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# Neonatal Hyperbilirubinemia and Phototherapy: The Implementation of Seminal Clinical Practice Guidelines

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# Neonatal Hyperbilirubinemia and Phototherapy: The Implementation of Seminal Clinical Practice Guidelines

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**Abstract**

*Problem*: On a postpartum care and pediatric unit from February 2022 to December 2023, the average monthly percentage of neonatal patients greater than 35 weeks gestation with hyperbilirubinemia who were treated with phototherapy before it was medically supported by the current guidelines was 42.855% (N=668). The department's goal was to decrease this number to 10%. Initiation of phototherapy with a subthreshold bilirubin level exposes many infants to an unnecessary treatment modality which can prolong the infant's length of stay in the hospital and can be associated with adverse effects, such as maternal-infant bonding and breastfeeding rates.

*Methods*: The study utilized a quasi-experimental before-after design and was guided by the Plan-Do-Study-Act framework. A retrospective chart review was used to assess the rate of subthreshold phototherapy initiation before and after the implementation of the Clinical Practice Guideline (CPG) quick-reference cards from November 2023 to April 2024.

*Results*: The study included 77 neonates ($n$ = 77); 39 infants were in the pre-implementation group, and 38 were in the post-implementation group. Before the implementation of the quick-reference cards, the rate of subthreshold phototherapy was 30.77% ($n$ = 12). After the implementation, the rate of subthreshold phototherapy was 42.11% ($n$ = 16). A Chi-Square Test found that the number of infants who underwent subthreshold phototherapy did not significantly differ based on the implementation of the quick-reference cards ($p$ =.30). A Two-Tailed Mann-Whitney test revealed that there were insignificant differences in the length of stay in hours between the groups of pre- and post-implementation of the reference cards, ($p$ = .476). Of the infants who received

subthreshold phototherapy initiation (n = 28, 36.36%), the most common reason documented by the provider for the initiation of phototherapy below the recommended TSB level was due to the rate of rise (*n* = 11, 39.39%). However, most providers did not document a reason for initiating subthreshold phototherapy (*n* = 17, 60.71%).

*Implications for Practice*: Implementing the quick-reference card did not significantly change the rate of subthreshold phototherapy initiation nor the infants' length of stay in hours. Findings support the need for future interventions to decrease the number of infants who undergo subthreshold phototherapy. A common reason for initiating subthreshold phototherapy was the rate of rise of the total serum bilirubin (TSB), which future studies should include in their investigations of phototherapy use. Additionally, the study revealed an opportunity to investigate the mother's Rh(D) immunoglobulin (RhIG) status during pregnancy to ensure the correct phototherapy threshold is utilized.

# Neonatal Hyperbilirubinemia and Phototherapy: The Implementation of Seminal Clinical Practice Guidelines

Neonatal hyperbilirubinemia, also commonly referred to as neonatal jaundice, is a prevalent condition in the neonatal period, with up to 80% of all newborns affected (Ansong-Assoku et al., 2023). Neonatal hyperbilirubinemia develops from elevated total serum bilirubin (TSB), manifesting as a yellow discoloration of the skin, sclera, and mucous membranes (Ansong-Assoku et al., 2023). For most neonates, hyperbilirubinemia is physiologic and will resolve with adequate intake as the liver transitions to extrauterine function (Ansong-Assoku et al., 2023).

Exclusively breastfed neonates and physiologic hyperbilirubinemia are strongly associated and can be differentiated into two main categories, suboptimal intake hyperbilirubinemia and breastmilk jaundice (Kemper et al., 2022). Suboptimal intake hyperbilirubinemia typically peaks 3 to 5 days after birth and is associated with weight loss and inadequate milk intake. Insufficient milk and caloric intake cause decreased stool frequency and elevated enterohepatic circulation of bilirubin (Flaherman et al., 2017). Hyperbilirubinemia which persists despite adequate breastmilk intake and appropriate weight gain is termed "breastmilk jaundice" and may last up to 3 months (Kemper et al., 2022).

However, for a subset of neonates, extremely elevated bilirubin concentrations can lead to neurotoxicity, including acute bilirubin encephalopathy and kernicterus (Kemper et al., 2022). Acute bilirubin encephalopathy is a reversible, acute illness caused by hyperbilirubinemia and presents with symptoms of difficulty feeding, lethargy, abnormal tone, high-pitched cry, retrocollis-opisthotonos, seizures, and death (Das & van

Landeghem, 2019). Kernicterus is a permanent, chronic neurological disorder resulting from acute bilirubin encephalopathy and is characterized by some or all of the following: (1) abnormal motor control, movements, and muscle tone, (2) auditory processing problems with or without hearing loss, (3) oculomotor impairments, specifically, issues with the upward gaze, and (4) abnormalities with the enamel of deciduous teeth (Das & van Landeghem, 2019).

