

Feeding and Swallowing in Neonates with Hypoxic Ischemic Encephalopathy (HIE): A Descriptive Study

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Author's Note

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Abstract

Background: Intrapartum-related complications, including intrapartum hypoxia and subsequent hypoxic ischemic encephalopathy (HIE), are the second highest cause of neonatal deaths in South Africa. For survivors, such complications may be associated with a substantial burden of impairment, including the inability to feed well and swallow safely, thus representing a possible neurological cause of oropharyngeal dysphagia (OPD). HIE may result in disturbances of physiological stability, state regulation, neuromuscular integration, coordinated oral movements, and/or feeding endurance. However, feeding and swallowing characteristics in this population of neonates are not well described in the literature.

Research Aims: To describe the feeding and swallowing profile of neonates with HIE in a neonatal unit in Cape Town, South Africa, including characteristics of oral feeding readiness, oromotor skill, oropharyngeal swallowing and clinical signs and symptoms of OPD, time taken to reach full oral feeds, and feeding method at discharge from the neonatal unit.

Method: A descriptive, exploratory, longitudinal design consisting of both prospective and retrospective data collection methods was used to examine the feeding and swallowing characteristics in a sample of 52 participants with HIE of varying severities. Clinical feeding and swallowing assessments were conducted for 13 participants using the Neonatal Feeding Assessment Scale (NFAS), and medical folder reviews were conducted for 39 participants. The medical and feeding information was documented using data collection forms, including the feeding management received from the on-site speech-language therapist. Data from both data collection methods were amalgamated onto Excel spreadsheets, and information from medically similar participants was identified and grouped together for descriptive and statistical analysis. Statistical analysis comprised the nonparametric Kruskal-Wallis test and the Mann-Whitney U test.

Results: A main effect of oral feeding readiness was indicated with a median of 4 days ($p = 0.036$), and an interquartile range of 4 – 5 days (standard deviation = 3.7 days). The median number of days to full oral feeds for the sample was 5 days ($p = 0.016$) with an interquartile range of 4 – 6.8 days (standard deviation = 4.3 days). Participants with a severely abnormal initial aEEG and who did not receive cooling treatment demonstrated the longest average time to oral feeding readiness and, subsequently, to full oral feeds. Participants of all severities presented with feeding and swallowing difficulties primarily in the oral phase of swallowing. Few pharyngeal signs and symptoms of OPD were identified. Most participants (96.2%; $n = 50$) were discharged on full oral feeds, while the remaining 3.8% ($n = 2$) were discharged on nasogastric tube feeds (NGT) while awaiting gastrostomy placement.

Conclusion: Regardless of severity, neonates with HIE face an increased risk of feeding and swallowing difficulties. The findings highlight that neonates with HIE should be screened by a speech-language therapist for feeding and swallowing difficulties before discharge from hospital. This study contributes to the small body of research on feeding and swallowing difficulties in neonates with HIE, and may guide future research.

Keywords: hypoxic-ischemic encephalopathy; neonate; feeding; swallowing; dysphagia; oropharyngeal dysphagia

Glossary and Descriptions of Selected Terms

Aspiration: The entry of food particles, liquid, or secretions into the airway below the level of the true vocal folds. Aspiration may occur before, during, or after the swallow, or after feeding due to gastro-oesophageal reflux (GOR) (Ficke et al., 2022), and can only be diagnosed via an instrumental evaluation of swallowing (Cordier et al., 2023).

Silent aspiration refers to the entry of food particles, liquid, or secretions into the airway below the level of the true vocal folds but without triggering the airway protective reflexes, i.e., no coughing or choking is observed (Arvedson, 2006; Durvasula et al., 2014).

Bolus: A small volume of food that is organised and shaped into a cohesive mass in the oral cavity for the process of swallowing and ingestion (Delaney & Arvedson, 2008).

Caregiver: For uniformity, the term ‘caregiver’ has been used to refer to the person primarily responsible for caring for the neonate, unless breastfeeding is specifically referenced, in which case the term ‘mother’ is used.

Central nervous system (CNS): The neurological system, comprising the brain and spinal cord, responsible for receiving, processing, and responding to sensory information (Thau et al., 2022).

Cerebral Functioning Monitoring (CFM): A non-invasive brain monitoring device that records sudden changes or stability in neural functioning (Britton et al., 2016). It evaluates trends in electrocortical background activity over a prolonged period to allow for continuous monitoring of cerebral activity, including seizures. This method is based on filtered and compressed electroencephalogram (EEG) that is presented as a relatively simple pattern, i.e., amplitude-integrated encephalograms (aEEG) (Hellström-Westas, 2018; Orman et al., 2018; Variane et al., 2022). Possible aEEG patterns and their clinical significance are indicated in Table 1.

An abnormal aEEG (DNV, CLV, burst suppression, flat trace) is, therefore, defined as one that qualifies a neonate for cooling treatment (Horn et al., 2013a).

Table 1. aEEG Patterns and their Clinical Significance

aEEG PATTERN	DEFINITION	CLINICAL SIGNIFICANCE/PROGNOSIS
Continuous normal voltage (CNV)	Organised brain activity ($>10\mu V - >5\mu V$)	Normal <i>Prognosis:</i> Healthy, term neonate
Discontinuous normal voltage (DNV)	Intermittent levels of lower brain activity, i.e., more variability in background brain activity ($>10\mu V - <5\mu V$)	Moderately abnormal <i>Prognosis:</i> Mild cerebral injury. Normal outcome if only present within the first 6 – 12 hours of life.
Burst suppression	Bursts of activity followed by periods of suppression, i.e., significant variability in brain activity	Moderate to severely abnormal Severely abnormal if prolonged > 24 hrs <i>Prognosis:</i> Moderate to severe cerebral injury. Severe brain damage may result if prolonged.
Continuous low voltage (CLV)	Brain activity is predominantly in the low μV range (around $5\mu V$)	Severely abnormal <i>Prognosis:</i> Severe brain damage
Isoelectric/flat trace	Brain activity is predominantly in the low voltage range or there is no μV activity ($<5\mu V - 0\mu V$)	Severely abnormal <i>Prognosis:</i> Severe brain damage or brain death
Electrical seizure	Sudden, abnormal, and excessive electrical activity in the brain (rapid rise in both lower and upper margins)	Severely abnormal <i>Prognosis:</i> Further brain damage may result

(de Vries & Hellström-Westas, 2005; Glass et al., 2013; Orman et al., 2018; Variane et al., 2022)

Enteral feeds: Nutrition delivered directly to the gut via a tube, i.e., non-oral feeding (Adeyinka et al., 2022). The following enteral feeding methods are referred to in this study:

Nasogastric tube (NGT): A thin, soft tube that is passed through the nose, oropharynx and oesophagus into the stomach for the purpose of transporting food and/or medicine (Sigmon & An, 2022).

Orogastric tube (OGT): A thin, soft tube passed through the mouth, oropharynx and oesophagus into the stomach to transporting food and/or medicine (The Royal Children's Hospital Melbourne, 2017).

Gastrostomy: A surgically placed feeding tube that is inserted directly into the stomach (Sullivan, 2008).

Fibreoptic endoscopic evaluation of swallowing (FEES): An assessment procedure that passes a small flexible telescope through the nose to assess swallow function and aerodigestive safety (Miller et al., 2020).

Hypoxic Ischemic Encephalopathy (HIE): An acquired neurological condition (encephalopathy) that follows an acute perinatal hypoxic-ischemic event that reduced the oxygen supply (hypoxia) and subsequent blood flow (ischemia) to the neonate's brain and other essential organs (e.g., heart and adrenal glands) (Gillam-Krakauer & Gowen, 2022; Hakobyan et al., 2019; Johnston, 2005; Speer & Hankins, 2003; Sugiura-Ogasawara et al., 2019).

Neonatal dysphagia: Dysphagia is a collective term that refers to “any disruption to the swallow sequence that results in a compromise of the safety, efficiency, or adequacy of nutritional intake” (Dodrill & Gosa, 2015, p.24). Neonatal dysphagia can occur in any or all three phases of swallowing (oral, pharyngeal, oesophageal) (Matsuo & Palmer, 2008); (dys = abnormal; phagia = swallowing) (Jadcherla et al., 2009).

Oropharyngeal dysphagia (OPD): Feeding and swallowing difficulties associated with a dysfunction in the oral and/or pharyngeal phase of swallowing (Durvasula et al., 2014).

Neonatal seizure: The neonatal seizure continuum ranges from occurring in isolation, to becoming recurrent, to evolving into status epilepticus (Španělová et al., 2022). Neonatal seizures are often subtle and many may be subclinical, i.e., there are no clinical manifestations such as jerking, eyelid blinking, or lip smacking, particularly after the initial clinical seizure (de Vries & Hellström-Westas, 2005; Variane et al., 2022).

Status epilepticus: A continuous clinical and/or electrical seizure that persists for ≥ 5 minutes, or recurrent seizure activity without returning to a baseline neurological state between seizures (Wylie et al., 2023). Status epilepticus reflects a high seizure burden state associated with mortality or poor neurological outcomes (Saini & Vinayan, 2018).

Neonate: Although the traditional definition of a neonate refers to a newborn infant who is < 28 days of age (World Health Organization, 2023), the term ‘neonate’ in this study refers to a newborn in hospital from birth.

Non-nutritive sucking (NNS): The act of sucking without the ingestion of milk, i.e., sucking on an expressed breast, a pacifier or a finger. NNS occurs at a rate of 2 sucks per second (Lau, 2016).

Nutritive sucking (NS): The ingestion of milk; occurs at a rate of 1 suck per second (Lau, 2016).

Oral feeding readiness: Oral feeding readiness can be defined in two contexts namely, maturational state, and readiness for a specific feeding event.

Maturational state: When a neonate who has been exclusively fed via NGT or OGT is ready to trial oral feeding by breast, cup, bottle, or syringe for the very first time. This form of oral feeding readiness is determined by medical stability criteria, as outlined in Appendix A.

Provided that the neonate does not regress neurologically and/or medically, this form of oral feeding readiness is a static concept (Groote Schuur Hospital, 2019; Jones, 2012).

Readiness for a specific feeding event: After medical stability is established (Appendix A), oral feeding readiness is determined by the neonate's readiness to feed orally at a given feeding time. This form of readiness is dependent on the neonates' level of alertness, physiological state (oxygen saturation (SpO₂), respiratory health, display of stress cues, general movement and muscle tone), and display of hunger cues at that feeding time (Jones, 2012). Oral feeding readiness in this context is referred to in this study.

Penetration: The entry of food particles, liquid, or secretions into the larynx that does not pass below the level of the true vocal folds. Similar to aspiration, penetration can occur before, during, or after the swallow. However, the chemoreceptors in the larynx trigger a protective response to expel the foreign material prior to entry into the airway (Arvedson, 2008). Penetration can only be diagnosed via an instrumental evaluation of swallowing (Cordier et al., 2023).

Physiological stability: The neonate's ability to respond appropriately to environmental factors or return to a state of equilibrium with the removal of inappropriate stimuli. It is a relationship of cause and effect whereby the neonate maintains stable vital signs (heart rate: 100 – 150 beats per minute; respiratory rate: 35 – 50 breaths per minute (Viviers et al., 2016); SpO₂ ≥ 95%), a good skin colour, and a normal fully flexed posture of all limbs at rest during simple handling, and with changes in their environment (Elshazzly et al., 2022; Groote Schuur Hospital, 2019).

Tachycardia: An abnormally rapid heart rate (Mayo Clinic, 2023) of > 150 beats per minute (Viviers et al., 2016).

Respiratory distress: A clinical picture based on observed respiratory signs and symptoms irrespective of aetiology. Clinical symptoms may include (but are not limited to) nasal flaring, irregular breathing (Ersch et al., 2007), and inspiratory stridor (Mathai et al., 2007).

Swallowing: The entire progression from milk getting, its placement in the mouth and the propulsion of the milk bolus to the automatic motor response of the muscles of the respiratory and gastrointestinal (GI) tracts to transport the liquid into the upper oesophagus. Swallowing, in addition to providing nourishment and hydration, also functions to clear secretions, including mucus and regurgitated stomach contents, out of the oral cavity and pharynx, thereby aiding in protecting the airway (Arvedson et al., 2020).

Oral phase of swallowing: In neonates, this phase is characterised by latching to the breast or bottle nipple, extracting the milk, lingual-palatal coordination, and transporting the milk bolus posteriorly (Arvedson et al., 2020; Jadcherla, 2016).

Pharyngeal phase: Characterised by the propulsion of the bolus through the pharynx and into the open upper oesophageal sphincter (UOS) while maintaining the safety of the airway (Jadcherla, 2016).

Therapeutic hypothermia (i.e., cooling): Intentional and controlled lowering of the neonate's body temperature to between 33°C and 34°C for 72 hours, via either selective head cooling or whole-body cooling to achieve a therapeutic benefit. Subsequently, the neonate's body temperature is rewarmed to the baseline physiologic range (36.7°C – 37.3°C) over the next 6 – 12 hours (Lemyre & Chau, 2018).

Videofluoroscopic swallow study (VFSS): Also referred to as a modified barium swallow study (MBSS), VFSS is an x-ray technique that provides real-time moving images of the oral, pharyngeal, and oesophageal phases of swallowing and the interaction between these phases while the neonate swallows milk with barium. VFSS enables analysis of the swallowing process from the start of the oral phase to the onset of the oesophageal phase, permitting the detection of aspiration and information about the timing and physiological cause/s of aspiration (Roig-Quilis, 2015).

Abbreviations

aEEG	amplitude-integrated electroencephalography
CFM	cerebral functioning monitoring
CNS	central nervous system
CNV	continuous normal voltage
DNV	discontinuous normal voltage
FEES	Fiberoptic endoscopic evaluation of swallowing
GOR	gastro oesophageal reflux
HIE	hypoxic ischemic encephalopathy
HREC	Human Research Ethics Committee
MBS	modified barium swallow study
MMH	Mowbray Maternity Hospital
N	total number of participants in the <i>sample</i>
n	total number of participants in the <i>group</i>
n/a	not applicable
NR	Not reported
NFAS	Neonatal Feeding Assessment Scale
NGT	nasogastric tube
NNS	non-nutritive suck/non-nutritive sucking
NS	nutritive suck/nutritive sucking
OGT	orogastric tube
OPD	oropharyngeal dysphagia
SLT	speech-language therapist/speech-language therapy
SpO ₂	oxygen saturation
SSB	suck-swallow-breathe
UCT	University of Cape Town
UOS	upper oesophageal sphincter
LOS	lower oesophageal sphincter
μV	voltage
VFSS	videofluoroscopic swallow study
WMA	World Medical Association

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1. Introduction

“Breathing and eating are the most basic physiologic functions defining the beginning of life for newborns outside of the womb” (Arvedson et al., 2020, p. 1). However, for neonates with hypoxic ischemic encephalopathy (HIE), these ‘basic’ functions may not come easily (Arvedson et al., 2020). HIE is one of the most serious birth complications that affects full term neonates and despite medical advances such as therapeutic hypothermia, it remains a major cause of life-long disability and mortality worldwide (United Nations, 2015).

