Optimization of Nutrition for Extremely Low Birth Weight Infants

Meghan Farquhar

Creighton University

Abstract

Background: Extremely low birth weight (ELBW) infants experience delayed postnatal growth and suboptimal weight gain. Additional calories and supplements are used to achieve better growth. When receiving full enteral feeds of human breast milk, the available sodium is less than the recommended 3-5 mEq/kg/day. In addition, prior research found that poor weight gain and not receiving the daily recommendation of sodium were related to late hyponatremia.

Purpose: This evidence-based practice project was to supplement the enteral feedings of ELBW (<1000 grams and/or 29 weeks' gestation) infants with sodium chloride, if needed, to achieve improvements in growth as shown by the weight z-score.

Methods: After full enteral feedings were reached, a serum sodium was obtained on each qualifying neonate. The neonate was then supplemented with sodium chloride based on their sodium level. An initial level of sodium <130 mEq/kg/day, supplementation was to a total of 6 mEq/kg/day. Initial level between 131-139, supplementation to a total of 4 mEq/kg/day. Initial level >140, no supplementation was indicated. Sodium was surveilled weekly while on supplementation. Once the infant had a stable serum sodium and adequate growth, the supplementation was discontinued. The change in weight z-score was used to determine adequate growth based on the standard that 0.8 difference is considered malnutrition. The goal is a z-score change between birth and discharge weight is ≤ 0.8.

Results: Twelve neonates were born since implementation that qualified for sodium surveillance weighing <1000 grams at birth and/or 29 weeks' gestation. Of the total project participants (n=12), 83% of the infants required early supplementation with sodium for serum levels less than 140 mEq/L. The two infants that did not receive supplementation maintained a serum sodium of greater than 140 mEq/L. The weight z-score difference from birth to discharge was 0.36-1.63. Prior to implementation, a comparison group of similar infants in gestational age and birth weight, only 30% were supplemented with sodium. The weight z-score range of this group was 0.99-2.41. The z-score difference between birth and discharge weight in the project group was overall closer to being ≤ 0.8, the target change.

Implications for Research: Infants were supplemented based on the serum sodium level; a urine sodium, the gold standard, would better reflect the infant's sodium status and need for supplementation. Additional data analysis is necessary to obtain a sample size between 40-50 to properly evaluate effectiveness.

Implications for Practice: This practice change improved the weight change z-score of ELBW infants. No adverse effects were discovered with the early supplementation of sodium.

Key Words: extremely low birth weight, sodium supplementation, z-score, NICU, postnatal growth

Optimization of Nutrition for Extremely Low Birth Weight Infants

Early adequate nutrition is essential for the growth and development of preterm infants in the Neonatal Intensive Care Unit (NICU). In the past, there was a delay to beginning any sort of nutrition, parental or enteral, for concern about its administration (Ziegler & Carlson, 2009). The delay caused major developmental delays and deficits. Delaying nutrition is no longer recommended nor is it the standard of practice in the NICU. Initiation of some type of nutrition (parental or enteral) takes place almost immediately after birth. The goals of early nutrition are to provide the means for uninterrupted growth, mimicking the same nutrients that the infant was getting from the placenta and to stimulate the intestine to being mature (Ziegler & Carlson, 2009). Achieving adequate nutrition can be difficult in the premature infant. Enteral feedings use the mother's expressed breast milk, donor human milk or specialized preterm formula.

Background

Enteral feedings begin with trophic feeds, or small volumes of human milk. The infant's gut is prepared for absorption and digestion. Enteral feedings are slowly increased as the infant transitions from parental to full enteral feedings. Whether human milk or formula, the feeding must provide ample amounts of fat, protein, calories, vitamins and minerals. Breast milk is fortified to meet the unique demands of the infant. If breast milk is not available for the infant, specialty formulas are created to meet the basic nutritional needs of premature infants. A lack of key macronutrients, vitamins and minerals can inhibit overall growth and contribute to neurological deficits. Preterm infants can face irreversible damage as a result of suboptimal nutrition (Ziegler & Carlson, 2009).

Preterm infants require optimized nutrition to support appropriate brain growth. Preterm infants are defined by their gestation or birth weight. Preterm is considered less than 37 weeks' gestation. Very preterm infants are defined as those born 28-32 weeks' gestation and extremely premature infants less than 28 weeks' gestation. Infants weighing less than 1000 grams (g) are considered extremely low birth weight (ELBW), 1000-1500g infant is very low birth weight (VLBW) and 1500-2500g infant is low birth weight (LBW).

Nutritional Requirements

The general daily fluid requirement for the preterm infant is a minimum of 135 mL/kg/day up to 200 mL/kg/day (Kumar et al., 2017). Premature infants have an estimated higher total body water composition per kilogram. At birth, the total body water decreases as the extracellular fluid adjusts to increased renal function (Bell, Segar, & Oh, 2016). In the first seven days of life, very low birth weight infants can lose up to 30% of their total body water due to insensible losses (Bell et al., 2016; Brumberg & La Gamma, 2003). Because of the sensitivity to fluid loss, the premature infant's initial fluid status must be carefully managed.