Hemolytic conditions are a significant risk factor for hyperbilirubinemia neurotoxicity (Kemper et al., 2022). Isoimmune hemolytic disease is an incompatibility between the pregnant woman and the fetus's red blood cells, which can result in hemolytic disease of the newborn. Subsequently, as the neonate's red blood cells are broken down, heme is catalyzed and creates an accumulation of bilirubin. The increase in bilirubin paired with the immature liver function of the neonate causes an increased risk of hyperbilirubinemia neurotoxicity (Hall & Avulakunta, 2022). Screening for isoimmune hemolytic disease is recommended to begin in pregnancy with the testing of the mother's blood to determine the need for treatment with Rh(D) immunoglobulin (RhIG) and to allow for close monitoring (Kemper et al., 2022).

Glucose-6-phosphate dehydrogenase (G6PD) deficiency is one of the most significant hemolytic risk factors causing hazardous hyperbilirubinemia and neurotoxicity (Kemper et al., 2022). G6PD is an enzyme which prevents cellular damage from reactive oxygen species (ROS) (Russ & O'Malley, 2022). Deficiencies in G6PD can result in hemolytic anemia during times of increased ROS production, such as times of stress, or exposure to foods and medications containing high levels of oxidative substances, such as fava beans and acetaminophen (Russ & O'Malley, 2022). G6PD deficiency is an X-linked

inherited disorder and is more prevalent in people of African, Mediterranean, and Asian descent (Russ & O'Malley, 2022). Neonates with G6PD deficiency are reportedly two times more likely to develop hyperbilirubinemia, and about 20% of the cases of kernicterus are associated with this condition (Russ & O'Malley, 2022). Careful monitoring and treatment of elevated bilirubin is essential in preventing severe neurological complications.

Phototherapy is often the recommended first-line intervention for the management of excessive neonatal hyperbilirubinemia because it accelerates the excretion of bilirubin (Ansong-Assoku et al., 2023; Kemper et al., 2022). The goal of phototherapy is to prevent further increases in bilirubin levels which would require escalation of care and exchange transfusion (Kemper et al., 2022). Exchange transfusions are complex and involve removing the neonate's blood and replacement with a donor's blood to remove bilirubin and antibodies which may be causing hemolysis (Okulu et al., 2021).

In 2022, the American Academy of Pediatrics (AAP) published an updated Clinical Practice Guideline (CPG) for managing and preventing hyperbilirubinemia in neonates 35 or more weeks of gestation (Kemper et al., 2022). The original guidelines were published nearly two decades prior to the most recent update (AAP Subcommittee on Hyperbilirubinemia, 2004). In the years between guidelines, data regarding neonatal hyperbilirubinemia and subsequent neurotoxicity has dramatically expanded. The increased knowledge allows clinicians to refine the treatment window to decrease the unwanted effects of phototherapy while still preventing kernicterus from hyperbilirubinemia.

The updated guidelines include many evidence-based changes to the care of neonates with hyperbilirubinemia. The most notable changes include different phototherapy and exchange transfusion initiation thresholds and a detailed risk-based assessment approach based on hour-specific bilirubin levels (Kemper et al., 2022). Additionally, the updated CPG provides recommendations regarding maternal and neonatal screening, feeding, discontinuation of phototherapy, follow-up care after phototherapy, and timing of the post-discharge follow-up appointment in the primary care setting (Kemper et al., 2022). With the implementation of the new guidelines, it is feasible to safely reduce unnecessary overtreatment of mild hyperbilirubinemia while still preventing neurotoxicity.

On inpatient units caring for neonates in suburban Saint Louis, Missouri, the nurse management and pediatric hospitalist providers are implementing a practice change to follow the updated 2022 AAP Hyperbilirubinemia CPG. The purpose of this clinical scholarship project was to reduce the number of subthreshold phototherapy treatment in infants 35 or more weeks of gestation with the implementation of a quick-reference card for providers caring for neonates with hyperbilirubinemia. For this clinical scholarship project, the rate of phototherapy initiation was analyzed to compare incidences of phototherapy initiation at subthreshold treatment levels and initiation at recommended thresholds according to the new AAP CPG. The Institute for Healthcare Improvements Model for Change was the theoretical framework used to guide this project utilizing the Plan-Do-Study-Act (PDSA) cycle. The primary outcome of this project was the number of neonates who undergo phototherapy with a subthreshold bilirubin level. The secondary outcome was the length of hospital stay in neonates with hyperbilirubinemia. The

question for study was: Has the implementation of a hyperbilirubinemia CPG quick-reference card changed the number of neonates who receive subthreshold phototherapy initiation during their hospital stay?

