University of Alberta

Characteristics of Premature Infants with Aspiration-Related Respiratory Illness Post-Discharge

by

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ABSTRACT

Children who were born preterm and admitted to a feeding and swallowing service because of an aspiration-related respiratory illness within one year post discharge from a neonatal intensive care unit/intermediate care nursery were described retrospectively. Charts of 52 infants were reviewed. Frequency of potential risk factors for an aspiration-related illness were compiled. Subgroups within the sample were described (tube fed at discharge; discharged on oral feeds and feeding problems within 90 days; mechanical ventilation for $\geq$ 7 days). These premature infants were a diverse group with multiple medical issues and developmental challenges that may act alone or in combination to affect their ability to safely eat orally. Medical complications of prematurity, extended mechanical ventilation, and clinical signs of feeding difficulty appear to be important in identifying premature infants at risk for aspiration. Comparison to a control group in a prospective study of risk factors is needed to verify the importance of these factors.

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LIST OF SYMBOLS AND ABBREVIATIONS

ASD	Atrial Septal Defect
CLD	Chronic Lung Disease
CPAP	Continuous Positive Airway Pressure
ELBW	Extremely Low Birth Weight
GA	Gestational Age
GI	Gastro Intestinal
GER	Gastroesphageal Reflux
G-Tube	Gastrostomy Tube
HMD	Hyaline Membrane Disease
ICN	Intermediate Care Nursery
IVH	Intraventricular Haemorrhage
LBW	Low Birth Weight
MMIH	Megacystis microcolon intestinal hypoperistalsis syndrome
MRI	Magnetic Resonance Imaging
n	Number of subjects in sub sample
N	Number of subjects in the sample
NEC	Necrotizing Enterocolitis
NG-Tube	Nasogastric Tube
NICU	Neonatal Intensive Care Unit
PDA	Patent Ductus Arteriosus
PMA	Postmenstrual Age (Gestational Age + Chronological Age)

SD	Standard Deviation
VLBW	Very Low Birth Weight
VSD	Ventricular Septal Defect
$\leq$	Less than or equal to
$\geq$	Greater than or equal to
χ^2	Chi square test statistic

CHAPTER 1

THE PROBLEM

Introduction

Occupational therapists and other health professionals are increasingly being asked to diagnose and treat swallowing disorders in infants born prematurely. These infants exhibit complications of feeding and swallowing difficulties that are different than those found in adults. As such, they are a unique group.

The act of oral eating is the most complex task of infancy and is influenced by multiple co-related factors and driven by a maturational process (McGrath & Braescu, 2004). The physical act of sucking, swallowing and breathing develops and changes with growth and maturation, making it vulnerable to medical conditions and delays or deviations in development. In addition to the infant's neurophysical development and medical status, an infant's feeding development is also influenced by the complex interaction of the infant's and/or family's ability to participate in feeding and the environmental influences of the Neonatal Intensive Care Unit (NICU) and the home.

Medical care in the NICU has evolved resulting in improved survival of preterm infants born less than 30 weeks gestation (Simpson, Schanler, & Lau, 2002). With the improved care of premature infants in the NICU, there has been a perceived increase in the number of premature infants with feeding and swallow disorders. These disorders are a direct result of the multiple health conditions associated with prematurity. For example, premature infants are at an increased risk of cerebral palsy, sensory impairments, and minor neuromotor dysfunction compared to full term controls (Allen, 2002). They often are born with underdeveloped cardiorespiratory and central nervous systems (Bu'Lock, Woolridge, & Baum, 1990); demonstrate immature motor patterns (e.g., decreased oral motor skills; poor suck, swallow and breathe patterns); are susceptible to long term health issues related to chronic lung damage, bronchopulmonary dysplasia, heart defects, and gastroesophageal reflux; and/or have developmental delays (Wolf & Glass, 1992).

As feeding has a direct impact on the nutrition available for the growth and development of all the body systems, it is imperative that premature infants with feeding and swallowing disorders be accurately diagnosed and managed aggressively because of a premature infant's reduced nutritional reserve and high energy needs (Newman, 2000). With the pressures to minimize the length of hospital stay and to have infants fully nipple feeding prior to their discharge, nipple feeding is offered sooner with the expectation that the infant will progress rapidly. At times, feeding progression is simultaneously occurring with decreasing respiratory support. The ultimate goal is to discharge the infant without respiratory support and on full oral feeds (Wolf & Glass, 1992). Given the limited resources and sheer numbers of premature children discharged everyday from the NICU, it is important for health care professionals to look for methods to help identify premature infants most at risk of developing feeding and swallowing difficulties. One such method would be to describe the association of minor and major complications of prematurity with the prevalence of feeding and swallowing disorders in order to identify possible predictors (Allen, 2002).

Studies have been completed on the developmental progression of oral eating in premature children and more recently on interventions to facilitate the transition to oral feeding. However there is little to no information on determinants of ongoing risk of aspiration-related respiratory illnesses once full oral feeds are established and the infant is discharged from NICU. With the perceived increase in infants being readmitted to hospital within 6 months post discharge with respiratory distress associated with aspiration, it is imperative that health care providers identify infants at risk for aspiration. Their reduced nutritional reserve and high energy needs can result in severe and even fatal consequences if aspirating (Newman, 2000).

The International Classification of Functioning, Disability and Health (ICF) is used by the World Health Organization as a framework for measuring health and disability at both individual and population levels. The ICF is a health status classification of function and disability secondary to the consequences of disease and conditions such as prematurity. It looks at the physical, biological, and social aspects of health and disability and records the impact of the environment on the person's functioning. Feeding and swallowing in a premature infant is a complex interaction between body functions and structures, the health condition of the infant, the activity of feeding, and contextual factors of the environment (e.g., NICU care guidelines, exposure to tobacco smoke and allergens, familial stress, neglect). However, before we can study the influences of the environment on feeding in the premature infant, we need to understand the influences of development and disease on the activity of feeding.

Problem Statement

This retrospective study describes children who were born preterm and admitted to a feeding and swallowing service within one year post discharge from NICU/Intermediate Care Nursery (ICN) because of an aspiration-related respiratory illness. The purpose of this descriptive exploratory study was to determine if there are salient medical and clinical feeding and swallowing characteristics which might be potential predictors for infants at risk for aspiration-related respiratory illnesses. Identifying these characteristics would lay the basis for a future comparative study with infants born preterm who were not admitted to a feeding and swallowing service with aspiration-related respiratory illness.

The development of feeding and swallowing skills parallel the psychosocial milestones of homeostasis, attachment, and separation/individuation (Chatoor, Schaefer, Dickson, & Egan, 1984); therefore, the act of eating is multi-factorial and is not solely reliant on medical and developmental influences. Future studies would be needed to study the influences of psychological, environmental and social factors such as the impact of stress on the parent-child interaction, infant's homeostasis within the NICU/ICN environment and the influences of the home environments on feeding in the premature infant.

CHAPTER 2

LITERATURE REVIEW

"Successful oral feeding requires that children have functional oral sensorimotor and swallowing skills, adequate pulmonary and gastrointestinal function, central nervous system integration and normal musculoskeletal tone" (Udall, 2007 p. 374). The length of stay in the neonatal intensive care unit (NICU/ICN) is influenced by a number of factors, but most significantly by gestational age (GA), weight at birth, and the ability to demonstrate competent oral feeding skills (Eichenwald et al., 2001; Simpson et al., 2002). Infants born with the earliest GAs have the longest hospital stays, in part because of the higher incidence of medical complications in extremely low birth weight infants. Before they can be safely discharged from hospital, premature infants must show medical stability and physiologic maturity, including adequate temperature control, adequate weight gain, cardiorespiratory control, and the ability to safely feed by mouth. The ability to feed by mouth implies the ability to take all formula/breast milk prescribed within an allotted time and maintain a desirable pattern of weight gain. The ability to feed by mouth safely implies the ability to coordinate suck, swallow and breathe patterns during eating (Simpson et al., 2002) in order to maintain adequate respiration and minimize the risk of fluid entering the lungs. Once the infant attains these maturational milestones, premature infants are observed for several days in NICU/ICN before discharge (Eichenwald et al., 2001). This study is the beginning in understanding the progression of the swallowing function with maturation past 1 month of chronological age and the relationship between medical diagnoses and swallowing function (Newman, Keckley, Petersen, & Hamner, 2001).

Anatomy/Physiology

The anatomy and musculature of an infant's mouth and throat are different than that of an adult. The infant has a smaller oral cavity with a slightly retracted jaw and fat pads located in the cheek musculature. The tongue fills the entire oral cavity, allowing for only anterior/posterior movements. The larynx is positioned higher in the throat and slightly forward under the tongue base. The tongue, larger soft palate, and epiglottis approximate functionally separating the respiratory and digestive tracts. This close proximity of structures and fat pads in cheeks provides the anatomical stability needed to support immature motor patterns and reduce the risk of aspiration (Rudolph & Link, 2002; Wolf & Glass, 1992).

The act of eating for an infant involves a suckling motion on the nipple. Lips are loose on the nipple. The tongue moves forward and backward and presses against the hard palate in a wave like fashion. The jaw moves upward and downward creating negative intra-oral pressure allowing milk to flow along the central groove of the tongue to the back of the oral cavity. The soft palate seals against the back on the tongue to keep liquids in the oral cavity until ready to swallow. With the initiation of the swallow, the soft palate elevates and lifts to seal the nasopharynx and allows milk to flow into the pharynx. The true and false vocal cords close and the larynx lifts upward and anterior slightly, while the epiglottis deflects over the laryngeal opening sealing the airway. With the movement of the larynx, the upper esophageal sphincter opens and allows milk to flow into the esophagous, where peristaltic waves propel it toward the stomach (Rudolph & Link, 2002; Wolf & Glass, 1992).

Maturation of Suck, Swallow, and Breathe

"Eating requires active effort by infants who must have exquisite timing and coordination of simultaneous breathing, sucking and swallowing" (Udall, 2007 p. 374). Any breakdown in the coordination of swallowing and breathing can result in aspiration (Udall). This coordination is complex and involves the functional interaction of several systems.

Swallowing is one of the first pharyngeal motor responses to mature and is necessary for maturation of the fetal gastrointestinal tract (Ross & Nyland, 1998) and managing secretions and larger milk boluses after birth (Bosma, 1972; Grybosksi, 1969). Ultrasound studies have shown that the fetus begins to swallow between 10 to 14 weeks and the swallowing pattern becomes consistent between 22 to 24 weeks (Gewolb, Bosma, Reynolds, & Vice, 2003; Gewolb, Vice, Schweitzer-Kenney, Taciak, & Bosma, 2001; Miller, Sonies, & Macedonia, 2003). Sucking movements are the second to mature, beginning as early as the 15^{th} week, with true suckling (anterior/posterior movements) developing at 18 to 24 weeks (Udall, 2007) and increasing in frequency and efficiency between 32 and 40 weeks (Lau, Alagugurusamy, Schanler, Smith, & Schulman, 2000; Gewolb et al., 2001; Miller et al.). Lastly, fetal breathing movements occur as early as 10 weeks, but are episodic and do not become continuous until closer to 34 to 36 weeks. The rhythm of breathing can continue to mature for up to 6 weeks after term (Rigatto, 1992).

The term infant begins feeding with 10 or more continuous sucks without taking a breath and then transitions into a suck/breathe pattern with pauses of four or more seconds between sucking bursts (Mathew, Clark, Pronske, Suna-Solarzarro, & Petersen, 1985). During the continuous sucking phase, the infant takes in less air (decreased minute volume) and then catches their breath during the pauses in a rhythmic pattern (Mathew et al.). The term infant swallows predominately at the beginning of expiration or inspiration and occasionally during inspiratory phase. This differs from adults, who mainly swallow during exhalation (Lau, Smith, & Schanler 2003; Selley, Ellis, Flack, & Brooks, 1990).

By 1 month chronological age, the term infant begins to adjust his/her feeding pattern to increase efficiency. He/she begins to take several sucks in a row prior to swallowing (2:1, 3:1, or 4:1). Suck rate, or the percentage of sucks in runs of more than 3, and the average length of suck runs increase over the first month. Swallow rate and percentage of swallows per run increase but less significantly. The amount of fluid taken per suck and the amount swallowed almost double over the first month (Qureshi, Vice, Taciak, Bosma, & Gewolb, 2002; Weber, Woolridge, & Baum, 1986). Sucking pressure, frequency and duration appear to mature with age and become more variable to improve efficiency (Mizuno & Ueda, 2003).

In addition to their individual functional rhythms, suck, swallow and breathe rhythms need to occur sequentially from the oral to pharyngeal to pulmonary phases for safe oral eating (minimal risk for aspiration) to occur (Amaizu, Shulman, Schanler & Lau, 2008). The mechanical maturation of these three functions needs to occur at both the muscular (peripheral) and the central nervous system levels (McFarland & Tremblay, 2006).

Suck, Swallow and Breathe Pattern of Premature Infant

The development of the suck, swallow and breathe pattern in a term infant is characterized by a predictable maturational pattern and also has a rhythm. In the premature infant, the oral, pharyngeal and postural musculature is not fully developed. Fat pads in cheek musculature that aid in ability to extract milk from a nipple may be absent or underdeveloped and medical and/or respiratory status may be compromised (Wolf & Glass, 1992).

By 34 weeks gestation, healthy preterm infants are likely able to suck and swallow well enough to sustain their nutrition by bottle or breast feedings and some healthy preterm infants have begun oral feeding as early as 32 to 33 weeks gestation (Udall, 2007). The coordination of suck-swallow begins when a preterm infant is introduced to oral eating; however, the ability to coordinate the swallow with breathing evolves more slowly. If a premature infant does have difficulty with feeding, it is more likely due to in-coordination of swallowing and breathing (e.g., aspiration) than sucking and swallowing (e.g., oral motor) rhythms (Amaizu et al., 2008; Lau et al., 2003).

Because the control of swallowing and breathing tends to lag behind the sucking and swallowing reflexes, oral eating is usually not begun in healthy preterm infants prior to 32 weeks gestation (Bosma, 1986). Infants born prior to 32 weeks GA and/or suffering from medical complications of prematurity, obtain their nutrition mainly by nasogastric or oral tube feedings (Greer, 2001).

Recent studies have shown a significant correlation between level of maturity of an infant's sucking and GA (Lau et al., 2000). Amaizu et al. (2008) compared the suck, swallow, and breathing skills of infants born 26/27 weeks and 28/29 weeks GA after being introduced to oral feeding at 33/34 weeks postmenstrual age (PMA). The infants had no identified central nervous system (CNS) injury, necrotizing entercolitis (NEC), chronic lung disease (CLD) or major congenital anomalies. Amaizu and colleagues found that the infants in both groups attained independent feeding at around 34 to 38 weeks PMA. However, the temporal maturation of swallow and breathe rhythms had not occurred in the 26/27 weeks GA infants by this period, suggesting that infants born at younger gestational ages may take all their nutrition orally at 34 to 38 weeks PMA, but take longer to obtain the rhythm of swallowing and breathing than infants born at older gestational ages. They found that the components of sucking, swallowing and breathing and their coordinated activity matured at different times and rates and the maturation levels of timing take longer to occur in infants born at younger gestational ages. Experience through non-nutritive oral stimulation offered prior to the introduction of oral feeding, could accelerate the attainment of full oral feeding (Fuscile, Gisel, & Lau, 2002; 2005).

In preterm infants of 32 to 33 weeks, sucking patterns are more often irregular and do not appear rhythmically linked to swallow and breathing activity (Gewolb et al., 2001; Weber et al., 1986). Premature infants tend to have more sucking and swallowing sequences with the breath held, followed by a period of continuous respirations; however the minute volume does not recover. These longer suck/swallow sequences can result in more frequent periods of apnea, bradycardia, and cyanosis (Bu'Lock et al., 1990; Koenig, Davies, & Tach, 1990; Selley et al., 1986; Shivapuri, Martin, Carol, & Fanaroff, 1983). Eichenwald et al. (2001) studied the influences on length of hospital stay in a sample of 435 healthy infants born at 30 to 35 weeks GA. They found that PMA at the last apnea or bradycardia episode in NICU was strongly correlated with the PMA at attaining all oral feeds. These events of apnea and bradycardia correlate with significantly longer transition times to take full oral feedings (Eichenwald et al.; Mandich, Ritchie, & Mullett, 1996). On videofluoroscopic swallow studies, premature infants that demonstrated apnea and bradycardia also demonstrated risk of aspiration with pooling of barium near the open airway and/or backflow of barium into the nasal cavity (Plaxico & Loughlin, 1981). Without experience, the premature infant swallows predominately during the inspiratory phase (Lau, et al., 2003). As the premature infant matures, the suck, swallow and breathe pattern becomes a 1:1:1 ratio, with swallows occurring more frequently after inspiration and followed by expiration. This suggests that with maturation and experience, the infant demonstrates more rhythmic and stable suck, swallow and breathe runs (Bu'Lock et al., 1990; Gewolb et al., 2001; Weber et al., 1986). However, premature infants with additional health issues (e.g., low birth weight or bronchopulmonary dyplasia) can continue to exhibit increased respiratory rates and have difficulty achieving and maintaining efficient suck, swallow, breathe rhythms (Goldfield, Wolff, & Schmidt, 1999). Therefore feeding efficiency in a premature infant is influenced by GA at birth and the effects of health conditions related with prematurity.