The term HIE describes an acquired neurological condition that follows an acute perinatal hypoxic-ischemic event, which reduced the oxygen supply (hypoxia) and subsequent blood flow (ischemia) to the neonate’s brain and other essential organs (e.g., heart and adrenal glands) (Gillam-Krakauer & Gowen, 2022; Hakobyan et al., 2019; Johnston, 2005; Speer & Hankins, 2003; Sugiura-Ogasawara et al., 2019). Although dependent on the extent of the cerebral injury, neonates with HIE are likely to present with varying degrees of encephalopathy, including a depressed level of consciousness, difficulty initiating and maintaining respiration, hypotonia, seizures, and weakened reflexes including delayed or absent feeding and swallowing responses (Gillam-Krakauer & Gowen, 2022; Gunn & Thoresen, 2019; Johnston, 2005; Sarnat & Sarnat, 1976; Shalak et al., 2003; Thompson et al., 1997). Thus, HIE has been referred to as a possible neurological cause of oropharyngeal dysphagia (OPD) (Da Costa et al., 2019; Krüger et al., 2017; 2019; Martinez-Biarge et al., 2012).

Although the prevalence and incidence of OPD in neonates with HIE is unknown, an increase in the frequency of neonatal dysphagia has been reported internationally, possibly attributable to the improved survival rates of neonates with medically complex conditions and the growth of the medical field of speech-language therapy (Jadcherla, 2016). Developing countries such as South Africa may be predisposed to higher prevalence rates for HIE and consequent OPD.

The complexity of the neuronal sucking network means the skill of sucking provides unique insights into the areas of the brain that may be damaged either before or during the birthing process (Martinez-Biarge et al., 2012; Quattrocchi et al., 2010). Thus, the interpretation of sucking and swallowing behaviours in neonates with HIE may guide therapy, and potentially mediate the damage early in life when neuroplasticity is high (Shandley et al., 2021). Evidence-based early intervention may assist in reducing the negative sequelae associated with OPD (Jadcherla, 2016; Larson-Nath & Biank, 2016; Shields et al., 2012), aspiration associated respiratory disease (Durvasula et al., 2014; Weir et al., 2007), interrupted feeding interactions, psychological distress symptoms in the caregiver (Franklin & Rodger, 2003; Jonsdottir et al., 2021; McDonald et al., 2013; Zanardo et al., 2017), and the length of

hospitalisation (American Academy of Pediatrics, 2008). This study, therefore, arose from a need to explore the feeding and swallowing characteristics of neonates with HIE at the introduction of oral feeds, including factors related to oral feeding readiness, and the possible clinical signs and symptoms of OPD that they may exhibit. This information may provide valuable insight into feeding and swallowing in neonates with HIE, which could be used to inform clinical practice.

2. Literature Review

South Africa is classified by the World Bank as an upper to middle income developing country (World Bank, 2023). However, inequality levels are high, and social determinants of health (e.g., unemployment, poverty, housing, and sanitation) are a cause for concern. These factors play a pivotal role in the disease patterns experienced in the country (Bradshaw et al., 2019). The National Burden of Disease (BOD) study in 2000 was the first to portray South Africa's unique quadruple BOD profile – described as a collision of four epidemics: communicable diseases (e.g., human immunodeficiency virus (HIV) and tuberculosis (TB)), non-communicable diseases (e.g., cancer and diabetes), maternal and/or perinatal conditions (e.g., HIE, prematurity and low birth weight (LBW)), and injury related trauma (e.g., violence and car accidents).

Although there has been a decline in mortality since 2000, South Africa still maintains a quadruple BOD status (Achoki et al., 2022; Bradshaw et al., 2003; Chopra et al., 2009; Pillay-van Wyk et al., 2016; World Health Organization, 2018). The country's BOD profile is twice as large as that of other developing countries, and four times greater than that of developed countries where the BOD is mainly from non-communicable diseases (Econex, 2009). With respect to the maternal and/or perinatal conditions category, the 2017 National Health Insurance White Paper reported that the incidence of disease was two to three times higher in South Africa compared with the average of other similar developing countries, and approximately 1% higher than the global BOD (Department of Health, 2017; Fisk et al., 2011). The high BOD in South Africa is noteworthy because neonates form part of a vulnerable population (Sarin, 2020) and thus, are at an increased risk for the conditions within the BOD categories, adversely impacting mortality rates and resulting in morbidity such as neurodevelopmental delays and/or disorders (Lu et al., 2016; Rocha et al., 2021).

Intrapartum-related complications, including intrapartum hypoxia and subsequent HIE, are reported as the second most prevalent cause of neonatal deaths in South Africa (Masaba & Mmusi-Phetoe, 2020). It is, however, difficult to determine the exact incidence of HIE as reports vary. Horn et al. (2013a) reported an incidence of 2.3 – 4.3 per 1000 live births in neonates diagnosed with HIE in public facilities in the Southern Cape peninsula between September 2008 and March 2009. In another South African study conducted in a public government hospital in Johannesburg, the incidence of HIE was reported as 8.5 – 13.3 per 1000 live births per annum (Bruckmann & Velaphi, 2015). A more recent review from a large public tertiary hospital in Gauteng indicated that the moderate to severe HIE rate at primary level ranged from 4.6 per 1000 at the Gauteng clinics, to 1.5 at the district hospital in Soweto (Nakwa et al., 2023). The reported incidence range of 1.5 – 13.3 per 1000 live births in South African

neonates contrasts with the approximate incidence of 1.5 per 1000 live births reported in high income countries (HICs) (Acun et al., 2022).

HIE is a potentially preventable condition and has relatively low incidence rates in HICs with adequate access to well-resourced maternal (including intrapartum) care. In contrast, factors relating to South Africa's developing status predispose the country to higher prevalence rates for HIE. These factors include the high BOD profile, poverty and a high demand for public healthcare services, a limited budget within public healthcare, fewer medical facilities and resources, inadequate ambulance services, and a high patient load with insufficient healthcare workers (Ballot et al., 2020; Cooper, 2015).

The incidence of HIE is also likely to be considerably higher in regions of South Africa with a relatively high number of home births and inadequate availability of medical facilities (Ballot et al., 2020). The mothers in these areas are likely to experience poor access to antenatal care, a lack of specialised professionals during delivery, and an increase in birth related complications, particularly neurological injuries (South Africa & UNDP, 2010; United Nations, 2010). In addition, the unequal distribution of resources in South Africa means that the medical facilities available in low-income areas may lack the level of intensive care required for adequate postnatal care in neonates with suspected HIE, including specialised assessment (i.e., amplitude-integrated electroencephalogram (aEEG)), and therapeutic hypothermia treatment. The limited availability of such care may also lead to adverse long-term outcomes (Cotten & Shankaran, 2010; Iwata et al., 2007; Tagin et al., 2012) placing additional pressure on the already strained healthcare system of South Africa.

The varied incidence of HIE within South Africa, and the higher rate compared with HICs, could also be attributed to the complexity of the condition, varying diagnostic criteria, poor record keeping (Ballot et al., 2020), and mortality and morbidity related information that does not account for deaths or disabilities that occurred outside of a health facility. Neonatal mortality and morbidity related information is frequently underreported at a regional and national level (Labadarios et al., 2016). Nevertheless, it is universally agreed that HIE is an important cause of mortality, and for survivors, it may be associated with a substantial burden of impairment including the inability to feed well and swallow safely (Ballot et al., 2020; Krüger et al., 2017, 2019; Malan et al., 2022).

To explore HIE and its possible impact on the development of feeding and swallowing, it is important to first describe the pathophysiology of the cerebral injury and the clinical signs of the associated encephalopathy. At the most fundamental level, a reduction in oxygen (hypoxia) and subsequent blood flow (ischemia) to the neonatal brain results in primary and secondary energy failure within the brain cells and, if prolonged, brain damage may follow (Gillam-Krakauer & Gowen, 2022; Hakobyan et al., 2019; Johnston, 2005; Speer & Hankins, 2003; Sugiura-Ogasawara et al., 2019).

Hypoxia may occur secondary to an adverse event either immediately before, during, or after the birthing process. Although the exact 'event' is not always identified, cord prolapse, uterine rupture, maternal hypertension, breech presentation, and shoulder dystocia are some of the possible antecedents to hypoxia (Allen & Brandon, 2011; Shankaran, 2009). Irrespective of the intrapartum complication, the placental (pre-natal) or pulmonary (immediately post-natal) gas exchange becomes compromised or ceases altogether, and a partial (hypoxia) or complete (anoxia) lack of oxygen to the vital organs results. Consequently, the brain becomes vulnerable to the effects of both hypoxic and ischemic injury and, if prolonged, the tissues and vital organs (muscles, liver, heart, and ultimately, the brain) develop an oxygen deficit that may lead to mixed respiratory and metabolic acidosis (Olofsson, 2023). When a reduction in cerebral blood flow beyond a critical threshold ensues, an immediate decrease in energy production within the brain cells occurs, i.e., primary energy failure, ultimately, leading to ischemic injury to the vital organs, including the brain. The severity of this initial insult sets the stage for further cell death and damage to the brain in the secondary energy failure phase of injury (Gillam-Krakauer & Gowen, 2022; Hakobyan et al., 2019; Johnston, 2005; Speer & Hankins, 2003; Sugiura-Ogasawara et al., 2019).

In the period between the primary and secondary energy failure phase of injury – approximately 6 hours – there is restoration of blood flow, and some brain cells recover. This phase, referred to as the latent phase, is characterised by normal cerebral metabolism and considered to be the optimal period for the initiation of therapeutic hypothermia (Cotten & Shankaran, 2010; Iwata et al., 2007). The 'secondary' brain injury and the adverse sequelae that follow may be minimised when therapeutic hypothermia is initiated appropriately within the latent phase window (Gagne-Loranger et al., 2015).

The secondary energy failure phase of injury, i.e., late neuronal injury, occurs over the next 6 – 48 hours. However, Although the exact mechanism of this secondary injury remains unclear, it appears to be related to oxidative stress, excitotoxicity, inflammation, and reperfusion causing toxic neurotransmitters to be transported to nearby healthy cells, thereby widening the area of the brain injury. As a result, the neonate's central nervous system (CNS) becomes permanently damaged, and encephalopathy ensues (Allen & Brandon, 2011; Gillam-Krakauer & Gowen, 2022). Thus, provided that intrapartum hypoxia is the presumptive cause of the encephalopathy, the acquired neurological disorder that transpires is termed HIE (Sarnat & Sarnat, 1976). The underlying pathologic events of HIE can, therefore, be considered as a series of repeated, evolving insults. However, with appropriate and timely medical care, the severity of the brain injury may be minimised (Allen & Brandon, 2011; Gillam-Krakauer & Gowen, 2022).

The early manifestations of hypoxia may include the presence of meconium-stained fluids (Kumar & Paterson-Brown, 2010), reduced heart rate, decreased movement, low Apgar scores (de Vries &

Cowan, 2009), poor umbilical cord gases (pH < 7.0 or base deficit $\geq$ 12 mmol/L) (Speer & Hankins, 2003), and the need for respiratory support – all of which may lead to HIE (Cotten & Shankaran, 2010). As the brain is highly protected via the blood brain barrier (Kadry et al., 2020), it is typically the last organ in the body to experience injury. Thus, it is characteristic for neonates with HIE to also experience dysfunction in other systems, including the renal, gastrointestinal, metabolic, liver, haematologic, respiratory, and cardiac systems (Kramer, 2017).

Although neonates with HIE frequently require respiratory support, respiratory management can be challenging because the hypoxic-ischemic insult and therapeutic hypothermia have an impact on respiratory functions. Perinatal hypoxia may increase pulmonary vascular resistance, which may be further complicated in the event of apnoea, pulmonary hypertension, micro aspiration syndrome, respiratory distress syndrome, and pulmonary haemorrhage (Rainaldi & Perlman, 2016; Szakmar et al., 2019). In addition, therapeutic hypothermia reduces the neonate's metabolic rate with a parallel reduction in oxygen utilisation and carbon dioxide production (Yenari & Han, 2012), and potentially compromises respiratory muscle function (Mills et al., 1997). In contrast, studies have shown that for neonates receiving ventilation, hypothermia can potentially increase minute ventilation and tidal volume with an improvement in oxygenation levels (Cavallaro et al., 2011; Dassios & Austin, 2014). Although contradictory results have been reported, it is universally acknowledged that neonates with HIE face an increased risk of altered respiratory function. They may require ventilation or additional respiratory support on admission and for the first few days of life, particularly during the hypothermia treatment period (Dassios & Austin, 2014; Mills et al., 1997; Szakmar et al., 2019; Thoresen, 2008; Yenali & Hal, 2012).

The risk for developing seizures is at its highest during the neonatal period, and studies have found that HIE is the most common aetiology (Jensen, 2009; Ronen et al., 1999). Glass et al. (2016) reported that within their sample of 426 neonates with seizures, 38% were diagnosed with HIE, more than double any of the other 'common' aetiologies for seizures (ischemic stroke: 18%; intracranial haemorrhage: 11%). The enhanced vulnerability for seizures during the neonatal period results from an imbalance between the excitatory and inhibitory neurotransmitters in the immature brain compared with the developed brain. Although this developmental mismatch is important for the development of neural circuitry, it increases a neonate's susceptibility to seizures (Shetty, 2015). Neonates are also more susceptible to neuronal complications if there are fluctuations in their temperature, blood glucose levels and oxygen requirements. For neonates with HIE, seizures may occur as a transient response to their acute cerebral pathology, which may be the first or – in some cases – only manifestation of a cerebral injury (Glass et al., 2016).

Neonates with HIE may, therefore, experience a culmination of multiple symptoms and present with a spectrum of clinical signs, shifting from asymptomatic to demonstrating varying degrees of encephalopathy. However, in keeping with the pattern of energy failure, these clinical symptoms may vary within the first few days of life (Gunn & Thoresen, 2019; Sarnat & Sarnat, 1976a; Thompson et al., 1997). The severity of the encephalopathy and the prevalence of the associated morbidities will also differ depending on the severity of the brain injury, the availability of appropriate medical interventions, and the timing of treatment.

The evolving nature of HIE means that daily clinical assessment is required prior to establishing a final or discharge severity diagnosis. Grading systems that describe the severity of HIE according to mild (stage 1), moderate (stage 2), or severe (stage 3) clinical signs are based on the original clinical observations made by Sarnat and Sarnat (1976) and adapted over time, e.g., the modified Sarnat encephalopathy grading system (Shalak et al., 2003). Other severity grading systems include a numerical score, e.g., the Thompson Encephalopathy score (Thompson et al., 1997) or instrumental assessment such as amplitude-integrated electroencephalography (aEEG). Resource-permitting, an aEEG is the optimum clinical marker for neonates who have, or who are at risk for, developing moderate to severe HIE (Chandrasekaran et al., 2017; Hallberg et al., 2010; Horn et al., 2013a) thus, aEEG monitoring will be described first.

Amplitude-integrated electroencephalography (aEEG)

In 1995, Hellström-Westas et al. described a pattern-based recognition system, which has been re-defined according to the voltage changes exhibited on the cerebral functioning monitoring (CFM) device (Hellström-Westas et al., 2006). According to this classification system, the aEEG background is classified as either normal (continuous normal voltage (CNV)), moderately abnormal (discontinuous normal voltage (DNV)), or severely abnormal (continuous low voltage (CLV), burst suppression, or an isoelectric/flat trace).

Prior to the implementation of therapeutic hypothermia, a severely abnormal aEEG background pattern within the first 3 – 6 hours of life was significantly predictive of a poor prognosis (Eken et al., 1995; Hellström-Westas et al., 1995; Toet et al., 1999). The prognostic implications of a DNV background pattern were, however, unclear, with researchers reporting both normal and severely abnormal outcomes. Therefore, neonates with a DNV aEEG background are still considered to benefit from cooling (Thoresen et al., 2010).