## Review of Literature

Four search engines were utilized to conduct the literature search, including Cochrane Library, PubMed, Medline (EBSCO), and CINAHL. Key search terms and phrases included *bilirubin*, *newborns*, and *phototherapy*, with the Boolean operator AND. All suggested variations of the terms and phrases such as *hyperbilirubinemia*, *jaundice*, *neonates*, *infants*, *baby*, *babies*, *light therapy*, *bright light therapy*, and *illumination therapy* were used, connected by the Boolean operator OR. The initial searches yielded 17,508 results. The inclusion criteria for this literature review were articles published between 2018 and 2023 in academic journals, in English, and subjects aged from birth to one month. Excluded criteria were articles published before 2018, in a non-English language, and subjects greater than one month old. After the inclusion and exclusion criteria were applied, 861 articles remained. Additionally, studies were excluded if the subjects were born at less than 35 weeks of gestation. Nineteen publications were chosen for this literature review.

The updated AAP guideline raised treatment thresholds due to the evidence that neurotoxicity does not occur until bilirubin levels are significantly higher than the original guidelines suggested. Multiple publications analyzed the recent trends regarding the incidence of hyperbilirubinemia, phototherapy, and the development of acute hyperbilirubinemia encephalopathy and kernicterus. Alken and colleagues (2019) completed a nationwide retrospective study in Sweden to determine incidence rates of

dangerous hyperbilirubinemia levels and kernicterus and assessed the adherence to best practice guidelines. Alken et al. (2019) concluded that 494 of 992,378 infants had extreme hyperbilirubinemia (TSB level of 25-29.9mg/dL), consistent with an incident rate of 50 per 100,000 infants; 67 infants had hazardous hyperbilirubinemia (TSB greater than 30 mg/dL), paralleling to an incidence rate of 6.8 per 100,000 infants. The presence of isoimmune hemolytic disease and G6PD deficiency were significant contributing factors in the development of hazardous hyperbilirubinemia.

Furthermore, Alken et al. (2019) noted that of the infants who developed kernicterus, 85% of the cases were deemed preventable and associated with non-adherence to the best practice guidelines utilized at that time. The study observed that 79% of infants were discharged from the hospital without a bilirubin level measurement before discharge, which was recommended in both the Swedish and AAP guidelines during the time of the study (Alken et al., 2019; AAP Subcommittee on Hyperbilirubinemia, 2004). These findings stress the importance of appropriately monitoring and treating hyperbilirubinemia to prevent adverse effects by adhering to published practice guidelines.

Two publications evaluated the trends of neonatal hyperbilirubinemia and the development of neurotoxicity in the U.S. over 15 years. Both studies discovered a significant increase in the use of phototherapy and a decrease in bilirubin toxicity and kernicterus in infants who were born between 38- and 42-weeks of gestation during the study periods (Qattea et al., 2022; Vidavalur & Devapatla, 2022). These findings may be related to the release of the initial AAP hyperbilirubinemia guidelines in 2004. Furthermore, Qattea et al. (2022) concluded African-American infants were less likely to

be diagnosed with hyperbilirubinemia but more likely to develop bilirubin neurotoxicity than Caucasian infants; this could be explained by the increased prevalence of G6PD deficiency in those of African descent. This disparity indicates an opportunity for decreasing racial bias in medicine and improving care for patients who are black, indigenous, and people of color (BIPOC). Diligently abiding by standardized guidelines, such as the updated AAP guidelines, may minimize clinician bias and subsequent racial disparities and complications.

Additionally, Kuzniewicz et al. (2014) completed a retrospective study in Northern California, including 525,409 infants born at 35 or more weeks of gestational age from 1995 to 2011. The study examined medical records of infants with a hazardous bilirubin level to determine the etiology and occurrence of neurotoxicity from hyperbilirubinemia. Of the sample, 47 infants had a hazardous bilirubin level, equivalent to 8.6 per 100,000 births. G6PD deficiency was the most common cause of hazardous hyperbilirubinemia when an etiology was identified, but many of the infants were not tested. Merely four of the 47 infants had acute hyperbilirubinemia encephalopathy, three of which were diagnosed with G6PD deficiency. Chronic neurotoxicity from hyperbilirubinemia was uncommon and occurred only in the setting of additional risk factors, such as prematurity, G6PD deficiency, isoimmune, and sepsis, and with a TSB significantly greater than the transfusion thresholds from the 2004 AAP guidelines. This study provides strong evidence to support the increased thresholds on the updated guidelines.

Walz et al. (2023) performed a large, multicenter, retrospective study in Northern California hospitals to evaluate the incident and death rates of kernicterus. The study

observed an incidence rate of 0.42 per 100,000 California live births and a crude death rate of 0.26 per 1,000,000 live births. Universal bilirubin screening before discharge was correlated with increased phototherapy use and decreased incidence of severe and extreme hyperbilirubinemia. There is ample evidence demonstrating the infrequency of neurotoxicity from hyperbilirubinemia and an increase in phototherapy use to support the raised phototherapy thresholds in the updated guidelines (Alken et al., 2019; Qattea et al., 2022; Vidavalur & Devapatla, 2022; Kuzniewicz et al., 2014; Walz et al., 2023).

