone when infants were between 24 and 36 months of age to determine the presence of long-term sequelae (eg, developmental delay or whether a child had special needs or required ongoing care by a pediatric specialist). We also identified cases and controls who had diagnoses that could lead to dehydration for reasons other than primary feeding failure. Examples of such diagnoses include anomalies (eg, cleft lip/palate, congenital heart disease, Hirschsprung disease, pyloric stenosis) and infections (eg, viral gastroenteritis, viral or bacterial meningitis). Breastfeeding status was based on medical record entries at the time of hospital discharge.

We assessed adherence to the American Academy of Pediatrics’ (AAP) infant follow-up guideline30 using a combination of electronic scanning of KPMC databases and review of paper medical records. The KPMC Patient Appointment, Registration, and Reporting System database records the projected dates and times for appointments, location of said appointments (eg, the Hayward Medical Center Pediatric Urgent Care Clinic), when such appointments were made, and cancellations. The KPMC Registration database records appointments that were actually kept, as well as any unscheduled (eg, urgent care or emergency department) appointments. Data are only entered in the KPMC Registration database when a patient physically registers at a KPMC care facility. Using these information sources, we could assign infants to categories such as: (1) the AAP follow-up guideline recommendations were met by virtue of having an LOS 48 hours or longer; (2) the guideline recommendations were not met because of provider nonadherence (ie, no appointment was scheduled); and (3) the guideline recommendations were not met because of a family’s failure to keep an appointment.

STATISTICAL METHODS

All statistical analyses were performed using SAS software.31 Initial analyses included χ² tests and t tests comparing cases and controls with respect to a variety of potential predictors. Variables that did not have a gaussian distribution were compared using the 2-sample nonparametric median test. Prior to conducting logistic regression analyses, we performed 2 sets of preliminary analyses. The first set consisted of recursive partitioning, which we performed to identify potential predictors, as well as to assist us in establishing cutoffs among continuous predictors (eg, percentage of weight loss before discharge from birth hospitalization). Recursive partitioning analyses were performed using the Classification and Regression Trees software.32,33 The second set consisted of correlation analyses on all potential predictors for assessing multicollinearity. Highly correlated variables were either transformed in such a way that both could be included in a model or one of the variables was omitted from the analysis. Remaining predictors were entered into a forward stepwise logistic regression analysis (P = .10) to identify the most important predictors. We conducted subset analyses based on whether infants were born of first-time mothers and whether exclusive breastfeeding was planned at the time of birth (vaginal or cesarean).

Outpatient Follow-up

The median age at the first postdischarge outpatient visit was 70 hours among cases and 135 hours among controls (P < .001). The median time difference between hospital discharge and first postdischarge outpatient visit was 43 hours among cases and 97 hours among controls (P < .001). The percentage of infants discharged when younger than 48 hours whose follow-up met the AAP’s criteria was 88% (87/99) among the cases but only 47% (152/323) among the controls (P < .001).

Since some infants met the AAP’s recommended follow-up because of parent-initiated visits at younger than 72 hours, we also compared the rates of clinician-initiated efforts at providing follow-up (ie, rates of appointments made before hospital discharge and home visits provided before 72 hours). After removing any infants rehospitalized within 24 hours, we found that an attempt to meet the AAP recommendation was made in 28% (26/93) of cases and 29% (95/326) of controls; this difference was not significant (P = .82).

BIVARIATE ANALYSES INVOLVING SUBSETS OF DEHYDRATED INFANTS

We performed the bivariate comparisons mentioned above using 2 subsets of dehydrated infants: those whose dehydration met weight loss criteria and the controls were not different from those reported above.

MULTIVARIATE ANALYSES

Correlation analyses identified some highly correlated variable pairs (eg, LOS and birth by cesarean delivery; birth weight and gestational age). With respect to birth weight and gestational age, we were able to investigate...
both variables as predictors by including 2 variables in the model: gestational age and small-for-gestational-age status, which modeled the relationship between gestation and birth weight. In the case of neonatal LOS and cesarean section, we elected to develop separate models for infants born vaginally and those born by cesarean section.