Although an abnormal aEEG is defined as one that qualifies a neonate for cooling (DNV, CLV, burst suppression, isoelectric/flat trace) (Horn et al., 2013b), the aEEG pattern post therapeutic hypothermia has been reported to hold a higher predictive value, while the recovery time to a normal background

pattern holds the best prognostic value (Chandrasekaran et al., 2017). More specifically, neonates with an abnormal initial aEEG pattern followed by a CNV at 48 hours are likely to have normal outcomes. Conversely, neonates with an abnormal aEEG pattern at 48 hours, or a persistently abnormal aEEG pattern despite therapeutic hypothermia, are likely to have a poor prognosis or later neurodevelopmental disability. The predictive value of an aEEG is, therefore, altered in the event of therapeutic hypothermia treatment (Azzopardi et al., 2008; Chandrasekaran et al., 2017; Hallberg et al., 2010; Pu et al., 2021; Simbruner et al., 2010; Spitzmiller et al., 2007; Thoresen, 2008; Weeke et al., 2017).

Thus, an aEEG pattern at or before age 6 hours is valuable in determining eligibility for cooling (i.e., DNV, CLV, burst suppression, isoelectric/flat trace), but continuous aEEG monitoring throughout the duration of the therapeutic hypothermia treatment, or at age 48 hours, allows for a more accurate prediction of neurodevelopmental outcomes (Azzopardi et al., 2008; Chandrasekaran et al., 2017; Hallberg et al., 2010; Pu et al., 2021; Simbruner et al., 2010; Spitzmiller et al., 2007; Thoresen, 2008; Weeke et al., 2017). aEEG assessment is especially valuable in detecting electrophysiological abnormalities associated with seizures and ensuring timely treatment given that neonatal seizures are often not clinically apparent (de Vries & Hellström-Westas, 2005; Hellström-Westas, 2018). In contrast with clinical assessments of a more subjective nature, the aEEG may be sent for a second opinion or expert review because it is an objective measure of recording severity (Weeke et al., 2017). To date, aEEG monitoring is the preferred choice for bedside CFM to determine the initial course of management, evaluate therapeutic responses if appropriate, determine the subsequent direction of care, and guide parental counselling (Massaro et al., 2012).

Thompson encephalopathy score

The Thompson Encephalopathy Score developed by Thompson et al. (1997) allows for a precise clinical description of infants by assigning a numerical score rather than a severity rating of mild, moderate, or severe. This scoring system was derived from a set of nine clinical signs associated with CNS dysfunction, namely: tone, level of consciousness (LOC), seizures, posture, moro, grasp, suck, respiratory pattern, and fontanelle, as indicated in Table 2. Each sign is assigned a score from 0 (normal) to 3 (severely abnormal), or a maximum of 2 for some, to collectively add up to a score out of 22 with the maximum score representing the worst possible outcome.

Table 2. The Thompson Encephalopathy Score

Sign \ Score	0	1	2	3	Day							
					0	1	2	3	4	5	6	7
Limb tone	Normal	Generally hypertonic	Generally hypotonic	Flaccid								
LOC	Normal	Hyper-alert, staring, or excessive irritability	Lethargic	Comatose or stuporous								
Visible fits	Normal	Infrequent: < 3/day	Frequent: > 2/day									
Posture	Normal	Fisting and/or cycling	Strong distal flexion	Decerebrate								
Moro	Normal	Partial	Absent									
Grasp	Normal	Poor	Absent									
Suck	Normal	Poor	Absent and/or bites									
Respiratory effort	Normal	Hyperventilation	Transient apnoea	Apnoea +IPPV								
Fontanel	Normal	Full	Tense									
TOTAL score												

Notes: LOC, level of consciousness; IPPV, Intermittent positive-pressure ventilation

In the original study, Thompson et al. (1997) concluded that the peak score had the best correlation with outcome. A peak Thompson score of > 10 during the first 7 days of life was associated with an abnormal outcome, while neonates with a peak score of 10 or less, and normal functioning by their seventh day of life, were likely to have normal outcomes. Although this system does not grade the severity of encephalopathy, a peak score of ≤ 10 has since been likened retrospectively to mild HIE, 11 – 14 to moderate HIE and 15 – 22 to severe HIE (Bhagwani et al., 2016). The simple design means that specific training is not required – each sign is scored individually, and signs that are associated with the different levels of severity are allowed to co-exist without influencing the final score, similar to the modified Sarnat encephalopathy grading system.

The Thompson scoring system was, however, developed in the pre-cooling era. Therefore, its ability to prognosticate on or before 6 hours of life for the initiation of therapeutic hypothermia treatment was not of particular importance. Hypothermia and pharmacological intervention such as sedation may falsely inflate the peak score, inaccurately representing the severity of the CNS dysfunction based on the original severity parameters set by Thompson et al. (1997). Furthermore, the application of therapeutic hypothermia itself may significantly influence short and long-term outcomes and the prognostic value of the peak Thompson score (Thorsen et al., 2016). Nevertheless, there is still value in the Thompson scoring system within resource constrained settings where there is great interest in its ability to prognosticate on or before 6 hours of life to allow for rapid triage of neonates for therapeutic hypothermia (Horn et al., 2013a). Horn et al. (2013b) analysed the predictive value of Thompson scores on abnormal 6-hour aEEGs, concluding that a Thompson score ≥ 7 at age 3 – 5 hours

predicted an abnormal aEEG at age 6 hours, and moderate to severe encephalopathy defined according to the modified Sarnat encephalopathy grading system at age 72 hours. Neonates with a score of < 7 did not present with an abnormal aEEG at age 6 hours and did not develop moderate to severe HIE. Hence, a Thompson score ≥ 7 is currently used as a benchmark at Mowbray Maternity Hospital (MMH, Cape Town, South Africa) in selecting neonates for cooling, while a Thompson score exceeding 7 has also been reported as an entry criterion for the initiation of therapeutic hypothermia (Groenendaal et al., 2013).

The Thompson score also provides some insight into early neonatal outcomes, such as the median length of stay and the need for antiseizure medication at discharge (Maphake et al., 2023). However, there is a lack of consensus about the Thompson scores that predict adverse short- and long-term outcomes in neonates who received therapeutic hypothermia treatment. Thorsen et al. (2016) demonstrated that in cooled neonates, a Thompson score ≥ 12 within 2 hours after birth was associated with increased odds for death before discharge and the development of severe seizures, compared with neonates with a Thompson score < 12 at admission. However, Weeke et al. (2017) reported that scores of ≥ 11 prior to the initiation of therapeutic hypothermia were associated with adverse outcomes post cooling. While it is universally agreed that higher Thompson scores are associated with more unfavourable outcomes, the score parameters for adverse outcomes in the era of therapeutic hypothermia remain unclear. In addition, the lack of uniformity in definitions of adverse outcomes and the varying cut-offs for the application of therapeutic hypothermia treatment hamper comparisons between studies. Further work related to the Thompson score as a predictive measure of assessment is warranted to better inform neurodevelopmental outcomes (Horn et al., 2013b; Mendler et al., 2018; Thorsen et al., 2016; Weeke et al., 2017).

The Thompson score may be particularly useful for triage of infants for cooling at district or rural facilities where specialist care or equipment such as computed tomography (CT) scanning, magnetic resonance imaging (MRI) or CFM with an aEEG are unavailable (Horn et al., 2013c; Thompson et al., 1997). Decisions regarding further assessment, management and possible referral for cooling within the critical 6-hour window are challenging when specialist resources are lacking.

The modified Sarnat encephalopathy grade

The modified Sarnat encephalopathy grade, developed by Shalak et al. in 2003, determines the presence of encephalopathy based on one or more clinical signs in at least three of the following six categories: level of consciousness, spontaneous activity, muscle tone, posture, primitive reflexes (suck and moro), and autonomic nervous system (pupils, heart rate and respiration). Mild, moderate, and severe signs are differentiated according to the severity of the impairment within each category, i.e., normal/exaggerated (mild); lethargic/decreased/weak (moderate); coma/absent (severe) as shown in

Table 3. Ultimately, the degree of encephalopathy is determined based on the number of mild, moderate, or severe clinical signs demonstrated. However, if these signs are equally distributed, the final severity grade is determined by the neonate's level of consciousness.

Table 3. *The Modified Sarnat Encephalopathy Grading System*

CLINICAL SIGN	MILD	MODERATE	SEVERE
Level of consciousness	Hyperalert	Lethargic	Stupor or coma
Spontaneous activity	Normal	Decreased	No activity
Muscle tone	Normal	Hypotonia	Flaccid
Posture	Normal	Distal flexion	Decerebrate
Primitive reflexes			
Suck	Normal	Weak	Absent
Moro	Exaggerated	Weak; incomplete	Absent
Autonomic function			
Pupils	Normal	Constricted	Deviated, dilated or non-reactive to light
Heart rate	Normal	Bradycardia (< 100 bpm)	Variable
Respiration	Normal	Periodic breathing	Apnoea

Note: bpm, beats per minute

Advantages of this grading system are the rapid administration, and the fact that signs associated with the different levels of severity can co-exist. However, some neonates with moderate to severe HIE may not initially fulfil the moderate to severe criteria despite abnormal aEEG findings (Horn et al., 2013b; Shalak et al., 2003). In addition, Shalak et al. (2003) reported a low sensitivity in predicting abnormal outcomes by discharge unless features of mild and moderate encephalopathy were both present. Other methods of early clinical assessment, such as the aEEG, may be more accurate in identifying neonates who have or will develop moderate to severe HIE (Horn et al., 2013a).

Globally, medical, surgical, and technical advances in neonatal medicine have improved diagnostics and enhanced survival rates of neonates with complex medical conditions, including those with HIE. As a result, there has been an increase in comorbid conditions associated with survivors (Rommel et al., 2003), including feeding and swallowing difficulties (Da Costa et al., 2019; Schoeman & Kritzinger, 2017). Neonates with moderate to severe HIE may have adverse long-term neurodevelopmental outcomes (Ballot et al., 2020). However, there is a paucity of data regarding the prevalence of OPD within this population. In Krüger et al.'s (2017) study, oral stage dysphagia and early breastfeeding difficulties were reported from birth until day 13 of life in a single neonate with HIE. In the follow-on

study, Krüger et al. (2019) reported that 89% of the 28 neonates with HIE in their study sample presented with at least one symptom of OPD compared with their control group of 30 healthy, term neonates who had no symptoms of OPD. Similarly, Malan et al. (2022) reported that 62.1% of the 29 neonates with HIE in their sample displayed swallowing and feeding difficulties at the start of oral feeding trials, and although the majority were feeding well at the time of discharge, 17.2% persisted with OPD symptoms. Some studies have also associated specific patterns of brain injury in neonates with HIE with the prevalence of the observed feeding difficulties. Martinez-Biarge et al. (2012) investigated the MRI brain scans of 175 term infants with basal ganglia and thalamus lesions following perinatal hypoxic-ischemic injury. They reported that 65% (n = 82) of the 126 surviving neonates had experienced some degree of feeding impairment. Of these, 50% (n = 41) demonstrated severe feeding difficulties with 87.8% (n = 36) requiring gastrostomy feeding and 12.2% (n = 5) needing NGT feeding for a minimum of 6 months.

Other studies have aimed to determine the pre- and perinatal risk factors associated with OPD in high-risk neonates and, subsequently, the incidence of OPD within these categories. Da Costa et al. (2019) conducted a prospective cross-sectional observational study with 81 neonates with various medical conditions. They concluded that neonates with a neurological condition were 3 and a half times more likely to experience OPD compared with those with other underlying conditions. However, it is noteworthy that due to the multitude of risk factors, and because risk factors were not assessed in isolation, participants may have presented with numerous factors that could have collectively influenced their feeding and swallowing development. The increased risk of OPD in neonates with HIE emphasises the need for appropriate early clinical assessment to prevent adverse consequences, including morbidity or feeding difficulties continuing into infancy and early childhood.

Feeding and swallowing difficulties, also referred to as dysphagia, are defined as “any disruption to the swallow sequence that results in a compromise of the safety, efficiency, or adequacy of nutritional intake” (Dodrill & Gosa, 2015, p.24). OPD is a combination of difficulties that occur in the oral and pharyngeal phases of swallowing (Jadcherla & Viswanathan, 2020), and has been reported in neonates with HIE (Krüger et al., 2017, 2019; Malan et al., 2022; Martinez-Biarge et al., 2011, 2012). Before exploring the relationship between HIE and OPD, the related physiology will be explored within the context of feeding and swallowing development in healthy, term neonates.

Neonates present with feeding and swallowing characteristics that are inherent to their stage of development to support their physiological needs. Successful feeding and swallowing require a synchronised interplay of the neonate’s anatomical structures, oral sensorimotor and swallowing skills, central nervous system (CNS) integration, muscle tone and posture, and overall health including respiratory, cardiac, and gastrointestinal function. Feeding is an interactive process and the neonate’s

interaction with their immediate environment, and their environment with them, in turn, is of equal importance (Arvedson, 2006; Arvedson & Lefton-Greif, 2020; Delaney & Arvedson, 2008a; Isaac & Choi, 2023; Lefton-Greif & Arvedson, 2016; Matsuo & Palmer, 2008; Miller, 2008; Rogers & Theis, 2020a; Walker, 2011).

Oral feeding readiness

Several models and theoretical approaches have been developed to describe typical neonatal feeding development, and have subsequently been used to address the complexity of OPD in the neonatal population. In this study, the Synactive Theory of Development by Heidelise Als (1982) has been used to describe oral feeding readiness, neonatal feeding development, and OPD. The Synactive Theory of Development groups neonatal behaviours according to the five subsystems of development – the autonomic nervous system, behavioural system, motor system, attention-to-interaction system, and self-regulation system. Als (1982) acknowledged that at each stage in development and at each moment in functioning, these subsystems exist side by side. Although they develop independently in utero and in the neonate, systemic functioning is interdependent and interrelated, and development occurs interactively with the environment. The model focuses on how the individual neonate manages individual experiences through subsystem interaction rather than on the functioning of each subsystem in isolation (Als, 1982, 1995), and is useful for facilitating understanding of neonatal behaviour. The model is still widely applied in research and clinical practice, and helps health care professionals by providing a theoretical framework for observing a neonate's processing of incoming sensory information within a medical context, i.e., self-regulation and the resultant impact on systemic functioning and interaction (McGrath & Medoff-Cooper, 2002; Pickler, 2004; Vandenberg, 2007).

Als' model of development enables SLTs to categorise feeding difficulties according to the neonate's ability to manage environmental inputs, which may in turn inform factors related to oral feeding readiness and subsequent oral feeding performance (Jones, 2012; Karl, 2004; McGrath, 2004; Pickler, 2004). Thus, neonatal feeding and swallowing difficulties can be considered as multi-factorial and complex in nature. For neonates with HIE, this may be attributed to their neurological compromise, their associated medical co-morbidities, and the neonate's limited ability to tolerate stress or self-regulate (Arvedson et al., 2020; Jadcherla, 2016). However, the manifestation of these feeding difficulties may vary greatly depending on the severity and site of the brain injury, the accompanying comorbidities, and stability of the autonomic nervous system (Durvasula et al., 2014).