An important question is what happens to premature children once the nervous system becomes less reliant on reflexes and more reliant on mature motor patterns? Do the health related conditions associated with prematurity begin to affect the premature infant's ability to maintain the complex neuro-motor patterns needed to coordinate the suck, swallow and breathe triad?

Factors Affecting Feeding In Premature Infants

Central nervous system development and neurodevelopmental delays

Poor long-term neurological outcomes have long been recognized in the younger premature infant and have been associated with smaller cortical brain volumes/grey matter (Inder, Warfield, Wang, Huppi & Volpe, 2005; Kinney, 2006). Late preterm infants (34 to 37 weeks GA) were believed to be spared substantial brain injury and considered almost normal; however, research is showing that this population is at risk of brain injury and adverse long-term neurodevelopmental outcomes as well. At 34 weeks, an infant has developed only 53% of their total cortical brain volume (Adams-Chapman, 2006; Kinney, 2006). A large proportion of brain growth, development and networking occur during the last six weeks of gestation. During this time, tissues can be vulnerable to injury [e.g., Intraventricular hemorrhage (IVH), periventricular leukomalacia (PVL), hypoxic respiratory failure, hyperbilirubinemia, hypoglycemia, temperature instability and sepsis] (Adams-Chapman, 2006; Kinney, 2006; Wang, Dorer, Fleming & Catlin, 2004). This is also the time period (35 to 41 weeks GA) that oral motor skills become more coordinated and states of alertness more predictable (Ludwig, 2007). Injuries from medical issues during this time can have an adverse affect on the development of feeding skills and prolong transition to oral eating. When these medical issues are combined with preterm infants' lack of full flexor tone, decreased endurance and less coordinated suck, swallow, and breathe synchrony, difficulty bottle feeding and risk for aspiration increases (Ludwig; Wolf & Glass, 1992). Although late preterm infants are historically treated much like term infants regarding oral feeding, these infants often show signs of 'poor feeding' but often take enough volume to 'get by' before discharge (Ludwig) only to be readmitted later with poor feeding. According to Wang et al. (2004), feeding difficulties are a common reason for readmission to hospital in infants born 34 to 37 weeks gestation.

Few other studies have looked directly at respiratory related illness secondary to aspiration in premature infants, yet this population is at significant risk of feeding and swallowing disorders as a consequence of the variety of health related concerns, reduced nutritional reserve, and high energy needs. As swallow impairments are often associated with central nervous system injury, looking at risk factors for and causes of central nervous system (CNS) injury in children younger than 1 year of age may give insight into risk factors and/or causes of swallow impairments.

One of the strongest predictors of major disability in preterm infants is abnormal findings on a neuroimaging study and/or neonatal neurodevelopmental examination (Allen, 2002). Reilly, Skuse, and Poblete (1996) studied the prevalence of feeding problems and oral motor dysfunction in 49 children with various levels of cerebral palsy. One in three was severely impaired and at high risk of undernourishment. Fifty-seven percent had sucking difficulties and 38.0% had swallowing difficulties in the first 12 months of life and 90.0% continued to show oral motor difficulties that affected adequate oral nutrition in the preschool years. As premature infants are at a higher risk of neurodevelopmental disorders such as cerebral palsy, it is imperative that children be thoroughly assessed and monitored past the NICU/ICN to ensure adequate nutrition can be obtained.

Gestational age and gender

Two possible risk factors are sex and GA. Preterm males are more vulnerable than preterm females to complications and neurodevelopmental disability (Allen, 2002; Hediger, Overpaeck, Ruan, & Troendle, 2002). Major complications of prematurity have been shown to increase with decreasing GA. Some of these complications that can affect the feeding process include necrotizing enterocolitis (NEC), Chronic Lung Disease, and Intraventricular Hemorrhage (IVH). These complications increase a preterm infant's risk for major disability (Allen). The probability of survival without disability increases with postnatal age and GA (Doyle, 2001).

Respiratory health (mechanical ventilation, oxygen use, and chronic lung disease)

Many premature infants require mechanical ventilation and are given postnatal steroids to improve lung function. Low and very low birth weight infants often require assisted ventilation for survival. Oliver, Forcht, and Lawrence (1998) demonstrated that as the number of days of ventilation increased, the severity of feeding and swallowing dysfunction increased. They eliminated infants with CNS injury, diagnosed syndromes or illnesses in order to determine the independent effects of mechanical ventilation. The severity of risk factors for the 7 to 12 day ventilated groups was approximately twice the nonventilated group and the 14 to 21 day ventilated group was approximately five times greater than the nonventilated group. A statistically significant difference was found between the nonventilated and the 14 to 21 day ventilated group with the 14 to 21 day group developing more pneumonia and oral aversion than the nonventilated and the 7 to 12 day ventilated group. They concluded that all premature infants who were ventilated for 14 days or longer should be closely monitored for feeding and swallowing complications prior to and after discharge from hospital.

Infants born less than 32 weeks GA requiring oxygen at 36 weeks PMA and infants born at 32 weeks or more GA requiring oxygen beyond 28 days are considered to have chronic lung disease (Allen, 2002; D'Angio & Maniscalco, 2006) which may contribute to difficulties with endurance while eating or with coordination of the suck, swallow and breathe triad. Chronic lung disease (CLD) has been shown to be a predictor of higher rates of infections, rehospitalization, reactive airway disease (e.g., asthma), and cerebral palsy.

Several studies have compared premature infants with and without CLD and found that premature infants with CLD demonstrated delayed maturation of suck-swallow rhythms and swallow-respiration rhythms (Gewolb & Vice 2006; Wood et al., 2003); prolonged transition time from tube feed to oral feeds (Pridham et al.,1998); more frequent, prolonged and severe desaturation events during feeding (Shiao, Brooker, & DiFiore, 1996); less intake and poorer growth (Pridham et al., 1999; Wood et al., 2003). Recently, the US National Institute of Health (NIH) proposed a definition that divided CLD into mild, moderate and severe categories based on GA and length and amount of oxygen support but it is unclear as to how these categories compare in terms of risk for feeding difficulties. Singer et al. (1992) found that infants with mild lung disease who were discharged home, continued to have oxygen desaturations during feeding, took longer to eat and had less intake volume than infants without lung disease. Little research has looked at the duration of the risk for desaturations during feeding. Burklow et al. (2002) found that history of assisted breathing was a stronger predictor of later feeding problems than prematurity alone. Postnatal steroids have been associated with disability (O'Shea, 2002). Of the premature infants born between 22-25 weeks gestation, 70 to 89% had chronic lung disease with 72% treated with postnatal steroids for a median of 24 days and, 13 to 64% had evidence of severe CNS injury on neuroimaging studies. Postnatal steroids given to preterm infants 1 to 30 days old improve gas exchange, decrease duration of mechanical ventilation and reduce the incidence of chronic lung disease, but have multiple side effects such as growth failure and increased incidence of cerebral palsy and neuromotor dysfunction at 1 to 2 years of age (Allen 2002; Shinwell et al., 2000).

Apnea

Apnea is a common condition of prematurity and is defined as pauses in breathing for periods of 10 to 20 seconds with or without bradycardia (slowed heart rate) or reduced oxygen saturations. There are three types: central apnea or complete cessation of breathing; obstructive apnea or absence of nasal airflow due to hypopharyngeal airway collapse; and mixed apnea or a combination of central and obstructive apnea. In premature infants, central apnea can be related to immaturity of the central nervous system in the brainstem, as apnea tends to resolve with increasing postnatal age (Holditch-Davis, Edwards, & Wigger, 1994). Apnea is generally detected through routine monitoring of heart and respiratory rates and oxygen saturation (Bhatia, 2000; Mathew, 1986). Apnea generally resolves by 36 to 38 weeks PMA but can continue for several more weeks. Some of the common causes of apnea in preterm infants include airway obstruction, impaired oxygenation, temperature instability, infection, neurological disorders, abdominal disorders, congenital heart disease, arrhythmia, and maternal drug exposure. Treatment may involve positioning the infant's head in neutral/midline, continuous positive airway pressure (CPAP) and/or mechanical ventilation, and caffeine therapy (Bhatia, 2000).

Because the suck, swallow, breathe pattern is also mediated by neural activity in the brain stem and requires a stable airway, it would seem reasonable that infants with immature cardiorespiratory control would be more likely to be inefficient feeders (Daniels et al., 1988; Shiopuri, Martin, Carolo, & Fanaroff, 1983). Mandich, Ritchie, and Mullett (1996) demonstrated a strong correlation between the severity of apnea and the number of days it takes a premature infant to attain full oral feeding (transition times). Bazyk (1990) found that the number of days it took a premature infant to reach full oral feeding correlated significantly with the number of medical complications as a newborn and certain medical complications related to respiration, digestive, neurological and cardiac status.

Medical Conditions

Research has shown consistently that premature infants with congenital or acquired medical conditions or those who have had extended stays in NICU are at a higher risk of developing feeding and nutritional problems than full-term healthy infants (Blackburn, 1995; Hawdon et al., 2000; Martin & Shaw, 1997). An analysis of six NICU in the United States showed that the two most common reasons for readmission of NICU graduates were jaundice (37.6%) and feeding difficulties (15.2%) and that infants born between 33 to 36 weeks GA with less than a 4 day length of hospital stay initially were re-hospitalized at a significantly higher rate than all other infants discharged from NICU (Escobar et al., 1999). Martens, Derksen, and Gupta (2004) found that of all the newborns born in Manitoba hospitals from 1997 through 2001, 4.0% were readmitted at least once within 6 weeks of post birth hospital discharge with respiratory illness, the leading cause (22.3% of the readmissions). The risk of readmission was higher for infants born prematurely (Martens et al., 2004).

Swallow Dysfunction

Taniguchi and Moyer (1994) completed a retrospective epidemiological case control study to help determine if there were predictable risk factors for pneumonia in children. They studied 142 children (including some premature children) suspected of difficulty swallowing, who had undergone videoflouroscopic swallow study (VFSS), but who may or may not have had pneumonia. The mean age of the children was 33 months. Medical records were retrospectively analyzed for the following risk factors: age (less than or greater than 1 year), sex, presence of endotracheal tube, presence of enteral feeding, presence of gastro-esophageal reflux and diagnosis. The results indicated that 44% of the children had identified aspiration on VFSS and 35% of these children had pneumonia within one year of the VFSS. These results suggest a relationship between swallowing dysfunction observed on VFSS and pneumonia in infants and children. Children with traumatic brain injury were five times less likely to develop pneumonia than children with other diagnoses suspected of dysphagia. They also found that there was a higher incidence of pneumonia in children one year old or less when compared to older children. This increase could have been caused by impaired pulmonary defense systems (e.g., ciliary action, cough, and alveolar macrophages), selection bias secondary to known vulnerability of respiratory morbidity in the premature infants studied, undiagnosed gastro-esophageal reflux or, occurred by chance.

Nutrition/Weight Gain

Good nutrition is extremely important in premature infants for normal growth and development, and for supporting the infant's ability to handle illness (Mascarenhas, Zemel, & Stallings, 1998). Hendricks et al. (1995) found that 25.5% of pediatric patients admitted to large tertiary hospitals in United States had anthropometric or laboratory evidence of acute or chronic protein-energy malnutrition. The highest rate of protein-energy malnutrition occurred in children receiving care in neonatology for chronic medical conditions. When looking at children from birth to 18 years, children less than 2 years of age showed significantly higher levels of protein-energy malnutrition than other ages. It is not clear whether feeding dysfunction plays a role in the high rate of malnutrition in this population, but it would stand to reason that children with food aversion, poor oral skills, and/or mild neuromotor disability would have difficulty in taking in adequate nutrition orally (Newman, 2000).

Infants who experience difficulty gaining weight or are diagnosed with failure to thrive may have poor feeding skills making it difficult for the infant to ingest adequate calories to grow. Infants born with Low Birth Weight (LBW), Very Low Birth Weight (VLBW) and Extremely Low Birth Weight (ELBW) have challenges in weight gain over the long term and are often less than the 5^{th} percentile at 12 to 30 months post discharge (Deloian, 1999; Ernst, Bull, Rickard, Brady, & Lemons, 1990; Kelleher et al., 1993).

Reilly, Skuse, Wolke, and Stevenson (1999) demonstrated that a significant number of term infants (≤ 1 yr of age) with no known reason for failure to thrive had difficulties with sucking, chewing, or swallowing, suggestive of mild neurodevelopmental disorders.

Summary

Swallowing disorders are perceived to be increasing in children born prematurely as a result of the multiple health problems associated with prematurity. Occupational therapists and other health professionals are increasingly being asked to diagnose and treat feeding and swallowing disorders in these children within and outside of the NICU/ICN. The process of feeding and swallowing is vulnerable to medical conditions and insults in development and is influenced by the complex interaction of the parent and child and the environmental influences of the NICU/ICN and the home. Based on the literature, being discharged on tube feeds, having oral/pharyngeal stage dysphagia identified by instrumental and/or clinical assessment, having chronic lung disease, having obvious CNS injury (e.g., IVH – III/IV), having airway abnormalities, or being mechanically ventilated greater than 14 days are strong predictors of infants at risk of aspiration. These infants should be referred to feeding and swallowing services prior to discharge. Other predictors such as early GA, days on oxygen/mechanical ventilation, or discharged below expected weight gain may be cumulative in terms of their effects predicting infants at risk for aspiration. For example, infants born extremely premature with no health concerns, may not have difficulty with feeding and swallowing post discharge; however an infant born at 27 weeks GA who received supplemental oxygen or a few days of mechanical ventilation, was discharged below expected average weight gain, and transitioned to oral feeds quickly may be at risk.

By understanding the influences of development and disease on the feeding process we will be better equipped to formulate intervention strategies to educate families and health care providers in the NICU and hopefully reduce the impact of environmental and social influences on feeding difficulties. By looking retrospectively at a group of premature infants referred to a feeding and swallowing service because of an aspiration related respiratory illnesses, we can begin to understand the common characteristics these infants share pre and post discharge from the NICU/ICN.

Objective

The objective of this study was to identify salient medical and clinical feeding/ swallowing characteristics as potential predictors for infants at risk for aspiration-related respiratory illnesses. More specifically there were two objectives.

Objective 1: Describe the sample at birth, at discharge from NICU/ICN, and at admission to a feeding and swallowing service to determine if there are any characteristics that are shared by a significant proportion of children in the sample or that are suggestive of differences from characteristics of the preterm population in general.

Given that preterm infants are a diverse group, there may be few shared characteristics. Therefore, subgroups within the sample were identified a priori. It was expected that subgroups might also emerge from the sample description in Objective 1.

Objective 2. To determine if subgroups within the sample share commonalities that might be suggestive of possible predictors of risk for a subset of infants and to determine if these commonalities are unique to that subset.

Subgroup A- Infants Discharged on Tube Feeds: Infants who are discharged on tube feeding have already been identified as having significant medical and clinical predictors for being at risk for aspiration. These medical and clinical predictors were explored to determine their prevalence in this subgroup. The prevalence was then compared to infants who were able sustain their nutrition orally at discharge to determine the uniqueness of those variables.

Subgroup B- Infants discharged on oral feeds but referred with aspiration in less than 90 days post discharge: Infants who develop aspiration during this period were likely not skilled oral feeders at discharge and may share some characteristics that would be useful predictors. Comparing this subgroup to infants who were oral feeders but developed aspiration after 90 days when more mature feeding skills are required would indicate unique characteristics for this early referred group. Developmentally, infants' feeding skills change at 3 to 6 months of age. They change from a more reflexive pattern with anatomical support due to close proximity of structures (e.g., epiglottis and soft palate) to separation of structures requiring more mature motor patterns, postural stability and volitional control. The comparison of early and later referred oral feeders would give insight into characteristics of less medically fragile infants that explain differences in length of time before referral.

Identifying characteristics of preterm infants who develop aspiration-related illnesses lays the basis for a future comparative study with infants born preterm who were discharged home on all oral feeds and not admitted to a feeding and swallowing service post discharge with an aspiration-related respiratory illness. This future comparative study would be the first step in developing a screening tool that would be studied prospectively to determine its ability to identify the premature infants most at risk for feeding and swallowing concerns and to identify the infants that may require ongoing monitoring/intervention for feeding and swallowing concerns after discharge from the NICU/ICN. It is hoped that by identifying premature infants most at risk for feeding and swallowing difficulties while in the NICU/ICN, it would reduce later admissions to hospital with aspiration-related illnesses and translate into better health outcomes for the premature infant.