The final set of candidate predictors that we tested in our models consisted of the following independent variables: race/ethnicity, maternal age, gestational age less than 39 weeks, exclusive breastfeeding at time of hospital discharge, LOS less than 48 hours, the infant’s sex, and small-for-gestational-age status. We elected to force race/ethnicity, the infant’s sex, and small-for-gestational-age status into the models because these were important predictors in a companion study employing the same control infants, the infant’s sex, and small-for-gestational-age status. We elected to force race/ethnicity, the infant’s sex, and small-for-gestational-age status into the models because these were important predictors in a companion study employing the same control infants.

Among the 67 infants born by cesarean section, LOS less than 48 hours, which was present in 3 of 8 cases and 7 of 59 controls, was associated with dehydration in bivariate analyses (OR, 4.5; 95% CI, 0.95-20.9). This was the only variable that was significant in multivariate analyses, but CIs were very wide because of the small numbers.

Table 2 shows the results of our final model for infants born vaginally (101 cases and 342 controls). The following predictors were associated with dehydration: being born of a first-time mother, maternal age 35 years or older, a gestational age less than 39 weeks, and being breastfed exclusively at the time of hospital discharge. This model had moderate discrimination (c = .81). We also performed a subset analysis involving only vaginal births among mothers who breastfed exclusively at the time of hospital discharge (97 cases and 237 controls). Results were similar to those of the final model, although there was some loss in discrimination (c = .76). We also conducted a subset analysis including only vaginal births involving a first-time mother (72 cases and 130 controls). In this subset analysis, only exclusive breastfeeding was predictive (adjusted odds ratio [AOR], 6.6; 95% CI, 2.2-20.2).

### Diagnoses That Could Lead to Dehydration for Other Reasons

Three (0.7%) of the 402 controls and 6 (5%) of the 110 cases had diagnoses that could possibly lead to dehydration. Among the cases with such diagnoses, 4 of 6 were apparent at the time of discharge from the birth hospitalization, while among the controls with such diagnoses, 2 of 3 were apparent at the time of discharge. Exclusion of these 9 infants did not significantly affect the results of our bivariate analyses. They did affect the results of our final multivariate model (LOS <48 hours became significant; AOR, 2.6; 95% CI, 1.2-5.8). Details about

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### Table 1. Comparison of Cases and Controls*