At the most fundamental level, a healthy, term neonate is equipped with an internal need to self-regulate, and in doing so defend themselves against inappropriately timed stimulation or stimulation that is too complex or intense, i.e., developmentally inappropriate. In contrast, a neonate will search and move towards a source of stimulation while maintaining a stable, balanced state, when it is suitably

timed and developmentally appropriate. In the context of daily interactive care, the tasks involved in self-regulation include the regulation of physiological functioning, such as the maintenance of body temperature, regulation of day-night cycles, homeostasis of breathing, heart rate and visceral control, control of motor behaviours, sleep-wake-cycles, and attention and interaction. Thus, adequate self-regulatory systemic functioning is at the core of the Synactive Theory of Development and observable through the neonate's ability to regulate and control behaviour expressed through the achievement and maintenance of adequate autonomic, motor, behavioural, and attention-interaction sub-system functioning (Als, 1982, 1995).

The autonomic nervous subsystem refers to the neonate's baseline functioning. It lies at the innermost position of systemic functioning and is observable through vital functions such as cardiac and respiratory frequency, temperature regulation, and colour changes. Therefore, the primary goal in the NICU is adequate functioning of the autonomic nervous system from which all other developmental tasks will follow, including the initiation of oral feeding (Als, 1982; Maltese et al., 2017).

Safe, efficient, and effective feeding is integral to a well-coordinated and sustained suck-swallow-breathe (SSB) sequence at the breast or bottle, accompanied by autonomic nervous system stability (Lau, 2015). Healthy, term neonates are typically able to simultaneously coordinate the suck/swallow and swallow/respiration functions while momentarily inhibiting their breathing and maintaining a stable, balanced state (Arvedson et al., 2020; Isaac & Choi, 2023; Lau, 2015). This highly complex sensorimotor process is one of several processes by which the airway is protected, creating airway and cardiac stability. Autonomic nervous system stability is of critical importance and a foundation of oral feeding. Physiologically stable newborns are more likely to feed successfully and meet their metabolic requirements via oral means and, therefore, a consistently stable autonomic nervous system is likely to aid in the timely transition to full oral feeds (Arvedson, 2006, 2008; Delaney & Arvedson, 2008; Enrique et al., 2011; Isaac & Choi, 2023; Rogers & Arvedson, 2005).

Physiological stability for feeding may be influenced by medical morbidity, demands on the synactive system by medical or nursing tasks prior to the feed, pre-feeding arousal level, oro-motor maturity, and previous feeding experience (Ross & Philbin, 2011). As hypoxic-ischemic injury alters the physiology of transition to extrauterine life, a deleterious impact on respiratory and cardiac functions may result (Sweet et al., 2017). Although the exact prevalence of altered respiratory or cardiac functions is unknown, abnormal breathing patterns during feeding have been reported in neonates with HIE (Malan et al., 2022), indicating that the initiation of oral feeding may have been inappropriately timed or developmentally inappropriate (Jones, 2012; McGrath, 2004; Pickler, 2004).

Neonates with a compromised respiratory system or autonomic system instability are more likely to have difficulty integrating their respiration with feeding, sustaining their nutritive suck (NS) during oral feeds (Arvedson, 2008; Gewolb & Vice, 2006; Pinnington et al., 2000), and achieving and maintaining control in their other subsystems (Als, 1982; Porges & Furman, 2011). As a result, they are more likely to present with a poorly coordinated SSB sequence, reduced feeding endurance (Arvedson, 2008; Gewolb & Vice, 2006; Pinnington et al., 2000), and poor interaction between subsystems (Als, 1995; Pickler, 2004; Porges & Furman, 2011). The occurrence of respiratory problems or autonomic system instability may therefore increase the risk of aspiration and slow weight gain or weight loss, consequently delaying the initiation of safe and efficient oral feeding (Barlow, 2009; Hu et al., 2022; Krüger et al., 2017, 2019).

Although physiological stability is the primary requirement for oral feeding success, the neonate must achieve motor control or motor subsystem stability to support safe and efficient oral feeding. A stable motor subsystem comprises adequate muscle tone and a flexed posture to facilitate body alignment and movement, including oral movement (McGrath, 2004; Pickler, 2004; Thomas, 2007). Hence, neonates with inadequate postural tone are at increased risk of experiencing feeding and swallowing difficulties (Wahyuni et al., 2022). A floppy/extended position during feeding may influence the initiation, sequencing, and timing of oral-pharyngeal movements, and the integration of these motoric actions with respiration. The maintenance of alignment and posture also requires additional energy expenditure that may lead to both muscular and respiratory fatigue, which together contribute to a general state of exhaustion and further compromise feeding safety and efficiency as a result (Thoyre et al., 2005). In Wahyuni et al.'s (2022) sample of 120 preterm neonates, the neonates with inadequate postural tone had more than double the risk of oral feeding difficulties than those with normal postural tone (prevalence ratio of 2.25; $p < 0.001$). This finding emphasises the importance of the oral structure alignment for feeding, which cannot be separated from head and trunk stability, i.e., motor subsystem stability (Wahyuni et al., 2022).

Neurological involvement means that neonates with HIE are likely to present with poor or abnormal general movement and muscle tone (Straathof et al., 2022) attributed to central nervous system dysfunction (Allen & Lipkin, 2005). Krüger et al. (2019) reported that 89.2% ($n = 25$) of the neonates with HIE in their sample presented with abnormal muscle tone of either hypertonicity (78.5%; $n = 22$) or hypotonicity (10.7%; $n = 3$). The abnormal muscle tone may have increased the risk of oral sensorimotor dysfunction, contributed to poorly controlled and ineffective SSB sequences, increased the risk of fatigue during feeding and of penetration and/or aspiration (Rogers & Theis, 2020).

A neonate with poor motor control may also move into a disorganised behavioural state when oral feeding is attempted (McGrath, 2004; Pickler, 2004; Thomas, 2007). As the behavioural, autonomic,

motor and self-regulatory systems are tightly coupled, the functioning and stability of the neonate's behavioural system can be determined by observing their unique pattern of behavioural and physiological cues (Porges & Furman, 2011). The behavioural system refers to the states of consciousness, sleep, wakefulness, and agitation; ability of the neonate to transition from one state to another, and the presence and duration of individual states (Als, 1982; Brazelton & Nugent, 1995; Maltese et al., 2017). Behavioural states are characterised by the physiological and behavioural patterns exhibited in the neonate and indicate the newborn's responsiveness to the environment (Karl, 2004) and the underlying activation of their central nervous system (Pfaff et al., 2008). Typically, neonates exist in a singular behavioural state at any given moment, cycling through a continuum of six states determined by the developmental task of life that is set before them or environmental stressors. Newborn behavioural states comprise two sleep states (deep sleep and light sleep), two transitional states (drowsy and quiet alert), and two awake states (active alert and crying) (Als, 1982; Brazelton & Nugent, 1995).

'Organised' newborns will experience all behavioural states at one time or another according to a pre-determined organisational pattern. As a result, they are more likely to achieve developmental success, including with oral feeding (Als, 1982; Brazelton & Nugent, 1995). A neonate's ability to regulate their state and come to a quiet alert state is also indicative of adequate functioning and stability of their attention-interaction system. The attention-interaction system is important for effective feeding because attentive neonates are more available for task mastery (White et al., 2002). They are also more responsive to environmental stimuli, and therefore, more likely to interact with their caregiver through eye contact and maintaining mutual gaze in support of infant-caregiver attachment. Neonates with adequate internal state control will alternate between states as they complete tasks, with limited frequency of change and minimal leaps over the state continuum. A well-organised neonate will also tolerate a reasonable amount of stimulation prior to becoming overwhelmed and signalling stress as a result. Yet, once in a stressed state, they will be more equipped to regain state control through self-soothing manoeuvres such as hand-to-mouth for the initiation of sucking, thereby demonstrating adequate functioning and stability of their self-regulation system (Karl, 2004).

Although the quiet alert state is considered the 'latchable' state, i.e., the optimal state of alertness for feeding, it is not easily achieved in the newborn period. In the first few weeks of life, newborns undergo organisational maturity and will initially respond to hunger with signs of drowsiness, fussiness, or crying rather than waking and immediately becoming alert and quiet. As a result, mothers often use situational stimuli to re-establish state control, such as bringing the baby to the breast to smell the milk. Newborns with adequate internal state control will easily regain control and engage in the feed actively and successfully (Karl, 2004).

In contrast, a disorganised neonate may appear to linger in one state and possibly exclude some states altogether. They are likely to have more difficulty in accomplishing tasks such as latching onto and maintaining the maternal nipple (Karl, 2004), and maintaining an appropriate state for feeding (Arvedson, 2008) – as observed in neonates with HIE (Krüger et al., 2017, 2019; Malan et al., 2022). Central to the feeding difficulties of neonates with HIE is their non-optimal state of alertness during feeding that may be secondary to the cerebral depression following the hypoxic-ischemic injury (Volpe, 2012) and possibly further influenced by the sedative effect of anticonvulsant medications (Mutanana et al., 2020). Krüger et al. (2017, 2019) and Malan et al. (2022) reported that neonates with HIE primarily present with closed eyes and minimal movement during feeding, characteristic of the sleep states. In contrast, the control group in Krüger et al.'s (2019) study demonstrated the ideal feeding behaviour of open eyes, eye contact, and minimal movement, characteristic of the quiet-alert state. Krüger et al. (2017) found NGT top-ups were required until day 13 of life because of the neonates' inability to complete all feeds orally, possibly because of inadequate state regulation and reduced endurance, thus representing a contributing factor to prolonged hospitalisation (American Academy of Pediatrics, 2008). Malan et al. (2022) also observed that 5 of the 29 (17.2%) participants in their study still presented with a non-optimal state of alertness for feeding at the time of discharge.

Als (1982, 1995) viewed the behavioural states as existing in an arousal paradigm, a useful framework for analysing breastfeeding difficulties related to non-optimal states of alertness. According to this paradigm, the sleep and drowsy states observed in the studies by Krüger et al. (2019) and Malan et al. (2022) were under-arousal patterns of alertness. Although newborns generally enter a state of either under (drowsy) or over (agitated/crying) arousal prior to establishing a quiet alert state for feeding, neurologically compromised newborns may have difficulty transitioning from unconscious sleep to conscious wakefulness because that requires a major behavioural shift and neurological reorganisation (Pal et al., 2016). Therefore, neonates with HIE may require increased or decreased stimulation to reach an optimal state of arousal for feeding (Karl, 2004; Thoyre et al., 2005; White & Parnell, 2013). Thus, the under-arousal pattern of alertness during feeding, as reported by Krüger et al. (2017, 2019) and Malan et al. (2022), suggests that those neonates were not ready to feed orally (Karl, 2004; Thoyre et al., 2005; White & Parnell, 2013). Poorly timed stimuli may infiltrate and disrupt all subsystems, whereas appropriately timed stimuli appear to maintain and enhance functional integration and support growth (Als, 1982, 1995). The ability to manage and integrate all five systems of development without stress is a chief component of early development and essential for oral feeding success, emphasising the importance of accurately reading and interpreting neonatal behavioural cues (Vandenberg, 2007).

Safe and efficient oral feeding also requires adequate and well-integrated oral-motor skills, and a synchronised interplay between the three main phases of swallowing: (1) the oral, (2) pharyngeal, and (3) oesophageal phases. Each phase serves a specific function that is orchestrated by specific areas in the brain and cranial nerves (Mistry & Hamdy, 2008; Shandley et al., 2021) and determined according to the location of the bolus (Arvedson & Lefton-Greif, 2020; Viswanathan & Jadcherla, 2020).

Feeding in the neonatal period is reflexive in nature. Central pattern generators (CPGs) located within the brainstem are at the core of this system and have been shown to generate a basic swallow without additional input (Barlow, 2009; Mistry & Hamdy, 2008; Poore & Barlow, 2009). The CPGs regulate the timing of the oral, pharyngeal, and oesophageal phases with the peripheral manifestation relying on sensory feedback through the reflexes of the pharynx and oesophagus. The second level of control involves subcortical structures, including the basal ganglia, hypothalamus, amygdala, and tegmental area of the midbrain with a third level in the suprabulbar cortical swallowing centre (Mistry & Hamdy, 2008). Integration of these three levels of control is required to coordinate the oral, pharyngeal, and oesophageal phases in nutritive swallowing (Shandley et al., 2021).

The oral phase of swallowing

The oral phase of swallowing encompasses bolus formation, although minimal, through anticipatory actions (i.e., rooting reflex), latching (breast or bottle), sucking (including SSB coordination), and bolus management (Delaney & Arvedson, 2008; Enrique et al., 2011; Isaac & Choi, 2023). The rhythmic nature of the SSB process means the oral phase of swallowing is an automated sequential motor pattern shaped and organised by the CPGs (Jean, 2001; Miller, 1986). Adequate neuromuscular control and functioning will enable healthy, term neonates to obtain their primary nutrition through breastfeeding or bottle feeding while exhibiting an effective and well-coordinated SSB sucking response (Shandley et al., 2021).

Nutritive sucking, which implies the ingestion of milk, occurs at a rate of one suck per second compared with a rate of two sucks per second during non-nutritive sucking, to allow for the suck/swallow and swallow/respiration functions to be correctly and timeously integrated for airway safety (Viswanathan & Jadcherla, 2020). The neonate's lips will function to locate the nipple and together with their tongue, draw the nipple into the mouth and stabilise its position. Following adequate nipple placement, a deep latch onto the whole nipple and some of the areola will be established. An NS will be initiated and the latch will be maintained (Enrique et al., 2011; Isaac & Choi, 2023). An NS that utilises the suction and compression components effectively will ensure sufficient oral intake and weight gain over time. The suction component is a requirement for breastfed neonates to enable them to latch onto and maintain the maternal nipple (Lau, 2015).

As healthy, term neonates are born with a reflexive sucking response, a brain injury before, during, or immediately after the birthing process may have a profound effect on these sucking patterns (Shandley et al., 2021). Basal ganglia and thalamus injuries are the most common pattern of perinatal hypoxic-ischemic injury, whereas brainstem injuries are the typical site of injury in neonates with severe HIE. Thus, oromotor dysfunction reported in neonates with HIE (Krüger et al., 2017, 2019; Malan et al., 2022; Martinez-Biarge et al., 2012; Quattrocchi et al., 2010) has been linked to basal ganglia, thalamus, and brainstem involvement (Martinez-Biarge et al., 2012; Quattrocchi et al., 2010), reinforcing oral phase dysphagia as a concern among neonates with HIE (Krüger et al., 2017, 2019; Malan et al., 2022). Neurologically compromised neonates may also present with abnormal muscle tone (Straathof et al., 2022), further affecting the oral phase of swallowing. Affected oral musculature may make it difficult to form and maintain an adequate latch and sustain adequate suction (Arvedson et al., 2020; Rogers & Arvedson, 2005).

Thus, neonates with HIE exhibit numerous oral phase difficulties that may extend their need for enteral feeds due to inadequate oral intake and/or increased risk for aspiration because of oral-motor dysfunction (Krüger et al., 2017, 2019; Malan et al., 2022; Martinez-Biarge et al., 2012). The most common oral phase difficulties reported in neonates with HIE include reduced or absent rooting responses, shallow latching, single sucks (Krüger et al., 2017, 2019), short sucking bursts (i.e., < 10 sucks per burst) (Krüger et al., 2017, 2019; Malan et al., 2022), and reduced sucking endurance (Krüger et al., 2017; Malan et al., 2022).