CHAPTER 3

METHODS

Design

The study group was identified from a cohort of premature infants who were either treated at the Stollery Children's Hospital (SCH) (the primary site of treatment for children in Northern Alberta) and/or admitted to the Pediatric Home Nutrition Support Program (PHNSP) (the primary site for treatment of children requiring supplemental tube feeding in Northern Alberta). These infants were admitted/treated for suspected aspiration-related respiratory illness within twelve months of being discharged from the NICU and/or intermediate care nurseries.

For this study, an aspiration-related respiratory illness was defined as respiratory symptoms suspected to be associated with aspiration. Aspiration was defined as any amount of food or liquid that was drawn into the larynx and moved below the vocal cords. Aspiration was verified by clinical or instrumental assessment (Videofluoroscopic Swallow Study) and resulted in a recommendation of an alternative to oral eating or a modified diet.

The study group met the following inclusion/exclusion criteria. Infants were admitted to the NICU/ICN due to prematurity, defined as being born less than 37 weeks gestation (Medline Plus Medical Encyclopedia, 2006). They were born in the Edmonton region. They were referred to SCH or PHNSP Feeding and Swallowing Services for evaluation of suspected aspiration-related respiratory illnesses within 12 months post-discharge from the NICU/ICN at Royal Alexandra Hospital, Miscericordia Community Hospital or Grey Nuns Community Hospital. Infants who had a medical condition that contraindicated enteral/oral feeding (e.g., tracheostomy), whose medical records were not available for review, and/or who did not meet the inclusion criteria were excluded from the study.

Participants

Infants for this study were identified through screening of Feeding and Swallowing Files from the SCH Speech and Language Department and the PHNSP. The original sample size was 158 infants referred to the Feeding and Swallowing services between January 1, 2005 and December 31, 2006. Of these, 106 were excluded based on exclusion criteria, or for missing records as outlined in Table 1. The final sample included 52 infants who met the inclusion criteria and had complete records.

Table 1: Reasons for exclusion from study

Reason for Exclusion	Number Excluded
Born outside Edmonton (no birth records available)	11
Deceased with incomplete records	5
Transferred to hospitals outside of Edmonton	9
Missing health records from one of the participating hospitals	14
Admitted to Feeding and Swallowing service, but no swallow impairment identified	34
Referred to Feeding and Swallowing Program greater than 1 year post discharge from NICU/ICN	30
Tracheostomized	3
Total	106

Data Collection: Measurement of Variables

Appendix A contains the Data Collection Sheet outlining the information that was transcribed from the clinical records. The Data Collection Sheet was used to check the inclusion and exclusion data, record the information needed for coding the variables, and record additional descriptive data to describe the sample, in order to better understand the general health of the infant and provide direction for future research.

Data Collection: Procedures

Ethics approval from the Health Research Ethics Board (HREB) panel B was obtained and administrative approval was given by the participating hospitals and services (Stollery Children's Hospital, Royal Alexandra Hospital, Misericordia Community Hospital, Grey Nuns Community Hospital, Pediatric Home Nutrition Support Program, Speech and Language Department). This study was a record review and a secondary data analysis with no contact with the infant or family. There was minimal to no risk to the child or family. Parents upon admission to all hospitals and programs had given consent for their information to be included in the health care data base.

The principal investigator accessed the information regarding potential participants in the study. She identified infants who were premature (<37 weeks gestation) by reviewing the clinical records of the children admitted to a feeding program secondary to an aspiration-related respiratory illnesses. Once the infants had been identified, hospital identification numbers were used to confirm previous admission(s) to the NICU and/or ICN.

Five charts from target infants were reviewed to determine if there was enough information to code each of the variables proposed and to clarify the study procedures. Once the procedures had been refined, data from the health records of the 52 target infants were entered into the Data Collection Sheet (Appendix A) by the principal investigator. The Data Collection Sheet contained the factual information from the Stollery Children's Hospital, Royal Alexandra Hospital - NICU, Miscericordia Community Hospital, Grey Nuns Community Hospital and Pediatric Home Nutrition Support Program clinical records.

To ensure that the best possible data was available, the principal investigator met with persons who routinely complete the medical records in the NICU/ICN to better understand the basis for entering specific information into the medical record. This decreased errors associated with differing definitions when entering information between hospitals and between recorders. If an individual record was missing information on one or two variables, the infant was retained in the study. Variables with missing information are noted in the results section.

Variables

The *variables* are listed below and further definitions related to the variable can be found in Appendix A: Data Collection Sheet. Information for each variable was recorded from the clinical health records of participating hospitals and feeding and swallowing service departments listed early.

Demographic Variables

1) Sex (1 = male or 2 = female)
2) Birth Weight

   This continuous variable was used in calculation of weight gain. Infants born with extremely low birth weight often have earlier GAs and more medical complications and complications in eating orally.

3) Gestational Age

This continuous variable was used in the calculations of postmenstrual age and adjusted age. Infants born with younger gestational ages are more at risk for medical complications.

Respiratory Variables

4) Known airway abnormality (0 = yes or 1 = no)

This categorical variable was defined but not limited to Vocal Cord Paralysis, Laryngomalacia and/or Tracheomalacia.

5) Chronic Lung Disease (0 = yes or 1= no).

This categorical variable was defined as: 1) infants less than 32 weeks gestation still requiring oxygen at greater than or equal to 36 weeks PMA or at discharge whichever came first or 2) infants greater than or equal to 32 weeks gestation that required oxygen for more than 28 days or at discharge whichever came first (Allen, 2002; D'Angio & Maniscalco, 2006).

6) Total Number of Days on Mechanical Ventilation

This continuous variable was defined as the total number of days an infant received ventilation. Mechanical ventilation is defined as a breathing tube placed into an infant's trachea (intubation) to improve the exchange of air between the lungs and the atmosphere.

Additional information such as use of continuous positive air pressure (CPAP) was collected to help describe the infant's overall respiratory health at time of discharge to home. CPAP was defined as using a nasal device that consists of a large tube with tiny prongs that fit into the infant's nose. This tube was hooked to a machine that provides oxygenated air and/or pressure into the infant's lungs to help keep the lungs open so he/she could breathe.

7) Total Number of Days on Oxygen

This is a continuous variable. The total number of days that the infant received supplemental oxygen was collected. Total number of days on oxygen was calculated by counting the total number of days the infant received greater than or equal to 21% oxygen. Because oxygen is often provided during CPAP and mechanical ventilation, these variables are expected to be correlated.

8) Postmenstrual Age (PMA) at time Cessation of Caffeine

This continuous variable was defined as the PMA when intervention for apnea ended as indicated by no reinstatement of caffeine.

Medical Variables

9) Number of Days in NICU/ICN

This continuous variable was calculated by counting the number of days between the date of admission to the NICU/ICN and the date of discharge home.

10) Central Nervous System (CNS) Abnormality: [Abnormal (0) vs Normal (1) vs Not reported (2)]

This categorical variable was identified on Ultrasound, EEG, CT or MRI and was defined but not limited to seizures, posthemorrhagic hydrocephalus (IVH –I/III), parenchymal ischemial bleed (IVH 4) and periventricular leukomalacia (PVL).

11) Other Medical Condition (0 = yes or 1 = no)

This categorical variable was defined but not limited to diagnosis of a genetic and/or cardiac abnormality. The type of Medical Condition and number of infants with greater than 1 diagnosis was recorded for descriptive purposes.

12) Abnormal swallow: (0 = yes or 1 = no)

This categorical variable was defined as the observation of aspiration and/or penetration of liquids into the trachea during a videofluoroscopic swallow study.

Feeding Variables

13) Weight gain: (0 = less than average expected weight gain; 1 = average or greater expected weight gain).

This is a categorical variable. Premature infants can lose up to 10 to 20% of their birth weight during the first week of life. This weight was expected to be regained by day 14 after birth. After initial weight loss and regain, premature infants were expected to gain 12 to 20 g/kg/day (Cooke, 2006; Katrine, 2000; Regional Nutrition and Food Service, 2006). As weight gain in premature infants varies from day to day, to determine if an infant met the average weight gain expected, the average daily weight gain in g/kg/day over the 6 days prior to discharge was calculated. In cases where weights were missing, the average expected weight gain was calculated using the initial weight minus the weight on discharge divided by the number of 24 hour periods from when the initial weight was recorded. See Appendix B for the formula used in the calculation.

14) Mode of Feeding on Discharge (0 = tube feed, 1 = oral feed)

This is a categorical variable. Mode of feeding is related to general health and continued risk of aspiration. For descriptive purposes the mode of oral intake (bottle or breast feed) was also recorded.

15) Transition Time

This continuous variable indicates the number of days for an infant to transition from nasogastric tube feedings to complete oral feeding. It was the time between the date when the infant took any nutrition from a nipple to the date when all nutrition was taken orally. Complete oral feeding was defined as the ability of the infant to maintain nutritional requirements solely by oral feeding without use of supplemental tube feeding for ≥ 3 days. Transition Time was calculated by subtracting the date tube feeds were discontinued from the date of the initiation of oral feeds.

16) Total Number of Days of Complete Oral Feeds:

This continuous variable was calculated by subtracting the first day that the infant took all his/her nutrition orally from the date the infant was discharged home.

Analysis

All analyses were conducted using the SPSS Version 15.0. Related to objective 1 and 2, sample characteristics were examined using the mean, standard deviation (*SD*), median, range, and shape of the distribution. Outliers were identified by locating values that were more than 3 *SD* from the mean (Duffy & Jacobsen, 2005). These infants were reviewed to determine whether they represented the preterm population and should be included in the sample or whether they were unlike most preterm infants and should be excluded for particular analyses or removed from the sample.

For objective 2, identification of commonalities within a subgroup through comparison with other subgroups, χ^2 analyses were used for categorical variables and t-tests adjusted for equal or unequal variances were used for continuous variables. For variables where outliers were identified but kept in the sample, group comparisons were run with and without the outliers. Median values were reported as well as the means for these variables.

There were many comparisons between subgroups which raised concern about spurious significant findings due to multiple comparisons. Therefore, comparisons were limited to key variables based on the strongest research literature findings and suggestive trends in the descriptive analysis. In addition, the relationship between variables addressing similar traits was explored to determine if the number of comparisons between groups could be reduced. For instance, birth weight and GA were expected to be related. Variables that were correlated at r = .80 or higher were considered to be strongly related (Munro, 2005). When variables were highly correlated (e.g., birth weight and GA), only one of the correlated variables was selected for statistical comparison. The selected variable was the one with the strongest basis in the literature or clinical practice. The significance level was set at $p \leq .01$. A true Bonferroni correction for number of comparisons was not done given the exploratory and hypothesis generating nature of this study. For variables that were not compared statistically, descriptive information was provided in order to better understand the groups.

CHAPTER 4

RESULTS

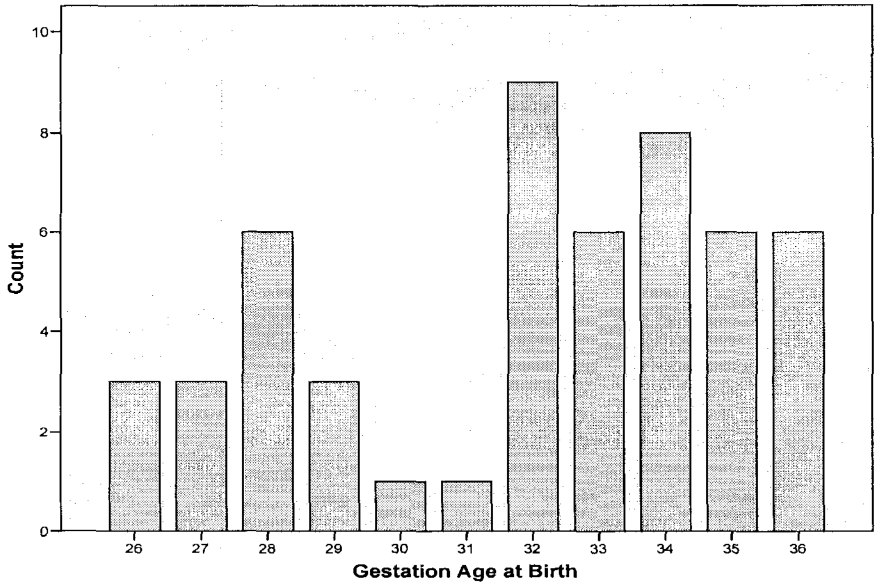
Objective 1: Sample Description at Birth, Discharge and Admission to Feeding and Swallowing Service

A. Demographic Variables at Birth

The sample was comprised of 52 premature infants who met the inclusion criteria. One infant (ID Number 63) was born with severe gastroschisis and had medical complications (sepsis, morphine dependency, renal failure, bilateral chylorthorax and cardiac, lobectomy) resulting in a markedly longer hospital stay and number of days on mechanical ventilation/CPAP/oxygen than the other infants. As other infants in the study also had similar diagnoses, this infant was not removed from the sample. Thus it was important to focus on the median values rather than the means for the three respiratory variables and length of stay.

The infants had a mean GA at birth of 31.9 weeks ($SD = 3.1$) with a range between 26 weeks and 36 weeks. The mean birth weight of the infants was 1916.9 grams ($SD = 723.7$) with birth weights ranging from 710 to 3585 grams. Twelve percent of the infants had a birth weight less than 1000 grams (Extreme Low Birth Weight), 21.0% weighed between 1001 and 1500 grams (Very Low Birth Weight), 44.0% weighed between 1501 and 2500 grams (Low Birth Weight) and 23.0% weighed equal to or more than 2500 grams. As expected, birth weight and GA were significantly correlated ($r = .82$, $p < .001$) with more infants born with lower GA having lower birth weights. Summary statistics of infant characteristics at birth are outlined in Figure 1. The greater proportion of males ($n = 33$, 63.5%) than females ($n = 19$, 36.5%) was expected (Allen, 2002; Hediger et al., 2002).

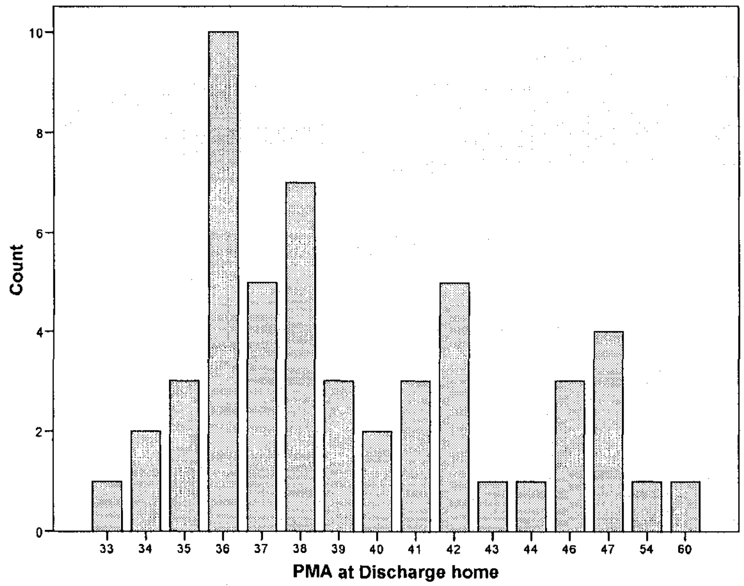
Figure 1.
Frequency of Gestational Age



B. Demographic Variables at Discharge

Discharge home occurred at a mean PMA of 39.9 ($SD = 5.2$) weeks with a range from 33 to 60 weeks. The frequencies for each age are outlined in Figure 2.

Figure 2.
Postmenstrual Age at Discharge (*N*=52)



C. Respiratory Variables at Discharge

For days on mechanical ventilation, CPAP and oxygen, there was one outlier (more than 3 standard deviations from the group mean, ID number 63). Thus it was important to focus on the median values rather than the means for these variables.

Thirty-two (61.5%) infants received mechanical ventilation for a median of 6.0 days with a range of 1 to 127 days while 20 (38.5%) infants were not ventilated. The average days of ventilation was 17.47 days (*SD* = 26.5) with infant 63 and 13.94 (SD= 17.6) without this infant. Eighteen infants received mechanical ventilation for 1 to 6 days, three for 7 to 13 days, three for 14 to 21 days, and eight for more than 22 days. According to Oliver et al. (1998), the 11 infants who were ventilated for 14 days or longer should have been closely monitored for feeding and swallowing complications. Of these 11 infants, 6 were referred to a feeding and swallowing service before discharge.