<table>
<thead>
<tr>
<th></th>
<th>Cases (N = 402)</th>
<th>Controls (n = 402)</th>
<th>OR (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean maternal age, y (range)</td>
<td>30 (18-44)</td>
<td>28 (14-46)</td>
<td>. . . .</td>
<td>.01</td>
</tr>
<tr>
<td>No. (%) born to first-time mother</td>
<td>79 (71.8)</td>
<td>168 (41.8)</td>
<td>3.6 (2.2-5.6)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>No. (%) born by cesarean delivery</td>
<td>8 (7.3)</td>
<td>59 (14.7)</td>
<td>0.46 (0.21-0.99)</td>
<td>.04</td>
</tr>
<tr>
<td>Median length of ROM, h (range)</td>
<td>6.3 (0.0-84.0)</td>
<td>3.4 (0.0-76.7)</td>
<td>. . . .</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Median maternal LOS, h (range)</td>
<td>36.1 (14.4-167.5)</td>
<td>37.0 (15.9-276.0)</td>
<td>. . . .</td>
<td>.67</td>
</tr>
<tr>
<td>Mean ± SD birth weight, g</td>
<td>3486 ± 494</td>
<td>3454 ± 489</td>
<td>. . . .</td>
<td>.54</td>
</tr>
<tr>
<td>Mean gestational age, wk (range)</td>
<td>39.5 (36.1-42.4)</td>
<td>39.7 (35.4-43.1)</td>
<td>. . . .</td>
<td>.13</td>
</tr>
<tr>
<td>No. (%) with gestational age &lt;39 wk</td>
<td>42 (38.2)</td>
<td>106 (26.4)</td>
<td>1.7 (1.1-2.7)</td>
<td>.02</td>
</tr>
<tr>
<td>No. (%) small for gestational age</td>
<td>2 (1.8)</td>
<td>13 (3.2)</td>
<td>0.55 (0.12-2.49)</td>
<td>.75</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>63 (57.3)</td>
<td>214 (53.2)</td>
<td>1.2 (0.77-1.80)</td>
<td>.45</td>
</tr>
<tr>
<td>Race/ethnicity, No. (%)‡</td>
<td>55 (50.0)</td>
<td>189 (47.0)</td>
<td>1.0 ( . . . )</td>
<td>. . .</td>
</tr>
<tr>
<td>White</td>
<td>4 (6.8)</td>
<td>40 (17.5)</td>
<td>0.3 (0.12-1.00)</td>
<td>.04</td>
</tr>
<tr>
<td>Asian</td>
<td>31 (36.0)</td>
<td>72 (27.6)</td>
<td>1.5 (0.88-2.48)</td>
<td>.14</td>
</tr>
<tr>
<td>Hispanic</td>
<td>19 (25.7)</td>
<td>100 (34.6)</td>
<td>0.67 (0.37-1.16)</td>
<td>.14</td>
</tr>
<tr>
<td>No. (%) admitted to intensive care nursery during birth hospitalization</td>
<td>4 (3.6)</td>
<td>12 (3.5)</td>
<td>0.44 (0.15-1.26)</td>
<td>.14</td>
</tr>
<tr>
<td>Feeding at hospital discharge, No. (%)§</td>
<td>101 (91.8)</td>
<td>270 (67.2)</td>
<td>1.0 ( . . . )</td>
<td>. . .</td>
</tr>
<tr>
<td>Exclusively breastfeeding at time of hospital discharge</td>
<td>7 (6.5)</td>
<td>44 (14.0)</td>
<td>0.43 (0.19-0.98)</td>
<td>.04</td>
</tr>
<tr>
<td>Breastfeeding and bottle feeding at time of hospital discharge</td>
<td>2 (1.9)</td>
<td>88 (24.6)</td>
<td>0.06 (0.02-0.25)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Median percent weight loss (range)</td>
<td></td>
<td>3.9 (0.1-11.9)</td>
<td>3.5 (0.1-13.5)</td>
<td>.12†</td>
</tr>
<tr>
<td>Mean percent weight loss per day (range)</td>
<td></td>
<td>2.7 (0.1-6.6)</td>
<td>2.5 (0.1-9.8)</td>
<td>.11</td>
</tr>
<tr>
<td>Median LOS, h (range)</td>
<td>30.5 (11.7-100.8)</td>
<td>29.1 (9.2-111.4)</td>
<td>. . . .</td>
<td>.24†</td>
</tr>
<tr>
<td>LOS in birth hospital &lt;48 h (%)</td>
<td>99 (90.0)</td>
<td>326 (81.1)</td>
<td>2.1 (1.1-4.1)</td>
<td>.028</td>
</tr>
<tr>
<td>No. (%) for whom drugs were used during delivery was associated with maternal discomfort</td>
<td></td>
<td>67 (60.9)</td>
<td>207 (51.5)</td>
<td>1.5 (0.96-2.26)</td>
</tr>
</tbody>
</table>

*OR indicates odds ratio; CI, confidence interval; ROM, rupture of membranes; LOS, length of stay; and ellipses, not applicable.
†Analyses performed using a 2-sample, nonparametric median comparison.
‡Race comparisons were made in 109 cases and 401 controls due to missing race information in 1 case and 1 control.
§Indicates a reference group.
¶Drugs included oxytocin and magnesium sulfate.

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POSTDISCHARGE OUTCOME

None of the infants developed gangrene or intracranial infarcts. Two infants (both controls) died. One was an infant with *Eschericia coli* sepsis and meningitis. The other was an infant who died at 4 months of age after leaving the KPMCP, apparently of sudden infant death syndrome.

We were able to contact 94 families (85%) of the 110 cases and 308 families (77%) of the 400 remaining controls. Follow-up calls occurred when infants were between 24 and 36 months of age. The families of 1 case and 6 controls reported that their child had some abnormality consistent with a neurological condition (eg, hearing impairment, learning difficulty, or the need for care by a pediatric neurologist or developmental pediatrician). We scanned KPMCP databases for information on the remaining 16 cases and 92 controls who were not interviewed. None of these 16 cases and 6 of these 92 controls had diagnoses or utilization patterns (eg, repeated visits with a neurologist) consistent with a neurological condition. We could not obtain follow-up data for at least 1 year in 2 cases, and we were able to obtain follow-up data for all controls for up to 1 year. Thus, 1 (0.9%) of 110 cases and 12 (3%) of the 400 controls had some evidence of neurological problems after discharge. The difference between cases and controls was not significant (*P* = 2). The 1 case with some evidence of sequelae was subsequently found to have Angelman syndrome, an associated seizure disorder, and developmental delay.