Although the rooting reflex may assist breastfed neonates with latching, it does not impact the functionality of feeding. Shallow latching implies that a neonate has difficulty generating adequate suction during breastfeeding (Lau, 2015), whereas poor NS characteristics indicate that they may present with inefficient feeding and poor oral-motor control. Consequently, anterior and/or premature spillage may be observed – impeding their nutrition and hydration, and potentially compromising the safety of the airway. Inefficient feeding may further increase the risk of weight loss or contribute to slow weight gain and delayed hospital discharge (Arvedson, 2008; Arvedson et al., 2020; Jadcherla, 2016), subsequently shifting the feeding focus from a social interaction to the newborn's weight gain (Cerro et al., 2002). Although understandable in the context of persistent feeding difficulties, this feeding attitude can result in impaired caregiver-newborn interactions (Thoyre, 2003).

Neonates with HIE may also present with delays in functional feeding independence. Although the feeding and swallowing skills of neonates with HIE are generally reported to improve during hospitalisation, some may present with oral phase dysphagia at discharge while on full oral feeds, mainly related to short sucking bursts (Malan et al., 2022). Persistent oral phase difficulties may potentially impact on feeding at home, including the administration of medication, leading to reduced

health and nutrition, adverse impacts on feeding interactions, reduced quality of life, and increased chance of hospital readmission (Arvedson et al., 2020; Martinez-Biarge et al., 2012).

The pharyngeal phase of swallowing

The oral phase of swallowing ends with the initiation of the pharyngeal swallow that serves to propel the bolus through the pharynx and upper oesophageal sphincter (UOS) and into the oesophagus while protecting and maintaining airway safety. This phase begins with tongue base propulsion and the elevation and retraction of the soft palate, which subsequently initiates the pharyngeal motor sequence, laryngeal closure (Arvedson & Lefton-Greif, 2020; Viswanathan & Jadcherla, 2020) and a 'deglutition apnoea – swallow – deglutition apnoea' swallow-breathing pattern (Lau et al., 2003; Thoyre & Carlson, 2003). The slower sucking pace of one suck per second during nutritive sucking provides time for the pharyngeal swallow to coordinate with breathing for maintenance of airway safety (Viswanathan & Jadcherla, 2020). Therefore, the risk of aspiration is at its peak during this phase, highlighting the importance of the pharyngeal swallow function (Arvedson et al., 2020).

Proper bolus formation and presentation to the pharynx is necessary to trigger an adequate pharyngeal swallow response and ensure integration with the respiratory cycle with sufficient airway closure. If achieved, the neonate will respond with a pharyngeal reflexive swallow, defined as pharyngeal contractile waveforms associated with UOS relaxation and swallowing related apnoea (Jadcherla et al., 2015). The bolus is likely to move through the pharynx and into the UOS smoothly and efficiently without interruption (Arvedson & Lefton-Greif, 2020; Viswanathan & Jadcherla, 2020).

However, a neurological impairment may lead to oral-motor dysfunction (Martinez-Biarge et al., 2012; Quattrocchi et al., 2010) and disrupt this process with a downstream effect on the pharyngeal swallow response, including SSB coordination (Arvedson, 2008; Viswanathan & Jadcherla, 2020). This is because of the close relationship between the generation and release of intraoral suction, and the generation and release of positive pharyngeal pressure to clear the bolus from the pharynx and into the oesophagus (McGrattan et al., 2016). Impaired suction may result in inadequate presentation to the pharynx, leading to a pharyngeal swallow reflex that is inefficient, delayed, or absent. It may also interrupt SSB coordination, with the poor oral motor control already resulting in premature spillage into the pharynx (Arvedson, 2006; Goldfield et al., 2006; Jadcherla et al., 2009; Viswanathan & Jadcherla, 2020).

In keeping with the described pathophysiology and its possible impact on feeding and swallowing, Krüger et al. (2019) reported that some of the neonates with HIE in their study presented with infrequent swallowing and/or failure to initiate a pharyngeal swallow response. Malan et al. (2022) also identified delayed pharyngeal swallow responses and uncoordinated SSB rhythms. Deglutition

apnoea or SSB coordination in a sucking infant is attributed to neuronal control rather than an airway protection mechanism as observed in more mature swallowing (Enrique et al., 2011; Maynard et al., 2020). Thus, the observed disruption in SSB coordination during feeding may have been attributable to their neurological compromise (Martinez-Biarge et al., 2012; Quattrocchi et al., 2010; Shandley et al., 2021). The delayed or inefficient pharyngeal swallow reflex may place these neonates at risk for pharyngeal pooling of milk or pharyngeal residue (Goldfield et al., 2006; Viswanathan & Jadcherla, 2020). It may also increase the duration of the deglutition apnoea causing desaturations and bradycardia related to oral feeding (Thoyre & Carlson, 2003) and consequently, further increase their risk for penetration and/or aspiration (Goldfield et al., 2006; Viswanathan & Jadcherla, 2020).

High-resolution manometry has been used to assess the pharyngo-oesophageal motility patterns of neonates with HIE to better understand the pathophysiology of OPD. Pharyngo-stimulus-induced reflexes are aberrant in neonates with HIE (Gulati et al., 2015; Jensen et al., 2017), and researchers have found that neonates with HIE present with an increased UOS basal tone (Gulati et al., 2015; Jensen et al., 2017), have more pharyngeal contractions per stimulus compared with healthy neonates, and respond to pharyngeal stimulation with more frequent pharyngo-UOS-contractile reflexes rather than pharyngeal reflexive swallows as observed in healthy neonates (Gulati et al., 2015). The increased UOS contractile reflexes may potentially increase the resistance of bolus flow through the UOS after each swallow, thus further increasing the risk for pharyngeal residue, delaying the clearance of feeds, and disrupting SSB coordination. Possible bolus retention in the hypopharynx increases the risk for aspiration and cardiorespiratory symptoms, which may further lead to fatigue and poor feeding endurance (Viswanathan & Jadcherla, 2020).

Gagging, coughing, choking, wheezing or wet respirations during feeding are clinical signs that indicate possible laryngeal penetration and/or aspiration, and signify compromised airway protective reflexes (Arvedson, 2006; Durvasula et al., 2014). Alternatively, if laryngotracheal sensation is reduced, aspiration may occur without triggering the airway protective reflexes, i.e., no coughing or choking will be observed (Arvedson, 2006; Durvasula et al., 2014). Although penetration or aspiration was not confirmed in Krüger et al.'s (2019) study due to the limitations of clinical assessment (Cordier et al., 2023), they reported that 25% (n = 7) of the neonates with HIE presented with coughing during feeding, signifying that these neonates may have been experiencing unsafe swallowing. More specifically, Malan et al. (2022) identified that 31% (n = 9) of the neonates with HIE in their sample presented with penetration (n = 4) or aspiration (n = 5) on the videofluoroscopic swallow study (VFSS) and more than half of the aspiration events had occurred silently (60%; n = 3).

Although neonates with HIE remain at high risk for aspiration and adverse outcomes, this risk appears to reduce over time (Jensen et al., 2017), suggesting neuroplasticity (Shandley et al., 2021). Jensen et

al. (2017) reported a partial recovery in the pharyngeal stimulus-induced reflexes in neonates with HIE with increasing post menstrual age. They reported that after 5 weeks of maturation, the UOS basal tone reduced, pharyngeal contractions decreased, and the latency to terminal swallow at the pharynx reduced. However, impaired pharyngeal swallow responses were still observed at the end of the 5-week maturation period, signifying a partial recovery of neuromuscular functions in neonates with HIE. These findings support the notion that feeding and swallowing skills of neonates with HIE may improve over time, but some neonates with HIE may still present with feeding difficulties at the time of discharge (Malan et al., 2022) necessitating long-term enteral feeding methods and/or continuous monitoring of oral intake (Martinez-Biarge et al., 2012; Sullivan, 2014).

Unsafe, inefficient, and inadequate oral feeding may be caused by a delay in functional maturation or coordination at any level of the swallowing system, including the oesophageal phase of swallowing (Dodrill & Gosa, 2015; Viswanathan & Jadcherla, 2020). Thus, it is important to acknowledge abnormalities that may occur in the oesophageal phase of swallowing because these may further contribute to the pathophysiology of OPD in neonates with HIE (Gulati et al., 2015; Jensen et al., 2017).

The oesophageal phase of swallowing

The oesophageal phase of swallowing, or primary peristalsis, is characterised by an automatic peristaltic wave that transports the swallowed material into the stomach. Primary peristalsis is triggered from the UOS at the end of the pharyngeal phase of swallowing to the lower oesophageal sphincter (LOS). The oesophagus is also characterised by secondary peristalsis, which is independent of the swallowing sequence and triggered by oesophageal provocation, such as during vomiting or gastro oesophageal reflux (GOR) events (Arvedson et al., 2020; Jadcherla, 2016).

During swallowing or vomiting, the oesophageal sphincters are relaxed to allow for the anterograde (swallowing) or retrograde (vomiting) flow of contents either into or from the stomach. Thus, in addition to the propulsion of the bolus into the stomach, oesophageal mechanisms prevent the backward flow of stomach contents into the oesophagus, or act as an aerodigestive defence response by clearing the oesophagus in the event of gastroesophageal reflux (Jadcherla et al., 2006). Thus, healthy, term neonates will respond to a pharyngeal stimulus with pharyngeal reflexive swallows to clear the bolus from the pharynx into the open UOS. Intact functioning of the LOS will facilitate bolus transit into the stomach and prevent the backflow of stomach contents into the oesophagus (Arvedson et al., 2020; Jadcherla, 2016).

In contrast, neonates with HIE present with an increased UOS basal tone, weaker, and prolonged proximal oesophageal peristaltic responses (Gulati et al., 2015; Jensen et al., 2017), and a decreased frequency of LOS relaxation (Gulati et al., 2015). Increased skeletal muscle hypertonicity of the UOS

and the proximal oesophagus, together with impaired functioning of the LOS, mean that neonates with HIE face increased risk for the pharyngeal pooling of secretions, improper bolus clearance, GOR, and aspiration (Viswanathan & Jadcherla, 2020).

Successful feeding and swallowing require active effort from the neonate and a well-coordinated SSB sequence at the breast or bottle (Arvedson, 2006), followed by the complete coordination in the UOS, LOS, and upper airway pathways along with their synchronised movements and physiological stability (Arora et al., 2022; Delaney & Arvedson, 2008). Intact normal swallowing mechanisms are important for handling secretions, smooth propulsion of the bolus into the oesophagus, airway safety, and adequate nutrition and hydration (Arora et al., 2022; Arvedson et al., 2020) – when achieved, adequate growth will occur over time and respiratory health will be maintained (Arvedson et al., 2020).

Impaired oral motor skills, pharyngeal and oesophageal swallow function and oesophageal peristaltic responses may cause many distressing symptoms in neonates with HIE (Arora et al., 2022), including bradycardia, desaturation, cardio-respiratory events, noisy breathing, recurrent wheeze, chronic cough, and GOR (Delaney & Arvedson, 2008; Jadcherla et al., 2009; 2016). Neonates with HIE are at an increased risk for aspiration-related respiratory sequelae (Cass et al., 2005; Dop et al., 2015; Morton et al., 2002) and, if left undiagnosed, recurrent pneumonia (Durvasula et al., 2014; Weir et al., 2007), reactive airway disease, chronic lung disease (Durvasula et al., 2014), and hospital readmissions (Arvedson et al., 2020; Dziewas et al., 2017). Chronic aspiration may cause permanent damage to the developing lungs of neonates (Adil et al., 2015) with direct cost implications due to hospital readmissions. Some studies have reported fatalities directly related to an aspiration episode (Baudon et al., 2009; Hu et al., 2014; Mizuno & Ueda, 2005). Although the degree of tolerance prior to developing any of the above outcomes is unknown, age, nutritional status, individual differences, and overall health are likely contributing factors to ‘tolerance’ (Arvedson, 2006; Durvasula et al., 2014).

Additionally, OPD may impede a neonate’s ability to receive adequate nutrition and hydration. OPD is associated with poor weight gain and undernutrition, and when prolonged, growth faltering may ensue (Larson-Nath & Biank, 2016; Shields et al., 2012). Although growth faltering is predominantly characterised by difficulty in achieving the appropriate weight, ongoing severe malnutrition may impair overall growth including weight, length, and head circumference. In extreme cases, growth faltering may compromise immune function and the achievement of developmental milestones and normal health (Homan, 2016).

Due to the complex nature of OPD and its potential adverse consequences, a feeding tube (i.e., orogastric (OGT) or nasogastric tube (NGT)) is often recommended as an interim measure to ensure optimal nutrition and hydration for growth and development without compromising the respiratory

system. OPD may then result in a prolonged reliance on tube feeding, consequently delaying hospital discharge (American Academy of Pediatrics, 2008; Krüger et al., 2017). Extended tube feeding means fewer opportunities for consistent oral practice and associated motor learning (Harding et al., 2012; Krüger et al., 2017; Martinez-Biarge et al., 2012). Earlier introduction to oral feeding may result in better feeding organisation, highlighting the significance of delayed transition to oral feeding on the development of feeding skill (Bromiker et al., 2005). Feeding tubes have also been found to further hinder the development of oral feeding skill by reducing the neonate's hunger drive and, in effect, motivation to feed (Mason et al., 2005). Furthermore, the development of sucking function may directly influence the development of masticatory function, implying that extended tube feeding in early infancy – and subsequent delay in sucking skill – may cause masticatory problems in later childhood (Matsubara et al., 2005).

Although adverse outcomes of OPD are primarily characterised by physical and physiological symptoms in the neonate, feeding requires caregiver and neonate involvement (Lau, 2020), encompassing both physical and emotional aspects (Jonsdottir et al., 2021). OPD and its associated comorbidities may, therefore, have wider consequences for the entire family unit (Sheikh et al., 2001; Swift & Scholten, 2010). Caregivers are often physically, mentally, and emotionally overwhelmed with the demands of taking care of a newborn with OPD, i.e., careful monitoring of oral or tube feeding and medication (Vizzari et al., 2023), which may lead to parental stress, anxiety, depression, and negative feeding experiences (Franklin & Rodger, 2003). Although secondary to the fact that their child is unwell, feeding difficulties have also been reported to result in feelings of a lack of competence and guilt for caregivers (Swift & Scholten, 2010), associated with higher levels of stress and ineffective coping strategies (Rosino, 2016). Heightened stress may intensify negative feeding experiences. Thus, a mother's experience of expressing breastmilk, the feeding difficulty, feeding intervention, and her parental feeding role are likely to be viewed more negatively when higher levels of stress are experienced (Swift & Scholten, 2010).

Poor mental health can lead to sleep disturbances and exhaustion, ultimately affecting caregivers' ability to care for their neonate and exacerbating challenges associated with feeding difficulties in neonates with HIE (Vizzari et al., 2023). In addition, maternal stress may have an inhibitory effect on oxytocin and prolactin secretion and interfere with lactation at the level of milk synthesis and milk ejection (Dewey, 2001; Lau, 2001, 2018). Moreover, reduced milk supply can lead to feelings of failure (Lasiuk et al., 2013), further affecting breastfeeding success and the negative feeding experience (Dewey, 2001). Thus, lactation may be impaired by milk supply and ejection during breastfeeding, and by the mother's motivation and opportunity to breastfeed and her overall well-being (Lau, 2018; Lau et al., 2007).

