Infant Mortality and Early Postpartum Discharge

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***Objective*: To assess additional risk of newborn death owing to early discharge.**

***Methods*: This was a historical cohort study using Washington State linked birth certificates, death certificates, and hospital discharge records that covered 47,879 live births in 1989 and 1990. Logistic regression was used to assess risk of death within the first year of life after early discharge (less than 30 hours after birth) compared with later discharge (30–78 hours after birth).**

***Results*: Newborns discharged early were more likely to die within 28 days of birth (odds ratio [OR] 3.65; 95% confidence interval [CI] 1.56, 8.54), between 29 days and 1 year (OR 1.61; 95% CI 1.10, 2.36), and any time within the first year (OR 1.84; 95% CI, 1.31, 2.60) of life than newborns sent home later. Newborns discharged early also were more likely to die of heart-related problems (OR 3.72; CI 1.25, 11.04) and infections (OR 4.72; CI 1.13, 19.67) within 1 year of birth than newborns discharged later.**

***Conclusion*: Newborns discharged within 30 hours of birth are at increased risk of death within the first year of life. (Obstet Gynecol 2000;96:183–8. © 2000 by The American College of Obstetricians and Gynecologists.)**

The rise of managed care during the past 3 decades has coincided with a dramatic reduction in the length of postpartum hospital stays. In 1970, the mean postpartum length of stay for vaginal deliveries in the United States was 3.9 days compared with 2.0 days in 1993. For cesarean deliveries, the mean postpartum stay in 1970 was 7.9 days compared with 3.9 days in 1993.[1] In a survey undertaken in 1995, half of new mothers who had vaginal deliveries said they were discharged in 1 day or less.[2]

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During the mid-1990s, concerns about potential adverse effects of early discharge of newborns prompted the United States Congress and most state legislatures to pass laws mandating that insurers cover minimum 48-hour hospital stays after vaginal deliveries and minimum 96-hour stays after cesarean deliveries. In the debate over those laws, proponents claimed that longer postpartum stays would avert adverse health outcomes caused by conditions often detected and treated earlier with longer postpartum stays, such as brain damage caused by untreated jaundice.[3]

The evidence supporting such claims is equivocal. Randomized controlled trials have failed to detect statistically significant differences in adverse outcomes between newborns and mothers with short stays and those with longer stays.[4–8] A literature review published in 1995 concluded that research neither proved nor disproved the safety of early discharge.[3]

At least four observational studies have assessed the association between early discharge and newborn hospital readmission.[9–12] However, the most common health problem prompting readmission, jaundice, has a low risk of longer-term adverse outcomes. Many newborns rehospitalized for jaundice might be better off without any treatment at all.[13]

A potential increase in hospital readmissions is one consideration when evaluating postpartum length of stay, but might be less important than delays in diagnosing curable, life-threatening conditions. For example, early discharge makes it more difficult to detect treatable congenital cardiac malformations before discharge.[14,15] As Beebe et al[16] observed, "Appearance of subtle signs of sepsis, congenital heart disease, or other anatomic anomalies may not be present in the first few hours after birth and may not be immediately recognized by parents at home."

In this study, we used secondary data from Washington State to examine the relationship between postpartum length of stay and newborn mortality.

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Materials and Methods

We conducted a historical cohort study using data from the 1989 to 1990 Washington State Birth Event Record Database, which links birth certificate and infant death certificate records with maternal and newborn hospital discharge records. The file includes time and date of birth, date (but not time) of discharge, and sociodemographic and clinical characteristics. Approval was obtained from the RAND Human Subjects Protection Committee.

Of approximately 150,000 total births in Washington in 1989 and 1990, 133,589 newborns were included in the data set. Approximately two thirds of the unrepresented births occurred in homes or federal hospitals and were not reported to Washington's Department of Health as part of the system.