The original hyperbilirubinemia guidelines from 2004 have reduced the rates of hyperbilirubinemia neurotoxicity (Walz et al., 2023; Qattea et al., 2022; Vidavalur & Devapatla, 2022). However, there is evidence that many clinicians are initiating phototherapy with bilirubin levels below the threshold values according to the AAP guidelines (So & Khurshid, 2022). So & Khurshid (2022) performed a retrospective case series of 305 neonates who received phototherapy for hyperbilirubinemia in a newborn nursery in Canada. Although the study was not completed in the U.S., the hospital imposed the 2004 AAP guidelines. Of those who received phototherapy, 77.4% met the threshold for initiation; 22.6% of neonates received subthreshold phototherapy, showcasing the significant variability in treatment practices regarding phototherapy initiation. The study attributes the variability to a lack of guidance detailing subthreshold phototherapy in the original 2004 AAP guidelines. However, this study was performed in a single institution, which limits the generalizability.

Wickremasinghe et al. (2018) performed a multicenter retrospective cohort study to evaluate the efficacy of subthreshold bilirubin phototherapy in preventing readmission for phototherapy. The sample size was robust, including 29,895 newborns at 35 or more

weeks of gestation with at least one TSB level below the appropriate AAP phototherapy initiation threshold. Among those included, 19.1% received subthreshold phototherapy, and 4.9% were readmitted for phototherapy, compared with 12.8% of newborns not treated with subthreshold phototherapy. Subthreshold phototherapy during the birth hospitalization may prevent readmission for phototherapy; however, phototherapy was associated with a 22-hour longer length of stay, and many newborns underwent phototherapy unnecessarily. The use of subthreshold phototherapy should include careful evaluation of risks and benefits before initiation to appropriately utilize the treatment modality without delaying discharge.

In addition to a potential increase in length of stay, phototherapy has financial implications. It is logical to assume an increased length of stay in the hospital and use of resources would also increase the cost. According to a report by Health Care Cost Institute, the average price of childbirth in the U.S. in 2020 was $17,103 for caesarian delivery and $11,453 for vaginal delivery (Valencia et al., 2022). However, this data only includes the delivery and may underestimate the price in circumstances requiring additional resources and prolonged length of stay. Clinicians must employ stewardship and responsible resource utilization to reduce unnecessary financial burdens and healthcare costs.

Furthermore, phototherapy is not a benign treatment and can pose a risk of rare immediate or delayed adverse effects. Acute side effects of phototherapy may include interference with maternal-infant bonding, alterations in circadian rhythm, skin rashes, loose stools, overheating, electrolyte disturbances, dehydration, and a grey-brown discoloration of the skin and urine termed "bronze baby syndrome" (Wong & Bhutani,

2023). Four studies included in this literature review evaluated the effects of phototherapy on breastfeeding. Three studies assessed the rates of exclusively breastfeeding after exposure to phototherapy; exclusive breastfeeding was discovered to be less common among those who received phototherapy during their birth hospitalization and those readmitted for phototherapy (Digitale et al., 2021; Digitale et al., 2022; Waite & Taylor, 2016). Furthermore, Chiu et al. (2021) evaluated the parental perspectives regarding neonatal hyperbilirubinemia and breastfeeding. Chiu et al. (2021) discovered that 29.6% of parents in the study identified breastfeeding as a risk factor for jaundice, and 24% indicated that cessation of breastfeeding was a treatment option for neonatal hyperbilirubinemia. These studies suggest phototherapy can present a significant barrier to breastfeeding.

Potential delayed adverse outcomes of phototherapy, such as the development of cancer and atopic disorders, have gained the attention of researchers; these outcomes are not well-understood and, therefore, should not be discounted until continued study supports the ongoing safety of the current treatment recommendations (Auger et al., 2019; Bugaiski-Shaked et al., 2022; Digitale et al., 2021; Kuniyoshi et al., 2021; Kuzniewicz et al., 2018; Tham et al., 2018). However, there are multiple studies suggesting neonatal phototherapy may be associated with epilepsy. Newman et al. (2018) and Maimburg et al. (2016) evaluated this association via large retrospective cohort studies in Northern California and Denmark, respectively. The studies concluded neonatal phototherapy was associated with a slight increase in the risk of childhood seizures, and the risk was more significant in males than females. Newman et al. (2018) controlled for many covariates, including bilirubin values. However, neither study

included information on the classifications of the seizures. Additionally, Newman et al. (2018) emphasized utilizing phototherapy to treat bilirubin levels lower than the threshold to prevent readmissions may pose a higher risk of neurological complications by unnecessarily exposing them to phototherapy. Newman et al. (2018) recommended raising the threshold bilirubin levels, as the updated AAP guidelines have done.