Adequate amounts of the macronutrients (carbohydrates, protein and fat) and vitamins and minerals are also important in overall infant growth. The energy requirement for the preterm infant is 110-135 kcal/kg/day. The requirement for is protein 3.5-4.5 g/kg/day and 4.8-6.6 g/kg/day for fats (Kumar et al., 2017). The sodium requirement of the preterm infant is higher than the term infant (Segar et al., 2018). Sufficient total body sodium bears a significant link to postnatal growth and neurodevelopment (Segar et al., 2018). Preterm infants may require as much as 3 mg/kg/day of zinc in order to have adequate retention (Terrin et al., 2013).

Sodium Chloride

A positive sodium balance is required for overall weight gain. The kidney, responsible for maintaining the sodium balance, is not fully matured until 32-34 weeks gestational age. Infants born prematurely have a negative sodium balance because of their higher fractional excretion of sodium than a term infant (Isemann, Mueller, Narendran, and Akinbi, 2016). The negative sodium balance happens from increased urinary sodium losses and a decreased ability to reabsorb the sodium in the proximal tubule (Nafday et al., 2016). Medications such as diuretics and caffeine can also contribute to the negative sodium balance (Isemann et al., 2016). A continued negative sodium balance results in hyponatremia, a serum sodium level less than 135 mEq/L.

The European Society for Paediatric Gastroenterology, Hepatology, and Nutrition Committee on Nutrition recommends 3 to 5 mEq/kg/day of sodium (Agostoni et al., 2010). Infants receiving full enteral feeds whether fortified breast milk or preterm infant formula are receiving less than 3 milliequivalents mEq/kg/day of sodium. Preterm infants are at risk for developing late hyponatremia and delayed weight gain given the inability to make up the previously lost stores of sodium (Isemann et al., 2016). A target serum sodium of 140 mEq/kg/day allows for optimal growth.

ELBW and VLBW Infants

Infants are born with an immature digestive system that must grow and mature postnatally, less reserve of brown fat and glycogen stores for energy and a higher caloric need due to the increase evaporative water loss. Current management strategies of enteral feedings focus on adequate fluid volume and calorie content. In addition to the base nutrition of human breast milk or formula, extra calories are often added providing calorie dense nutrition. Despite the current strategies, linear growth is suboptimal in these premature infants. Identifying ways to improve nutrition and overall growth is crucial in the improvement of long-term outcomes for neonates. Preterm infants are often deficient in key vitamins and minerals such as sodium chloride and zinc. Supplementing sodium chloride to the enteral feed contributes to better linear growth (Segar et al., 2018).

Significance

The World Health Organization estimates 15 million babies are born premature every year (World Health Organization, 2012). Preterm birth and subsequent medical care is estimated at $16.9 billion annually (Allen, 2008). Premature birth is associated with many morbidities including chronic lung disease, poor growth and feeding problems, necrotizing enterocolitis, infection, developmental delays and disabilities. Nutrition is directly linked to each of these morbidities. Without complete and adequate nutrition, the infant lacks the basic caloric requirements to meet the physiologic needs, let alone allow the infant to grow.

Delayed Growth

Ideal postnatal nutrition is comparable to that of a normal fetus of similar gestation and body composition (de Curtis & Rigo, 2012). LBW and VLBW infants can experience an extrauterine growth restriction or growth failure due to the difficulties in providing adequate nutrition to meet the metabolic demands of their bodies (Lunde, 2014). The extrauterine growth restriction is considered a weight less than the 10^{th} percentile compared to a normal fetus of the same age (Lunde, 2014). Recommended growth is around 20 grams/kilogram/day which is between 13-30 grams per day (Ziegler & Carlson, 2009). Despite demonstrated weight gain during the NICU stay, the majority of infants are still below the 10^{th} percentile compared to an infant of the same postmenstrual age (Ehrenkranz et al., 2016). Furthermore, data from the National Institute of Child and Human Development (NICHID) Neonatal Research Network show nearly all of VLBW and ELBW infants experience some type of growth restriction by 36 weeks corrected gestation age (Lemons et al., 2001).

In addition to overall weight gain, inadequate nutrition is associated to poor head growth. The circumference of the head is used to determine growth. This measurement reflects actual brain size (Lee & Hayes, 2015). A steady increase in head circumference indicates the brain is growing and developing appropriately. Persistent poor head growth early in the premature infant's life contributes to cognitive delays and abnormal neurological findings by 5.4 years of life (Franz et al., 2009). Delayed motor development is strongly associated with head circumference growth from birth to discharge (Franz et al., 2009).

The premature infant's energy requirements alone can be increased by an increase in energy expenditure. Infants born premature face other physiologic stress such as infection, lung disease, cardiovascular lesions, metabolic changes that increase the energy expenditure (Brumberg & La Gamma, 2003). These stresses can also inhibit appropriate digestion and absorption which hinders overall weight gain. Ehrenkranz et al. (2006) showed that infants with the slowest weight gain had the highest incidences in diagnosed necrotizing enterocolitis, late-onset infection, bronchopulmonary dysplasia and postnatal steroid therapy.

Neurodevelopment

The first 1000 days of the infant's life can be critical in the brain's cellular and structure changes. These changes take place in a preprogrammed order and speed (Schwarzenberg & Georgieff, 2018). With an accidental delay or change in course, the sequence can fail leaving the infant with the possibility of loss in function later in life (Schwarzenberg & Georgieff, 2018). Preterm infants are already at risk for poor neurodevelopment as any noxious stimuli can have a negative impact such as inflammation, infection, stress or emotional deprivation (Schwarzenberg

& Georgieff, 2018). A nutrient deficient diet adds yet another risk factor for healthy neurodevelopment (Ziegler & Carlson, 2009).

