Readmission Rates, Risk Zones and Demographic Factors of Healthy term Breastfed Newborns with Hyperbilirubinemia: A Retrospective Chart Review

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Research Article

ABSTRACT

Newborn readmission for hyperbilirubinemia (HB) increased by 160% in the past decade. Hospital readmission rates are higher among healthy term newborns who are exclusively breastfed compared to similar newborns with other feeding types. HB is preventable with frequent breastfeeding during the immediate postnatal period.

Purpose: Describe readmission rates, costs and demographic factors of healthy term newborns hospitalized with HB from years 2013 to 2015 at a Baby-Friendly Hospital.

Methods: Retrospective data of 192 healthy term newborns.

Findings: HB rates decreased by 35.5% one year after recognition as a Baby-Friendly Hospital. Over 92% of newborns readmitted were breastfed with length of hospital stay 1 to 3 days and median costs $8,777 to $10, 784. Age, maternal ($r_s$=0.27, p=0.0002) and newborn (r_s=0.25, p=0.0004), and parity (r_s=0.19, p=0.0082) were related to total serum bilirubin (TSB) levels at readmission with maternal and newborn age predictors of TSB level (F=9.12, 2 df, p<0.0001). Race, feeding type, gender or gestation was not associated with TSB (p>0.05).

Conclusion: Results aid in future patient centered strategies of home visits and telephone follow-up emphasizing supportive breastfeeding to reduce HB readmissions of healthy-term newborns.

Keywords: Newborn hyperbilirubinemia, Newborn jaundice, Breastfeeding, Newborn readmission rates

BACKGROUND

Jaundice, a medical condition that results in an observable yellowish pigmentation to the sclera and skin, is a common and often harmless condition occurring in many full-term healthy newborns during the post-natal period [1,2]. The discoloration is due to high blood levels of bilirubin referred as hyperbilirubinemia (HB) with clinical symptoms usually manifesting within the first week of life [3,4]. For the majority of newborn HB cases, the condition referred to as physiological jaundice is non-pathological, often mild and resolves spontaneously warranting no treatment. For some healthy term newborns however, particularly those who are exclusively breastfed, the serum bilirubin levels can increase requiring hospital readmission to prevent adverse health outcomes and even death. This is significant since annual newborn hospital readmission rates for newborn HB have increased by 160% over the past decade [5]. This increase in hospital readmission for HB is considered a U.S. public health concern due to morbidity, increased costs, the potential for mortality, as well as anxiety and stress for family members [6]. Severe HB can lead to acute encephalopathy occurring within the first weeks of life or result in chronic and permanent neurological problems associated with bilirubin toxicity or kernicterus [7].

Readmission rates for HB among healthy newborns who are breastfed are considered preventable. Implementation of primary preventive measures can play an important role towards reducing or eliminating HB readmission rates among breastfed newborns. Ensuring educative measures and breastfeeding support are important to eliminating newborn HB

as inadequate breastfeeding or insufficient breast milk production that can lead to newborn poor caloric intake and dehydration have been attributed to the condition [3]. The American Academy of Pediatrics (AAP) recommends regular breastfeeding 8 to 12 times per day for the first several days after birth to decrease the risk of HB among breastfed infants [7]. Facilities recognized as Baby-Friendly Hospitals have shown to increase the rate of breastfeeding by providing comprehensive evidence-based care to achieve optimal breastfeeding outcomes and bonding as part of maternity care [8,9]. However, prior studies of newborn HB readmission rates within 7-days post discharge have not always shown to be impacted solely by these hospitals [9,10], particularly given the declining length of hospital stays after birth that average 48 h for most healthy term newborns and non-complicated deliveries [11].

Previous studies have found that certain maternal and/or newborn socio-demographic characteristics may also affect HB among healthy term newborns. Exclusive breastfeeding for example, has shown to be a risk factor in healthy term newborns with HB when compared to other feeding strategies [12-15]. Some studies have also shown that Asian and Caucasian mothers had higher rates of newborns readmitted for HB when compared to other racial/ethnic groups such as African Americans or Hispanics [12,14,16]. Others studies found that women aged 25 years and older or first term mothers were predictors of newborns diagnosed with HB [12,14], but conflicting findings were also found in a study that revealed no significant difference in maternal age and newborn HB [13]. In one study that assessed both maternal and newborn factors regarding HB and readmission, male gender and the presence of a cephalohematoma at time of birth were found to predict extreme neonatal HB [14]. When these newborn factors were assessed further with maternal demographic factors of age and race, exclusive breastfeeding and early jaundice were found to be the 'strongest predictors' of newborn HB and readmission [14].