The Institute for Healthcare Improvements Model for Change was used throughout this project utilizing the Plan-Do-Study-Act (PDSA) cycle. Cycles of PDSA are a practical approach to testing and learning about change through manageable steps which may be repeated as needed (Melnyk & Fineout-Overholt, 2023). In the PDSA cycle, a change is planned and implemented, results are studied, and action is taken on what is learned (Melnyk & Fineout-Overholt, 2023). Continuous improvement through the PDSA cycle supports ongoing modifications. This project's "planning" stage involved assembling a quality improvement team, maintaining consistent contact with the team, and creating the quick-reference card. The "do" phase included implementing the quick-reference card and collecting data. The "study" phase consisted of data collection and analysis, and the "act" stage entailed meeting with stakeholders, discussing and disseminating results, and planning for the next PDSA cycle.

In summary, evidence demonstrated the infrequency of dangerous hyperbilirubinemia levels, acute hyperbilirubinemia encephalopathy, and kernicterus, supporting the rise in the phototherapy threshold levels (Alken et al., 2019; Qattea et al, 2022; Vidavalur & Devapatla, 2022; Kuzniewicz et al., 2014; Walz et al., 2023). Meanwhile, there has been an increase in phototherapy use, including with a bilirubin level below what is supported by guidelines (So & Khurshid, 2022; Wickremasinghe et

al., 2018). Subthreshold phototherapy initiation may expose many neonates to a treatment modality which may otherwise be unnecessary. It is crucial to utilize interventions at the minimal effective dose to minimize the potential adverse effects of a treatment. Many of the delayed, long-term adverse effects of phototherapy are not yet well understood; however, the literature suggests those who were exposed to neonatal phototherapy may be at an increased risk of developing childhood epilepsy (Newman et al., 2018; Maimburg et al., 2016). Many studies included in this literature review had robust sample sizes and long follow-up periods. However, the majority were retrospective cohort studies, which cannot provide definitive causality. Further research with large-sized longitudinal studies is needed to establish the long-term adverse effects of phototherapy conclusively. In the nearly two decades between AAP guidelines, knowledge has been gained to further refine the treatment to decrease the acute adverse outcomes while still protecting against hyperbilirubinemia neurotoxicity.

## Methods

### Design

This evidence-based practice quality improvement project used a quasi-experimental before-and-after study design. Data was collected via retrospective chart review before and after the implementation of the reference cards.

### Setting

This project occurred in a suburban area of Missouri in a large, nonprofit hospital on units caring for neonates during their birth hospitalization and those readmitted for phototherapy. This included the postpartum care unit and pediatric unit. There are

approximately 16 full-time and part-time pediatric hospitalist providers, including physicians and advanced practice providers (APPs).

**Sample**

This project's sample utilized a convenience sample via a retrospective chart review of those meeting the inclusion and exclusion criteria. The sample included neonates 35 or more weeks gestation, neonates who underwent phototherapy during their birth admission and/or readmission hospitalizations, and neonates under the care of a pediatric hospitalist. The sample excluded neonates less than 35 weeks of gestation, neonates who did not undergo phototherapy treatment during hospitalization, neonates who underwent phototherapy at home or elsewhere, and neonates under the care of a neonatologist.

**Approval Processes**

Approval was granted from the hospital where the project takes place. Approval for participation in Project: Learning and Implementing Guidelines for Hyperbilirubinemia Treatment (LIGHT) through the American Academy of Pediatrics was granted. Approval was granted by the doctoral committee and IRB of the University of Missouri – Saint Louis.

**Data Collection Analysis**

The data was obtained pre- and post-implementation of the quick-reference cards for comparison. The site's lead pediatric hospitalist nurse practitioner generated a report of the patients meeting the inclusion and exclusion criteria. No identifying data was recorded, and identifying information was removed from the data before report

generation. The data and files were password-protected on the hospital system computers. This project used descriptive data analysis along with the appropriate inferential statistics.

**Procedures**

The inpatient pediatric hospitalists are implementing a practice change to follow the updated 2022 AAP Hyperbilirubinemia Guidelines as part of Project: Learning and Implementing Guidelines for Hyperbilirubinemia Treatment (LIGHT). The practice change has already been initiated into the electronic medical record via a visualization of the infant's bilirubin level plotted onto the appropriate threshold curve, depicting the degree or severity and treatment levels. Stakeholders expressed interest in the creation of an updated CPG quick-reference card. The quick-reference cards were distributed to the providers by the lead pediatric hospitalist nurse practitioner. The stakeholders expressed interest in obtaining data specifically related to the incidence of subthreshold phototherapy initiation (before it is medically necessary) before and after the implementation of the reference cards. Figure 1 displays the reference cards.