Poor neurodevelopment outcomes can lead to cerebral palsy, cognitive, visual and hearing impairments and behavioral and emotion problems. Infants born weighing less than 1000 grams are more likely to develop cerebral palsy, with the greatest risk being the smallest infants (Behrman & Butler, 2007). Motor development is strongly associated with head circumference growth from birth to discharge (Franz et al., 2009). An estimated 2.7% of all the preterm births had a moderate or severe type of neurodevelopmental impairment (Blencowe et al., 2013). The cost for special education is an estimated $1.1 billion and early intervention services for qualifying preterm infants is $ 611 million every year (Allen, 2008).

Local Problem

A standardized feeding protocol was initiated in March 2019 in a Level III Midwest NICU. The goal of this protocol was to unify the feeding practice and decrease the incidence and risk of necrotizing enterocolitis. By implementing this protocol, the premature infants would have less days of parenteral nutrition leading to better overall growth. However, the protocol did not account for the addition of micronutrients such as sodium chloride. Infants in this NICU have been supplemented with sodium chloride retroactively to boost growth and improve sodium absorption. Extremely low and very low birth weight infants are experiencing suboptimal weight gain at this Midwest Level III NICU.

Purpose

The purpose of this evidence-based scholarly project was to implement the supplementation of the enteral feeds of ELBW and VLBW (<1000 grams and/or 29 weeks' gestation) infants with sodium chloride once infants had achieved full enteral feeding volumes.

The overall weight gain and days to return to birth weight were outcome measures that were evaluated throughout this scholarly project. The aims included:

1) Identify which infants were at risk for poor growth,
2) Development of guidelines for early sodium chloride supplementation,
3) Implementation of sodium supplementation into the standardized feeding protocols,
4) Measurement of the specific outcomes:
    a. Days to birth weight
    b. Z Score growth parameters

Literature Review

Sodium Chloride Supplementation

Early sodium supplementation is associated with improve growth in premature infants. In a randomized controlled trial, Isemann et al., (2016) evaluated the use of sodium supplements in infants ≤32 weeks' gestational age. Infants were excluded from the study if they were incompatible with life, had any renal insufficiency or had a disease state characterized by edema (Isemann et al., 2016). The trial was masked, and placebo controlled allowing for optimal randomization. Infants were equally placed in gestational age brackets and then randomized by the clinical pharmacist to determine who would receive the supplement. Beginning on day of life 7 and ending after 28 days, the infants received 4 mEq/kg/day of sodium chloride supplement. If an infant had a serum sodium concentration greater than 150 mml/L, that infant was removed from the study. Results from the study demonstrated that infants who received the supplement had a faster rate of growth, particularly the infants born <28 weeks' gestation (Isemann et al., 2016). Additionally, at six weeks, 79% of infants who received the supplements were able to maintain birth weight percentile compared to only 13% of those who received the placebo.

However, there was no significant difference when it came to length and head circumference (Isemann et al., 2016).

Segar et al. (2018) identified similar results after implementing a sodium chloride supplementation algorithm. In this study, serum sodium concentrations were used to evaluate sodium supplementation goals. The infants received 4 mEq/kg/day of sodium supplement as well and would receive an additional 2 mEq/kg/day if the serum sodium was below their goal measurement (Segar et al., 2018). The cohort of infants was randomized to include 40 infants of similar gestational age and birth weight which were compared to a 50-infant cohort from the previous year. The study showed a significantly greater weight change between the second and eighth week in the tested group compared to the previous cohort. The authors did not have to remove any patients from the study for hypernatremia (Segar et al., 2018). This study was not a randomized controlled trial. The study only looked at growth, not lean mass changes, nor head and length. Finally, serum sodium concentrations were found to be dependent on time of day and may not have always been reflective of sodium status (Segar et al., 2018). A follow-up study is being designed to evaluate the algorithm and this approach and monitor changes in body composition to better correlate with the sodium supplementation (Segar et al., 2018).

In a retrospective study, Mansour, Petersen, De Coppi and Eaton (2014) looked at sodium deficiency and growth in surgical infants. Over a previous seven-year time frame, infants (less than 1 year) who had some type of ostomy and a sodium deficiency up to one-year post-operation were included. Many of the patients had a diagnosis of necrotizing enterocolitis. The major finding was a link between sodium and growth in each of the 40 patients about which data was collected (Mansour et al., 2014). An infant with optimal growth did not have a serum sodium of less than 30mM, but infants with a less than 10mM serum sodium had poor growth

(Mansour et al., 2014). Upon further evaluation, being able to measure the serum sodium prospectively and using a guideline for monitoring and supplementation would help draw a more specific conclusion between sodium deficiency and growth in this population (Mansour et al., 2014).