Breastfeeding, particularly exclusive breastfeeding, continues to be the recommended source of newborn nutrition by the AAP and other professional organizations based upon maternal health benefits and its optimal effect on infant health, growth and development [17,18]. While HB tend to be higher among breastfed newborns compared to other newborn feeding types, evidence have shown that the rates of the disorder can be prevented or reduced among healthy term infants with regular breastfeedings with appropriate follow-up in the first few days after discharge as recommended by the AAP [6,7,19]. Community referrals or home visits can also provide measures to improve breastfeeding post-delivery as mothers of newborns with HB often reported poor feeding patterns prior to their newborn becoming jaundiced [1]. Further, it is estimated that over 50% of mothers experience problems with breastfeeding that can reduce the frequency of breastfeeding and breast milk production [20].

The purpose of this study was to: (1) describe and compare the number/percentage of newborns readmitted with HB during each of the years 2013, 2014 and 2015 and assess trends over time; (2) describe total serum bilirubin levels and the bilirubin risk zones of newborns; (3) describe the maternal and newborn demographic characteristics and costs of readmissions; and (4) assess whether maternal or newborn demographic characteristics predict readmission rates. Data from the study will be used to develop future primary prevention strategies to reduce HB among breastfed infants through appropriate follow-up after delivery and provide support to mothers who breastfeed that fosters regular/continuous breastfeeding 8 to 12 times per day during the early postnatal period.

MATERIALS AND METHODS

A retrospective chart review of newborns re-admitted for HB during the years 2013, 2014 and 2015 provided the data source and design for the current study. The review was conducted at a designated Baby-Friendly Hospital recognized since 2014 as a facility that offers breastfeeding mothers information, confidence and other skills necessary to successfully initiate and continue breastfeeding of their infants [21]. The hospital was selected as the study's setting due to researcher accessibility, its large number of annual births and its designated title as a Baby-Friendly Hospital. The hospital delivers more than 7000 babies annually, offering a wide range of obstetrical services to low and high-risk mothers [22]. Newborn inclusion criteria at the time of data collection included: (a) healthy full-term newborns without a prior or current medical condition at time of birth; and (b) current diagnosis of HB at time of readmission as determined by the appropriate International Classification of Disease Diagnosis Code (ICD-10-CM) P59.9 recorded on the computerized record. For the purpose of this study, full-term included newborns at time of maternal delivery with a documented $\geq$ 37 weeks gestational age. While the study focused predominantly on HB among breastfed infants, all newborns who met the inclusion criteria regardless of feeding type were included in the study with specific analyses conducted on those who were exclusively breastfed or a combination of breast and bottle fed with bilirubin levels compared with that of bottle fed infants. Newborns were excluded from the study if there was a history of any of the following: (a) preterm newborns or gestational age <37 weeks; (b) a prior or current history of other diagnoses; and (c) non-diagnosis of HB at time of readmission.

A spreadsheet was used to record data collected from the newborn's medical records. No patient identifiers (i.e., name, address, etc.) were retrieved or included in the study. The non-identifying information comprised solely of maternal and newborn demographic characteristics to meet the study's purposes based upon prior literature review and included

the following: (1) age of the infant at time of readmission; (2) newborn gender; (3) type of feeding; (4) newborn length of hospital after readmission; (5) maternal age at time of birth; (6) parity; (7) gestational age at time of delivery; (8) total serum bilirubin level at time of readmission; (9) race/ethnicity; (10) year of admission; and (11) costs of hospitalization. There were 192 newborns who were hospitalized for HB during the 3 year time period assessed and who met the inclusion criteria for the study. Data that incorporated the 11 variables were extracted from the medical records of all 192 newborn for study analyses. The study protocol was approved by the Baby-Friendly hospital, the Western University of Health Sciences and the California Baptist University institutional review boards prior to data collection. Because this was a retrospective chart review, informed consent was not required and waived.