Thirty-two (61.5%) infants received CPAP for a median of 12 days with a range of 1 to 68 days while 20 (38.5%) did not receive CPAP. The average time on CPAP was 18.63 (*SD* = 18.6) days with infant 63 and 18.77 (SD= 18.9) without this infant. Twenty-nine of these infants had transitioned from mechanical ventilation.

Thirty-six (69.2%) infants received oxygen for a median of 16.5 days with a range of 1 to 151 days while 16 (30.8%) did not receive oxygen. The average days on oxygen was 32.67 (*SD* = 39.5) with infant 63 and 29.29 days (*SD* = 34.4) without him.

The correlation between days on mechanical ventilation and days on oxygen was $r = .85$ ($p < .001$). Days on CPAP was less highly correlated with days on mechanical ventilation ($r = .34$, $p = .02$) and days on oxygen ($r = .47$, $p < .001$).

Thirty-one (59.6%) infants (all born less than 34 weeks GA) were prescribed caffeine in the NICU/ICN. Fourteen of these infants discontinued caffeine after 38 weeks PMA when apnea generally resolves (Bhatia, 2000). Thirteen infants were discharged home on caffeine. As expected (Darnall et al., 1997), the chronological age of the infants at the time of resolution of apnea was inversely proportional to GA at birth with infants born younger requiring caffeine longer. Thirteen (25.0%) infants were diagnosed with chronic lung disease. Five infants were diagnosed with an airway abnormality while in hospital; however, an additional 10 infants were diagnosed with an airway abnormality post discharge (See Table 5 for airway abnormalities post discharge). Summary statistics of infant respiratory characteristics at discharge are outlined in Tables 2 and 3.

Table 2.
Frequencies of Airway Abnormalities and Medications of Infants at Discharge (*N*=52)

		Freq.	%
Airway Abnormality (Discharge)	Yes	5	9.6
	No	47	90.4
Type of Airway Abnormality	Laryngomalacia	1	20.0
	Tracheomalacia	1	20.0
	Vocal Cord Paralysis	1	20.0
	Laryngomalacia & Vocal Cord Paralysis	1	20.0
	Subglottic Stenosis	1	20.0
Respiratory Medication	Yes	8	15.4
	No	44	84.6

Table 3.
Means and Standard Deviations of Respiratory Characteristics of the Infants at Discharge (*N*= 52)

	Mean *(SD)*	Median	Range
Days until discontinue Caffeine*	56.71 (34.2)	53.0	1 - 123
PMA at Discontinue Caffeine*	38.23 (3.9)	38.0	29 - 45

* With those not on caffeine removed, *N* = 31

D. Medical Variables at Discharge

For days of hospitalization, there was one outlier (ID Number 63); therefore it was important to consider the median for this variable. The infants stayed in hospital for a median of 57.5 days. The average was 59.9 days (*SD* = 41.5) with infants 63 and 57.5 (*SD* = 37.8) without this infant.

Thirteen (25.0%) of the infants were diagnosed with a central nervous system abnormality by ultrasound, MRI or EEG prior to discharge. For 23 (44.2%) of the infants, there was no record of being formally assessed for a CNS abnormality and no CNS abnormalities were identified in hospital records upon future admissions. Intraventricular

Hemorrhage Grades I through IV, HIE, Hydrocephalus and other are reported in Table 6. Three of the 13 infants had more than one CNS abnormality in addition to the above diagnoses: infant #34 was diagnosed with both IVH-III and Arnold Chiari Malformation, infant #37 with IVH – I and polymicrogyria & macrocephaly, and infant #47 with hydrocephalus and agenesis corpus collosum. Twenty-seven (52%) of the infants in the sample had more than 1 medical condition. Medical conditions and medications are summarized in Table 4.

Table 4.
Frequencies of Medical Characteristics of the Children at Discharge (*N*= 52)

		Freq.	%
CNS Abnormality	Abnormal	13	25.0
	Normal	16	30.8
	Not reported	23	44.2
Type of Abnormality	IVH[a] – Grade I/II	3	23.1
	IVH[a] – Grade I/II with HIE & seizures	3	23.1
	IVH[a] Grade III/IV	3	23.1
	Hydrocephalus	2	15.4
	Other[b]	2	15.4
Medical Condition	Yes	36	69.2
	No	16	30.8
Type of Condition	Cardiac Condition[c]	25	69.4
	NEC[d].	3	8.3
	Gastroschisis	2	5.6
	Syndrome[e]	6	16.7
	Maternal Drug Exposure	9	25.0
	Sepsis/Infection	18	50.0
	Other medical diagnosis[f]	11	30.6
Discharged on Medications	Yes	28	53.8
	No	24	46.2
Type of Medication[g]	Aldactazide	7	
	Ativan	1	
	Benadryl	1	
	Cloxacillin	1	
	Dorzolamide	1	
	Erythromycin	1	
	Ferrous Sulfate	2	
	Lasix	1	
	Losec/Ranitidine	13	
	Methadone	1	
	Morphine	2	
	Phenobarbital	1	
	Racemic Epinephrine	1	
	Trimethoprin	1	
	Tinazaparin	1	
	Ursodiol	4	

[a]Intraventricular Haemorrhage; [b] subependymal cyst, small calcification basal ganglia and white matter
[c] includes Atrial Septal Defects, Ventricular Septal Defect, PDA with and without Ligation, patent foramen ovale, pulmonary stenosis, congenital heart failure, Tetralogy of Fallot, murmur; [d] Necrotising Entercolitis; [e] Includes Dandy Walker Syndrome (*n* = 1), Down Syndrome (*n* = 4) and Syndrome unidentified (*n* = 1); [f] Includes Renal failure, liver condition, Q10 duplication, TEF, submucosal cleft, CMV, cystic hygroma, asphyxia, Hirschsprung Disease; [g] some infants were on more than one medication. Note: infants could have more than one medical condition; percentages are out of those with medical conditions

E. Feeding Variables at Discharge

Fifty-one (98.0%) infants received tube feeding for a mean of 55.9 days (*SD* = 42.3) with a range of 4 to 187 days while in NICU/ICN. Fourteen (26.9%) infants went home on tube feeds or a combination of oral and tube feeds and 38 (73.1%) were discharged home on all oral feeds. Nine were discharged on breast feeds, 17 on bottle feeds and 12 on a combination of breast and bottle feeds.

The expected weight gain was calculated as described in the methods section. Three of the 52 infants were either admitted for one day or less with one weight provided or the last 7 days of weights were not recorded. Of the 49 infants who had weights recorded in the last 7 days of admission, 24 (49.0%) infants were discharged home with less than expected weight gain and 25 (51.0%) were above or equal to expected weight gain.

Twenty-five (48.1%) of the infants were assessed by a feeding therapist prior to being discharged home. Two infants were referred to a Feeding and Swallowing Service but were too sick to complete a clinical or videofloroscopic swallow study. Eleven of the infants received a videoflouroscopic swallow study and bedside swallowing assessment prior to discharge. Fourteen were assessed by a feeding therapist using a bed side swallow assessment only. Of the 25 infants that were either assessed by VFSS, bedside swallow assessment or both, 12 were discharged on tube feeds and 13 on oral feeds. Feeding behaviors at time of discharge were not recorded.

F. Characteristics of Infants at Admission to Feeding and Swallowing Service

The mean number of days from discharge from NICU/ICN to admission to a feeding and swallowing service was 83.6 days (*SD* = 99.3). Seventeen were admitted while in NICU/ICN, 15 were admitted in less than 90 days after discharge and 20 were admitted 90 days or more after discharge. Thirty-two (61.5%) were admitted before they were 3 months adjusted age, and 20 (38.5%) were admitted at 3 months adjusted age or older.

From the time the infant was discharged home from NICU/ICN to the time of admission to a feeding and swallowing service, 33 (63.5%) of the infants had visited Emergency or had been admitted to a hospital for respiratory illness. Ten infants were identified with airway abnormalities post discharge in addition to the five diagnosed while in NICU/ICN for a total of 15 (28.8%) infants. Airway abnormalities are summarized in Table 5.

Table 5.
Frequency of airway abnormalities pre & post discharge (*N*=15)

		Freq.	%
Type of Airway Abnormality	Laryngo/Tracheomalacia	6	40.0
	Tracheo/Laryngomalacia & Vocal Cord Paralysis	2	13.3
	Vocal Cord Paralysis	1	6.7
	Subglottic Stenosis	1	6.7
	Subglottic granulations/ulcers	2	13.3
	Asthma	3	20.0

Twenty-seven (51.9%) infants had reflux or emesis on admission to feeding and swallowing service and 7 (13.5%) of these infants received a fundoplication and gastrostomy tube. Since discharge, three of the infants had received medical intervention (lobectomy = 2, cardiac arrest = 1) for diagnoses previously identified in the NICU/ICN.

Four infants received an additional diagnosis that had not been found prior to discharge from the NICU/ICN. Three infants were diagnosed with a cardiac condition (PDA/PDA ligation = 1, small PFO/VSD = 2) and 1 infant was diagnosed with MMIH. No additional CNS diagnoses were recorded in the clinical records; however assessments may not have occurred in the health region and/or results may have gone directly to the pediatrician involved in care and were not included in the clinical records of participating hospitals.

G. Feeding Behaviors on Initial Assessment at Admission to Feeding and Swallowing Service

Three of the 14 children that were discharged on tube feeds were too sick to clinically assess oral eating while in hospital and for greater than 1 month post discharge. These 3 infants (ID Numbers 7, 8 and 63) had consistent missing data on feeding behaviors and were removed for the summaries below resulting in a sample size of 49. Of the 49 infants, 34 (69.4%) showed clinical signs of oral dysphagia with the most common sign being loss of liquid/food from the mouth. Forty-eight (98.0%) showed clinical signs of pharyngeal dysphagia with the most common signs being noisy breathing or coughing. The proportion of infants showing the clinical signs of feeding problems is summarized in Table 6.

Table 6.
Signs of Feeding problems Identified upon assessment by Feeding Therapist (*N*=49)

		Freq.	%
Clinical Signs of Oral Stage Dysphagia	Yes	34	69.4
	No	15	30.6
Feeding Time >30 minutes		16	47.1
Weak/inefficient suck		11	32.4
Loss of liquid/food from mouth		25	73.5
Clinical Signs of Pharyngeal Stage Dysphagia	Yes	48	98.0
	No	1	2.0
Audible swallow/gulping		23	47.9
Food/liquid coming from nose		19	39.6
Nasal congestion during/after feed		17	35.4
Noisy breathing/wheeze/stridor/work of breathing during/after meal		34	70.8
Desats/Apnea with Feeds		15	31.3
Wet/gurgley voice during/after feed		25	52.1
Coughing during/after feed		33	68.8
Gags during/after feed		6	12.5
Turns blue/circumoral cyanosis during/after feed		12	25.0
Chokes during/after feed		13	27.1

Note: infants could have more than one feeding behavior; percentages are out of those with oral stage dysphagia and pharyngeal stage dysphagia.

H. Comparison to the literature

Part of the objective for the sample description was to compare the incidence of various characteristics to the literature describing the preterm population in general. Comparison of all of the variables to the literature is very difficult because definitions and classifications of variables differ from study to study. Table 7 presents the general comparisons which were possible. The GA range of the sample is very similar to the literature given the much lower survival rate for infants who are born under 26 weeks

GA. While the definitions vary for CLD, the proportions are remarkably similar to some of the literature and higher than the proportion in other literature.

Table 7.
Comparisons of Sample Characteristics to the Literature

Gestational Age		
Current sample		Range= 26 to 36 weeks
Literature		Range= 24 to 36 weeks
Length of some form of ventilatory support		
Current sample	≤ 1000 grams (n=7)	4 weeks mech ventilation 4.6 weeks CPAP 6.6 weeks oxygen
	1001-1250 grams (n=7)	2.6 wks. mech ventilation 4 weeks CPAP 8.7 weeks oxygen
Literature (Capital Health NICU report)[b]		
	≤ 1000 grams	6 weeks
	1001-1250 grams	5 weeks
Chronic Lung Disease & Born < 32 wks. GA		
Current Sample (N= 26)		42% (n=11)
Manktelow et al. (2001),		
	28 day definition (N= 388)	42% (n=162)
	36 wk. GA definition (N= 382)	29% (n=110)
Chronic Lung Disease, & < 32 wks. GA, or 750-1500 g		
Current Sample (N= 26)		39% (n=10)
Fenton et al. (1996; BC cohort)		
	28 day definition (N= 433)	24% (n= 105)
	36 wk. GA definition (N= 432)	19% (n= 80)

[a] Note there were differences in definitions of CLD
[b] Alberta Reproductive Health Report Working Group, 2007

Objective 2: Subgroup A, Infants Discharged on Tube Feeds

Fourteen infants were discharged on tube feeds (n = 14) in comparison to 38 discharged on oral feeding. Infants discharged on tube feeds had birth weights ranging from 710 grams to 3585 grams. Gestational age at birth ranged from 26 to 36 weeks with the largest proportion being born at 32 (21.4%) or 36 weeks (21.4%) (See Table 8). More boys than girls were discharged on tube feeds.

Related to respiration, all but one of the 14 infants discharged on tube feeds received mechanical ventilation. One infant was on mechanical ventilation from 7 days and 6 infants received mechanical ventilation for greater than 14 days with one mechanically ventilated for 127 days. Half of the 14 infants had a diagnosis of CLD. Five of the infants diagnosed with CLD received greater than 14 days ventilation and also transitioned to CPAP and oxygen. The other two infants diagnosed with CLD only had mechanical ventilation for one day and were twin brothers diagnosed with cystic fibrotic pulmonary dysplasia post discharge. One underwent a thoracotomy, right middle lobectomy and fundoplication/G-tube. Prior to their diagnosis infant #7 was on CPAP for 48 days and received oxygen for 16 days and infant #8 was on CPAP for 8 days and received oxygen for 68 days. Four of the infants discharged on tube feeds had airway abnormalities with three receiving mechanical ventilation. Seven of the infants were on caffeine and all infants discontinued caffeine while in hospital except one.

Seventy-one percent had diagnosed medical conditions with the largest proportion having cardiac conditions and other diagnoses (Ascities- liver, liver hematoma, renal failure, small bowel resection, Q10 duplication). Eight of the infants had more than 1 medical diagnosis. For the 8 infants without cardiac conditions, three had mechanical ventilation for greater than 7 days and 1 was diagnosed with CLD. Of the remaining 4 infants, one had Dandy Walker Syndrome and maternal drug exposure resulting in CNS abnormalities with an abnormal swallow and the other had CNS and airway abnormality with emesis with feeds and swallow concerns. Interestingly, the two remaining infants did not have clear medical or respiratory difficulties. Infant #40 had an abnormal swallow identified on VFSS while in the NICU/ICN and Infant #28 had emesis with every feed and an abnormal swallow.

In summary, it appears that infants discharged on tube feeds were likely to have respiratory related difficulties and medical conditions that could impact on their ability to be oral eaters. The majority of infants received mechanical ventilation and had a diagnosis of a cardiac condition or CLD. Those who did not have CLD or a cardiac condition were diagnosed with a CNS abnormality or combination of CNS and airway abnormalities associated with a syndrome. The one infant that did not have respiratory or medical conditions identified was born at 28 weeks and was reported to have difficulties with emesis with feeds and abnormal swallow identified on VFSS. To analyze the uniqueness of these proportions, the infants discharged on tube feeds were compared to infants discharged on oral feeds.

Tube Fed versus Oral Fed

GAs at birth were similar between the groups except for larger proportions of infants discharged on oral feeds born at 28 weeks GA than tube fed infants. The tube fed infants were significantly different from oral fed infants as indicated by a significant t-test for PMA at discharge, days on oxygen in hospital, and number of days in hospital. The tube fed infants were hospitalized twice as long as the oral fed infants. They required more days on mechanical ventilation and days on oxygen which contributed to a larger percentage of infants discharged on tube feeds being diagnosed with chronic lung disease. Nearly identical proportions of tube fed (28.6%) and oral fed infants (28.9%) had airway abnormalities.

Demographics, respiratory and medical statistics of infants tube fed versus oral fed at birth and discharge are summarized in Tables 8 to 11.

