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Feeding Outcomes in Preterm Infants After Discharge From the Neonatal Intensive Care Unit (NICU): A Systematic Review☆

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ABSTRACT

Optimal growth and successful feeding in the neonatal intensive care unit (NICU) are difficult to achieve, and data indicate premature infants continue to struggle after discharge. The purpose of this systematic review was to identify growth and feeding outcomes in the NICU published within the last 10 years. Available evidence suggests weight-for-age decreases between birth and discharge from the NICU, and continues to lag behind expectations after discharge. Prevalence rates of breastfeeding differ across countries, with declining rates after discharge from the NICU. Interventions focused on increasing breastfeeding rates are effective. Most healthy preterm infants successfully nipple feed at a gestational age ≥36 weeks, but infants may be discharged prior to achieving full oral feeding, or eating with poor coordination. Earlier born preterm infants are later at achieving full oral feedings. After discharge, preterm infants are slower to develop eating skills, parental reports of feeding problems are prevalent, and parents introduce solids to their infants earlier than recommended. This review enhances professionals' understanding of the difficulties of feeding and growth in preterm born infants that are faced by parents.

Many premature infants have difficulty with successful feeding in the neonatal intensive care unit (NICU), and data indicate that premature infants are at increased risk of eating problems even after discharge. Medical and procedural interventions necessary for treating the hospitalized infant present challenges for the development of successful eating skills in the NICU and may have long-lasting effects on the ability and desire to eat well throughout childhood. Eating has been described as a neurodevelopmental process that follows a predictable sequence of acquisition of eating skills, and which relies upon the infant's organization of autonomic function, motor and muscle tone and movement patterns, behavioral state, and ability to regulate all of these processes simultaneously.[1] The extent of prematurity, severity of illness and the number of medical interventions all are positively correlated with a delay in acquisition of eating skills.[2,3] While the infant begins to establish a foundation for successful eating within the NICU setting, eating skills continue to develop and new skills must be acquired for the infant to transition to solid food. If the infant was successful at eating sufficient quantities for discharge from NICU to home without the need for supplemental feedings via a nasal–gastric or gastrostomy tube, the staff of the NICU often believe that the infant is not at further risk of feeding problems. However, given the neurodevelopmental nature of eating, it is evident that eating while in the NICU is not a predictor of successful eating after discharge. A recent study found that, in a cohort of extremely premature infants evaluated at 6 years of age, the odds of having an eating problem were 3.6 times that of their term counterparts.[4] A thorough understanding of the feeding outcomes of premature and low-birth-weight infants both during the NICU experience and across the first 10 years after birth will provide a more comprehensive understanding of the challenges faced by these infants and their families. For the purposes of this review, "feeding" refers both to the experience and the actions of the caregiver; "eating" refers to the actions of the infant.

Neurodevelopmental Nature of Eating

As described by Browne and Ross,[1] eating is a neurodevelopmental process that has been shown to be neurologically based and

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developmental in nature. Assessment of the maturation of sucking skills as well as the rhythm of sucking (specifically the integration of suction and compression during breast and bottle feeding) may predict longer term neurodevelopmental outcomes.[5] As such, the experiences of the infant during the development of these skills contribute to a foundation for later successful eating. Eating requires the ability to maintain stability in autonomic function, motor balance and tone, and arousal states, while integrating the incoming sensory components of both the feeding environment and the food itself.

The motor activity of sucking is initially driven by primitive motor processes controlled by a central pattern generator (CPG).[6] However, for infants born early, at approximately 3 months corrected age, the primitive motor patterns controlled by the central pattern generator(CPG) are integrated and eating becomes a volitional task.[6] While the infant younger than 3 months may continue to eat using the primitive reflexes of rooting, sucking and swallowing when they are eating, the infant older than 3 to 4 months may stop eating if the experience is or has been unpleasant. The developmental nature of successful eating behavior makes imperative a thorough understanding of the feeding outcomes both in the NICU and after discharge. Prediction of positive eating outcomes made before discharge from the NICU may be unreliable, as the process is driven primarily by the CPG's. A systematic review of feeding outcomes was therefore conducted with the intent of providing additional information regarding the following clinical questions:

Clinical Question #1: What is the available evidence regarding breastfeeding rates, eating skill/feeding problems, eating/feeding outcomes and growth outcomes in premature infants at the time of discharge from the NICU?
Clinical Question #2: What is the available evidence regarding breastfeeding rates, eating skill/feeding problems, eating/feeding outcomes and growth outcomes in premature infants after discharge from the Neonatal Intensive Care Unit?