STATISTICAL ANALYSES

Descriptive analyses were conducted on all study variables. Continuous/ratio variables of age in days of the infant at time of readmission, maternal age in years, parity, gestational age at time of delivery, newborn length of hospital stay in days, total serum bilirubin (TSB) levels and costs of hospitalization were first analyzed for normality, and if determined normal level data, were then reported using minimum, maximum, mean (M), standard deviation (SD) and 95% confidence interval (CI) levels; non-normal data were described via the median (Md) and 95% CI of the Md. Categorical data for newborn gender, type of feeding (i.e., exclusive breast; bottle; breast and bottle) and race/ethnicity were analyzed via frequency counts (N) and percentages. The number of newborns readmitted for HB were stratified for each of the 3 years (2013, 2014, 2015) to describe trend data and summarized to reflect the number of admissions overall for the entire time period.

The actual TSB level of the newborn at time of readmission was recorded from the medical record and was reported in mg/dL. The TSB level serves as a measure of HB and provides a means to measure concentrations of bilirubin that reflects the effects of bilirubin production, conjugation and liver effects. In the majority of healthy term newborns, increased levels of bilirubin causing jaundice usually last approximately 5 days with TSB up to 12 mg/dL decreasing to approximately 2 mg/dL (normal levels) within two weeks [23]. In a study that evaluated 1,044 predominantly breastfed newborns regarding natural history of jaundice, one in every three newborns had TCB levels of $\geq$ 5 mg/dL with one out of five appearing jaundice at 1 month after birth [24]. It is estimated that nearly 2% to 4% of exclusively breastfed infants will have jaundice with TSB levels in excess of 10 mg/dL in the third week of life. Moreover, approximately 97% of term newborns will have TSB levels less than 13 mg/dL with further evaluation and work-up usually warranted for infants with levels over 13 mg/dL [25]. Extremely high bilirubin levels (TSB>20-25 mg/dL) are of particular concern as these levels significantly increase the risk of acute encephalopathy and kernicterus [26].

While the TSB levels were used to describe newborn's HB, additional analyses were conducted based on the TSB level at time of admission and newborn's age in hours (recalculated from age in days). The TSB and postnatal age in hours were then plotted and analyzed based upon a nomogram depicting four levels of bilirubin risk zones (BRZ): (1) low risk zone; (2) low intermediate risk zone; (3) high intermediate risk zone; and (4) high-risk zone **(Figure 1)**. The BRZ is normally used to assess systematic risk after birth and prior to discharge [7]; however, for the purpose of this study the zones were also used to 'describe the bilirubin risk at time of readmission' based upon the TSB and newborn's age (in hours). Because data are displayed for BRZ for newborns aged 0 to 144 h, those newborns readmitted for HB and who were over the age of 144 h were not analyzed using this measure. The TSB levels and newborn's BRZs provide two sources of measures to describe newborn's HB at time of admission and the severity of the disorder based upon quantifiable measures.

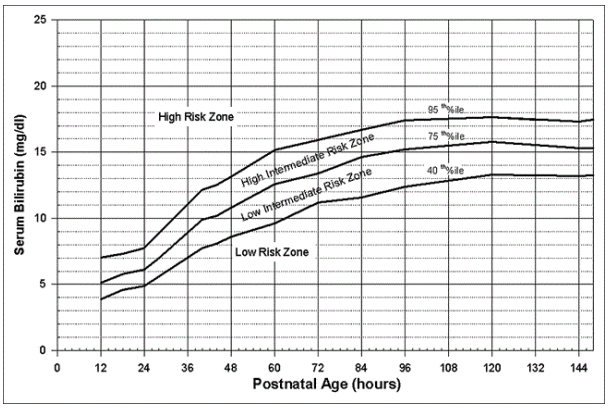

Figure 1. Nomogram representing bilirubin risk zones based upon serum bilirubin level and post-natal age in hours. Reproduced with permission from Copyright Clearance Center, American Academy of Pediatrics.