Table 8.
Frequencies of Demographic Variables at Birth: Tube Fed versus Oral Fed Infants (*N*= 52)

		Tube Fed (*n* = 14)		Oral Fed (*n* = 38)	
		Freq	%	*Freq*	%
Gender	Male	10	71.4	23	60.5
	Female	4	28.6	15	39.5
Birth weight	<1000 gm (ELBW)	1	7.1	5	13.2
	1001-1500 gm (VLBW)	1	7.1	10	26.3
	1501- 2500 gm (LBW)	8	57.1	15	39.5
	>2500 gm	4	28.6	8	21.1
Gestational Age at Birth	26 weeks	1	7.1	2	5.3
	27	0	0.0	3	7.9
	28	1	7.1	5	13.2
	29	1	7.1	2	5.3
	30	0	0.0	1	2.6
	31	0	0.0	1	2.6
	32	3	21.4	6	15.8
	33	1	7.1	5	13.2
	34	2	14.3	6	15.8
	35	2	14.3	4	10.5
	36	3	21.4	3	7.9

Table 9.
Means of Demographic Variables at Birth and Discharge - Tube fed versus Oral Fed (*N*=52)

	Tube Fed (*n* = 14)		Oral Feeding (*n* = 38)			
	M	*(SD)*	*M*	*(SD)*	*t*	*p value (2-tailed)*
GA at Birth	32.7	(3.1)	31.6	(3.1)	1.138	.261
Weight At Birth	2131.1	(738.4)	1838.0	(711.8)		
PMA at Discharge (weeks)	45.9	(5.5)	37.7	(2.8)	7.007	.000

Table 10.
Frequencies for Respiratory Variables - Tube fed versus Oral Fed (*N*=52)

		Tube Fed (*n* = 14)		Oral Fed (*n* = 38)				
		Freq	*%*	*Freq*	*%*	χ^2	*df*	*Sig (2-sided)*
Airway Abnormality (pre & post discharge)	Yes	4	28.6	11	28.9	.001	1	.979
	No	10	71.4	27	71.1			
Chronic Lung Disease	Yes	7	50.0	6	15.8	6.386	1	.012
	No	7	50.0	32	84.2			
Mechanical Ventilation (Ranges)	0 days	1	7.1	19	50.0			
	1 to 6 days	6	42.9	12	31.6			
	7 to 13 days	1	7.1	2	5.3			
	14 to 21 days	3	21.4	0	0.0			
	>22 days	3	21.4	5	13.2			

Table 11.
Means and Standard Deviations for Medical & Respiratory Variables - Tube fed versus Oral Fed (*N*=52)

	Tube Fed (*n* = 14)		Oral Feeding (*n* = 38)			
	M	*(SD)*	*M*	*(SD)*	*t*	*p value (2-tailed)*
[a] Days in Hospital	92.7	(42.8)	47.9	(34.2)	3.92	.000
Days of Mechanical ventilation	21.4	(35.6)	6.8	(13.6)	1.50	.156
[b] Days on Oxygen	40.9	(54.7)	15.2	(24.4)	2.59	.013
Days on CPAP	14.1	(16.9)	10.5	(17.4)		
Days until discontinue Caffeine	31.3	(39.7)	35.6	(38.5)		
PMA at time of Discontinue Caffeine	38.43 (*n*=7)	(3.5)	38.17 (*n*=24)	(4.0)	.16	.877

[a] Days in Hospital ($N = 51$; $t = 3.390$, $p < .01$)
[b] Days on Oxygen ($N = 51$; $t = 1.976$, $p = .055$)

Sixty-eight to 71% of both groups had additional medical diagnoses, with 43% of the tube fed infants compared to 13% of the oral fed infants having a medical diagnosis in the ‘Other’ category. Medical variables at discharge are summarized in Table 12.

Table 12.
Frequencies for Medical Variables at Discharge - Tube fed versus Oral Fed (N=52)

		Tube Fed (*n* = 14)		Oral Fed (*n* = 38)				
		Freq	%	*Freq*	%	χ^2	*df*	*Sig* (2-sided)
Weight Gain at discharge (n=49)	< average	5	38.5	19	52.8			
	≥ average	8	61.5	17	47.2			
CNS Abnormality	Yes	7	50.0	6	15.8			
	No	5	35.7	11	28.9			
	Not Reported	2	14.3	21	55.3			
Type of Abnormality	IVH [a] I/II	0	0	3	50.0			
	IVH [a] I/II & HIE	2	28.6	1	16.7			
	IVH [a] III/IV	1	14.2	2	33.3			
	Hydrocephalus	2	28.6	0	0			
	Other	2	28.6	0	0			
Medical Condition(s)	Yes	10	71.4	26	68.4	.043	1	.835
	No	4	28.6	12	31.6			
Type of Condition	Cardiac [b]	6	60.0	19	73.1			
	Maternal Drug Exposure	2	20.0	7	26.9			
	NEC [c]	2	20.0	1	3.8			
	Gastroschisis	1	10.0	1	3.8			
	Syndrome [d]	2	20.0	4	15.4			
	Sepsis	4	40.0	14	53.8			
	Other [e]	6	60.0	5	19.2			
Reflux/Emesis	Yes	8	57.1	19	50.0	.209	1	.647
	No	6	42.9	19	50.0			
Known Admissions/ER visits	Yes	7	50.0	26	68.4	1.497	1	.221
	No	7	50.0	12	31.6			

Chi Square analysis; [a]Intraventricular Haemorrhage; [b] includes Atrial Septal Defects, Ventral Septal Defect, PDA with and without Ligation, patent foramen ovale, pulmonary stenosis, congenital heart failure, Tetralogy of Fallot, murmur; [c] Necrotising Entercolitis; [d] Includes Dandy Walker Syndrome (*n* = 1), Down Syndrome (*n* = 4) and Syndrome unidentified (*n* = 1); [e] Includes Renal failure, liver condition, TEF, submucosal cleft, CMV, cystic hygroma, asphyxia, Hirschsprung Disease. Note: infants could have more than one medical condition; percentages are out of those with medical conditions.

All of the tube fed infants were referred to a feeding and swallowing service prior to being discharged from the NICU/ICN. This meant they were younger than the oral fed infants at time of admission to the feeding and swallowing service. The mean adjusted age of infants at time of admission to feeding service was 1.5 months for tube fed infants and 3.6 months for oral fed infants. Frequencies, means and standard deviations of Feeding Variables for tube fed and oral fed infants are summarized in Tables 13 and 14.

Table 13.
Frequencies of Feeding Variables at Discharge - Tube Fed and Oral Fed (*N*=52)

		Tube Fed (*n* = 14)		Oral Feeding (*n* = 38)	
Variable		*Freq*	%	*Freq*	%
Assessed by Feeding Therapist Pre- Discharge	Yes	12	85.7	13	34.2
	No	2	14.3	25	65.8
VFSS by Discharge	Yes	6	42.9	5	13.2
	Not completed	8	57.1	33	86.8
Bedside assessment only Pre- Discharge	Yes	6	75.0	8	24.2
	Not Completed	2	25.0	25	75.8
Days of all oral to discharge	1 Day			2	3.8
	2 to 4 Days			12	23.1
	5 to 6 Days			8	15.4
	7 to 10 Days			4	7.7
	>10 days			12	23.1

Table 14.
Frequencies of Feeding Variables at admission to Feeding Service - Tube fed versus Oral Fed (N=52)

		Tube Fed (*n* = 14)		Oral Fed (*n* = 38)	
		Freq	%	*Freq*	%
Days to Admission to F/S	< 90 days	14	100.0	18	47.4
	≥ 90 days	0		20	52.6
Abnormal VFSS on initial assessment	Yes	8	57.1	24	63.2
	Not Completed	6	42.9	14	36.8
Feeding Recommendation at admission to feeding and swallowing	Tube	11	78.6	13	34.2
	Oral (Modified)	0	0.0	19	50.0
	Oral (Modified) & Tube	2	14.3	6	15.8
	Oral (thin) & Tube	1	7.1	0	0.0

Because three of the tube fed infants were too sick to assess feeding behaviors upon admission to the feeding service, not all the feeding behaviors could accurately be recorded. These 3 cases (ID Number 7, 8, and 63) were excluded from the analysis. Sixty-eight to 73% of the infants showed clinical signs of oral stage dysphagia and 91% to 100% showed clinical signs of pharyngeal stage dysphagia. A larger percentage of tube fed infants showed desaturation/apnea with feeds which would be consistent with younger adjusted age at assessment (1.5 months) and by the fact that inpatients have access to equipment to consistently monitor for desaturations or apnea events when feeding. Outpatients may or may not have had access to this same equipment and apnea events generally resolve with development and as such may no longer be a concern in older infants. Clinical signs of audible swallow/gulping and coughing during/after feed occurred in larger number of oral fed infants. Signs of feeding problems for infants discharged on tube feed and oral feeds are summarized in Table 15.

Table 15.
Signs of Feeding Problems – Tube Fed versus Oral Fed (*N*=49)

		Tube Fed (n = 11)		Oral Fed (n = 38)				
		Freq	%	*Freq*	%	χ^2	*df*	*Sig* *(2-sided)*
Clinical Signs of Oral Stage Dysphagia	Yes	8	72.7	26	68.4	.074	1	.785
	No	3	7.3	12	31.6			
Clinical Signs of Pharyngeal Dysphagia	Yes	10	90.9	38	100.0	3.517	1	.060
	No	1	9.1	0	0.0			

After admission to the feeding and swallowing service, 10 (71.4%) of the infants discharged on tube feeds were able to transition from tube feeds to oral feeds by the end of the data collection period (7 Nov 2007) with a mean of 507.9 days (*SD* = 313.9) of tube feeding. Of the 38 infants discharged on all oral feeds, 14 were placed on full tube feeds, 4 on a combination of tube feeds and modified oral diet, and 20 on full modified oral diet (e.g., thickened liquids or combination of solids and thickened liquids). The infants placed on tube feeds (n = 18) were on tube feeds for a mean of 242.2 days (SD = 230.1) or approximately 8 months with 4 infants (ID Number 37, 53, 71, and 72) still on tube feeding at the end of the data collection period.

In summary, the infants who were discharged on tube feeds had some unique characteristics in comparison to infants discharged on oral feeds. There were significant differences in the length of time spent in hospital, also indicated by differences in PMA at discharge. Although the difference was not significant with the adjusted p value, there was a suggestive difference in the number of days on oxygen. Thus, there are some possible predictors based on exploring the tube fed infants' characteristics. However, there were variables such as medical conditions that had appeared to be unique to infants who were discharged on tube feeds which proved to be equally prevalent in infants discharged on oral feeds.

Objective 2: Subgroup B. Oral eaters admitted to a feeding and swallowing service in less than 90 days (n = *18*)

Eighteen infants discharged on all oral feeds were admitted to the feeding and swallowing service in less than 90 days. Three of these were admitted while in the NICU/ICN and the remaining infants were admitted after discharge home. Birth weights ranged from 900 to 3105 grams and gestational age at birth ranged from 27 to 36 weeks GA with 7 of the infants born 31 weeks or less before feeding readiness skills have emerged.

Related to respiration, 11 were admitted to emergency or to hospital with respiratory illness post discharge. Half (9) of the infants received mechanical ventilation. Five infants received mechanical ventilation for 1 to 6 days, two for 10 days, and two infants for 39 to 49 days. There were 2 infants diagnosed with CLD and both received mechanical ventilation. Five infants were diagnosed with airway abnormalities.

Thirteen (72.2%) infants were diagnosed with medical conditions with the largest proportion being 10 infants with cardiac conditions. Two infants with cardiac conditions also had diagnosis of CNS abnormality, 1 had NEC and airway abnormality, 2 with Down Syndrome, 1 with maternal drug exposure and meningitis, 1 with maternal drug exposure and sepsis and airway abnormality and 1 with maternal drug exposure only. Of the 8 infants without a cardiac condition, three had respiratory diagnoses; 2 with airway abnormalities (laryngomalacia and tracheomalacia) and 1 with CLD. One (infant #19) received 6 days of mechanical ventilation, 3 days of CPAP and 1 day of oxygen, sepsis and discontinued caffeine post discharge at 39 weeks PMA, and dysphagia identified upon bedside swallow assessment. One was diagnosed with CMV and had emesis with feeds. Interestingly three infants had no respiration concerns or medical conditions identified. Two had difficulties with emesis with feeds and were born at 33 to 34 weeks GA.

In summary, it appears that infants discharged on oral feeds who were referred with aspiration related illness within 90 days of discharge were more likely to have respiratory related difficulties, medical conditions or specific diagnosis associated with swallow impairments (e.g., airway abnormality, CNS abnormality, CMV) that could impact on their ability to be oral eaters. Two infants had received mechanical ventilation of greater than 14 days and 7 received shorter term mechanical ventilation. Of the five infants with airway abnormalities, two of these did not have any other associated conditions. Those who did not have respiratory or medical conditions were diagnosed with CMV and/or had difficulties with emesis with feeds. To analyze the uniqueness of these proportions, the infants were compared to other infants who were discharged on oral feeds and referred for aspiration related illnesses after 90 days.

Infants discharged on oral feeds and admitted to feeding and swallowing service in less than 90 days (n = 18) and those admitted in 90 or more days (n = 20)

Infants admitted to feeding service in less than 90 days (early referral) and those admitted in 90 days or more (later referral) were similar in GA, birth weight, and PMA at discharge. The mean number of days in hospital was similar between groups; early referral = 50.7 (*SD* = 36.0), later referral= 45.3 (*SD* = 33.3), t (36) = .483, p = .632. They were all on tube feeds prior to discharge for similar periods of time. Although the difference was not significant, the early referral infants took more days to transition from tube feeds to oral feeds while in the NICU. The later referral infants had 1 ½ times as many infants with difficulties with emesis. The mean number of days on oxygen was similar for both groups. Both groups showed equal diversity in medical complications, CNS abnormalities and airway abnormalities. Characteristics of the infants in both groups are summarized in Tables 16 to 20.

Table 16.
Demographics at Birth of Infants admitted in less than 90 days versus 90 or more days after discharge from NICU (*N*= 38)

		< 90 days (*n* = 18)		≥ 90 Days (*n* = 20)	
		Freq	%	*Freq*	%
Gender	Male	9	50.0	14	70.0
	Female	9	50.0	6	30.0
Birth weight	<1000 gm (ELBW)	2	11.1	3	15.0
	1001-1500 gm (VLBW)	5	27.8	5	25.0
	1501- 2500 gm (LBW)	7	38.9	8	40.0
	>2500 gm	4	22.2	4	20.0
Gestational Age at Birth	26 weeks	0	0.0	2	10.0
	27	2	11.1	1	5.0
	28	3	16.7	2	10.0
	29	1	5.6	1	5.0
	30	1	5.6	0	0.0
	31	0	0.0	1	5.0
	32	2	11.1	4	20.0
	33	3	16.7	2	10.0
	34	3	16.7	3	15.0
	35	1	5.6	3	15.0
	36	2	11.1	1	5.0

Table 17.
Demographics at birth and discharge of infants admitted to a F/S Service in less than 90 days versus 90 days or more after discharge from NICU (*N*= 38)

	< 90 days (*n* = 18)		≥ 90 Days (*n* = 20)			
	M	*(SD)*	*M*	*(SD)*	*t*	*p value (2-tailed)*
GA at birth	31.6	(3.1)	31.6	(3.2)		
Birth weight	1854.3	(664.5)	1823.2	(768.7)		
PMA at Discharge	38.3	(3.2)	37.1	(2.4)	1.352	.185

Table 18.
Means & standard deviations of respiratory variables at birth and discharge of infants admitted to a F/S Service in less than 90 days versus 90 days or more after discharge from NICU (N= 38)

	< 90 days (n = 18)		≥ 90 Days (n = 20)			
	M	*(SD)*	*M*	*(SD)*	*t*	*p value (2-tailed)*
Days on Mechanical Ventilation	6.9	(14.0)	6.7	(13.6)		
Days on CPAP	11.7	(19.4)	9.5	(15.8)		
Days on Oxygen	13.6	(22.0)	16.6	(26.9)	-.366	.717
PMA at time of discontinue Caffeine	38.5 (n=12)	(3.8)	37.8 (n=12)	(4.4)	.398	.695

Table 19.
Frequencies of respiratory characteristics of Infants admitted in less than 90 days versus 90 or more days after discharge from NICU (N= 38)

		< 90 days (n = 18)		≥ 90 Days (n = 20)				
		Freq	%	*Freq*	%	χ^2	*df*	*Sig (2-sided)*
Chronic Lung Disease	Y	2	11.1	4	20.0	.433	1	.510
	N	16	88.9	16	80.0			
Airway Abnormality Pre/Post Discharge	Y	5	27.8	6	30.0	.021	1	.885
	N	13	72.2	14	70.0			
Ventilation Ranges	0 Days	9	50.0	10	50.0			
	1 to 6 Days	5	27.8	7	35.0			
	7 to 13 Days	2	11.1	0	0.0			
	>22 Days	2	11.1	3	15.0			

Table 20.
Frequencies of Medical characteristics of Infants admitted in less than 90 days versus 90 or more days after discharge from NICU (*N*= 38)

		< 90 days (*n* = 18)		≥ 90 Days (*n* = 20)				
		Freq	*%*	*Freq*	*%*	χ^2	*df*	*Sig (2-sided)*
Medical Condition	Y	13	72.2	13	65.0	.229	1	.632
	N	5	27.8	7	35.0			
Type of Condition	Cardiac [b]	10	76.9	9	69.2			
	Maternal Drug Exposure	3	23.1	4	30.8			
	NEC [c]	1	7.7	0	0			
	Gastroschisis	0	0	1	7.7			
	Syndrome [d]	2	15.4	2	15.4			
	Sepsis	8	61.5	6	46.2			
	Other [e]	1	7.7	4	30.8			
Put on Caffeine	Y	12		12				
	N	6		8				
Reflux/Emesis Reported	Y	7	38.9	12	60.0	1.689	1	.194
	N	11	61.1	8	40.0			
Fundoplication	Y	3	16.7	0	0.0			
Admission/ER visit with respiratory illness	Y	11	61.1	15	75.0	.846	1	.358
	N	7	38.9	5	25.0			

[a]Intraventricular Haemorrhage; [b] includes Atrial Septal Defects (2), Ventral Septal Defect (3), PDA with and without Ligation (11), patent foramen ovale (5), pulmonary stenosis (1), congenital heart failure (2), murmur (1), other (2); [c] Necrotising Entercolitis; [d] Includes Dandy Walker Syndrome (*n* = 1) , Down Syndrome (*n* = 4) and Syndrome unidentified (*n* = 1); [e] Includes Renal failure, liver condition, TEF, submucosal cleft, CMV, cystic hygroma, asphyxia, Hirschsprung Disease. Note: infants could have more than one medical condition; percentages are out of those with medical conditions.