In addition to managing the adverse psychological outcomes related to having a hospitalised newborn with feeding difficulties, caregivers still need to develop their own feeding practices in an unfamiliar medical environment. Caregivers are entrusted with the timing and initiation of feeds, positioning the baby, and guiding the newborn during feeding. They learn to read their neonate's behavioural cues to facilitate oral feeding success (Karl, 2004). Thus, caregiver psychological status may result in difficulty reading oral feeding readiness cues (Dosani et al., 2016; Vizzari et al., 2023), and for neonates with HIE, this may include inadequate behavioural state organisation and poor self-regulatory capacity (Arvedson, 2008; Jadcherla, 2016).

As parenting influences the trajectory of development for high-risk neonates (Lemmon et al., 2017; Natarajan et al., 2014; Wallander et al., 2014), maternal mental health is crucial for successful feeding initiation, establishing a harmonious dyadic relationship (Gerhardsson et al., 2020), and overall well-being of both the neonate and the mother. As a fundamental task of early parenting, the act of feeding has been shown to be an important symbol of parenting to mothers of hospitalised neonates. For some, it enables them to feel involved and connected to their newborn. For others, it is viewed as an opportunity to provide nourishment and contribute to growth and development (Thoyre, 2000). Ultimately, early feeding is the primary interactive relationship for neonates, providing an opportunity for caregivers to communicate with their newborn, anticipate and respond appropriately to their needs, and interpret feeding behaviours. As a result, caregiver-child bonds are strengthened, forming the foundation for successful feeding experiences, physical growth, development, social communication, and psychosocial well-being. Successful feeding and swallowing are important for health, general development, and somatic growth – and for communication and relationship development and holistic well-being in the neonate (Arvedson et al., 2020; Franklin & Rodger, 2003; Lefton-Greif, 2008).

Having a newborn in the NICU is an unexpected and traumatic event that brings about heightened feelings of distress, including anxiety, depression, and trauma symptoms (Carter et al., 2005; Shaw et al., 2006). Research has shown that postnatal post-traumatic stress disorder related to the stress of the experience of an emergent delivery and life-threatening neonatal conditions affects nearly a quarter of all neonatal intensive care mothers in the short term (Kersting et al., 2004; Shaw et al., 2006; Vanderbilt et al., 2009). In addition to the typical stressors associated with having a new baby, the parents of neonates with HIE have to cope with many uncertainties about their child's health and prognosis, frequent medical check-ups and procedures, and the additional workload of caring for a child with medical requirements (Barnett et al., 2003). Family stress may also be exacerbated by the associated cost of extended hospital stays and future services that may be required to address developmental delays and continued feeding difficulties (Lasiuk et al., 2013). Thus, OPD can have a

significant impact on the neonate and their family in terms of health, growth, and development, including social-communication, and the mental and physical well-being of the entire family unit.

The relatively high incidence of HIE in South Africa means that SLTs are likely to encounter neonates with HIE and subsequent OPD in their caseloads. If these difficulties are not identified and addressed early on, more adverse consequences may arise, placing additional strain on the country's already overburdened health care system. Feeding and swallowing difficulties in neonates with HIE, thus represent a real concern for health care providers working in the NICU. Health care professionals in the field of paediatric dysphagia should be cognisant of the possible feeding and swallowing difficulties in this population of neonates (Da Costa et al., 2019; Krüger et al., 2017, 2019; Malan et al., 2022). However, factors such as inexperienced and unsupervised community service SLTs working in the NICU or High Care Units (Singh et al., 2015), inadequate or no SLTs available to provide feeding services in some settings (Strasheim & Kritzinger, 2011), and limited research in the field, are ongoing obstacles to the assessment and management of OPD in neonates with HIE in South Africa.

Thus, a need exists for more population-based studies that describe early OPD in neonates with HIE, which could be used to inform clinical practice. The early identification and management of OPD in neonates with HIE may prevent aspiration and consequent pulmonary morbidities (Macintyre et al., 2003; Sheikh et al., 2001), reduce the associated neonatal mortalities and lengthy hospital stays, support the caregiver-neonate dyad, and improve quality of life for both (American Academy of Pediatrics, 2008; Baudon et al., 2009; Hu et al., 2014; Lefton-Greif, 2008; Mizuno & Ueda, 2005; Sheikh et al., 2001). Input from specialist feeding therapists will maximise oral feeding potential and support families to understand, anticipate, and manage feeding difficulties during and following admission to the neonatal unit, ultimately reducing caregiver psychological distress and associated medical costs.

The purpose of this study was, therefore, to explore the feeding and swallowing characteristics of neonates with HIE, including the feeding difficulties that they may experience. The information gained from the study may increase the efficacy of SLT, and as a result enable SLTs to render comprehensive services to this vulnerable population of neonates and their families while facilitating earlier discharge with direct cost-benefit implications.

3. Methodology

3.1. Aims

3.1.1. Main aim

To describe the feeding and swallowing profile of neonates with hypoxic-ischemic encephalopathy (HIE) in a neonatal unit in Cape Town, South Africa.

3.1.2. Sub-aims

To achieve the main aim, the following sub-aims were addressed.

To describe from initial assessment until full oral feeds were achieved or, if not achieved, until discharge from MMH:

- 1: Oral feeding readiness
- 2: Oromotor skill, oropharyngeal swallowing and clinical signs of oropharyngeal dysphagia (OPD)
- 3: Time taken to reach full oral feeds
- 4: Feeding method at discharge from the neonatal unit.

3.2. Research Design

This research study used a descriptive, exploratory, longitudinal design comprising both prospective and retrospective data collection methods.

The descriptive design was deemed suitable because feeding and swallowing characteristics in the HIE population have not yet been well described in the literature (Krüger et al., 2017) and systematic observation and folder reviews allow for further knowledge to be generated (Mohajan, 2020; Walker, 2005). Although this design did not permit the researcher to generalise results to the entire population of neonates with HIE or establish causal relationships between variables (Etikan, 2016), it did allow for descriptors of feeding and swallowing to be documented to align with the sub-aims of the study. In addition, the longitudinal element permitted the researcher to generate multiple data collection entries over time, which revealed patterns in feeding difficulties and development in neonates with HIE.

The prospective design enabled the researcher to pre-determine what feeding and swallowing information would be documented, and it allowed for this information to be recorded as it occurred rather than relying on the retrospective accounts of others (Foster, 2006). However, a limitation of the prospective data collection was that the sample size depended on the number of admissions that

occurred during the dedicated data collection timeframe (Setia, 2016; Song & Chung, 2010). Therefore, the retrospective component was added as an amendment to the original protocol because it permitted the researcher to collect historical data through the review of past medical records, increasing the sample size without impacting the dedicated data collection timeframe and without cost implications (Mann, 2003). A drawback, however, was that some of the information, such as the NFAS assessment results, was not recorded in the medical folders, resulting in incomplete data sets for some participants – a limitation that is commonly reported in retrospective designs (Foster, 2006). Nevertheless, the inclusion of the retrospective component enhanced the information that was available for statistical analysis.

The descriptive, exploratory, longitudinal design was best suited to provide a comprehensive description of feeding and swallowing in neonates with HIE without influencing the data or inflicting harm on participants. In addition, the combination of both prospective and retrospective data collection methods was deemed suitable as it capitalised on the strengths of both research designs, while minimising their individual limitations (Landes et al., 2019; Soon et al., 2011) and addressing the research aims. Figure 1 depicts an outline of the data collection procedure for reference (explained in more detail in section 3.6.2).

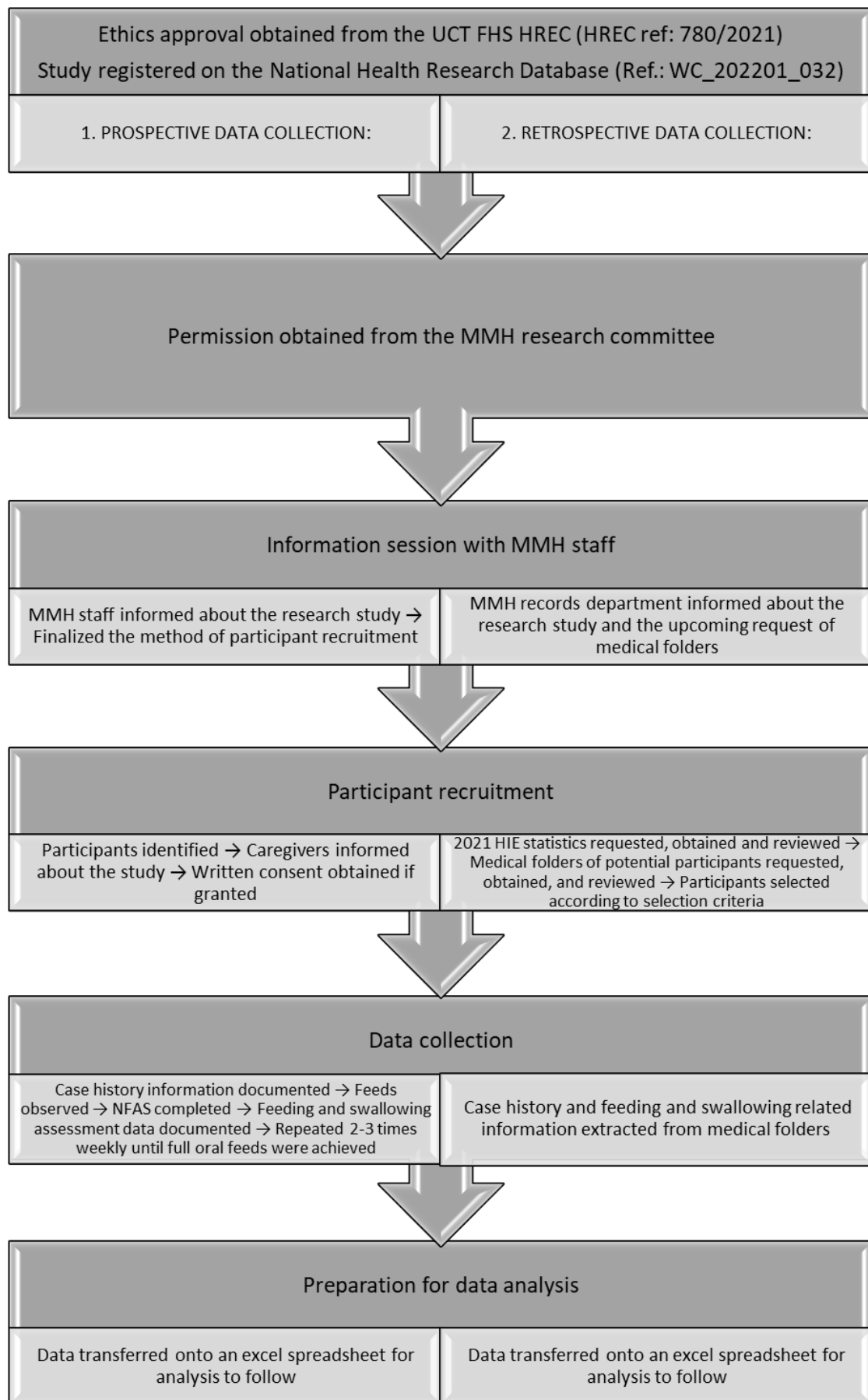


Figure 1. Data Collection Procedure

3.3. Participants

3.3.1. Selection Criteria (inclusion and exclusion criteria)

Neonates/medical records of neonates were recruited if they met the following inclusion criteria: a primary diagnosis of HIE without comorbid conditions associated with OPD, term birth, medically stable, and admitted to MMH during the specified dates. These criteria are explained in more detail below.

Primary diagnosis of HIE (see Appendix B)

To address the research aim, participants required a primary diagnosis of HIE. Potential participants who were diagnosed with an additional confounding diagnosis such as a cleft lip/palate, Down syndrome, foetal alcohol syndrome, congenital heart defects, and/or meningitis, were excluded because OPD could relate to the additional medical diagnosis, not only the HIE diagnosis. Thus, the internal validity of the study was increased by applying this criterion (Roberts & Priest, 2006).

Medically stable (see Appendix A)

All participants needed to be deemed medically stable by their treating doctor for a continuous period of 24 hours prior to conducting the oral feeding assessments.

Born at term, i.e., ≥ 37 weeks gestation (Quinn et al., 2016)

Potential participants who were born prematurely, i.e., before 37 weeks gestation (Quinn et al., 2016), were excluded from this study as these neonates may have feeding and swallowing difficulties due to immaturity rather than, or in addition to, the associated neurological involvement (Hawdon et al., 2007).

Research site (Mowbray Maternity Hospital (MMH))

MMH was recorded to have a total drainage of 20 000 deliveries per annum and therefore, deemed a suitable research site. In addition, MMH is a referral facility in the Metro west geographical area for neonates with HIE (Mowbray Maternity Hospital, 2021) and thus, appropriate for the recruitment of participants in this study.

Admission dates

Participants were recruited if they were admitted to MMH between February 2022 and September 2022. The medical folders of potential participants were reviewed if they were admitted to MMH between January 2021 and December 2021.

Additional exclusion criteria

Potential participants were excluded from this study if they met the inclusion criteria but the data set could not be completed as a) they were transferred to another health facility prior to the

establishment of full oral feeds and their feeding plan was unknown prior to transfer to another facility, b) their medical folder was unavailable during the data collection time period or c) they died during admission. In addition, potential participants were excluded if their caregiver did not understand English, Afrikaans, or isiXhosa (the dominant languages spoken in the Western Cape) because the informed consent form and interpretation were only available in these three languages.

3.3.2. Sampling method

Participants were selected using a purposive non-probability sampling technique. They were deliberately chosen according to the specific inclusion and exclusion criteria mentioned above (Etikan, 2016), and although there was a component of convenience sampling involved, the very specific criterion for inclusion and exclusion of participants made it non-probabilistic and purposive in nature (Campbell et al., 2020).

3.3.3. Participant recruitment

To conduct this study, ethics approval was obtained from the University of Cape Town's (UCT) Faculty of Health Sciences' Human Research Ethics Committee (HREC) (HREC Reference: 780/2021 (Appendix C). The study was registered on the National Health Research Database (WC_202201_032 (Appendix D)), and permission was obtained from MMH's Research Committee (Appendix E). Following the inclusion of the retrospective data collection component in this study, this process was repeated prior to reviewing any medical folders (see Appendix F for Ethics Approval of Amended Protocol and Appendix G for the MMH Research Committee's permission letter regarding the amended protocol).

Prospective participant recruitment

Once the necessary permissions were obtained, the researcher arranged a meeting with the unit managers and relevant staff members to provide information on the study, propose a face-to-face participant recruitment process, and allow them an opportunity to ask questions and make suggestions regarding the best method for participant recruitment, which was amended accordingly.

The researcher identified potential participants in person, in consultation with the unit doctor twice or three times per week. Once identified, the researcher approached the caregivers of potential participants face-to-face to inform them about the study verbally and in writing (Appendix H) in their language of preference (English, Afrikaans or isiXhosa). English was the language chosen by the caregivers of the 13 participants. Caregivers were given the opportunity to ask questions and consider whether they would like their neonate to participate in the study. They were not required to provide consent on that day as the researcher returned the following day to follow up. If they agreed to participation, they were requested to complete and sign the 'Informed Consent Form' (Appendix H).