With the same general conclusion about sodium and its effect on growth, Hartnoll, Bétrémieux, and Modi (2000), looked at the timing of the sodium supplement in relationship to the oxygen requirement of the infant. In this study, half the infants received sodium supplement early and the other half delayed until the infant had lost around 6% of birth weight (Hartnoll et al., 2000). The results found improved oxygenation requirement on the infants with delayed initiation without compromising the growth of the infant indicating initiation of the sodium supplement should begin after the initial diuresis is taking place (Hartnoll et al., 2000

Conceptual Model & Framework

Implementing an evidence-based practice change is often guided by a conceptual model or framework. The model provides a systematic approach to making a change or improvement. The Iowa Model Revised was used to guide this scholarly project. An important question in this Level III Midwest NICU is about nutrition and investigating how to best provide optimal nutrition to the premature infants. Because nutrition is essential to the survival of all neonates and future growth and development, the topic is a priority. A small team was formed to implement this practice change including the neonatologists, neonatal nurse practitioners, registered dietician, and clinical pharmacist (Iowa Model Collaborative, 2017).

Once the topic was deemed a priority, a body of evidence was assembled and appraised to determine if there was sufficient literature to allow for this improvement. In this project, sufficient evidence would demonstrate the advantageous effects of prophylactic supplementation of sodium chloride in improving linear growth and long-term neurodevelopment outcomes. The quality, quantity, consistency and risks associated with the change were evaluated. With sufficient evidence, the practice change will be designed and piloted (Iowa Model Collaborative, 2017). A localized protocol was developed and distributed along with the implementation plan to include when and how much to supplement, how to monitor and when to stop. The clinicians were introduced to and presented with the existing evidence and plan for implementation as well as the timeline for the pilot project. Baseline data including birthweight and weight percentile, weekly measurements, electrolyte status were collected on each infant before the change is implemented. After discharge, data was collected again on the same infants which will include weight and percentile and the growth trend while the baby was inpatient.

Important for this practice change is its sustainability and necessity for integration into the clinical practice. If the change is appropriate, the next steps are for its formal adoption into practice. The Iowa Model Revised specifically outlines the need to integrate the change, beginning with engaging the key personnel, which in this case would be the neonatologists and nurse practitioners (Iowa Model Collaborative, 2017). Secondly, the change would need to be hardwired into the system. This involves making sure the change is sustainable and implemented beyond the pilot period. Finally, the results were disseminated. The dissemination may be the most important aspect of the entire project and practice change. Communicating what was learned and changes to a greater group of clinicians can and will benefit future practice (Iowa Model Collaborative, 2017).

Methodology

This quality improvement scholarly project obtained baseline measurement data of all infants at risk for poor growth. For this project, those infants are considered extremely low birth weight and very low birth weight infants with a birth weight of less than 1000 grams or <29 weeks' gestation. Measurement data included birth weight, head circumference, length, current weight for age z-score. Patients were randomly assigned a number and identified using this number. No patient identifiers were used, documented or stored during data collection. Data was collected and placed into an Excel spreadsheet and stored on a CHI Health computer in the neonatal nurse practitioner office. The spreadsheet was password secured and only the investigators had access. After data analysis, the spreadsheet will be maintained securely on the CHI Health computer for further information gathering.

A point of care electrolyte test, which includes a serum sodium, was collected as part of the new protocol from each infant as part of routine laboratory testing to establish a baseline level. Subsequent orders, after the initial order, was placed in the electronic medical record by the neonatal nurse practitioner. These specimens were obtained on each infant each week after supplementation begins and then two weeks after supplementation is discontinued. Once infants reached full enteral feeding volume, on day of life ten, sodium supplementation began based on serum sodium level collected the previous day. Supplementation started at approximately 2 mEq/kg/day and adjusted based on the weekly levels, for a goal of at least 4mEq/kg/day. Table 1 outlines supplementation guidelines based on serum sodium levels. The supplementation guideline was incorporated into the existing feeding protocol.

An educational session was completed with the current neonatal nurse practitioner group, neonatologists, and dietician to go over supplementation guidelines and review the role each group would play. The provider ordered the supplements and laboratory studies at the correct intervals. The provider guided the supplementation process ensuring the infant did not receive too much sodium. The dietician offered a reminder to the practitioners as the infant neared full feeding.

Table 1. Sodium Supplementation Guidelines

Initiate Level	Action	Follow-up Level	Optimal Growth	Growth Failure
≤130	Add NaCl to achieve a total of 6 mEq/kg/day with enteral feeds	≤130	Increase to a total of 8 mEq/kg/day	Increase to a total of 10 mEq/kg/day
131-139	Add NaCl to achieve total of 4 mEq/kg/day	131-139	Continue same dose	Increase to total of 8 mEq/kg/day
≥140	No supplementation indicated	≥140	Discontinue supplement	Continue same dose

Supplementation lasted until the serum sodium indicated supplementation was no longer needed and adequate growth was maintained. Weekly measurements were taken after the supplementation period for two more weeks. The number of days it took for the infant to return to birth weight were recorded with measurement data. The weight for age z-scores was calculated for birth weight, weight at two, four weeks, and six weeks, or two weeks after supplementation was discontinued, whichever came first. The z-score was tracked and compared to z-scores of infants with similar weight and gestation prior to the implementation of supplementation. The z-score represents a number of standard deviations above or below a referenced mean allowing data to be standardized. A positive z-score indicates the data point is above the average whereas a negative score indicates below the average. Using the z-score the growth rate for the individual infant could be better examined especially with those infants that were at higher risk for poor weight gain.