## Results

The total number of infants in the study was 77 ($n$ = 77) (Table 1). The most frequently observed gender category was female ($n$ = 41, 53.25%). The race most observed was White ($n$ = 49, 63.64%). The ethnicity most frequently observed was non-Hispanic ($n$ = 71, 92.21%). Birth hospitalization was the most frequent admission type ($n$ = 49, 63.64%). The most frequently observed provider type was an advanced practice provider ($n$ = 38, 49.35%). The most frequent unit was the Postpartum Care Unit ($n$ = 49, 63.64%). Of the 77 infants, merely 2 (n = 2, 2.60%) had a TSB level that met the escalation of care threshold (Table 2). None of the infants ($n$ = 0) in the study received an

exchange transfusion or had a documented concern for acute hyperbilirubinemia encephalopathy.

The average age of the infant in hours of life (HOL) at phototherapy initiation was 69.36. The lowest HOL at initiation was 9.73, and the greatest was 301.4 HOL at initiation. The average TSB before phototherapy initiation was 15.71 mg/dL. The lowest TSB before phototherapy initiation was 9.7 mg/dL, while the highest was 24.4 mg/dL.

Before the implementation of the quick-reference cards, the rate of subthreshold phototherapy was 30.77%, ($n$ = 12). After the implementation, the rate of subthreshold phototherapy was 42.11% ($n$ = 16). Table 3 displays the subthreshold and at-threshold frequencies based on the pre-implementation or post-implementation of the reference cards. A Chi-square Test of Independence was performed to examine the relationship between the implementation of the reference cards and the initiation of phototherapy below or above the threshold per AAP guidelines. The assumption of adequate cell size was assessed and met. The results of the Chi-square test were not significant based on an alpha value of 0.05, $\chi 2(1) = 1.07$, $p = .30$. Therefore, it was found that the number of infants who underwent phototherapy with a TSB below the recommended threshold did not significantly differ based on the implementation of the reference cards (Table 4).

A Two-Tailed Independent $t$-test could not examine the relationship between the length of stay (LOS) in hours and the implementation of the reference card, as it did not meet the assumption of normality. Therefore, a Two-Tailed Mann-Whitney two-sample rank-sum test was conducted to examine whether there were significant differences in the LOS in hours between the groups of pre-implementation and post-implementation of the reference cards. There were 39 infants in the pre-implementation group and 38 in the

post-implementation group. The result of the two-tailed Mann-Whitney U test was insignificant based on an alpha value of 0.5, $U = 671$, $z = -0.71$, $p = .476$. The mean LOS for the pre-implementation of the reference card group was 37.21 hours, and the mean LOS for the post-implementation was 40.84. This suggests that the distribution of LOS in hours for the pre-implementation group (*Mdn* = 57.82) was not significantly different from the distribution of LOS in hours for the post-implementation group (*Mdn* = 62.50). Table 5 presents the result of the two-tailed Mann-Whitney U test.

Table 6 presents the documented rational for the initiation of subthreshold phototherapy. Of the 28 infants who received subthreshold phototherapy initiation (n = 28, 36.36%), the most common reason documented by the provider for the initiation of phototherapy below the recommended TSB level was due to the rate of rise (n = 11, 39.39%). However, most providers did not document a reason for initiating subthreshold phototherapy (n = 17, 60.71%).

Table 7 details if the infant was at or below the threshold level by their admission type. Many of the infants readmitted for phototherapy were referred by their primary care providers, with 32.14% of infants' TSB levels plotting below the phototherapy threshold.

## Discussion

Findings of this study are consistent with the literature regarding the infrequency of severely elevated TSB levels and neurotoxicity. Findings support the need for further interventions to decrease the number of infants who undergo subthreshold phototherapy. This quality improvement project found that implementing a hyperbilirubinemia CPG quick-reference card did not significantly change the number of neonates receiving subthreshold phototherapy during their hospital stay. This project was implemented to

meet the department's goal of reducing the rate of subthreshold phototherapy initiation to 10%. After the reference card's implementation, the subthreshold phototherapy rate remained elevated at 42.11% (Table 3).

Limitations in this project included a small sample size of 77 neonates, causing it to be less likely to find significance in the data. Additionally, the project occurred over a small timeframe. The sample excluded infants under the care of a neonatologist; including infants in the NICU would have expanded the sample and potential significance. One infant's data was eliminated from the study, as they were readmitted by their primary care provider with an unknown TSB level, and the primary investigator was unable to establish if they met the threshold for phototherapy.

Despite the limitations, this study provided valuable insight for further PDSA cycles. Many of the infants readmitted for phototherapy were referred by their primary care providers, with 32.14% of infants' TSB levels plotting below the phototherapy threshold (Table 7). This indicates that many infants may not have required an additional hospital stay and may have been managed with at-home phototherapy interventions. Recommendations include reviewing the updated phototherapy guidelines and available treatment modalities with primary care providers.

Additionally, during the chart review, it was observed that many providers who ordered the phototherapy were incorrectly utilizing the updated guidelines. An infant with a positive DAT status due to the mother receiving RhIG during pregnancy should not be treated as having a neurotoxicity risk factor (Kemper et al., 2022). However, it was noted during chart review that many providers overlooked the administration of RhIG during the mother's pregnancy and continued to treat the infant's DAT status as a

hyperbilirubinemia neurotoxicity risk factor, causing the threshold for initiation to be incorrectly lowered. Recommendations include reviewing with staff the importance of questioning if the mother received RhIG during pregnancy and including a designated place in the electronic medical record to easily find this information.