Inferential statistics were also conducted to determine if any of the demographic variables predicted newborn HB at time of readmission. Newborn age at time of readmission, newborn gender, type of feeding, maternal age at time of birth, parity, race/ethnicity and gestational age at time of delivery served as independent or predictor variables of the study. Total serum bilirubin level and the BRZ at time of readmission were dependent/outcome variables used in the study. Initial statistical tests were conducted to determine if there was a relationship or association between the predictor variables and the outcome variables of TSB or BRZ using Pearson correlation (Spearman Rho, if non-normal data), Pearson Chi-Square or Fisher exact test based upon the level of measurement. The independent t-test, Mann-Whitney U, one way Analysis of Variance or non-parametric Kruskall-Wallis tests were also used as appropriate to assess independent categorical variables (gender; race/ethnicity; feeding type) and the outcome variable of TSB. Reported p values at $p<0.05$ were further analyzed using multinomial logistic regression or multiple regression based upon the outcome variable BRZ or TSB respectively to determine predictors of newborn HB readmission. Analyses were conducted using NCSS statistical program version 10.0 (NCSS, LLC, Kaysville, Utah).

RESULTS

Data was collected and analyzed on 192 newborns that met the inclusion criteria. The number of healthy-term newborn diagnosed and readmitted for HB varied over the 3 year period of the study, but declined over time with the lowest number of cases (N=49) reported in 2015, compared to the years 2013 (N=67) and 2014 (N=76). These findings indicated a 35.5% reduction in the number of cases in 2015 when compared the prior year, favourable downward trend post recognition of the facility as a Baby-Friendly Hospital that was awarded in 2014.

Descriptive Data – Newborn Demographic Characteristics

Most of the newborns diagnosed with HB were male, had a Md age at time of admission at 6 days (95% CI of Md 5, 6) and were exclusively breastfed at time of readmission. The TSB levels of all newborns were elevated at time of readmission, confirming the diagnosis of HB with levels ranging from a low of 10.5 mg/dL to a high level of 27.9 mg/dL and averaging 18.5 mg/dL (95% CI, 18.5, 19.2). **Table 1** provides a summary of the demographic characteristics of newborns readmitted for HB.

Table 1. Demographic characteristics of newborns hospitalized for hyperbilirubinemia at one hospital in Southern California (N= 192).

Demographic Characteristics	Number (%)
Infant's Gender (N=192)	
Male	107 (55.7)
Infant Feeding Status (N=192)	
Breast (only)	179 (60.4)
Breast and Bottle	63 (32.8)
Bottle	13 (6.8)
Infant's Age at Time of Hospitalization (days) (N=192)	
2-3	16 (8.3)
4-5	71 (37.0)
6-7	65 (33.9)
8 to 14	36 (18.7)
15 to 27	4 (2.1)
Length of Status (days) (N=192)	
One	135 (70.3)
Two	50 (26.0)
Three	7 (3.7)

Bilirubin Status at Time of Hospitalization, mg/dL (N=191)	
*M 18.8 (SD 2.7; 95% CI=18.5, 19.2)	
≤ or equal 17 mg/dL	36 (18.9)
18 and over	155 (81.1)
Total Serum Bilirubin Levels by Type of Feeding (M mg/dL)	M (SD)
Exclusively Breastfeeding	18.7 (2.8)
Breast and Bottle Feeding	18.8 (2.5)
Bottle Feeding	19.6 (2.1)

Of the 192 newborns readmitted for HB, 117 (60.9%) were analyzed according to the BRZ nomogram (age of readmission among newborns ≤ 144 h old). When assessed by age in hours, the ages of the newborns ranged from 48 to 144 h (Md 144; 95% CI, 120, 144). The majority (93.2%) of the newborns diagnosed with HB had BRZ levels that were characterized in the high-intermediate or high-risk zone with 75.2% of newborns considered at the high-risk zone or 95% percentile with regards to TSB based upon age **(Figure 2)**.

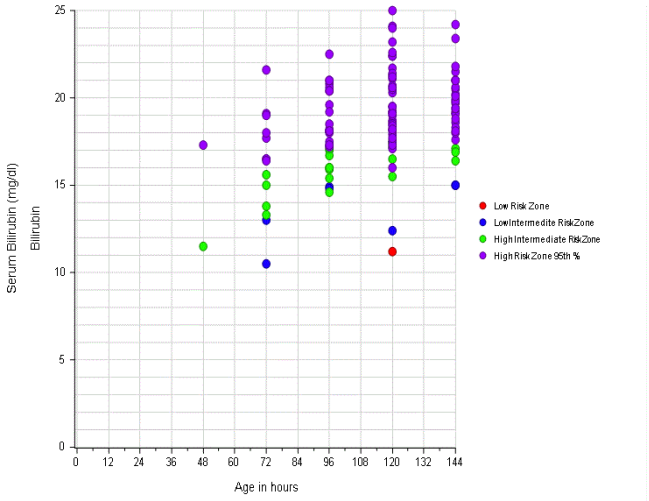

Figure 2. Bilirubin risk zones and newborn age in hours at time of hospital readmission among healthy-term newborns with hyperbilirubinemia.