A retrospective chart review was completed to identify infants meeting the same weight criteria in the last year who did not receive this early sodium supplementation. The birth weight and measurements were documented. The z-score of these infants at birth, two, four, and six weeks was calculated and recorded. If serum sodium was available, they were documented.

Results

Pre-Implementation

A retrospective chart review was completed evaluating 58 infants born less than 1000 grams and/or less than 29 weeks of gestation between January 2018 and May 2019. Of the 58 infants, 42 were able to be counted as they discharged from the NICU. The other sixteen infants were excluded for either being transferred to a higher level of care or passing away. Figure 1 shows 31 infants (74%) had a weight z-score change of greater than 0.8 and 11 infants (26%) had a weight z-score change of less than 0.8.

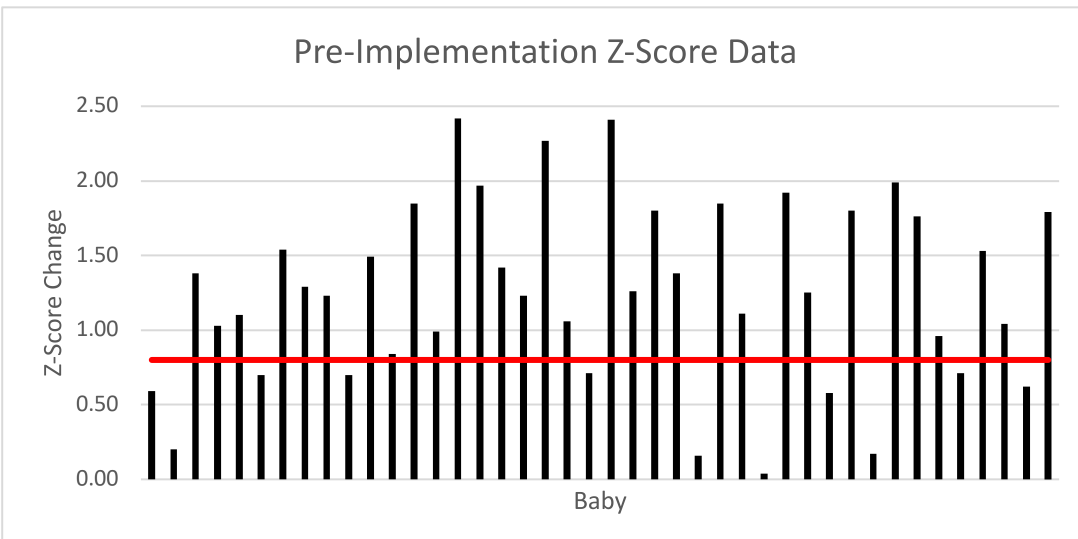

Figure 1. The Z-Score difference between birth weight and discharge weight. The goal is >0.8 shown by a horizontal line.

A total of 16 of the infants were supplemented with sodium, but usually after three to four weeks. The infants who received a sodium supplementation, five met the goal of the weight z-score change being less than 0.8. Of the 26 infants who were not supplemented, six had a z-score change of less than 0.8. Figure 2 shows, by color, the infants who were supplemented and their respective z-score change.

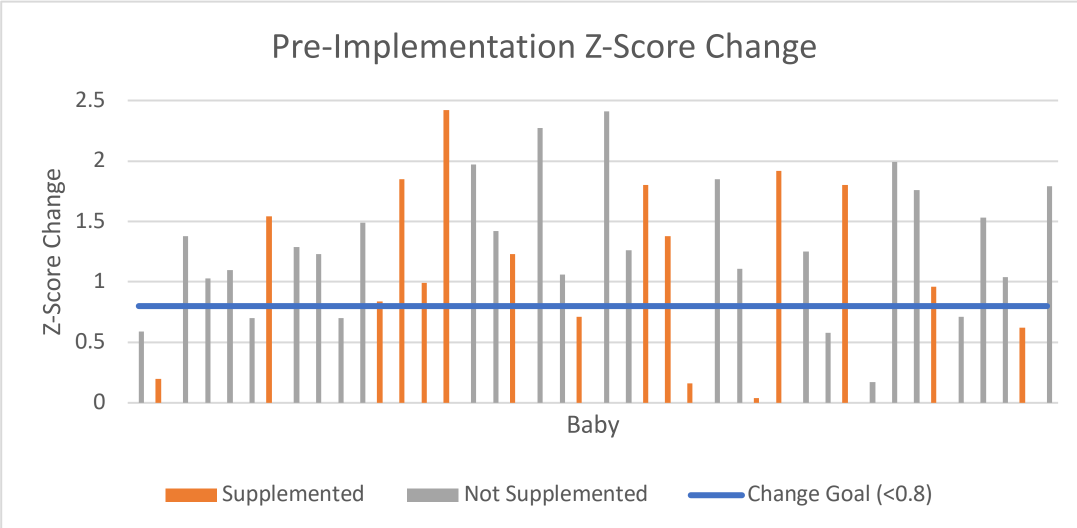

Figure 2. The z-score change of all 42 infants color coded to show whether they were supplemented (orange) or not supplemented (grey).