Our findings expand on previous work in this area and highlight many important issues that need to be addressed by perinatal and pediatric health services researchers.

INCIDENCE

We found that the frequency of rehospitalization for strictly defined dehydration in the immediate neonatal period ranged between 1.2 to 3.4 per 1000 live births among infants born at 11 KPMCP hospitals. Although relatively rare at individual hospitals, neonatal dehydration requiring rehospitalization is not uncommon. Extrapolating our findings to the 4.2 million infants born in the United States, we would expect between 5000 to 14000 cases each year. Conditions other than feeding failure were present in approximately 5% of dehydrated infants. This suggests that pediatricians who hospitalize infants for dehydration should be alert for the presence of other diagnoses such as sepsis, meningitis, and previously unrecognized anomalies.

Many studies report on neonatal rehospitalizations, but not all permit estimation of the incidence of neonatal dehydration. Lee et al, in a Canadian study based primarily on discharge abstracts, reported that decreasing neonatal LOS was associated with an increase in rehospitalization in general, and for dehydration and jaundice in particular. They reported a dehydration rate of 0.58 per 1000 live births, which is substantially lower than the rate we found at KPMCP. Applying their more restrictive case definition (only ICD-9-CM codes 276.0 and 276.5, birth weight ≥2500 g, and no history of neonatal intensive care) to our cohort did not result in a change in our incidence rate (2.5 per 1000 live births).

Recent studies by Edmonson et al and Liu et al conducted in the United States use case definitions more similar to ours. Edmonson et al reported an incidence of approximately 1.7 per 1000 live births, while Liu et al reported an incidence of 5.5 per 1000 live births. Both of these studies report rates that are in the same range as those in our study (1.2 to 3.4 per 1000 live births). The study by Lock and Ray, which reported a decrease in “feeding-related” rehospitalizations after an early discharge program was implemented (from 5.9 per 1000 live births to 2.8 per 1000 live births), also reports a rate within this general range. It is likely that apparent variations in incidence are the result of a combination of differences in case definition, how ICD-9-CM codes are actually used, prevalence of risk factors such as breastfeeding, as well as differences in follow-up or early intervention for feeding difficulties.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Adjusted Odds Ratio</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-time mother</td>
<td>5.5</td>
<td>3.1-9.6</td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White‡</td>
<td>1.0</td>
<td>. . .</td>
</tr>
<tr>
<td>African American</td>
<td>0.5</td>
<td>0.1-1.9</td>
</tr>
<tr>
<td>Asian</td>
<td>1.5</td>
<td>0.8-2.8</td>
</tr>
<tr>
<td>Hispanic</td>
<td>0.9</td>
<td>0.5-1.9</td>
</tr>
<tr>
<td>Maternal age, y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤35</td>
<td>3.0</td>
<td>1.5-6.0</td>
</tr>
<tr>
<td>20-34‡</td>
<td>1.0</td>
<td>. . .</td>
</tr>
<tr>
<td>&lt;20</td>
<td>0.5</td>
<td>0.2-1.2</td>
</tr>
<tr>
<td>Gestational age (&lt;39 wk vs ≥39 wk)</td>
<td>2.0</td>
<td>1.2-3.5</td>
</tr>
<tr>
<td>Exclusive breastfeeding</td>
<td>11.2</td>
<td>3.9-32.6</td>
</tr>
<tr>
<td>at time of hospital discharge (yes vs no)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of hospital stay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(&lt;48 h vs ≥48 h)</td>
<td>1.2</td>
<td>0.4-3.4</td>
</tr>
<tr>
<td>Sex of infant (male vs female)</td>
<td>1.3</td>
<td>0.8-2.1</td>
</tr>
<tr>
<td>Small for gestational age (yes vs no)</td>
<td>0.1</td>
<td>0.01-1.4</td>
</tr>
</tbody>
</table>

* A total of 101 cases and 342 controls (1 case and 1 control with missing race/ethnicity data removed) constituted the cohort. Ellipses indicate not applicable.
† Estimated from coefficients of logistic regression model adjusted for all given variables.
‡ Indicates a reference group.