We excluded newborns who died before they were discharged or were transferred to another facility upon discharge ($n = 1204$) because presumably they would not have benefited by mandated longer stays. We also excluded 1067 multiple births, 6120 newborns under 2500 g birth weight, 36 newborns whose times of birth were not recorded, and 32 other cases with extensive missing data. To increase the homogeneity of the sample, we excluded 4676 preterm newborns (estimated gestational age less than 37 weeks) who weighed 2500 g or more. However, we included the preterm newborns in one of our sensitivity analyses. In additional sensitivity analyses, we excluded cesarean delivery newborns.

Our primary dependent variables measured whether newborns died within 28 days of birth (the neonatal period), between 29 days and 1 year after birth (postneonatal infancy), and within 1 year of birth (infancy). We classified newborns as having died if they had a death certificate. We considered separately deaths within 1 year of birth that were attributed to sudden infant death syndrome, heart-related conditions, and infection. We used the International Classification of Diseases, 9th Revision, Clinical Modification code on death certificates to determine newborns' causes of death.

We emphasized sudden infant death syndrome, heart-related conditions, and infection because they are common causes of death among newborns and might be prevented by extending postpartum stays. Sudden infant death syndrome can be reduced if mothers are trained to have infants sleep on their backs. To the extent that early discharge limits such training, we expected early discharge to increase the rate of sudden infant death syndrome. Heart problems and infections can sometimes be cured if they are detected and treated expeditiously; a recent study suggested that longer postpartum stays increased the probability of detecting congenital heart anomalies.[15]

We could not calculate newborns' lengths of hospital stay to the hour because hours of discharge were not reported in our data set. However, following Liu et al,[9] we could use available information—date of discharge and date and hour of birth—to identify newborns whose stays were definitely less than 30 hours and another set whose stays were definitely between 30 and 78 hours. We call the former set of newborns the early discharge group and the latter set the late discharge group. We excluded newborns for whom information was not sufficient to determine whether length of stay was more or less than 30 hours.

More specifically, the early discharge group includes all newborns who were discharged the same day they were born and, therefore, had lengths of stay less than 24 hours, or were born at 6 PM or later and spent exactly 1 night in the hospital and, therefore, had lengths of stay between 6 and 30 hours. The late discharge group included newborns who spent 2 nights in the hospital and were born before 6 PM and, therefore, had lengths of stay between 30 and 72 hours, or spent 3 nights in the hospital and were born at 6 PM or later and, therefore, had lengths of stay between 48 and 78 hours.

Newborns who did not conform to either of those definitions were excluded. Excluded newborns fell into one of two categories: First, there were 46,326 newborns whose dates and hours of birth and dates of discharge left it uncertain whether their lengths of stay were more or less than 30 hours. This indeterminate category group included newborns who stayed in the hospital for 1 night and were born before 6 PM and, therefore, had lengths of stay between 6 and 48 hours, or stayed 2 nights and were born at 6 PM or later and, therefore, had lengths of stay between 24 and 54 hours. Those newborns could not be assigned to the early or late discharge groups. We also excluded from analyses 26,446 newborns whose lengths of stay were at least 78 hours, which included newborns who stayed 3 nights and were born before 6 PM, or stayed more than 3 nights. We excluded this very late discharge group because for them the adverse effects of pre-existing health problems for which we were unable to control statistically could have swamped any beneficial effects of longer stays. In sensitivity analyses, we considered alternative definitions of the early and late discharge groups.

The resulting sample included 9101 newborns in the early discharge group (0–30 hours) and 38,778 newborns in the late discharge group (30–78 hours). In practice, it was likely that almost all in the early discharge group had stays less than 28 hours because virtually all newborns are discharged between 8 AM and

Table 1. Maternal and Newborn Characteristics (%)*

Characteristics	Early discharge (0–30 h) (n = 9101)	Category indeterminate† (6–54 h) (n = 46,326)	Late discharge (30–78 h) (n = 38,778)	Very late discharge† (>78 h) (n = 26,446)
Maternal				
Covered by Medicaid	38.6	33.6	22.9	27.6
Married	72.4	74.0	79.7	77.1
Multiparous	68.3	60.3	57.1	53.5
Under 18 y of age	4.2	4.2	3.0	2.9
Newborn				
Black	2.2	3.8	4.5	5.7
Hispanic	14.4	11.6	6.6	8.7
Delivered by cesarean	0.7	0.5	8.0	78.3
Low Apgar score‡	0.4	0.5	0.6	1.5
Mild or moderate trauma	5.6	7.5	9.7	5.8
Infection	0.2	0.1	0.3	2.8
Severe respiratory problems	1.2	1.3	2.0	5.7
Severe trauma	1.8	2.3	2.7	2.2
Seizures	0.1	0.2	0.3	1.1