Descriptive Data - Maternal Demographic Characteristics

Maternal age was available on 183 of the 192 women who delivered during the 3 year time period (95.3%). Overall age of all of the participants ranged from 14 to 42 years with the average age at 28.5 years (SD, 5.5; 95% CI, 27.7, 29.3). There were slightly more women who were multiparous compared to first time mothers. Over half of the mothers were of Hispanic race/ethnicity, which was representative of the community's racial/ethnicity group. Most women (67.2%) delivered at less than 40 weeks gestation but all were considered 'term' (defined at ≥ 37 weeks gestation). **Table 2** provides a summary of the maternal demographic characteristics of newborns diagnosed and readmitted for HB.

Table 2. Maternal demographic characteristics of newborns hospitalized for hyperbilirubinemia at one hospital in Southern California Hospital (N=192), * Missing data; **Gestational age 37 weeks; M: Mean; SD: Standard Deviation; CI: Confidence Intervals.

Demographic Characteristics	Number (%)
Maternal Age at time of Delivery (years) (N=183*)	
≤ 20	14 (7.7)
21 to 30	100 (54.6)
31 to 40	67 (36.6)

41 and over	2 (1.1)
Race/Ethnicity (N=191*)	
Hispanic/Latino	109 (57.1)
Caucasian/White	38 (19.9)
Asian	29 (15.2)
Other (not specified)	13 (16.8)
African American/Black	2 (1.0)
Maternal Parity after Delivery (N=190*)	
1	88 (48.9)
2	46 (25.6)
3-8	46 (25.5)
Gestational Age at time of Delivery (N=192)**	
Less than 40 weeks	129 (67.2)
40 weeks and over	63 (32.8)

Predictors of Newborn Hyperbilirubinemia

All of the independent/predictor variables were first assessed to determine if the maternal or newborn demographic characteristics were statistically related or associated with newborn's TSB and BRZ respectively depending upon the level of measurement. There was a statistically significant positive correlation for maternal age (rs=0.27, p=0.0002), newborn's age at time of admission (rs=0.25, p=0.0004) and maternal parity (rs=0.19, p=0.008) with that of TSB levels at the time of the newborn's hospital readmission for HB. There were no differences in the maternal demographic characteristics of race/ethnicity (F=1.27, df 4, p=0.28), type of feeding status (exclusively breast, breast and bottle or bottle) (F=0.50, df 2, p=0.60), nor gestational age (rs=0.11, p=0.83) and newborn's TSB levels at time of readmission. When race/ethnicity and type of feeding status were further assessed regarding BRZ, neither variable was found to be statistically associated with newborn's BRZ at time of HB diagnosis and hospital readmission (race/ethnicity X^2=1.5, df 4, p=0.83; type of feeding status X^2=0.46, df 2, p=0.79). Similar non-statistically significant findings were found regarding newborn's gender and BRZ (X^2=0.11, df 1, p=0.74).

Newborn age at time of admission, maternal age and parity were further assessed as predictor variables for high TSB levels via a multiple linear regression model. When the three variables were all entered simultaneously into the model, only newborn age and maternal age were found to be predictors of high TSB levels at time of newborn readmission for HB (F=9.19, df 3, p<0.0001; R2=0.134) with these two variables explaining 13.4% of the variance.

Additional Data – Newborn Length of Hospital Stay and Costs

Length of hospital stay (LOS) has been associated with HB [27]. Newborns readmitted for HB often have socio-economic burdens associated with length of hospital stay and hospital costs due to management of the HB that has the potential for familial anxiety and stress. The LOS among newborns readmitted for HB in this current study ranged from 1 to 3 days (Md, 1) with no difference in the LOS by feeding type. Hospital costs of the 192 newborns assessed in this current study varied from a minimum cost of $42 to maximum costs of $29,720 dollars as reported via data on the medical record. Median hospital costs were $9,798 (95% CI of Md $8,777, $10,784) with costs varying by feeding type of $10,629, $10,074 and $9,002 for newborns who were exclusively breastfed, breast and bottle fed or solely bottle fed respectively at time of readmission. The Md hospital costs also increased as LOS increased with a 3 day LOS at $15,903 compared to $8,608 for a 1 day LOS.