Retrospective participant recruitment

The 'HIE' statistics were requested from the NICU at MMH. Once received, the medical folders of the neonates who were admitted between January 2021 and December 2021 were requested from the hospital's records department. Their medical folders were then reviewed on site to determine eligibility for inclusion in this study based on the selection criteria.

3.3.4. Sample size

A total of 13 neonates were included in the prospective data collection, and 39 of the 71 potential medical folders reviewed met the inclusion criteria for retrospective data collection. The medical records of the other 32 potential participants were excluded from this study as these neonates were either born prematurely (i.e., ≤ 37 weeks gestation), transferred to another health facility without a known feeding plan, or had died during admission. Thus, a total of 52 participants were included in this study.

3.3.5. Participant description

Participants are described according to their biographical characteristics (sex, gestational age, and birth weight) and their clinical presentation on admission to the neonatal unit (initial aEEG reading, initial Thompson score) including the subsequent initiation or absence of therapeutic hypothermia treatment. Participant characteristics are presented in Table 4.

Table 4. Participant Characteristics on Admission (N = 52)

#	BIOGRAPHICAL CHARACTERISTICS				CLINICAL PRESENTATION		Therapeutic hypothermia
	Sex	GA		BW (grams (g))	Initial aEEG	Initial Thompson Score	
		weeks	days				
Normal initial aEEG (n = 7)							
1.05	M	41 weeks	1 day	3430 g	CNV	5	No
1.07	M	39 weeks	3 days	3270 g	CNV	6	No
2.03	M	41 weeks	3 days	3690 g	CNV	7	No
2.11	F	41 weeks	4 days	3860 g	CNV	6	No
2.15	M	39 weeks	0 days	2680 g	CNV	1	No
2.22	F	38 weeks	0 days	2690 g	CNV	0	No
2.39	F	Term		3120 g	CNV	1	No
Severely abnormal initial aEEG (n = 6)							
1.02	M	39 weeks	1 day	2880 g	CLV	7	No
1.03	M	39 weeks	5 days	3210 g	CLV	15	No
1.11	M	39 weeks	1 day	2700 g	Electrical	16	No
2.05	M	38 weeks	0 days	2250 g	CLV	1 → 12	No
2.25	F	38 weeks	5 days	2370 g	Electrical	8	No
2.37	F	40 weeks	1 day	2370 g	CLV	15	No
Abnormal initial aEEG (n = 26)							
1.01	F	40 weeks	6 days	3250 g	DNV	8	Yes
1.04	M	40 weeks	2 days	3330 g	DNV	9	Yes
1.08	F	41 weeks	1 day	3600 g	DNV	8	Yes
1.13	M	38 weeks	2 days	2900 g	DNV	9	Yes
2.02	F	39 weeks	5 days	2590 g	DNV	7	Yes
2.04	F	39 weeks	6 days	3040 g	DNV	4	Yes
2.06	M	Term		3780 g	DNV	7	Yes
2.07	F	Term		3650 g	DNV	11	Yes
2.08	F	38 weeks	6 days	2790 g	DNV	5	Yes
2.09	F	37 weeks	0 days	2950 g	DNV	3	Yes
2.10	M	40 weeks	5 days	3710 g	DNV	6	Yes
2.16	M	40 weeks	5 days	3610 g	DNV	5	Yes
2.17	M	39 weeks	3 days	2670 g	DNV	14	Yes
2.19	F	39 weeks	0 days	3220 g	DNV	4	Yes
2.20	M	41 weeks	0 days	3360 g	DNV	7	Yes
2.21	F	40 weeks	5 days	3530 g	DNV	5	Yes
2.23	F	41 weeks	5 days	2790 g	DNV	11	Yes
2.24	M	41 weeks	6 days	3440 g	DNV	6	Yes
2.26	F	40 weeks	0 days	3220 g	DNV	5	Yes
2.27	M	41 weeks	5 days	4170 g	DNV	0 → 2	Yes
2.28	M	38 weeks	2 days	2730 g	DNV	2	Yes
2.30	M	40 weeks	0 days	3340 g	DNV	4	Yes
2.32	M	37 weeks	0 days	2630 g	DNV	8	Yes
2.33	F	41 weeks	1 day	2760 g	DNV	9	Yes
2.35	F	40 weeks	0 day	3650 g	DNV	7	Yes
2.38	F	40 weeks	5 days	3330 g	DNV	5	Yes
Severely abnormal initial aEEG (n = 13)							
1.06	M	39 weeks	1 day	2800 g	CLV	7	Yes
1.09	F	38 weeks	2 days	2820 g	CLV	11	Yes
1.12	M	39 weeks	0 days	3270 g	CLV	7	Yes
2.01	M	41 weeks	6 days	3100 g	CLV	9	Yes
2.12	M	39 weeks	3 days	3310 g	CLV	7	Yes
2.13	M	41 weeks	2 days	3990 g	CLV	10	Yes
2.14	M	40 weeks	2 days	4100 g	CLV	5	Yes
2.29	F	42 weeks	2 days	3100 g	CLV	9	Yes
2.34	F	40 weeks	0 days	3240 g	CLV	6	Yes
2.36	M	40 weeks	0 days	3170 g	CLV	11	Yes
2.31	F	Term		3260 g	Burst suppression	10	Yes
2.18	M	42 weeks	0 days	4035 g	Isoelectric/flat trace	13	Yes
1.10	M	39 weeks	6 days	2885 g	Isoelectric	11	Yes
Mean:		40 weeks		3185.4 g			

Notes: GA, Gestational age; BW, birth weight; CNV, Continuous normal voltage; CLV, Continuous low voltage; DNV Discontinuous normal voltage (See Table 1 for further information regarding aEEG interpretation).

Within the sample, there were 29 male participants and 23 female participants. The gestational age (GA) was missing for 4 participants. However, it was recorded that they were born at term (≥ 37 weeks). The mean gestational age for the 48 participants was 40 weeks, and the mean birth weight for the sample was 3185.4 grams.

Of the 52 participants, 7 presented with a normal and maintained aEEG trace (CNV) and a low initial Thompson score. These neonates were considered to have mild HIE and did not meet criteria for therapeutic hypothermia. Most of the sample ($n = 45$; 86.5%) were initially considered to have moderate to severe HIE as they exhibited an abnormal (moderate/severe) initial aEEG pattern (DNV, CLV, burst suppression, isoelectric/flat trace). However, only 39 participants (75.0%) met the additional inclusion criterion for undergoing therapeutic hypothermia (see Appendix I for Therapeutic Hypothermia Criteria), while the remaining 6 participants either missed the cooling period or were too medically unstable to undergo cooling.

3.4. Materials and Equipment

3.4.1 Materials

3.4.1.1. Data Collection Forms

Data collection forms were created to ensure that structure and consistency were maintained throughout the data collection process. The 'Prospective Data Collection Form' (Appendix J) was used to collect prospective data and the 'Retrospective Data Collection Form' (Appendix K) applied for retrospective data abstraction. Both forms were divided into two parts: (1) Case History (including basic feeding history) and (2) Feeding and Swallowing Assessments.

Case History

Prospective Data Collection Form (Appendix J)

This section documented the biographical, birth, medical and feeding history of participants. This included the participant's date of birth, birth weight, Apgar scores, co-morbidities, neurological health (i.e., seizures, CFM, Thompson scores, head scan), the medical intervention that was received, the first oral feeding trial if initiated prior to the first NFAS assessment and feeding related referrals. The rationales for the inclusion of items, together with supporting literature, are provided in Appendix L.

Retrospective Data Collection Form (Appendix K)

The case history items described above were captured on the retrospective data collection form with the addition of information pertaining to lower respiratory tract infections (LRTI). Rationales for the inclusion of items and supporting literature are also provided in Appendix L.

3.4.1.2. Feeding and Swallowing Assessments

Prospective Data Collection Form (Appendix J)

The feeding assessment section allowed for multiple assessment summaries to be recorded, permitting the researcher to follow each participant's feeding progress over time. Each entry was dated and included information related to the participant's feeding method/s prior to assessment, feed time intervals, weight, physiological state (respiratory health and SpO₂ before, during and after feeding), feeding method/s assessed, volume completed (if applicable), duration of feed, and a summary of the NFAS results. The rationales for the inclusion of items and supporting literature are presented in Appendix M.

Retrospective Data Collection Form (Appendix K)

This section was only applicable to the participants who were assessed by the on-site SLT. Each entry recorded the participant's chronological age on the date that the SLT notes were documented, their medical status, and feeding and swallowing related information. The feeding and swallowing information included the participant's feeding method/s prior to the assessment, the feeding method/s that were assessed, NNS/NS characteristics including the reported clinical signs and symptoms of OPD, and the feeding management received thereafter. Items not reported in the participant's medical file were recorded as 'not reported' (NR). The rationales for the inclusion of items and supporting literature appear in Appendix N.

Neonatal Feeding Assessment Scale (NFAS) (Appendix O)

The NFAS was used, with permission (Appendix P) and referenced accordingly, to document feeding and swallowing difficulties and development over time (Viviers, 2016; Viviers et al., 2016). The NFAS, an observational feeding assessment tool for use with neonates, was developed and validated in South Africa. First devised according to theoretical constructs of neonatal feeding and dysphagia and current paediatric feeding and swallowing assessments, a first draft of the tool was sent to a Delphi panel of 2 international and 3 local SLTs to refine its content, structure, and format. The final format of the NFAS was concluded once majority agreement among the panel members was achieved (Viviers et al., 2016).

The NFAS was then piloted in two studies, both comparing its outcome with the 'gold standard' of swallowing assessments, the Modified Barium Swallow Study (MBSS), to investigate its reliability and validity in identifying the presence of OPD in clinical settings. The NFAS was found to be valid and reliable. Although it is more subjective than instrumental assessments, it offers a more descriptive profile of neonatal feeding and swallowing at the bedside (Viviers et al., 2019). In addition, the NFAS was used for multiple feeds, which allowed the researcher to accumulate a representative feeding

profile (Viviers, et al., 2019). The reliability and validity of the NFAS is described further in the reliability and validity section below (3.5.1.).

The final version of the NFAS comprises six sections, namely: physiological functioning, state of alertness during feeding, stress cues during feeding, general movement and muscle tone at rest and during feeding, an oral peripheral examination (OPE), and a clinical feeding and swallowing evaluation (Viviers et al., 2016).

3.4.2 Equipment

Personal protective equipment (PPE) and feeding equipment were not used in the retrospective data collection component of this study.

3.4.2.1. Personal Protective Equipment (PPE)

When conducting the feeding and swallowing assessments, the appropriate PPE was worn in accordance with the requirements of the neonatal unit (e.g., disposable masks, gloves, and gowns) and supplied by the researcher.

3.4.2.2. Oxygen Saturation (SpO₂) Monitors

All infants in the neonatal unit were monitored using pulse oximeters, specifically, calibrated Nellcor monitors, to measure their heart rate (HR) and SpO₂ before, during and after feeding. Changes in these parameters may have indicated OPD and/or aspiration and therefore, provided objective physiological data (Thoyre & Carlson, 2003).

3.4.2.3. Feeding Equipment

Feeding and swallowing skill was assessed based on the method of feeding that the participants were using at a given feeding time. For example, if the participant was breastfeeding or cup feeding, the NFAS was completed based on observations of either breastfeeding or cup feeding. Alternatively, if more than one method was used (e.g., breastfeeding and cup feeding), both methods of feeding were assessed. Any feeding equipment (e.g., cup, syringe) that was used in the study was provided by the neonatal unit as standard of care.

3.5. Validity and Reliability

3.5.1. The Neonatal Feeding Assessment Scale (NFAS)

The NFAS was developed and validated in South Africa where its practicality and effectiveness for use within resource constrained settings was specifically considered. Thus, with respect to contextual appropriacy, the NFAS was valid and reliable for use within this study (Viviers et al., 2019).

The validity of the NFAS refers to the extent to which it will be able to accurately identify the presence or absence of OPD in neonates. This was measured through its ability to accurately assess the presence/absence of OPD outside of the study setting (external validity) and the degree to which the results were trustworthy and not influenced by other factors or variables (internal validity). Internal validity is further divided into content validity, criterion validity, and construct validity (Heale & Twycross, 2015).

Content validity of the NFAS was determined and confirmed by a Delphi panel who assessed whether the NFAS accurately and comprehensively covered content related to neonatal feeding and swallowing (Viviers et al., 2016). Criterion validity is measured by comparing an instrument of interest with another instrument that measures that same variable. The criterion validity of the NFAS was measured by assessing the extent to which it accurately assessed feeding and swallowing in neonates and subsequently, the presence/absence of OPD, by comparing it with the MBSS (Heale & Twycross, 2015; Viviers et al., 2019). The NFAS demonstrated a positive predictive value of 78.6% (presence of OPD) and a negative predictive value of 88.2% (absence of OPD) (Viviers, et al., 2019). The construct validity, i.e., the accuracy of an instrument in measuring the variable that it intends to measure (Heale & Twycross, 2015), was therefore concluded to be 85.4% accurate in detecting the presence or absence of OPD in neonates (Viviers et al., 2019).

The reliability of the NFAS refers to the extent to which the diagnostic outcome will consistently provide the same result on multiple occasions (Heale & Twycross, 2015). This was measured through inter-rater reliability where two independent raters completed the NFAS at the same time for 35% (n = 17) of the sample, and were blinded to each other's results. Substantial agreement beyond chance (58.6%) was found, which resulted in a satisfactory asymptotic standard error (ASE) of 0.211 (Viviers et al., 2019).

3.5.2. Data Collection

3.5.2.1. Validity of the data collection forms

Appendices L and M summarize the content validity of the items included in the prospective data collection form. The content validity of the retrospective data collection form is presented in Appendices L and N.

3.5.2.2. Reliability: Using the NFAS

The inter-rater reliability of the NFAS was determined for 23% (n = 3) of the sample. The researcher and the research assistant completed the NFAS at the same time – independently and blinded to each other's results. After completion of the first inter-rater reliability check, the outcome of each

subsection was compared and initially an agreement of 100% was not achieved. The researcher and assistant reviewed the results to discuss the difference and an agreement of 100% was subsequently achieved, including for the NFAS assessments that followed thereafter. To ensure procedural reliability in obtaining the prospective data and administering the NFAS, the NFAS guidelines, instructions, and scoring provided by Viviers et al. (2016) were strictly adhered to.

3.5.2.3. Reliability: Reviewing folders

Inter-rater reliability of the retrospective component of the study was determined for 15% ($n = 6$) of the sample. The research assistant and the researcher completed the data collection form independently and blinded to each other's results. After completion, the outcome of the form was compared and initially an agreement of 100% was not achieved. The researcher and the research assistant reviewed the results to discuss the difference and an agreement of 100% was subsequently achieved including for the retrospective data collection that followed thereafter.

3.6. Procedures

3.6.1. Research personnel

This research study comprised 3 research personnel who were actively involved in the data collection process, and 2 research personnel as co-supervisors. To ensure that ethical standards were maintained throughout the research process, all research personnel were registered with the Health Professions Council of South Africa (HPCSA). The members who were actively involved in the data collection process included:

- i. *The researcher*, a qualified SLT with 6 years of clinical experience and 3 years' experience working predominantly in NICUs and high care units where feeding assessments were routinely performed, who conducted the prospective and retrospective data collection.
- ii. *Research assistant*, a qualified SLT with 5 years' experience working in the field of paediatric dysphagia, specifically with neonates, who assisted the researcher with inter-rater reliability checks of the prospective and retrospective data collection.
- iii. *Primary supervisor*, a senior lecturer at UCT and SLT with more than 20 years' experience in the field of paediatric dysphagia, specifically neonatal OPD, who oversaw this research project in its entirety.