Post-Implementation

Data collection began in September 2019 and ended in January 2020. Twelve babies have qualified for protocol. All the infants that qualified met the criteria for gestational age. The lowest birth gestational age was 22 weeks 6 days and oldest birth gestational age was 28 weeks 6 days. The lowest birth weight was 550 grams and highest birth weight 1200 gm. The range of birth weight z-scores was -0.61-1.75. Of the 12 infants, two did not qualify for sodium supplementation because they maintained a serum sodium greater than 140 mEq/L. One infant was transferred to a higher level of care prior to being eligible for supplementation and one infant who was transferred was requiring supplementation at time of transfer. A total of nine infants were supplemented. Of the 12 total infants, two are still inpatient. Discharge data for eight infants was recorded and shown in Figure 3.

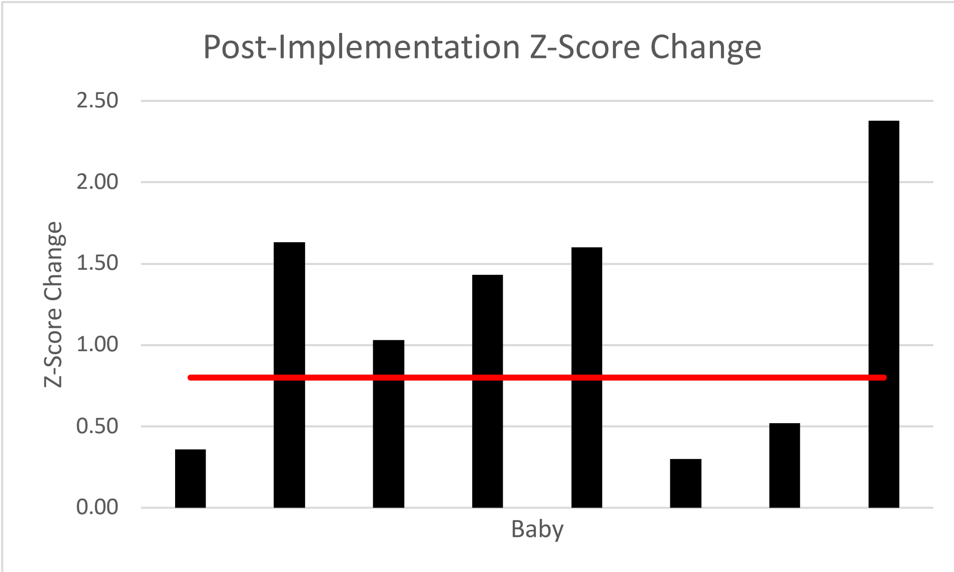

Figure 3. Z-Score change for the eight infants who have discharged.

The range of discharge weight was 2000gm to 3300gm. The range of discharge weigh z-score was -2.63-0.12. The change in birth to discharge weight z-score range was 0.3-2.38, with three being less than 0.8. The two infants who were able to maintain a serum sodium greater than 140 mEq/L, had a z-score change of 0.3 and 0.36.

Given the small sample size, a random sample matching weight and gestation age was extracted from the pre-implementation group. Figure 4 shows the infant's z-score change and if they were supplemented for the pre-implementation group and Figure 5 for the post-implementation group.

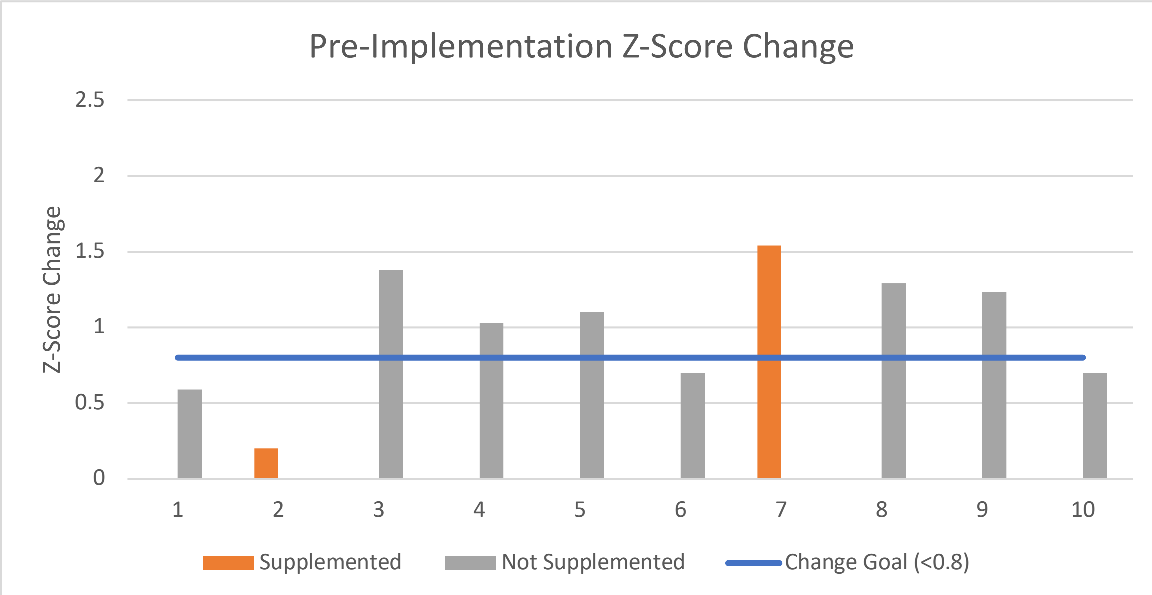

Figure 4. The z-score change of the extracted 10 infants from the pre-implementation group, color coded to show whether they were supplemented (orange) or not supplemented (grey).