Infants with early referral took longer in the NICU/ICN to transition off tube feeds than the infants with later referral, although the difference was not significant. The two groups were similar in mean PMA when taking all feeds orally. Means and standard deviations of feeding variables for the two groups of infants are summarized in Tables 21 and 22.

Table 21.
Frequencies of Feeding Variables of Infants admitted in less than 90 days versus 90 or more days after discharge from NICU (*N*= 38)

		< 90 days (*n* = 18)		≥ 90 Days (*n* = 20)	
		Freq	%	*Freq*	%
VFSS prior to discharge	Yes	4	22.2	1	5.0
	No	14	77.8	19	95.0
Clinical signs of difficulty feeding predischarge	Yes	5	27.8	5	25.0
	No	2	11.1	1	5.0
	Not assessed	11	61.1	14	70.0
Days Oral till Discharge	1 Day	2	11.1	0	0.0
	2 to 4 Days	5	27.8	7	35.0
	5 to 6 Days	2	11.1	6	30.0
	7 to 10 Days	2	11.1	2	10.0
	>10 Days	7	38.9	5	25.0

Table 22.
Means and standard deviations of Feeding Variables of Infants admitted in less than 90 days versus 90 or more days after Discharge from NICU (*N*= 38)

	< 90 days (*n* = 18)		≥ 90 Days (*n* = 20)			
	M	*(SD)*	*M*	*(SD)*	*t*	*p value (2-tailed)*
Days tube fed by Discharge	42.6	(31.6)	35.6	(28.4)	.720	.476
Days from start of oral feed to no tube	14.7	(9.9)	8.9	(5.8)	2.228	.032
PMA Age when taking all oral (weeks)	39	(4.0)	38	(3.29)	.976	.335
Days complete oral feed to discharge	9.1	(7.1)	9.1	(7.8)		
Adjusted Age at Admit to F/S Service (Months)*	0.8	(1.1)	5.9	(3.2)		
Total # Days on tube (Outpatient)	134.9	(212.8)	96.6	(188.1)	.590	.559

Upon admission to the feeding and swallowing service, all the infants in both groups demonstrated clinical signs of pharyngeal stage dysphagia when assessed by a feeding therapist. Infants admitted earlier showed slightly more clinical signs of oral stage dysphagia than the later referral infants. Signs of feeding problems are summarized in Table 23 for both groups.

Table 23.
Signs of Feeding Problems on Admission– Infants admitted in less than 90 days versus 90 or more days after Discharge from NICU (*N*= 38)

		< 90 days (*n* = 18)		≥ 90 Days (*n* = 20)				
		Freq	*%*	*Freq*	*%*	χ^2	*df*	*Sig (2-sided)*
Clinical Signs of Oral Stage Dysphagia	Yes	14	77.8	12	60.0	1.386	1	.239
	No	4	22.2	8	40.0			
Clinical Signs of Pharyngeal Dysphagia	Yes	18	100.0	20	100.0			

In summary, there were very few characteristics that were unique to either group. Both groups were similar in GA, PMA at discharge and respiratory health. Some variables that had appeared to be unique to infants who were admitted to a feeding and swallowing service in less than 90 days were equally prevalent in infants who were admitted at 90 days or more. For instance both groups had similar rates of medical conditions, days on oxygen, and days in hospital. The one suggestive difference was the time required to transition from tube feeding to full oral feeding.

Objective 2: Additional Subgroup analyses – Infants who received Mechanical Ventilation 7 or more days (*n* = 14)

Days of mechanical ventilation were a common risk factor identified in a large proportion of the infants in this study who went on to have difficulties with aspiration. Given the findings by Oliver et al. (1998) and the trends noted in the analyses related to the overall sample description for Objective 1, it was decided to further explore the variable of mechanical ventilation.

Fourteen infants received ventilation for more than 7 days while in the NICU with a median of 32.0 days and range of 8 to 127 days with infant #63 included and a median of 29.2 days and range from 8 to 70 days without this infant. Birth weights ranged from 710 to 2650 with gestational ages at birth ranging from 26 to 36 weeks. Infants were discharged from NICU/ICN at an average PMA of 44.3 weeks (SD = 6.5) ranging from 37 to 60 weeks. Half (7) of the infants were discharged home on tube feeds. The other half of the infants discharged on all oral feeds took between 5 to 22 days to transition to all oral feeds between PMA of 37 weeks to 47 weeks. Once oral feeds were achieved, infants stayed in hospital a mean of 15 days (SD = 10.1) with a range of 2 to 28 days.

In relation to respiration, 5 had airway abnormalities and 10 were diagnosed with CLD. Infants received CPAP for median of 18.5 to 19 days with a range of 1 to 68 days with and without infant #63. Infants received oxygen for a median of 44.5 days with a range 16 to 151 days of oxygen with infant #63 and 41.0 days with a range of 16 to 128 days without this infant.

Infants in this group stayed in hospital for median of 100 days with a range of 70 to 186 days with infant #63 and a median of 98 days with a range of 70 to 148 days without this infant. In relation to medical conditions, 7 were diagnosed with CNS abnormality and 12 were diagnosed with a medical condition (cardiac = 10, maternal drug exposure = 3, NEC = 2, gastroschesis = 1, a syndrome = 1, Sepsis/Infection = 8). Ten infants were put on caffeine for between 17 and 123 days. Infants discontinued caffeine at a mean PMA of 39.30 weeks (*SD* = 5.3) with a range of 29 to 45 weeks. Seven infants had difficulties with emesis and 9 were admitted to Emergency/hospital with aspiration related illnesses post discharge. Interestingly, 10 of the 13 infants assessed by a feeding therapist while in the NICU/ICN were in this group. Eight were admitted to a feeding service while in NICU/ICN, 3 admitted within 90 days and 3 in 90 days or more of being discharged from NICU/ICN. Average age at time of admission to a feeding service was 3.1 months (*SD* = 3.6).

In order to determine the uniqueness of the group proportions, infants mechanically ventilated for more than 7 days were compared to infants that did not receive mechanical ventilation.

Comparison of infants non-ventilated (n = 20) versus ventilated ≥ 7 days (n = 14)

Infants who were not ventilated and those ventilated 7 or more days were similar in number of airway abnormalities, emesis, number of days tube fed in the NICU/ICN, age when caffeine was discontinued, admissions to emergency or hospital with respiratory illnesses post discharge from the NICU, and timing and age of admission to feeding and swallowing service (see Tables 24 to 30). Significant differences between the groups occurred for GA at birth, PMA at discharge, days on oxygen, chronic lung disease, days in NICU/ICN, mode of feeding on discharge, days tube fed in NICU, and PMA when taking all oral feeds.

Infants who received mechanical ventilation greater than 7 days had more CNS abnormalities, and had markedly, although not significantly, more medical diagnoses. They were born at earlier gestational ages (26 to 28 weeks GA) and subsequently were more often in the VLBW and ELBW ranges. Almost three-quarters of the infants (71.4%) were diagnosed with CLD. With increased medical complexities, these infants were tube fed longer in hospital, had longer NICU/ICU stays and were 10 times more likely to be discharged on tube feeds than non-ventilated infants. The infants that were discharged home on all oral feeds took longer to transition to oral feeds and stayed in hospital longer once all oral feeds were achieved.

In summary, infants who received 7 or more days of mechanical ventilation should be monitored closely for feeding and swallowing disorders. These infants appear to warrant immediate referral to feeding and swallowing services in NICU/ICN and post discharge. Further research will be required to determine if short term ventilation contributes to the risk for aspiration and to verify the predictive value of 7 or more days of mechanical ventilation.

Table 24.
Frequencies of Demographic Variables at Birth and Discharge: Non-ventilated versus Ventilated ≥ 7 days (*N* = 34)

		Non-ventilated (*n* = 20)		Ventilated ≥7 days (*n* = 14)	
		Freq	%	*Freq*	%
Gender	Male	13	65.0	10	71.4
	Female	7	35.0	4	28.6
Birth weight	<1000 gm (ELBW)	1	5.0	4	28.6
	1001-1500 gm (VLBW)	1	5.0	5	35.7
	1501- 2500 gm (LBW)	11	55.0	4	28.6
	>2500 gm	7	35.0	1	7.1
Gestational Age at Birth	26 weeks	0	0	2	14.3
	27	0	0	3	21.4
	28	0	0	4	28.6
	29	0	0	0	0
	30	0	0	0	0
	31	1	5.0	0	0
	32	4	20.0	1	7.1
	33	3	15.0	0	0
	34	6	30.0	2	14.3
	35	3	15.0	0	0
	36	3	15.0	2	14.3

Table 25.
Means of Variables at Birth, Discharge and Admission of infants discharged on tube and oral feeds – Non-ventilated versus Ventilated ≥ 7 days (*N* = 34)

	Non-ventilated (*n* = 20)		Ventilated ≥7 days (*n* = 14)			
	M	*(SD)*	*M*	*(SD)*	*t*	*p value (2-tailed)*
Gestational Age *	33.75	1.5	29.79	3.7	3.760	.002
Weight at Birth	2271.35	646.8	1490.21	672.7		
PMA at Discharge (weeks)	36.75	2.381	44.29	6.5	-4.170	.001

Table 26.
Frequencies for Respiratory Variables at Discharge - Non-ventilated versus Ventilated ≥ 7 days (*N* = 34)

		Non-ventilated (*n* = 20)		Ventilated ≥7 days (*n* = 14)				
		Freq	*%*	*Freq*	*%*	χ^2	*df*	*Sig* *(2-sided)*
Airway Abnormality	Yes	6	30.0	5	35.7	.123	1	.726
Pre & Post Discharge	No	14	70.0	9	64.3			
Chronic Lung	Yes	0	0.0	10	71.4	20.238	1	.000
Disease	No	20	100.0	4	28.6			

Table 27.
Means of Respiratory Variables at Birth, Discharge and Admission of infants discharged on tube and oral feeds – Non-ventilated versus Ventilated ≥ 7 days (*N* = 34)

	Non-ventilated (*n* = 20)		Ventilated ≥7 days (*n* = 14)			
	M	*(SD)*	*M*	*(SD)*	*t*	*p value* *(2-tailed)*
Days on CPAP	.40	1.2	24.21	19.5		
[a] Days on Oxygen *	1.00	2.1	63.2	45.5	-6.144	.000
[b] Days in NICU/ICN *	24.30	16.8	106.71	32.7	-8.652	.000
PMA discontinue Caffeine	37.63	3.8	39.3	5.3	-.749	.465

*$p < .01$
[a] Days on Oxygen ($N = 51$; $t = -5.069$, $p < .001$)
[b] Days in NICU/ICN ($N = 51$; $t = -10.648$, $p < .001$)

Table 28.
Frequencies for Medical Variables at Discharge – Non-ventilated versus Ventilated ≥ 7 days (N = 34)

		Non-ventilated (n = 20)		Ventilated ≥7 days (n = 14)				
		Freq	%	*Freq*	%	χ^2	*df*	*Sig (2-sided)*
Weight Gain at discharge (n=32)	< average	12	60.0	4	28.6	3.239	1	.072
	≥ average	7	35.0	9	64.3			
CNS Abnormality	Yes	1	5.0	7	50.0			
	No	2	10.0	5	35.7			
	Not Reported	17	85.0	2	14.3			
Type of Abnormality	IVH [a] I/II	1	100.0	1	14.3			
	IVH [a] I/II & HIE	0		1	14.3			
	IVH [a] III/IV	0		2	28.6			
	Hydrocephalus	0		1	14.3			
	Other	0		2	28.6			
Put on Caffeine	Yes	8	40.0	10	71.4			
	No	12	60.0	4	28.6			
Medical Condition(s)	Yes	9	45.0	12	85.7	5.781	1	.016
	No	11	55.0	2	14.3			
Type of Condition	Cardiac [b]	8	88.9	10	83.3			
	Maternal Drug Exposure	3	33.3	3	25.0			
	NEC [c]	0	0	2	16.7			
	Gastroschisis	0	0	1	8.3			
	Syndrome [d]	3	33.3	1	8.3			
	Sepsis	2	22.2	8	66.7			
	Other [e]							
Reflux/Emesis	Yes	10	50.0	7	50.0			
	No	10	50.0	7	50.0			
Known Admissions/ER visits	Yes	10	50.0	9	64.3	.682	1	.409
	No	10	50.0	5	35.7			

Chi Square analysis; [a]Intraventricular Haemorrhage; [b] includes Atrial Septal Defects, Ventral Septal Defect, PDA with and without Ligation, patent foramen ovale, pulmonary stenosis, congenital heart failure, Tetralogy of Fallot, murmur; [c] Necrotising Entercolitis; [d] Includes Dandy Walker Syndrome (n = 1) , Down Syndrome (n = 4) and Syndrome unidentified (n = 1); [e] Includes Renal failure, liver condition, TEF, submucosal cleft, CMV, cystic hygroma, asphyxia, Hirschsprung Disease. Note: infants could have more than one medical condition; percentages are out of those with medical conditions.

Table 29.
Frequencies for Feeding Variables at Discharge - Non-ventilated versus Ventilated ≥ 7 days (N = 34)

		Non-ventilated (n = 20)		Ventilated ≥7 days (n = 14)				
		Freq	%	*Freq*	%	χ^2	*df*	*Sig* (2-sided)
Mode of Feeding on Discharge	Tube	1	5.0	7	50.0	9.268	1	.002
	Oral	19	95.0	7	50.0			
Days to Oral	1 Day	2	10.5	0	0.0			
	2 to 4 Days	8	42.1	2	28.6			
	5 to 6 Days	7	36.8	0	0.0			
	7 to 10 Days	1	5.3	0	0.0			
	>10 Days	1 (n = 19)	5.3	5 (n = 7)	71.4			
Admission to F/S Service	< 90 days	10	50.0	11	78.6	2.847	1	.092
	≥ 90 days	10	50.0	3	21.4			

Table 30.
Means of Feeding Variables at Birth, Discharge and Admission of Infants Discharged on all oral feeds - Non-ventilated versus Ventilated ≥ 7 days (N = 34)

	Non-ventilated (n = 20)		Ventilated ≥7 days (n = 14)			
	M	*(SD)*	*M*	*(SD)*	*t*	*p value* (2-tailed)
Days Tube Fed in NICU *	18.85	13.307	100.29	36.5	-7.979	.000
Days to transition to oral	11.68 (n = 19)	9.346	15.29 (n = 7)	7.2	-.920	.366
PMA when taking all oral *	36.47 (n = 19)	1.172	41.57 (n = 7)	3.3	-6.006	.006
Days all oral to discharge	5.05 (n = 19)	3.4	15.00 (n = 7)	10.1	-2.562	.040
Days until admitted to F/S Program	100.75	77.7	57.7	112.4	1.323	.195
Adjusted Age at Admission	2.75	2.7	3.13	3.6	-.346	.731

CHAPTER 5

DISCUSSION

The results confirm that premature infants treated in an NICU/ICN environment are a diverse group with multiple medical issues and developmental challenges that may act alone or in combination to affect an infant's ability to safely eat orally. Based on the study findings, infants who are tube fed warrant immediate referral to feeding and swallowing services for support along with infants who received greater than 7 days of mechanical ventilation who appear to be at risk of aspiration. Having a diagnosis of CLD, airway abnormalities, CNS abnormalities or medical conditions (e.g., cardiac condition) during the neonatal period also appear to warrant immediate referral to feeding and swallowing services based on the relatively high prevalence of these conditions in the 52 infants. For infants that do not have one of the above concerns, days in NICU/ICN, number of days to transition to oral feeds, and clinical signs of feeding difficulty appear useful in predicting which of the less medically fragile infants that may not be "skilled feeders" and would benefit from assessment by feeding and swallowing services.