A systematic literature search of published research studies listed on PubMed was conducted. MeSH terms included infant, premature or infant, low-birth-weight and feeding behaviors, producing a total of 816 articles. After applying the following limits, 339 citations appropriate to the review were identified: Human, English (as this is the primary language spoken by the authors) and those published within the last 10 years. Studies were excluded if the title indicated a focus on specific medical conditions (e.g., ankyloglossia, HIV), if they focused on maternal factors exclusively (e.g., increasing breast milk supply) or if they focused primarily on nutritional factors rather than feeding or growth outcomes (e.g., benefits of breast milk on cognition). As there was only one identified article that looked specifically at small-for-gestational age, full-term infants,[7] it was rejected and the review focused on the outcomes of preterm infants. Efficacy of specific interventions on feeding development was not included in this review, as Dodrill recently published a review of feeding difficulties that included both feeding development and feeding management.[8]

Abstracts for each of the 339 citations were reviewed and 278 were excluded for one or more of the following reasons: the article did not directly address questions or the target population, or were review articles. All 61 resulting full-text articles were reviewed. A total of 27 articles focused on feeding or growth outcomes at the time of discharge from the NICU, and an additional 29 articles were identified that focused on premature infants after discharge from the NICU. Nine articles focused on feeding or growth at the time of discharge as well as after discharge, and were included in the analysis for both clinical questions. The articles were further divided into either feeding or growth outcomes, and then subdivided by the following methods of feeding: breastfeeding, bottle feeding, or either mixed feedings or unknown methods of feeding (Fig 1).

The full-text articles for each study question were reviewed by both authors, and key elements from each publication were summarized and compiled by the first author, and reviewed by the second author for any areas of disagreement. For many articles, feeding and growth outcomes were not the primary foci of the study. However, full-text articles that presented prevalence rates for feeding or growth problems were considered valuable and therefore were included in the analysis. Any differences were discussed until consensus was reached.

Results

Clinical Question #1: What is the available evidence regarding breastfeeding rates, eating skill/feeding problems, eating/feeding outcomes and growth outcomes in premature infants at the time of discharge from the NICU?

Articles regarding feeding outcomes at the time of discharge were grouped according to breastfed or bottle fed methods. The majority of articles (14) identified were focused on breastfeeding; nine articles focused on both breast and bottle fed infants and one article focused on bottle feeding skills. Breastfeeding outcomes are hard to interpret specifically, as many articles did not differentiate between direct breastfeeding and the provision of expressed human breast milk. The World Health Organization (WHO) defines "exclusive" breastfeeding as when an infant only receives breast milk. While some articles defined "exclusive breastfeeding" according to the WHO definition, others did not describe how "breastfeeding" was interpreted.

Breastfeeding Outcomes at Discharge

Two main themes regarding breastfeeding outcomes emerged. 1) Sweden routinely presents the highest breastfeeding rates in preterm infants at the time of discharge, and 2) interventions designed to improve breastfeeding rates are effective. In 2010, Funkquist and colleagues,[9] published rates at the time of discharge from the NICU of 97% for any breastfeeding, and full breastfeeding for 84% of a cohort of Swedish infants ranging from 25.0 to <36 weeks at birth. However, they defined breastfeeding as including both direct breastfeeding as well as provision of expressed breast milk at the time of discharge. Akerstrom and colleagues[10] defined exclusive breastfeeding as direct breastfeeding without bottle or tube feedings. Partial breastfeeding included direct breastfeeding as well as bottle feeding (expressed human milk or formula). Using these definitions, 92% of their cohort of 785 preterm infants discharged with some level of breastfeeding. Exclusive breastfeeding was most prevalent in the late preterm group (32–36 weeks at birth), with 56% of this cohort achieving full breastfeeding, compared with 35%–38% in the more preterm born groups. For infants partially breastfed, those in the group of 28–31 weeks at birth achieved the highest rate of 50%, with 38%–40% of the other two groups discharged with partial breastfeeding. In Denmark, rates are reported to also be high, with 60% of preterm infants reported to exclusively breastfeed and an additional 5% both breast and bottle fed.[11]

In contrast, United States rates of initiation of breastfeeding are lower. Pineda[12] reported 78% of mothers initiating breast milk feeds, but only 52% of the infants ever breastfeeding in the NICU. Colaizy and colleagues[13] reported an initiation rate of 70% for infants born <35 weeks gestational age, with approximately 50% breastfed for greater than 4 weeks. However, there were no data reported for percent of breastfeeding at the time of discharge. Hake-Brooks and Anderson[14] conducted an intervention study and found in their control group 60% of infants breastfed exclusively at discharge. The definition for this study included both breast and bottle feeding of human breast milk. An additional 3% of their cohort received 50%–80% of their nutrition with breast milk via breast or bottle feeding methods. Smith and colleagues[15] reported data regarding the