RISK FACTORS

Among infants born vaginally, the most important risk factors for dehydration were exclusive breastfeeding at the time of hospital discharge, being born of a first-time mother, maternal age 35 years or older, and gestational age of 38 weeks or less. In this group of infants, an LOS less than 48 hours was associated with dehydration in one set of analyses (those from which infants with other diagnoses that could lead
In developed nations, feeding difficulties, failure to gain weight, and dehydration are common reasons for neonatal rehospitalization. Recent studies have raised concerns about possible increases in neonatal dehydration rates due to shorter postpartum lengths of stay. Few studies from community population settings or that provide clinical or postrehospitalization outcomes data are available. We found that, in a managed care population, rehospitalization for dehydration occurred in 2.1 of 1000 live births and that the most important risk factors were being born of a first-time mother and exclusive breastfeeding. Adherence to the AAP’s follow-up recommendations did not prevent rehospitalization, but it probably prevented the occurrence of deaths and other catastrophic outcomes (eg, limb gangrene), which did not occur in our cohort. Between 24 and 36 months postdischarge, we did not find evidence of increased neurological problems among dehydrated infants when compared with control infants.

**What This Study Adds**

In our study, cases were more likely than controls to have received follow-up visits meeting the AAP recommendations. The main reason for this seems to be that parents initiated these contacts. When we examined rates of clinician-initiated follow-up, we did not find significant differences between cases and controls. That is, follow-up was initiated by KPMCP clinicians among those infants with LOS less than 48 hours in 26 (28%) of 93 cases and 95 (29%) of 326 controls.

In our population, most infants were rehospitalized prior to 72 hours after initial discharge. These data suggest that if the goal is to prevent rehospitalization, outpatient contacts or home visits need to occur sooner. On the other hand, although not effective at preventing rehospitalization, an outpatient visit at 48 to 72 hours may be effective at preventing serious morbidity or mortality, perhaps through the mechanism of timely readmission. Outpatient visits can be preventive (ie, the visit prevents an infant from being dehydrated), palliative (ie, an infant who is mildly dehydrated is prevented from getting worse), or emergent (ie, the visit leads to a decision to admit the infant). Any of these visit types, including the last, would thus be expected to prevent severe sequelae. In this insured population, where parents seem to recognize feeding problems early, the key factor in preventing severe sequelae may be the ease of access to care rather than the timing of follow-up appointments. Different approaches may be necessary for other populations.

Our study results are also of relevance for the design of interventions aimed at decreasing neonatal dehydration. Given the rarity of the outcome and the high prevalence of exclusive breastfeeding, it would be difficult to design inexpensive interventions using hospitalization for dehydration as the key outcome of interest. For example, one might propose a specific intervention to decrease the excess risk associated with exclusive breastfeeding. In our study, this predictor has a prevalence of 91.8% in the cases and 67.2% in the controls, which yields an OR of 5.5 in a bivariate comparison. Given the low (2.1 per 1000 live births) risk of dehydration, and assuming 100% effectiveness, the intervention would need to be applied to more than 500 mother-infant pairs for each readmission for dehydration prevented. However,
since dehydration can be seen as an extreme point in a clinical continuum of suboptimal nutrition in breastfed infants, future interventions could employ end points that could serve as proxies for an elevated risk for dehydration (e.g., weight loss of 10% at 1 week after discharge).

CONCLUSIONS

Since breastfeeding practices and first-time mother status are extremely common risk factors, they should be the focus of research aimed at preventing neonatal dehydration. In populations with health insurance and integrated care systems, severe adverse outcomes (death, shock, limb gangrene) are rare. Follow-up within 72 hours after discharge may be sufficient to prevent serious morbidity, but earlier follow-up may be necessary to prevent the need for rehospitalization. While increasing LOS beyond 48 hours could decrease rehospitalizations among infants born vaginally, it is probably more efficient to develop outpatient follow-up strategies that occur between 24 and 48 hours after discharge. Serious consideration should be given to establishing a minimum LOS of 48 to 72 hours for infants born by cesarean section. Given the risk factors identified in this and other studies, the most important preventive measure would be to ensure successful initiation and continuation of breastfeeding, particularly among first-time mothers. However, quantification of the effectiveness of such measures requires further research, and studies such as this one should be repeated in the future so as to determine whether the frequency of neonatal dehydration is rising, falling, or staying constant.

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