Significant differences between infants discharged home from NICU/ICN on tube feeds versus infants discharged on oral feeds were found in the postmenstrual age of the infants at discharge, number of days infants were tube fed in hospital, number of days on oxygen, and length of hospital stay. These results suggest that the tube fed infants were more medically compromised than the infants discharged on all oral feeds and as such had little to no opportunity to sustain their nutrition orally. They required more days on oxygen and more days in hospital before they were stable enough for discharge home. As infants that are tube fed need ongoing monitoring, these infants were referred to a feeding and swallowing service such as the Pediatric Home Nutrition Support Program to facilitate growth/nutrition and transition to oral feeds upon discharge.

Previous studies suggest that endotracheal tubes contribute to feeding problems and that length of mechanical ventilation correlates better with severity of lung disease than does GA at birth or days on oxygen (> 60% oxygen) (D'Angio & Maniscalco, 2004; Palmer, Crawley, & Blanco, 1993). Infants who required 7 or more days on mechanical ventilation do appear to be a distinct subgroup in many ways. As with infants who are discharged on tube feeds where being on tube feeds may represent more medical challenges, it is hard to sort out whether mechanical ventilation is the key variable or whether the number of days on mechanical ventilation is a marker for other risk factors. Infants in this group were younger and smaller at birth. There were a number of variables that were highly associated with days of mechanical ventilation such as days on oxygen, days on CPAP, and the incidence of chronic lung disease. Days of mechanical ventilation may be a marker for infants with substantial needs for respiratory support which makes oral feeding difficult to attain. Oliver et al. (1998) demonstrated that as the number of days of ventilation increased, the severity of feeding and swallowing dysfunction increased. They concluded that all premature infants who were ventilated for 14 days or longer should be closely monitored for feeding and swallowing complications. A future study similar to that of Oliver et al. (1998) is required to look at short and long term ventilation in healthy premature infants to determine if mechanical ventilation is a key marker of risk of aspiration.

Infants who are discharged on all oral feeds have less obvious needs for ongoing monitoring. These infants were less medically fragile but still went on to have aspiration related respiratory illnesses even though all but seven of 38 infants received no ventilation or less than 7 days of ventilation. When looking at the infants who were discharged on all oral feeds, there were no significant differences between the infants referred to a feeding service in less than 90 days (early referral) versus those referred in 90 days or more (later referral) although the time it took to transition from tube feeds to oral feeds was markedly, though not significantly, different. Infants with early referrals required, on average, 5 more days to transition from tube feeds to oral feed while in the NICU/ICN. Wang et al. (2004) found that feeding difficulties were the dominant reason for a delay in discharge in infants 35 to 37 weeks PMA. These results suggest that the infants with early referrals were more delayed in their feeding skills or had slightly more medical complications taking longer to transition to oral feeds than the infants with later referrals. The infants may have been able to take all of their nutrition orally by discharge, but were not yet skilled eaters (Thoyre, 2003, 2007). These infants may lack the skills and mature motor patterns required to sustain increasing nutritional needs and/or over time these poor skills resulted in fatigue, aspiration and the development aspiration-related respiratory illnesses sooner than the infants that transitioned quicker.

The majority of the infants discharged on oral feeds who went on to have later feeding problems were not assessed by a feeding therapist in the NICU/ICN. This makes it difficult to determine if infants were showing clinical signs of feeding difficulties prior to being discharged. Of the infants who were assessed, 5 received a VFSS and 5 infants had a bedside swallow assessment only. All the infants assessed showed oral and/or pharyngeal signs of difficulty eating orally (dysphagia). All five of the infants assessed by VFSS had abnormal swallows or difficulties with sucking and swallowing and/or swallowing and breathing. The infants seen for a bedside swallow assessment showed clinical signs of fatigue, oral loss, need for pacing, and/or bradycardia, desaturations or apnea with oral feeds. All the infants assessed by VFSS and most of the other 5 infants were assessed earlier in their hospitalization and notes about feeding skills just prior to discharge were not always recorded making it hard to determine if problems persisted.

If we look at groups based on mode of feeding at discharge upon admission to the feeding and swallowing services, 68.4% of the infants discharged on oral feeds and 72.7% of the infants discharged on tube feeds showed clinical signs of oral dysphagia. All of the infants discharged on oral feeds and 90.9% of the infants discharged on tube feeds showed clinical signs of pharyngeal dysphagia. The feeding behaviors markedly differed with the clinical signs of audible swallow/gulping and coughing during/after feed occurring in a larger number of oral fed infants and a larger number of tube fed infants demonstrating more difficulties with desats/apnea with feeds. The infants on tube feeds would have experienced more days on mechanical ventilation, suffered more medical issues, were more likely to have underdeveloped lungs, and may not have the endurance or sensory responsiveness of the infants discharged on all oral feeds. It would be reasonable that clinical signs of coughing may not be reliable or occur in younger and more medically compromised infants and would be a more reliable indicator of feeding difficulty in a more mature and stable infant. Therefore, while more research is needed, oral and pharyngeal signs of feeding difficulty at discharge appear important in identifying infants who will need extra feeding services post NICU/ICN.

Characteristics of the 52 infants were considered and compared to the literature on a few selected variables. This sample was similar in terms of the range of birthweight and gestational age in the preterm population in general. The amount of time infants spent on some form of ventilatory support was somewhat similar to data from the local neonatal intensive care for preterm infants. There is a suggestion that the rate of chronic lung disease in the sample may be a bit higher than the rate reported in British Columbia (Fenton et al., 1996). However, the way in which chronic lung disease was defined does vary between samples. Chronic lung disease may be worth exploring as a possible risk factor and this is discussed in a later section.

In order to evaluate the importance of different variables in detecting infants at risk for aspiration, the remainder of the discussion focuses on common characteristics and comparisons within infants discharged on oral feeds. Tube fed infants and infants on mechanical ventilation for longer were more medically compromised and were less likely to sustain nutrition orally so are not discussed further.

Development of Suck, Swallow, Breathe

Infants at 32 weeks of age begin to coordinate sucking, swallowing and breathing rhythms through maturation and experience (Lau et al., 2003). Complications of prematurity such as impaired respiratory health, fatigue secondary to medical conditions (e.g., cardiac impairments) and neuromotor incoordination interfere with an infant's experience and maturation in feeding skills (Burklow et al., 2002; Rommel, De Meyer, Feenstra, & Veereman-Wauters, 2003). In our study, 53.0% of the infants discharged on all oral feeds were born less than or equal to 32 weeks GA or born before feeding readiness has been established. However, 47.0% of the infants with substantial feeding problems were born between 33 and 36 weeks gestation. In keeping with Ludwig (2007), GA alone is not sufficient for early identification of future feeding problems.

In our study, infants discharged on oral feeds were admitted to a feeding and swallowing service at a mean adjusted age of 3.5 months. At this age, primitive reflexes are beginning to be integrated and motor movements put a greater demand on the nervous system and are beginning to be under volitional control. This is also the time that cheek fat pads dissolve, the tongue base starts to retract and a greater oral space is created. The proximal stability created from anatomical structures being in close proximity is lost. The infant must begin to rely on developing postural stability through more mature and volitional neuromuscular patterns/control. This control places a larger demand on the infant's nervous system that he/she may not be ready for and can be one sign of immature or delayed motor skills (Wolf & Glass, 1992). It is possible that the infants discharged on all oral skills were later admitted to feeding service with aspiration related respiratory illnesses due to an inability to transition to the more mature feeding patterns required and/or were starting to show the first signs of neurodevelopment problems.

Several studies have shown that premature infants continue to be at risk for disorganized suck-swallow and swallow-respiration interactions after discharge from NICU/ICN (Burklow et al., 2002; Fucile, Gisel, & Lau, 2002; Fucile, Gisel, & Lau, 2005; Lau et al., 2003; Mathisen, Worrall, O'Callaghan, Wall, & Shepherd, 1999; Rommel, De Meyer, Feenstra, & Veereman-Wauters, 2003) which was definitely the case in the current study. Researchers hypothesize that the impaired oral feeding skills of some premature infants could be transient and likely resolve, while others may be early indicators of neurodevelopmental impairment (Hawdon et al., 2000; Medoff-Cooper &

Gennaro, 1996). Hawdon et al. followed 35 infants (28 of whom were premature) in the neonatal care unit and found that 40.0% of the infants had impaired oral motor patterns that were either disorganized (sign of immaturity) or dysfunctional (sign of neurological impairment). The infants were younger in GA at birth and had more neurological and respiratory conditions diagnosed during the neonatal period. Families of these infants continued to report coughing, gagging and vomiting with meals at 6 months of age and coughing and difficulty transitioning to textured foods at 12 months of age (Hawdon et al.). In our study, infants were referred to a feeding service ranging from prior to discharge to up to 12 months post discharge. In keeping with Hawdon et al., premature infants can continue to have difficulty with feeding and swallowing for up to one year post discharge.

Amaizu et al. (2008) studied stable premature infants of 26/27 and 28/29 weeks GA and found that infants in both groups attained independent feeding at around 34 to 38 week PMA. The temporal maturation of swallow and breathe did not yet occur in the 26/27 weeks GA infants, suggesting that infants born at younger gestational ages may take all their nutrition orally at 34 to 38 weeks PMA, but take longer to obtain the rhythm of swallowing and breathing than infants born at older gestational ages. In our study, 57.9% of the infants (with 44.7% born 28 weeks GA or older) did not transition to all oral feeds between 34 and 38 weeks PMA. The infants continued to have feeding difficulties past 38 weeks PMA and past the age when the rhythm of swallowing and breathing was to mature. These results suggest that GA and medical/respiratory conditions impacted their ability to coordinate swallowing and breathing increasing the risk for aspiration related respiratory illnesses post discharge.

In order to be discharged home, infants need to demonstrate sufficient weight gain, have the ability to regulate temperature, have cessation of apnea and bradycardia and are able to feed orally. In general, infants are kept in NICU/ICN after attaining all oral feeds for several (5 to 7) days (Eichenwald et al., 2001; Escobar et al., 1999). In our study, 14 of the infants discharged on all oral feeds were discharged in 4 or less days of achieving all oral nutrition, which is quicker than the time recommended by Eichenwald et al.

Medical conditions and Suck, Swallow, Breathe

The incidence of medical complications in premature infants increases as gestational age decreases and these complications in turn increase the risk for developing feeding difficulties (Thoyre, 2007, Vohr et al., 2000). Wang et al. (2004) compared term infants with near-term infants (35 to 37 week GA) and found that the near-term infants were much more likely to have 2 or more medical diagnoses assigned. Fifty percent of infants discharged on oral feeds in our study had 2 or more diagnoses/clinical issues. Sixteen percent were diagnosed with a Central Nervous System abnormality in NICU/ICN prior to discharge; however, 55.3% of the infants had no record of being formally assessed for a CNS abnormality as an inpatient and as such could not be compared. Half of the infants discharged on oral feeds had a cardiac condition. It is possible that feeding difficulties are related to the severity of illness and prematurity (Hawdon et al., 2000)

When looking at the literature on premature infants born less than 2500 grams, our results are comparable. Kelleher et al. (1993) found that 20.0% of LBW infants continued to meet the criteria for failure to thrive after 30 months and Ernst et al. (1990) showed that 30.0% of infants weighing less than 1500 grams (VLBW & ELBW) at birth were below the 5^{th} percentile for weight at 12 months adjusted age. In our study, 30 (79.0%) of the infants discharged on all oral feeds were born less than 2500 grams (LBW) and 14 (35.9%) of the infants were discharged below average expected weight gain. Further research is required to know if poor feeding skills impacted expected weight gain.

Respiratory Health and Suck, Swallow, Breathe

Sixteen percent of the infants discharged on oral feeds in this study had a diagnosis of chronic lung disease. The relationship of Bronchopulmonary Dysplasia or chronic lung disease to feeding difficulties is the respiratory variable best understood in the literature. Several studies have documented that CLD interferes with suck, swallow and breathe rhythm during feeding (Craig, Less, Freer, & Laing, 1999; Garg, Jurzner, Bautista, & Keens, 1988; Gewolb & Vice, 2006; Morris el al., 1999; Shiao et al., 1996; Singer et al., 1992; Wood et al., 2003). According to Pridham et al. (1998), infants with CLD take longer to transition from tube feeds to oral feeds and have poorer growth. The number of infants discharged on oral feeds diagnosed with CLD in our study was small and diverse making it difficult to determine if ability to transition to oral feeds was more difficult than for infants without CLD. Although CLD and its methods of treatment may influence ability to coordinate suck, swallow and breathe synchrony, infants without CLD have also shown difficulty with coordinating breathing with eating orally. Dodrill et al. (2004) found that infants born between 32 and 37 weeks GA without CLD continued to take more frequent breathing pauses at 12 months CA. This suggests that although CLD is important in identifying infants at risk of aspiration, low risk premature infants without CLD may still have challenges coordinating breathing and eating function and also need continued monitoring post discharge.

GI motility is immature in many later preterm infants and may result in feeding difficulty and prolonged hospitalization (Neu, 2006). Akintorin et al. (1997) found that food intolerance by the GI tract is common in the first weeks of life in extremely premature infants and is particularly common in infants who require a longer duration of mechanical ventilation. A large percentage of infants leave the nursery with symptoms of gastroesophageal reflux (Thoyre, 2007). Mathisen et al. (1999) studied term infants with and without gastroesophageal reflux and found that mothers reported more emesis, difficulty swallowing, respiratory symptoms and crying with feedings. Mathisen also reported that 11 of the infants received VFSS and all 11 had clinical signs of oral dysphagia. In our study, half of the infants discharged on oral feeds had reported difficulties with emesis and 3 went on to receive fundoplications as part of their treatment for aspiration related respiratory illnesses post discharge from the NICU. As only 5 VFSS were completed in infants discharged on oral feeds prior to discharge, it is difficult to determine how many of the infants with gastroesphageal reflux would have shown signs of dysphagia at discharge.

Apnea is a common condition of prematurity and is defined as pauses in breathing for periods of 10 to 20 seconds with or without bradycardia or cyanosis. Apnea generally resolves by 36 to 38 weeks PMA but can continue for several more weeks (Bhatia, 2000; Holditch-Davis et al., 1994). In keeping with Bhatia (2000), infants in this study share some of the common causes of apnea in preterm infants. These include airway obstruction, impaired oxygenation, temperature instability, infection, neurologic disorders, abdominal disorders, congenital heart disease, arrhythmia, and maternal drug exposure. The infants also underwent common treatment for apnea, including CPAP and/or mechanical ventilation and caffeine therapy (Bhatia, 2000). In our study, resolution of apnea was measured by PMA when caffeine has been discontinued. All of the infants born less than 32 weeks GA were prescribed caffeine meaning that 63.0% of the infants discharged on oral feeds were diagnosed with apnea and placed on caffeine. Eleven of these infants were discharged home on caffeine and of these 11, 8 were admitted to feeding and swallowing in less than 90 days and 3 were admitted in 90 or more days. Of the infants prescribed caffeine, 72.7% of them discontinued caffeine between 39 and 43 weeks PMA which is beyond the common age when apnea resolves. These results suggest that the infants discharged on caffeine may have continued difficulties with desaturations and/or apnea with feeds after discharged home and that these difficulties likely contributed to the infants developing aspiration related respiratory illness post discharge.

Lastly, airway patency can greatly impact on infants' ability to coordinate suck, swallow and breathe during oral feeding. Laryngomalacia, tracheomalacia, vocal cord paralysis and subglottic stenosis can increase the work of breathing and interfere with an infant's ability to protect their airway during feeding. Infants with these concerns often aspirate, especially with thin fluids until it resolves. In our study, 28.9% of the infants discharged on all oral feeds were diagnosed with airway abnormality as either an inpatient or an outpatient. This suggests that infants diagnosed with congenital or acquired airway abnormalities should be monitored for feeding and swallowing difficulties post discharge from NICU.