## Conclusion

The pediatric hospitalists have implemented a practice change to follow the updated 2022 Hyperbilirubinemia CPG. A quick-reference card was created and distributed to the pediatric hospitalist team to decrease the rate of subthreshold phototherapy initiation. Implementing the quick-reference card did not significantly change the rate of subthreshold phototherapy initiation nor the infants' length of stay in hours. A common reason for initiating subthreshold phototherapy was the rate of rise of the TSB, which is addressed in the updated CPG but was not considered in this study. Future studies might include the rate of rise in their investigation of phototherapy use. Future studies should also encompass various providers, such as neonatologists and primary care providers. Reviewing the updated CPG with pediatric primary care providers may reduce unnecessary readmissions for phototherapy. Additionally, the study showed an opportunity to investigate the mother's RhIG status during pregnancy to ensure the provider utilizes the correct phototherapy threshold.

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# Appendix

## Figure 1

*Hyperbilirubinemia CPG quick-reference cards*

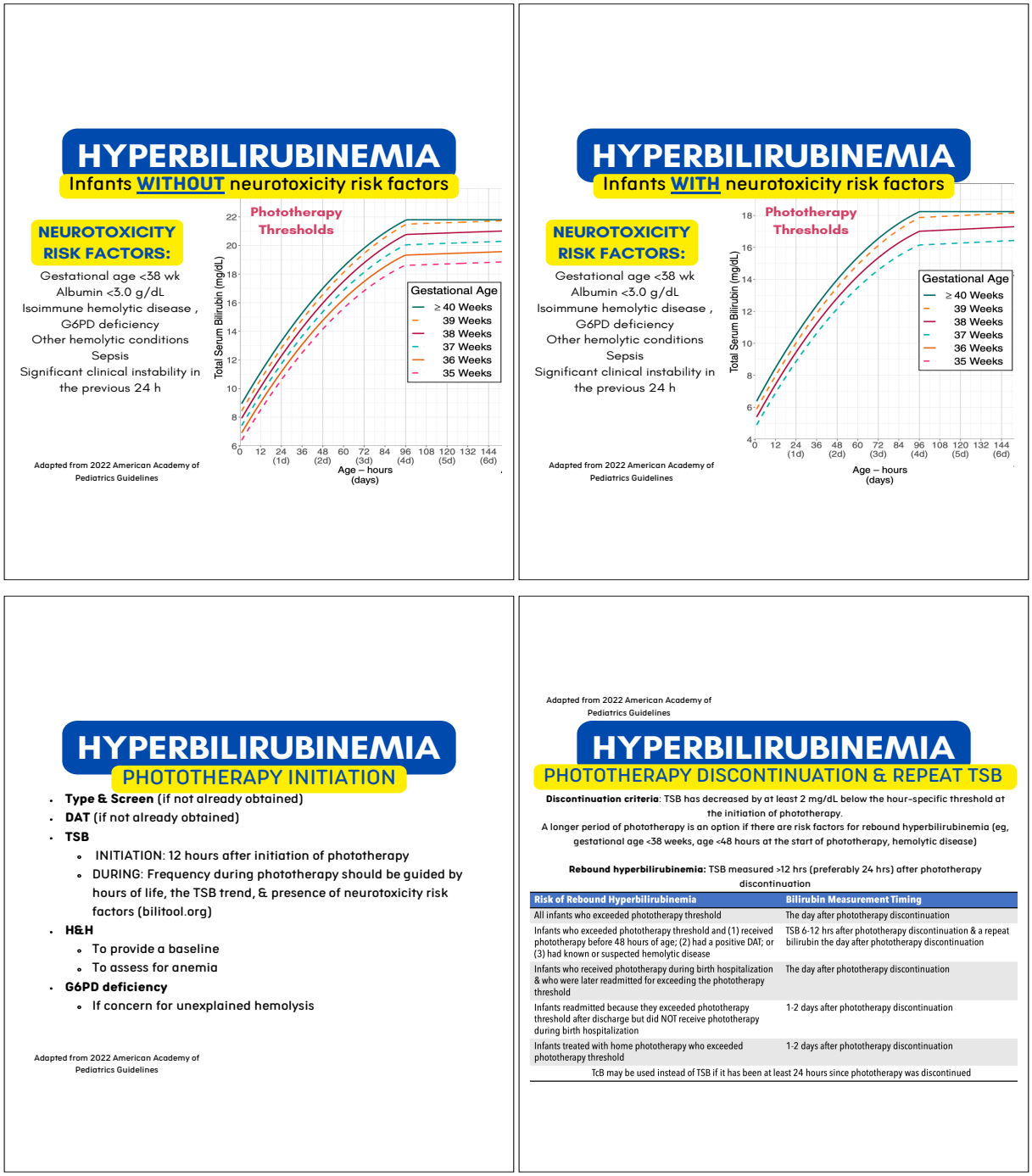

**Table 1**

*Demographics*

| Variable | *n* | *%* |
|---|---|---|
| Gender | | |
| Male | 36 | 46.75 |
| Female | 41 | 53.25 |
| Race | | |
| Not listed or unknown | 7 | 9.09 |
| White | 49 | 63.64 |
| Black or African American | 18 | 23.38 |
| Asian | 3 | 3.90 |
| Ethnicity | | |
| Hispanic | 5 | 6.49 |
| Non-Hispanic | 71 | 92.21 |
| Not listed or unknown | 1 | 1.30 |
| Admission type | | |
| Readmission hospitalization | 28 | 36.36 |
| Birth hospitalization | 49 | 63.64 |
| Provider type | | |
| General Pediatrician/Pediatric Hospitalist | 37 | 48.05 |
| Advanced Practice Provider | 38 | 49.35 |
| Family Medicine Physician | 2 | 2.60 |
| Unit | | |
| Pediatric | 28 | 36.36 |
| Postpartum care | 49 | 63.64 |
| Phototherapy initiation: At or below threshold | | |
| Below phototherapy threshold | 28 | 36.36 |
| At or above phototherapy threshold | 49 | 63.64 |
| Did infant reach or exceed escalation of care threshold | | |
| No | 75 | 97.40 |
| Yes | 2 | 2.60 |
| Received an exchange transfusion | | |
| No | 77 | 100.00 |
| Documented concern for bilirubin encephalopathy | | |
| No | 77 | 100.00 |

*Note.* Due to rounding errors, percentages may not equal 100%.

**Table 2**

*Hours of life at phototherapy initiation & TSB level prior to phototherapy start*

| Variable | *M* | *SD* | *n* | $SE_M$ | Min | Max | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|---|