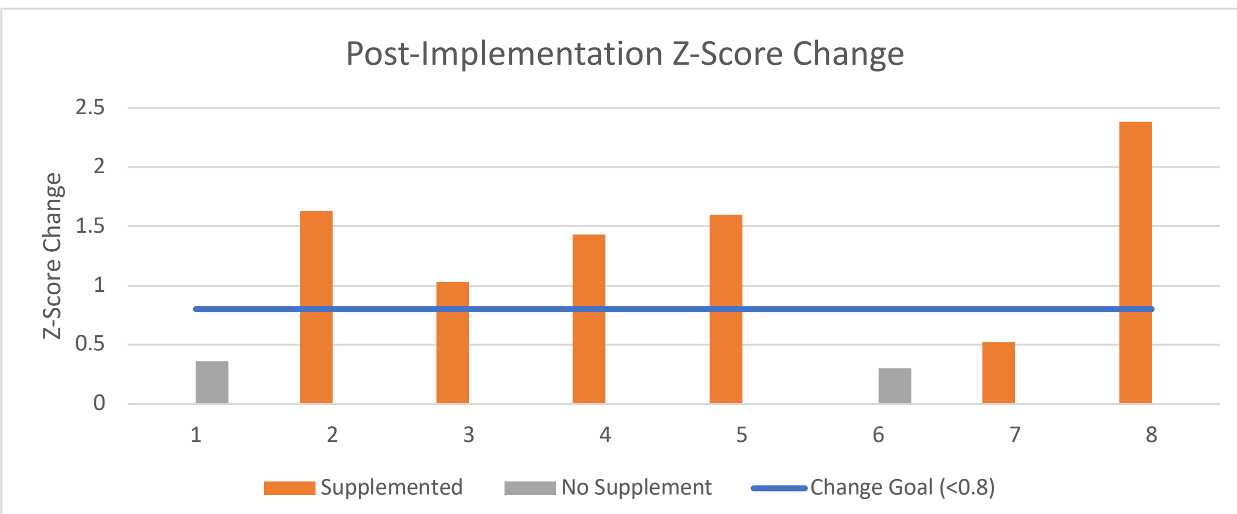

Figure 5. The z-score change of the eight infants from the post-implementation group color coded to show whether they were supplemented (orange) or not supplemented (grey).

Discussion

Given the small sample size and the performance improvement nature of the project, the statistical significance cannot be accurately obtained. Data collection must mirror the pre-implementation data collection time frame in order to better determine statistical significance. The overall change in z-score between the pre- and post-implementation group was improved; more infants were demonstrating a z-score closer to greater than 0.8. This finding related favorably to the literature citing improved weight gain and growth in this population of infants.

Limitations

The initial data collection and implementation of the protocol required new learning and adjusting current management styles by the medical providers. Often, the initial sodium would not be ordered within the protocol's time limit. Sodium supplements were stopped for a normal sodium value (135 mEq/L – 139 mEq/L) without consideration to the target value of 140 mEq/L and evaluation of growth. Many of the patients were primarily managed by the rotating pediatric resident, requiring additional oversight by the nurse practitioner.

Implications for Nursing Practice

The improvement in growth in this population of infants has been observed and discussed by multiple care team providers. By making the small evidence-based change, the infants were growing better despite being born prematurely. A continuation of the supplementation and continued fine-tuning of the protocol and timeline will likely yield further improvements in their postnatal growth.

Recommendations

Additional data collection and evaluation is recommended to mirror that of the pre-implementation data. To better follow the protocol and supplementation timeline, a care plan or standard order set would be beneficial in the electronic medical record. A better understanding of the z-score and using the metric to assess appropriate growth is needed. A potential for more research would be the comparison of the serum sodium to the urine sodium, the gold standard for evaluating actual sodium levels in the body. Further research into the literature to evaluate other micronutrients and their supplementation related to improved growth is an opportunity for expanding this project.

Conclusion

Prior to the implementation of the standardized feeding protocol, this Level III Midwest NICU experienced discrepancies between providers on how infants in the NICU were fed and provided nutrition. The standardized feeding protocol put into place specific targets for each gestation and weight category. While infants were receiving nutrition based on a standard protocol, the overall growth was still suboptimal. The addition of a sodium supplementation protocol of the ELBW feeding protocol aimed to improve the overall growth in this population. With a relatively small sample size, growth did make an improvement. Without being able to identify the statistical significance at this time, the key metric, the z-score change, was improved. The supplementation was recently built into the feeding protocol, cuing the medical team into the need for initial surveillance, likely supplementation, and follow-up surveillance of the serum sodium. Because of these changes, the protocol will be sustainable and adjusted as needed based on new research and the patient population. By optimizing the specific nutrition of these infants in the immediate postnatal period, their future growth and development will be better in line with their gestational peers.