* For each of the characteristics listed, the difference between the four length-of-stay categories is statistically significant ($P < .01$ by χ^2 test).
† Newborns in the category indeterminate and very late discharge groups were not included in the logistic regression analyses.
‡ Five-minute Apgar score less than 7.

10 PM. Newborns in the late discharge group probably had stays of 38–76 hours.

Unadjusted and adjusted (for covariates) odds ratios (ORs) and associated 95% confidence intervals (CIs) were estimated using logistic regression. Rates of mortality were so low that ORs were within 1% of the relative risk (RR) in all cases. In the multivariable analyses that yielded the adjusted ORs, we controlled for sociodemographic characteristics that might be associated with newborn lengths of stay and newborn mortality: mothers' marital status (married or unmarried), the mothers' Medicaid status (enrolled in Medicaid at time of birth or not), maternal parity (multiparous or primaparous), maternal age (under 18 years old or over 17), newborns' gender (male or female) and newborns' race (black or not, Hispanic or not). In sensitivity analyses, we also controlled for six clinical variables recorded during the initial postpartum stay: low Apgar score (5-minute Apgar score of less than 7), mild or moderate trauma, severe trauma, infection, severe respiratory problems, and seizures. In additional sensitivity analyses, we included three newborns in the late discharge group who died in-hospital, then excluded one whose death certificate did not list a cause of death.

Results

Comparisons of average maternal characteristics for the groups, such as marital status, Medicaid status, and age, indicated that newborns discharged early had significantly lower socioeconomic status than newborns with longer stays (Table 1). Other measures indicated that newborns discharged early were significantly healthier on average and that their mothers were sig-

Table 2. Newborn Death Rates (%)

Outcome	Early discharge (0–30 h) (n = 9101)	Category indeterminate‡ (6–54 h) (n = 46,326)	Late discharge (30–78 h) (n = 38,778)	Very late discharge‡ (>78 h) (n = 26,446)
Died within 28 d of birth†	0.13	0.04	0.03	0.04
Died between 29 d and 1 y of birth†	0.44	0.31	0.24	0.25
Died within 1 y of birth†	0.57	0.35	0.27	0.29
Heart-related problem*	0.08	0.04	0.02	0.03
Sudden infant death syndrome*	0.33	0.23	0.19	0.18
Infection†	0.04	0.00	0.01	0.01
Other	0.12	0.07	0.05	0.08

* The difference between the four length-of-stay categories is statistically significant ($P < .05$ by χ^2 test).
† The difference between the four length-of-stay categories is statistically significant ($P < .01$ by χ^2 test).
‡ Newborns in the category indeterminate and very late discharge groups were not included in the logistic regression analyses.

Table 3. Death of Newborns Discharged Early or Late

Outcome	Unadjusted OR (95% CI)	Adjusted OR* (95% CI)
Death within 28 d	4.65 (2.05, 10.55)	3.65 (1.56, 8.54)
Death between 29 d and 1 y	1.86 (1.28, 2.69)	1.61 (1.10, 2.36)
Death within 1 y	2.16 (1.54, 3.01)	1.84 (1.31, 2.60)
Heart-related problem	4.26 (1.50, 12.16)	3.72 (1.25, 11.04)
Sudden infant death syndrome	1.75 (1.15, 2.68)	1.44 (0.93, 2.22)
Infection	4.26 (1.07, 17.05)	4.72 (1.13, 19.67)
Other	2.47 (1.17, 5.19)	2.27 (1.05, 4.88)

OR = odds ratio; CI = confidence interval. Sample size = 47,879.
* Adjusted for newborn gender and race, mother's marital status, Medicaid status, parity, and age.

nificantly more likely to be multiparous—perhaps because second and subsequent vaginal deliveries were often easier than first.