| HOL at phototherapy initiation | 69.36 | 51.39 | 77 | 5.86 | 9.73 | 301.40 | 1.87 | 4.75 |
| TSB in mg/dL prior to phototherapy start | 15.71 | 3.90 | 77 | 0.44 | 9.70 | 24.40 | 0.25 | -1.10 |

*Note.* '-' indicates the statistic is undefined due to constant data or an insufficient sample size.

**Table 3**

*Subthreshold vs. at threshold frequencies pre- and post-implementation of the reference card*

| Phototherapy initiation at or below threshold | *n* | *%* |
|---|---|---|
| Pre-implementation | | |
| Below phototherapy threshold | 12 | 30.77 |
| At or above phototherapy threshold | 27 | 69.23 |
| Post-implementation | | |
| Below phototherapy threshold | 16 | 42.11 |
| At or above phototherapy threshold | 22 | 57.89 |

*Note.* Due to rounding errors, percentages may not equal 100%.

**Table 4**

*Chi-Square test: the relationship between the implementation of the reference cards and the initiation of phototherapy below or above the threshold*

| Implementation of reference card | Phototherapy initiation: At or below threshold | | $\chi^2$ | *df* | *p* |
|---|---|---|---|---|---|
| | Below phototherapy threshold | At or above phototherapy threshold | | | |
| Pre-implementation of reference card | 12[14.18] | 27[24.82] | 1.07 | 1 | .301 |

| | | |
|---|---|---|
| Post-implementation of reference card | 16[13.82] | 22[24.18] |

*Note.* Values formatted as Observed[Expected].

**Table 5**

*Two-Tailed Mann-Whitney test: The relationship between length of stay in hours between the groups of pre- and post-implementation*

| | Pre-implementation of reference card | | Post-implementation of reference card | | | | |
|---|---|---|---|---|---|---|---|
| Variable | Mean Rank | *n* | Mean Rank | *n* | *U* | *z* | *p* |
| LOS in hours | 37.21 | 39 | 40.84 | 38 | 671.00 | -0.71 | .476 |

**Table 6**

*Frequencies of the documented reason for the use of subthreshold phototherapy*

| Documented reason for subthreshold phototherapy initiation | *n* | *%* |
|---|---|---|
| Rate of rise | 11 | 39.29 |
| Not documented | 17 | 60.71 |

*Note.* Due to rounding errors, percentages may not equal 100%.

**Table 7**

*Subthreshold vs. at threshold frequencies by admission type*

| Phototherapy initiation at or below threshold | *n* | *%* |
|---|---|---|
| Birth Hospitalization | | |
| Below phototherapy threshold | 9 | 32.14 |
| At or above phototherapy threshold | 19 | 67.86 |
| Readmission hospitalization | | |
| Below phototherapy threshold | 19 | 38.78 |
| At or above phototherapy threshold | 30 | 61.22 |

*Note.* Due to rounding errors, percentages may not equal 100%.