Limitations

This study was a descriptive explorative study reliant on retrospective review of medical records, and is therefore subject to limitations inherent in all such studies. Clinical records contain important health information but time is not always taken to record data consistently and the detail and accuracy of the information can vary between clinicians. Abstracting information from clinical health records can be challenging. Records often contain conflicting medical histories or poor agreement between professionals in interpreting diagnostic tests and/or physical signs of disease. Gilbert, Lowenstein, Koziol-McLain, Barta, & Steiner (1996) indicate that "common sources of error in chart abstraction include: (1) missing charts; (2) inability to locate needed information; (3) multiple conflicting entries; (4) chart entries that are vague, incomplete or illegible; (5) inconsistent coding of data into categories; (6) handling of uncertain or missing data; and (7) mistakes in transcription of information from charts to a computer database" (p. 308). In this study, the principal investigator minimized sources of error by excluding cases where charts were missing, defining the inclusion and exclusion criteria, defining variables, meeting with staff in NICU and ICNs to discuss methods of charting and coding of information (e.g., type of respiratory ventilation), setting limits on number of cases with missing data before variable was removed from study, and using a standardized data collection sheet and numerical codes to enter information from charts to computer database.

The sample is biased by the selection of only premature infants who were admitted to the NICU/ICN and admitted to SCH and PHNSP feeding services with an aspiration-related respiratory illness as other older premature infants may have been cared for in well-baby nurseries or admitted to other feeding and swallowing services and as such would not have been part of the study. To address this bias, the sample was compared to infants in the literature based on GA, sex and birth weight. However, no specific studies looked at infants admitted post discharge with aspiration-related respiratory illness and therefore comparison had to be extrapolated from variable specific studies e.g., studies on prospective weight gain of LBW infants.

Variables such as days on oxygen, days on mechanical ventilation and chronic lung disease have differences, but are also closely related to each other. For example, the diagnosis of chronic lung disease is based on the number of days on oxygen and CPAP and mechanical ventilation can occur with and without oxygen. The infants admitted to the Stollery Children's Hospital have access to a multidisciplinary evaluation by a variety of specialty services (i.e. Pulmonologist, Ear, Nose and Throat (ENT) specialist, etc.) which allows for clearer identification of the reason for the respiratory illness. If this data was to be compared to a control group in future studies, the control group(s) may not have the same access to specialty services resulting in less confidence in the clarity of diagnosis/insults.

The determination of aspiration-related respiratory illnesses and need to recommend tube feeding or modified diet in the study sample was based on clinical expertise, with no way to determine the reliability or consistency in interpreting the signs of aspiration and need for tube feeding or modified diet. There was no other independent verification of aspiration other than clinical assessment/opinion.

This study does not take into account the effects of socioeconomic, cultural influences, or environmental exposures that can affect health outcomes both in the NICU/ICN and after discharge. For example, this study does not take into account the effects of parent/child interaction in the NICU/ICN or the effect of second hand smoke, access to community health resources or high risk living situations once discharged that can increase risk of aspiration-related respiratory illnesses. This information cannot be obtained from clinical health records.

With the analysis of only the last 7 days of admission to the NICU/ICN, weight gain may not be accurately reflected. Infants may have gained weight quickly while on tube feeding and slowed down with transitioning from tube feeds to full oral feeds. As data on growth was not collected, the impact of growth on feeding and swallowing difficulties and vice versa could not be made.

Implications for Health Care Providers

The act of feeding in infants is complex and affected by an infant's physical health, development and environment. Many medical issues can affect an infant's ability to feed independently. Infants with complex medical needs often require tube feeding past NICU/ICN stays and should be referred to feeding and swallowing services prior to discharge for continued monitoring and transition to oral feeds. Health care providers should also recognize that infants who receive mechanical ventilation greater than 7 days, have been diagnosed with airway abnormalities, cardiac conditions and CNS abnormalities may need closer monitoring for feeding and swallowing disorders and referral to outpatient feeding services for monitoring post discharge. While health care professionals are aware of the developmental challenges of feeding in infants born less than 32 weeks, it is important to recognize that infants born at 34 weeks GA or more may have developmental difficulties with feeding as well. This group may appear similar to infants born at term, but their neurological systems are immature and they may need time and support to master the skills of oral feeding (Ludwig, 2007).

Health professionals can help to monitor all premature infants for concerns by focusing on the clinical signs of feeding readiness in conjunction with volume and weight gain. The majority of the infants in the study that were discharged on all oral feeds were referred to a feeding and swallowing service for intervention under 6 months adjusted age and after emergency/additional hospitalizations secondary to respiratory illnesses. By recognizing the challenges in the developmental progression of feeding in infants from birth to 6 months of age and by recognizing that medical conditions commonly affect feeding performance (e.g., cardiac conditions, sepsis, CNS insult) during and after this time period, health care professionals can be proactive in identifying infants at risk of feeding difficulties and refer these infants to a feeding and swallowing service early when they are most amenable to support and change. By establishing a means of early follow-up for these infants, adaptations to their method of eating can be made and hopefully result in fewer infants being hospitalized for respiratory illnesses.

The perception is that there are an increasing number of infants being referred for feeding difficulties and in particular, premature infants referred for aspiration-related respiratory illnesses. Currently, the participating facilities in the study do not have a data base that can keep track of the infants by gestation, age of referral, reason for referral to a feeding service or outcome. By collecting this information, health care professionals can gain a better understanding of which infants are being referred and their morbidity pre and post discharge. To facilitate further information gathering, healthcare professionals can assure seamless service delivery between hospitals and upon discharge by utilizing standardized methods of measuring and charting feeding performance and risk factors (e.g., agree on abbreviations for methods of delivering oxygen, clinical signs of oral and pharyngeal dysphagia, times of assessment) and provide standardized discharge sheets to follow children between hospitals. With standardized methods of documentation and/or charting, we can obtain more reliable data, facilitate learning, develop prevention and follow-up programs to address the concerns, and educate parents on the difficulties that may lie ahead and services available to them.

The study also identified some recommended practices in the literature which had not occurred with the infants in the sample. For instance, Eichenwald et al. (2001) recommend that premature infants be monitored for several days after attaining all oral feeds. Fourteen infants discharged on all oral feeds were discharged in 4 or less days of achieving all oral nutrition. Health care providers need to continue evaluating current practice and its relationship to recommended evidence based practice.

Future Research

There is little research that has been conducted on feeding the premature infant after discharge, yet feeding and swallowing difficulties remain a primary concern of families once home (Kavanaugh, Mead, Meier, & Mangurten, 1995; Pridham, Saxe, &

Limbo, 2004; Thoyre, 2007). This study explored selected characteristics of infants born premature who were admitted to a feeding service with aspiration-related respiratory illness. Future studies are required to confirm that factors such as GA, respiratory health, and medical diagnosis are indeed potential risk factors for aspiration in premature infants. Studies are required to 1) compare current study results to a group of infants who have not been admitted to a feeding service with an aspiration-related respiratory illness, and 2) prospectively following premature infants with and without suspicion of aspiration in order to confirm the predictive value of identified risk factors. It would also be useful to assess a cohort of preterm infants who are oral feeders using a bedside assessment just prior to discharge and determine the presence or absence of various clinical signs of feeding difficulties. The infants would be followed over time to see if there are any signs at discharge which would have been predictive of a rapid referral versus a later referral versus no referral.

In addition to a number of infants being referred for aspiration related feeding difficulties, a persistent number of infants are also being referred for intervention post discharge for selective eating, inability to eat more than a small portion of food at one time, difficulty transitioning to textured foods and food refusal (Field, Garland, & Williams, 2003; Hawdon et al., 2000; Rommel et al., 2003; Thoyre, 2007). We need a better understanding of how the hospital and home environments impact feeding. Further epidemiological studies are needed to identify the prevalence of the feeding difficulties described above and to understand how these difficulties develop. We can then explore which premature infants are at risk for developing feeding difficulties, when and why the difficulties occur, how the expression of these feeding difficulties change over time, and what intervention and timing of intervention is most effective (Thoyre).

Summary and Relevance

Premature infants treated in an NICU/ICN environment are a diverse group with multiple medical issues and developmental challenges that may act alone or in combination to affect an infant's ability to safely eat orally. A retrospective chart review of 52 premature infants who later developed aspiration related illnesses indicated that 36.8% were not able to demonstrate the suck, swallow and breathe rhythms necessary to transition to all oral feeds prior to being discharged from NICU/ICN. The variables distinguishing these infants from those discharged on oral feeding suggested that these infants were more medically compromised. Infants who received mechanical ventilation greater than 7 days had more CNS abnormalities and medical diagnoses. Seventy-one percent were diagnosed with chronic lung disease and a large proportion was discharged on tube feeds. Infants who received 7 or more days of mechanical ventilation appeared to warrant a rapid referral to feeding and swallowing services. However, premature infants who were gaining weight and developing reasonably well were discharged on oral feeds with few referrals to feeding services. These infants did go on to develop aspiration related illnesses for which there were no clear indicators as to which infants would develop illnesses in the first three months versus those who would do so three to six months after discharge. Further research is required to identify predictive variables.

Feeding may seem upon first glance to be a simple intuitive act, but is actually a complex process requiring coordination of multiple systems and is not solely reliant on medical and physical influences. The feeding needs of premature infants are complex and require a multidisciplinary team approach that begins with the initiation of oral eating and continues "seamlessly" after discharge until the child attains his or her growth potential and participates in family meals without concern (Thoyre, 2007).

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APPENDIX A

DATA COLLECTION SHEET

Assigned #: ________________

Screen Charts from F/S Service and /hospital data bases/Netcare for:

Inclusion/Exclusion Data:

1. Gestational Age at birth is <37 weeks:	Yes	No
2. Diagnosis at Admission to F/S Service of Aspiration-related Respiratory Illness:	Yes	No
3. Is Admission within 12 months post discharge from NICU/ICN Date of Admission to SCH or PHNSP feeding service: ________________ Date of Discharge from NICU/ICN: ____________________________ Date of Admission to F/S Service minus Date of Discharge from NICU/ICN = _______# of months	Yes	No
4. Born and stayed in Participating hospital for entire care until discharged home. Year: _______________ Hospital/City/Health Region: ________________	Yes	No
5. Medical records are available for review	Yes	No
6. Medical condition is contraindicated to enteral/oral feeding e.g. tracheostomy	Yes	No

* For a target infants, Items 1-5 must be answered "Yes" and Item 6 answered "no"

* For a control infant, Items 1, 3-5 must be answered "yes" ad items 2 & 6 answered "no"

Information to Be Gathered from NICU/ICN Charts: *Items in Italics are collected for descriptive purposes only or are used in calculation of other variables.*

Demographic

1. Sex: 0 = male 1 = female

2. Birth Weight: ____________________

D.O.B.: ____________________________

GA at Birth: __________________ *(based on* ______________________________ *)*

PMA at Discharge Home: ____________________________

Discharge Destination from NICU/ICN: Home/Miscercordia/Grey Nuns/SCH
Other: _______________________

Feeding Variables:

3. Weight Gain:

0 = < expected average weight gain
1 = ≥ expected average weight gain

(See Appendix C for more detail)

Weight on Discharge (W1)	*Weight on 7th day prior to discharge (W2)*	*Average Weight Gain (g/day) = (W1-W2)/6*	*Average Weight Gain (g/kg/day) = Gain (g/day) / W1*

4. Mode of Feeding on Discharge 0 = Tube Feed 1 = Oral Feed
(Check Primary means of nutrition)

Bottle	*Breast*	Tube Feed

5. Transition Time:
Number of days for transition to complete oral feeding in infants fed by nasogatric tubes is defined as the difference between the dates he/she first took any nutrition from a nipple to the date when he/she took all nutrition orally. Complete oral feeding is defined as the ability of the infant to maintain nutritional requirements solely by oral feeding without use of supplemental tube feeding.

Initiation of Oral Feeds (d/m/y)	
Discontinuation of Tube Feeds (d/m/y)	

Difference (#days)	

6. Total Number of Days of complete oral feeds until Discharge:

Discontinuation of Tube Feeds (d/m/y)	
Discharge Date (d/m/y)	
Difference (#days)	

Reason for hospital stay >4 days after achieving all oral feeding to be recorded

____

Respiratory Variables:

7. Known Airway Abnormalities: 0 = Yes 1 = No

__ *Laryngomalacia* __ *tracheomalacia* __ *vocal cord paralysis*

Other _______________

8. Chronic Lung Disease
Based on if requires oxygen ≥ 36 weeks GA: 0 = Yes 1 = No

9. Number of Days of Mechanical Ventilation:

# of days on HFOV	
# of days on IPPV	
Total # of days of mechanical ventilation	
# of days on CPAP/Cycling -Prongs	

**CPAP information is to be gathered for descriptive purposes only as means to describe general respiratory health of infants.*

10. Number of Days on Oxygen:

Date Oxygen began (year/mon/day):	
Date oxygen ended (year/mon/day):	
Total number of days on Oxygen:	

11. Apnea (PMA age when intervention for apnea ended as indicated by no reinstatement of caffeine) ________________________.

Medical Variables:

12. Number of Days in NICU/ICN:

Date of Admission to NICU/ICN (year/mon/day):	
Date of discharge from NICU/ICN (year/mon/day):	
Total Number of Days in NICU/ICN:	
Date of discharge home (year/mon/day):	
Total Number of Days in Hospital:	

13. Central Nervous System Investigations: 0 = Abnormal 1 = Normal 2 = Not reported

__ *EEG* __ *CT* __ *Ultrasound* __ *MRI*

Descriptive information on diagnosis collected such as seizures, IVH and other neurological diagnoses such as cerebral palsy and hydrocephalus will be collected).

____

____

14. Other Diagnosed Medical Condition: 0 = Yes 1 = No

Descriptive information will be collected such as Genetic Abnormality, and/or cardiac

____

____

15. Abnormal swallow identified on VFSS: 0 = Yes 1 = No

Descriptive Data will be collected to compare to assessments completed at Stollery Children's Hospital to explore changes in swallowing ability and recommendations.

Oral Stage: ____

____

____

____

Pharyngeal Stage: ____

____

____

____

Recommendations: ____

____

____

____

16. List of Discharge Medications (e.g., Anticonvulsants, steroids, etc.):

___

___

Admission Data to Feeding Service (SCH/PHNSP Clinical Charts):

The following information will be collected for descriptive purposes in order to describe the target sample, provide information on general health of infants and to guide future research.

Date of Referral:	*Date of Discharge:*
PMA at admission:	*PMA at Discharge:*
	Discharge Destination: *Home/Foster/Adoption/Hospital*

Feeding Method Upon Admission *(check all that apply)*
__ Breast __ Bottle __ Tube

Feeding and Swallowing Assessment:
Type of Assessment: *Clinical or VFSS (Circle)*

Abnormal swallow identified on VFSS: *Y / N*

Oral Stage:

Pharyngeal Stage:

Recommendations:

Discharged home on Oxygen: *Y / N*

History of GER: *Y / N*

Respiratory Diagnosis: *e.g., pneumonia, chronic lung disease, hyaline membrane disease, asthma etc.*

Known Airway Abnormalities:

__ *Laryngomalacia* __ *tracheomalacia* __ *vocal cord paralysis*

Other ____________________

Cardiovascular Diagnosis/Surgery:

Central Nervous System Diagnosis:

Other Medical Diagnosis:

List of Discharge Medications:

APPENDIX B

WEIGHT GAIN CALCULATION

Age Interval (weeks)	Average Daily Weight Gain (g/day)	Mean Weight (g)	Average Daily Weight Gain* (g/kg/day)
24-25	11.4	904-961	12.2
25-26	15.7	961-1001	16.0
26-27	18.6	1001-1065	18.0
27-28	21.4	1065-1236	18.6
28-29	22.6	1236-1300	17.8
29-30	23.1	1300-1484	16.6
30-31	24.3	1484-1590	15.8
31-32	25.7	1590-1732	15.5
32-33	27.1	1732-1957	14.7
33-34	30.0	1957-2278	14.2
34-35	31.4	2278-2483	13.3
35-36	34.3	2483-2753	13.1
36-37	35.7	2753-2866	12.7
37-38	31.4	2866-3025	10.7
Mean	25.2	N/A	14.9

* Calculated from average daily gain + midrange of mean weight
Reprinted from Groh-Wargo S., Thompson M., Cox JH, eds. *Nutritional Care for High-Risk Newborns.* Chicago, Ill: Precept Press; 2000:13.

To calculate whether goals of expected weight gain were met, we need to calculate the Average Daily Weight Gain (g/kg/day) for the particular infant and compare to the chart above.

Step 1: Determine Average Daily Weight Gain (g/day) over a seven day period prior to discharge.

W1 = Weight on discharge
W2 = Weight six days prior to discharge

$$\text{Average Daily Weight Gain (g/day)} = \frac{W1 - W2}{6}$$

Step 2: Determine Average Daily Weight Gain (g/kg/day)

$$\text{Average Daily Weight Gain (g/kg/day)} = \frac{\text{Average Daily Weight Gain (g/day)}}{W1^*}$$

* Use actual weight or birth weight which ever is greater.