Table 2 reports newborn death rates and distinguishes them by cause. There were 155 deaths in our sample. Among those, 103 (66.5%) were attributed to sudden infant death syndrome, 14 (9.0%) were caused by heart-related conditions, and 8 (5.2%) by infection. The remaining deaths were attributed to accidents and injuries ($n = 13$), nervous system conditions ($n = 5$), respiratory conditions ($n = 5$), gastrointestinal conditions ($n = 3$), other conditions ($n = 3$), and unknown ($n = 1$).

Our bivariate and multivariable logistic regression analyses indicated that there was a significant positive association between early discharge and newborn mortality (Table 3). According to multivariable analyses, newborns discharged early were significantly more likely to die of heart-related illnesses (OR 3.72; CI 1.25, 11.04), infection (OR 4.72; CI 1.13, 19.67), and other causes (OR 2.27; CI 1.05, 4.88) within 1 year of birth than newborns discharged later. The association between early discharge and sudden infant death syndrome was statistically significant only in the bivariate analysis (unadjusted OR 1.75; CI 1.15, 2.68; adjusted OR 1.44; CI 0.93, 2.22).

We did several sensitivity analyses to probe the robustness of the results. Excluding newborns delivered by cesarean, including preterm newborns, and adjusting for additional clinical variables (Apgar score, trauma, infection, respiratory problems, seizures, and assisted ventilation) had little effect on those findings (results not shown). Changing the definition of early and late discharge had no effect or strengthened the association between early discharge and newborn mortality, except when the upper bound of the early discharge window was increased to 48 hours (Table 4). Early discharge appeared to be particularly hazardous when the early discharge group was limited to newborns discharged on the same day they were born (that is, stays of 0–24 hours). When we included the three newborns in the late discharge group who died in-hospital, the adjusted OR for death within 28 days declined from 3.65 to 2.90 (CI 1.30, 6.47). When we excluded the newborn whose death certificate did not list a cause of death, the other category was no longer significantly associated with increased death rate (adjusted OR 2.08; CI 0.95, 4.58).

Discussion

Based on our reading of two literature reviews[3,17] and 37 abstracts identified through the MEDLINE database (1996–1999) using the search terms "infant," "newborn," "postpartum," "maternal," "perinatal," "birth," "length of stay," "early discharge," "death," and "mortality," this is the first study to establish a statistically significant association between early postpartum discharge and newborn mortality. One retrospective case-control study[16] and one randomized controlled trial[18]

Table 4. Risk of Death According to Various Definitions of Early and Late Discharge*

Early discharge	Late discharge	Death within 28 d of birth	Death between 29 d of birth and 1 y of birth	Death within 1 y of birth
0–30 h ($n = 9101$)	30–78 h ($n = 38{,}778$)	3.65 (1.56, 8.54)	1.61 (1.10, 2.36)	1.84 (1.31, 2.60)
0–30 h ($n = 9101$)	30–96 h‡ ($n = 50{,}202$)	3.66 (1.67, 8.00)	1.67 (1.16, 2.41)	1.90 (1.37, 2.65)
0–24 h† ($n = 3432$)	24–72 h§ ($n = 49{,}944$)	7.71 (3.16, 18.82)	1.45 (0.83, 2.54)	2.07 (1.31, 3.27)
0–24 h† ($n = 3432$)	24–96 h‖ ($n = 65{,}499$)	7.07 (3.06, 16.37)	1.49 (0.86, 2.59)	2.10 (1.34, 3.29)
0–48 h¶ ($n = 40{,}130$)	48–96 h # ($n = 15{,}555$)	1.38 (0.56, 3.40)	1.37 (0.94, 2.00)	1.37 (0.97, 1.94)

Data represent adjusted odds ratios (ORs) and 95% confidence intervals.
* All ORs adjusted for newborn gender and race, mother's marital status, Medicaid, parity, and age.
† Discharged the day of birth.
‡ Discharged 2 days after birth and born before 6 PM or discharged 3 days after birth.
§ Discharged 2 days after birth.
‖ Discharged 2 or 3 days after birth.
¶ Discharged within 1 day of birth.
# Discharged 3 days after birth.

found that newborns with short postpartum stays were at increased risk of death; however, the associations in those studies were not statistically significant. In the case-control study, the OR for mortality within 28 days of death for discharge at less than 24 hours was 1.65 (CI 0.42, 3.34). In the randomized controlled trial, the OR for death within 7 days of birth was 4.04 (CI 0.80, 39.17).