References

Agostoni, C., Buonocore, G., Carnielli, V. P., De Curtis, M., Darmaun, D., Decsi, T., … Ziegler, E. E. (2010). Enteral nutrition supply for preterm infants: Commentary from the European Society for Pediatric Gastroenterology, Hepatology, and Nutrition Committee on Nutrition. *Hepatology and Nutrition 50*(1). doi: 10.1097/MPG.0b013e3181adaee0

Allen, M. C. (2008). Neurodevelopmental outcomes of preterm infants. *Current Opinion in Neurology 21*(2). doi: 10.1097/WCO.0b013e3282f88bb4

Behrman, R. E. & Butler, A. S. (2007). Preterm birth: Causes, consequences, and prevention. Retrieved from http://www.nap.edu/catalog/11622.html

Bell, E. F., Segar, J. L., & Oh, W. (2016). Fluid and electrolyte management. In M.G. MacDonald & M. Seshia (7th Edition), Avery's Neonatology (265-279). Singapore: Wolters Kluwer.

Blencowe, H., Lee, A. CC., Cousens, S., Bahalim, A., Narwal, R. Zhong, N. … Lawn, J. E. (2013). Preterm birth-associated neurodevelopmental impairment estimates at regional and global levels for 2010. *Pediatric Research 74*(s1). doi: 10.1038/pr.2013.204.

Brumberg, H., & La Gamma, E. F. (2003). New perspectives on nutrition enhance outcomes for premature infants. *Pediatric Annals, 32*(9). doi: https://doi.org/10.3928/0090-4481-20030901-10

de Curtis, M. & Rigo, J. (2012). The nutrition of preterm infants. *Early Human Development 88.* doi: 10.1016/j.earlhumdev.2011.12.020

Ehrenkranz, R. A., Dusick, A. M. Vohr, B. R., Wright, L. L., Wrage, L. A. Poole, K. (2006). Growth in the neonatal intensive care unit influences neurodevelopmental and growth outcomes of extremely low birth weight infants. *Pediatrics 117*(4). doi: 10.1542/peds.2005-1368

Franz, A. R., Pohlandt, F., Bode, H., Mihatsch, W. A., Sander, S., Kron, M., & Steinmacher, J. (2009). Intrauterine, early neonatal, and postdischarge growth and neurodevelopmental outcome at 5.4 years in extremely preterm infants after intensive neonatal nutritional support. *Pediatrics, 123*(1). doi: 10.1542/peds.2008-1352

Hartnoll, G., Bétrémieux, P. & Modi, N. (2000). Randomised controlled trial of postnatal sodium supplementation on body composition in 25 to 30 week gestational age infants. *Archives of Disease in Childhood: Fetal and Neonatal Edition 82*(1). F24-28. http://dx.doi.org/10.1136/fn.82.1.F24

Isemann, B., Mueller, E. W., Narendran, V., & Akinbi, H. (2016). Impact of early sodium supplementation on hyponatremia and growth in preterm infants: A randomized controlled trial. *Journal of Parenteral and Enteral Nutrition 40*(1). doi: 10.1177/0148607114558303

Kumar, R. K., Singhal, A., Vaidya, U., Banerjee, S., Anwar, F., & Rao, S. (2017). Optimizing nutrition in premature low birth weight infants—consensus summary. *Frontiers in Nutrition, 4*(20). doi: 10.3389/fnut.2017.00020

Lee, K. A. & Hayes, B. C. (2015). Head size and growth in the very preterm infant: A literature review. *Research and Reports in Neonatology 5.* doi: 10.2147/RRN.S74449

Lemons, J. A., Bauer, C. R., Oh, W., Korones, S. B., Papile, L., Stoll, B. J., … Stevenson, D. K. (2001). Very low birth weight outcomes of the National Institute of Child Health and Human Development Neonatal Resarch Network, January 1995 through December 1996.

Pediatrics 107(1). Retrieved from https://pediatrics.aappublications.org/content/107/1/e1.long

Lunde, D. (2014). Extrauterine growth restriction: What is the evidence for better nutritional practices in the neonatal intensive care unit? *Newborn & Infant Nursing Reviews 14*(3). doi: 10.1053/j.nainr.2014.06.008

Mansour, F., Petersen, D., De Coppi, P., & Eaton, S. (2014). Effect of sodium deficiency on growth of surgical infants: a retrospective observational study. *Pediatric surgery international*, *30*(12), 1279–1284. doi:10.1007/s00383-014-3619-2

Nafday, S. M., Woda, C. B., Saland, J. M., Flynn, J. T., Askenazi, D. J., Benchimol, C., & Brion, L. P. (2016). Renal disease. In M.G. MacDonald & M. Seshia (7th Edition), Avery's Neonatology (754-755). Singapore: Wolters Kluwer.

Schwarzenberg, S. J., & Georgieff, M. K. (2018). Advocacy for Improving Nutrition in the First 1000 Days to Support Childhood Development and Adult Health. *Pediatrics, 141*(2). doi:10.1542/peds.2017-3716

Segar, D. E., Segar, E. K., Harshman, L. A., Dagle, J. M., Carlson, S. J., & Segar, J. L. (2018). Physiological approach to sodium supplementation in preterm infants. *American Journal of Perinatology 35*(10). doi: 10.1055/s-0038-1632366

Ziegler, E. E. & Carlson, S. J. (2009). Early nutrition of very low birth weight infants. *The Journal of maternal-Fetal & Neonatal Medicine 22*(3). doi: 10.1080/14767050802630169