DISCUSSION

In this study, readmission rates for newborn HB continue resulting in significant costs however, readmission for the disorder in this Baby-Friendly Hospital were low, accounting for only 1.0% of all total births. Further, a significant 35.5% reduction in healthy term newborn readmission rates for HB was observed 1 year after recognition of this facility as a Baby-Friendly Hospital. These positive findings may be attributed to educational and supportive breastfeeding initiatives

that were established from required protocols for Baby-Friendly Hospitals. Further longitudinal studies are recommended to ensure rates of readmissions for HB among healthy term newborns continue to decrease.

Prior studies have shown that newborns who are breastfed, particularly among those who are exclusively breastfed, are more likely to have HB that requires hospitalization than newborns who are bottle fed [12,15,28]. These findings were consistent with the current study that found 93.2% of newborns were receiving some type of breastfeeding prior to readmission with most (60.4%) exclusively breastfeeding. While breastfeeding was a major contributing factor in newborn readmission for HB, TSB or BRZ levels at time of newborn readmission for the disorder were similar despite feeding type prior to hospitalization. Slightly higher Md TSB levels of 19 mg/dL were found among bottle fed newborns compared to 18 mg/dL Md TSB levels among exclusively breastfed or breast and bottle fed newborns.

Jaundice due to HB usually occurs visibly in the first 2 to 4 days of life resolving spontaneously in one to two weeks [28]. In this study, the occurrence of jaundice among newborns diagnosed with HB frequently required readmission during the first week of the newborn's life. This finding denotes the importance of meeting AAP guidelines in reducing or preventing HB through continuous and frequent feedings during the first several days of the post-natal period among newborns who are breastfed with appropriate follow-up evaluation of all newborns several days post-discharge [7]. This is especially important given the evidence that shortened hospital stays for normal healthy term newborns (often $\leq$ 48 h) frequently result in newborn HB readmission [15].

Some studies have shown that maternal age, particularly women aged 25 years and older, was related to high levels of HB compared to younger aged women [16,29]. Further, first term mothers were more likely to have higher TSB levels warranting readmission for HB compared to mothers who had prior births. Comparable findings were found in the current study. Lack of maternal knowledge regarding proper breastfeeding and infrequent and non-continuous feedings regardless of age and parity may contribute to these findings. Up to 50% of mothers experience problems with breastfeeding after hospital discharge that can result in decreases in breastfeeding frequency and/or production of breast milk [20].

In this study, there were no differences in race/ethnicity on TSB or BRZ levels. Some studies have shown that mothers of Caucasian or Asian race/ethnicity are more likely to have newborns readmitted for HB compared to other racial/ethnic groups [12,14]. While the exact reason for these racial differences is unclear, possible explanations may be due to a variant in the UGT1A1 gene that is responsible for metabolism and excretion of bilirubin. Variants in this gene particularly among newborns may impair the ability to eliminate bilirubin that contributes to HB with higher rates of the genetic variants found among certain racial/ethnic groups especially individuals of Asian descent [13,30,31]. In the current study there were no differences in the TSB levels by race/ethnicity these findings could be explained by the lack of racial diversity among the newborns that were predominantly of Hispanic race/ethnicity.

A past study revealed that the average LOS for readmission of newborn HB was two to three days compared to that of one day in this current study. Despite lower LOS, high costs in this study were comparable to past studies averaging $4,548 to $8,893 [32,33].

CONCLUSION

Newborn readmission for HB among healthy newborns particularly among breastfed newborns is preventable. Implementation of strategies like home nursing visits during the first 10 days of newborns after birth has shown to reduce HB readmission rates and costs [33]. Understanding factors assessed in this study are useful in developing future culturally-sensitive strategies to reduce and prevent newborn HB. Intervention study comparing the effects of home visits and follow-up telephone consultations to that of traditional follow-up during the immediate post-natal period is under consideration to determine the effectiveness of reducing newborn HB readmission rates.

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