The finding that early discharge increased risk of death invites a consideration of the cost of requiring longer hospital stays. We did not undertake that evaluation in the present study, but we calculated the number needed to treat, which helps gauge the overall cost of an intervention.[19] The number needed to treat is defined as the number of patients who would have to receive the intervention—in this case, have their discharge prolonged—to prevent one death. The number needed to treat to prevent one death during the first 28 days of life was roughly 1400. Thus, according to our estimates, about 1400 infants in the early discharge group would have to be moved to the late discharge category to prevent one infant death.

Congenital heart anomalies can sometimes be cured when they are detected and treated expeditiously.[20] Fourteen newborns in our sample died of heart-related problems. Among that group, four newborns were discharged early and did not receive diagnoses of heart-related problems during their birth hospitalizations. Some of those deaths might have been averted by longer postpartum stays.

The incidence of sudden infant death syndrome in our sample was 0.22%, higher than the 0.14% rate for infants nationally in 1989.[21] There were 103 deaths in our analytic sample that were attributed to sudden infant death syndrome, including seven infants who died during the neonatal period (within 28 days of birth).

The data from Washington State are detailed and have been used in other analyses of the postpartum length-of-stay issue.[9,10] How might our reliance on those data limit the generalizability of our estimates? First, Washington has proportionately fewer teen births and racial and ethnic minority births than the national average.[9] If an increase in length of stay has a disproportionately beneficial effect on minorities or teen mothers (for example, teen mothers may have a greater need than older mothers to receive instruction on caring for their newborns), the mortality effects of early discharge estimated using data from Washington might understate those effects nationally.

Our data predate the surge in proposed and actual length-of-stay laws. It is most appropriate to evaluate the mandate using data from an era with a distribution of length of stay that approximates the distribution without a mandate. Thus, the age of our data is a strength. The only major initiative in pediatric care since the time these data were collected was the initiation of the Back to Sleep campaign by the American Academy of Pediatrics. It was designed to educate mothers about proper sleep position to decrease the risk of sudden infant death syndrome. That our data predate that campaign biases our results toward the null hypothesis (that early discharge does not affect mortality). In the presence of such a concerted educational effort, we hypothesize that longer postpartum stays would decrease mortality even further than what was seen in our sample.

A limitation of this study is that because time of discharge was not included in the data set, lengths of stay could not be calculated to the hour. This problem is common to all studies of postpartum length-of-stay based on administrative data.[9–12] Following Liu et al,[9] we used hour of birth and number of nights to classify newborns into two nonoverlapping length-of-stay groups. Our finding that shorter stays were associated with increased mortality was robust to modest changes in the definitions of early and late discharge.

Another limitation of retrospective studies of early postpartum discharge is that some newborns have longer hospital stays because of health conditions that increase their risk of death. We observed and controlled for some such conditions, but it is likely that health care providers delay the discharge of some newborns for health reasons not noted on birth certificates or hospital discharge records. Any biases caused by omitting variables indicating adverse health conditions depend on the partial correlations between them and the early-discharge variable, and the partial correlation between them and the newborn death variables. In our case, the first type of correlation was likely to be negative (sicker newborns were less likely to be discharged early than healthier newborns), and the second type of correlation was likely to be positive (sicker newborns were more likely to die within 1 year of birth than healthier newborns). Under these conditions, the estimated OR for early discharge was downwardly biased, meaning that short postpartum stays would appear less hazardous than they actually are. In summary, our estimates might understate the additional risk of early discharge.

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