3.6.2. Data collection procedures

3.6.2.1. Prospective data collection

After ethical approval from UCT's Faculty of Health Sciences' Human Research Ethics Committee (HREC) (Appendix C), permission was obtained from the Department of Health via the National Health

Research Database (Appendix D) and from the MMH Research Committee (Appendix E). Thereafter, the researcher arranged a meeting with the unit managers and relevant staff members of MMH to inform them about the study and finalise the participant recruitment method. Following this, potential participants were identified, and their caregivers were approached to inform them about the study. Subsequently, they were invited to participate with their neonates. If consent was obtained, the participant was allocated a reference number that replaced any identifiable information on their assessment forms. The participant's medical records were then reviewed and, if required, additional information was obtained from their caregiver and treating doctor, and documented on the 'Prospective Data Collection Form' (Appendix J).

After the relevant case history information was obtained, feeds were systematically observed (Viviers et al., 2016) at the participant's bedside during typical feeding times, without being involved in the treatment of the participant. The NFAS was completed at each feeding observation and a summary of the NFAS results were documented on the data collection form (Appendix J). This process was repeated 2 to 3 times weekly until full oral feeds were achieved. The number of assessments per participant varied because the time taken to reach full oral feeds differed, with one assessment recorded for 7 participants and multiple assessments for the remaining 6 participants. Thus, only the first NFAS assessment was used in the analysis of feeding and swallowing characteristics as described in 3.6.3. It is also important to note that following 4 months of data collection, only 3 participants had been recruited following the study's selection criteria. Thus, an amendment to include neonates with 'mild' HIE into the selection criteria (as well as to include retrospective data collection) was submitted as described in section 3.6.2.2.

3.6.2.2. Retrospective data collection

After ethical approval from UCT's Faculty of Health Sciences' HREC (Appendix F) and permission from the MMH Research Committee (Appendix G) was obtained, selection of medical folders began. Seventy-one potential participants were identified from the neonatal unit's HIE statistics for 2021. These folders were requested from the hospital's records department and reviewed in the research room at MMH. Of the 71 potential participants, 39 neonates met the inclusion criteria and were allocated a reference number to replace any identifiable information on the 'Retrospective Data Collection Form' (Appendix K). This form was used to capture the relevant case history and feeding and swallowing related data as documented in the medical files. Of note, only 6 participants in the retrospective component of the study were referred to the SLT for feeding management. Thus, feeding and swallowing assessment data were only available for 6 of the total 39 participants, as described below.

3.6.3. Data analysis

The case history information that was obtained across both data collection methods was entered onto a single Excel spreadsheet to facilitate statistical analysis. This process enabled the researcher to identify and group medically similar participants together and subsequently, categorise participants according to the severity of their encephalopathy. Groups were created according to the aEEG pattern upon admission into the neonatal unit and whether therapeutic hypothermia treatment was initiated. The groups were as follows:

- i. Normal initial aEEG; not cooled (n = 7)
- ii. Severely abnormal initial aEEG; not cooled (n = 6)
- iii. Abnormal initial aEEG; cooled (n = 26)
- iv. Severely abnormal initial aEEG; cooled (n = 13).

The oral feeding readiness characteristics, the time taken to full oral feeds, and the feeding method/s that were used at the time of discharge, were also recorded in a single Excel workbook for statistical analysis to follow (N = 52). Feeding and swallowing assessment data were only available for the participants who were assessed in the prospective part of the study (n = 13), and for the participants assessed by the on-site SLT for feeding management in the retrospective part of the study (n = 6), thus totalling 19 participants. The oropharyngeal characteristics as observed in the NFAS and documented in the SLT clinical notes were therefore combined, organised, simplified, and summarised onto a separate Excel spreadsheet (N = 19).

As per the NFAS scoring guidelines, each item in the NFAS was scored using a binary yes/no system. Items were scored 'yes' if the specified sign or symptom was observed during feeding, or 'no' if the sign or symptom was not observed. The final sub-section outcome was scored 'yes' if dysphagia was likely to be present, or 'no' if dysphagia was likely to be absent. Within the NNS skills diagnostic area, an outcome of dysphagia was indicated if 2 or more clinical signs and/or symptoms of oral phase difficulties were documented. Within the NS/oral feeding diagnostic area, an outcome of OPD was indicated if 1 or more clinical sign/s and/or symptom/s of OPD was/were documented. This scoring system of the exact clinical signs and symptoms was also applied to the information obtained from the SLT clinical notes in the retrospective component of the study (i.e., on the 'Retrospective Data Collection Form' (Appendix K)). Where undocumented or missing data points were encountered, the researcher recorded that feeding characteristic as 'not reported' (NR).

The NFAS overall diagnostic outcome of OPD – only applicable to the participants within the prospective part of the study – was indicated if three or more sub-sections, inclusive of sub-section E (*Oral peripheral evaluation*) or sub-section F (*Clinical feeding and swallowing evaluation*), indicated that OPD was likely to be present. Therefore, it was possible for the participants within the NFAS

assessments to present with signs and symptoms of OPD in at least one NFAS diagnostic area, but to not present with an overall diagnosis of OPD.

Descriptive statistics (mean, range, median, interquartile range, and standard deviation) and statistics of probability were used to quantify and describe the data to provide a comprehensive description of the feeding and swallowing characteristics of neonates with HIE (Allen, 2017). Using the Statistical Package for the Social Sciences (SPSS v.18, IBM, 2009), a post-hoc analysis using the nonparametric Kruskal-Wallis test determined if there was a statistical significance in the time taken (days) to oral feeding readiness, and in the time taken (days) to full oral feeds among the four groups (Xia, 2020). The Mann-Whitney U test was used to determine if there were significant between-group differences within these two measures of assessment (McIntosh et al., 2010). Frequency counts were used to describe the regularity of a specific feeding and swallowing characteristic within the sample and within each group (N = 19), including factors related to oral feeding readiness (only applicable to participants within the prospective part of the study; N = 13). Cross-tabulations allowed for descriptions between groups (Douglas, 2004). Furthermore, Fisher's exact test was run to determine if there was a statistical significance in the NNS skills assessment and the presence of OPD, and in the NS/oral feeding assessment and the presence of OPD (Vierra et al., 2023). In this study, *p*-values of less than 0.05 indicated statistical significance (Kwak, 2023).

3.7. Ethical Considerations

The health, well-being, and rights of participants were of utmost priority in this study. Thus, the ethical principles of autonomy, non-maleficence, beneficence, justice, and confidentiality, as outlined by the World Medical Association (WMA, 2013) in the Declaration of Helsinki, were maintained throughout.

Autonomy refers to the importance of respecting a person's right to make an informed decision for themselves or for their children according to their own system of morals and beliefs (Bosnjak, 2001). To uphold this ethical principal, the caregivers of potential participants were informed about the study verbally and in written format in their language of preference, to ensure that they fully understood its purpose, methods, and anticipated benefits/risks. It was also emphasised that participation was entirely voluntary and that they could withdraw consent at any stage without their neonate's usual care at the hospital being affected (WMA, 2013). After ensuring that they understood the study in its entirety, and if they agreed to participation, they were requested to complete and sign a consent form on behalf of their neonate (WMA, 2013).

To minimise COVID-19 and other infection risks, the researcher followed the infection prevention and control measures of the neonatal unit and the National Department of Health (Department of Health,

2021). This included wearing the appropriate PPE (e.g., disposable masks, gloves, and aprons) and maintaining frequent hand washing before and after interacting with patients and caregivers or handling medical folders and/or equipment using an alcohol-based hand wash or sanitiser.

Vulnerability in research refers to a participant being incapable of protecting their own interests (González-Duarte et al., 2019) and at “an increased likelihood of being wronged or of incurring additional harm” (WMA, 2013, p. 2192). Neonates form part of a vulnerable population, and thus, additional safeguards were put in place to protect their rights and welfare. Vulnerability in this study was twofold: neonates were not able to give consent, and they were at an increased risk of aspiration by virtue of their neurological condition. Prior to conducting this research, the researcher evaluated the non-maleficence principle, which ensures that participants are not harmed as a result of research being conducted (WMA, 2013). The researcher concluded that this research was required to yield information that could not be obtained in any other way, but in doing so, participants were not at an ‘additional’ risk. The study involved no additional, physical, legal, social, or economic harm to participants as they were seen during their admission at MMH, and swallowing assessments would typically occur as part of the standard of care. The researcher consulted with each participant’s treating doctor to determine whether the participant was medically stable for a swallowing assessment. If any indicators of medical instability and/or aspiration were identified, the assessment either did not take place or it was discontinued, as would occur as the standard of care.

Beneficence relates to any benefits that the research may bring to participants (WMA, 2013). Although this study did not have a direct benefit for participants because the observed feeding and swallowing characteristics did not necessitate SLT referral, it may have benefited participants if SLT referral was deemed necessary. In addition, this research may benefit health care professionals in the future by providing insight into the nature and frequency of feeding and swallowing difficulties in neonates with HIE, ultimately facilitating earlier identification and intervention.

The principle of justice required the researcher to select participants fairly and without bias, and that the benefits and risks of the research were equally distributed between communities (WMA, 2013). To maintain this principle, all caregivers of neonates with HIE who were admitted into the neonatal unit at MMH during the data collection period and met the inclusion criteria, were approached to participate. Although this research only took place at one facility, it included a sample over a wide geographical area given the lack of specialised services for these neonates. Thus, the sample represented a wide range of communities and cultures. In addition, all caregivers were provided with feedback regarding their neonate’s performance at the end of each assessment. The researcher’s contact number was provided should the caregivers require further feedback on completion of the study. Lastly, the final dissertation will be made available to the research site, and the information

gained from this study will apply to any community within resource-constrained settings that share the same phenomenon: HIE.

To maintain participant confidentiality, identifiable information was not shared beyond the individuals who were directly involved in the research (i.e., the researcher, research assistant, and supervisor). Each participant was assigned a reference number to replace any identifying information on the data sheets (WMA, 2013). While working with the data, the details of each participant's identity, along with their corresponding reference number, were stored electronically in a password protected folder. To maintain privacy, caregivers were also given the option to discuss their baby's medical condition in the counselling room, if they preferred. Completed assessment forms were stored in a cupboard in an access-controlled room and, thus, separated from any identifying information. On completion of the research, the data will be stored securely at UCT for a minimum of 5 years.

4. Results

The results are presented in accordance with the sub-aims of the study to achieve the overarching aim: To describe the feeding and swallowing profile of neonates with HIE in a neonatal unit in Cape Town, South Africa.

4.1. Oral feeding readiness

Oral feeding readiness is described according to the median number of days until oral feeds were safely introduced ($N = 50$), together with subsystem functioning that may have contributed, either positively or negatively, to the oral feeding performance of participants during the first NFAS assessment ($N = 13$).

4.1.1. Time taken to oral feeding readiness

Oral feeding readiness in this context refers to the number of days until milk via breast, cup, or syringe was safely swallowed for the first time. A main effect for the entire sample was indicated ($p = 0.036$), with a median of 4 days, and an interquartile range of 4 – 5 days ($SD = 3.7$ days). The median number of days to oral feeding readiness for the sample and for each group, including the interquartile range and standard deviation, is presented in Table 5.

Table 5. *Time Taken to Oral Feeding Readiness*

	N	Median (days)	IQR (days)	SD (days)	p
OVERALL	50*	4	4 – 5	3.7	0.036
Normal aEEG; not cooled	7	1	1 – 6	2.8	
Severely abnormal aEEG; not cooled	4*	12.5	4.3 – 19.3	7.9	
Moderately abnormal aEEG; cooled	26	4	4 – 5	2.8	
Severely abnormal aEEG; cooled	13	5	4.5 – 5.5	0.9	

*Total $N = 50$ (i.e., $52 - 2$): 2 participants with a severely abnormal initial aEEG and who were not cooled did not achieve oral feeding readiness.

The participants who presented with a severely abnormal initial aEEG ($n = 4$) and who were not cooled demonstrated the highest median to oral feeding readiness (12.5 days) with an interquartile range of 4.3 – 19.3 days and a standard deviation of 7.9 days. These participants took significantly longer to establish oral feeding readiness compared with the participants with a normal initial aEEG ($p = 0.042$). No other statistical differences between groups were found, as indicated in Table 6.

Table 6. *Comparison Between HIE Groups of Time Taken to Oral Feeding Readiness*

HIE groups	<i>p</i> -value
Normal not cooled vs Severely abnormal not cooled	0.042*
Normal not cooled vs Moderately abnormal cooled	0.156
Normal not cooled vs Severely abnormal cooled	0.135
Severely abnormal not cooled vs Moderately abnormal cooled	0.123
Severely abnormal not cooled vs Severely abnormal cooled	0.130
Moderately abnormal cooled vs Severely abnormal cooled	0.050

*Statistically significant at $p < .05$

4.1.2. Sub-system functioning during the first NFAS assessment

The physiological stability, level of alertness, and stress cues displayed by participants during the first NFAS assessment, and the interaction between the subsystems, provide additional oral feeding readiness information on the participants ($N = 13$) who were assessed in the prospective part of the study. All 13 participants were considered medically stable for oral feeding trials, and therefore, the NFAS assessment was conducted according to the study's medical stability criteria. These included a normal body temperature maintained in an open environment, stable SpO_2 with a maximum of 30% supplemental oxygen, stable respiratory rate, and a stable heart rate (see Appendix B for a detailed description of the medical stability criteria). Table 7 presents the participants' subsystem functioning (physiological (autonomic), behavioural, and self-regulation) and their diagnostic outcome of OPD on the initial NFAS.

Table 7. Physiological, Behavioural, and Self-regulation Sub-System Functioning during the First NFAS Assessment and the Diagnostic Outcome of OPD

SUB-SYSTEM	RESPONSE	OVERALL N = 13		
		Total n	OPD n	(%)
Physiological	Normal HR/respiration	9	1	(11.1%)
	Tachycardia/abnormal respiratory patterns	4	3	(75.0%)
Behavioural	Optimal state of alertness	6	0	(0.0%)
	Non-optimal state of alertness	7	4	(57.1%)
Self-regulation	< 3 stress cues	9	0	(0.0%)
	≥ 3 stress cues	4	4	(100%)
Subsystem interactions	^a Adequate	9	0	(0.0%)
	^b Inadequate	4	4	(100%)

^aAdequate: ≤ 1 unstable/disorganised subsystem (physiological/behavioural/self-regulation)

^bInadequate: ≥ 2 unstable/disorganised subsystems (physiological, behavioural, and/or self-regulation)

Four participants (30.8%) demonstrated autonomic nervous system signs, namely tachycardia and/or abnormal respiratory patterns with feeding, suggesting that they may not have been ready for oral feeding at that time. Three of these participants (75.0%) presented with a diagnosis of OPD. Seven of the 13 participants (53.8%) demonstrated a non-optimal state of alertness during feeding, and of these, 4 (57.1%) presented with a diagnosis of OPD. All 4 participants who presented with three or more stress cues during feeding, and ≥ 2 unstable or disorganised physiological subsystems, presented with a diagnosis of OPD. None of the participants who demonstrated an optimal state of alertness, less than three stress cues, or one/no unstable/disorganised physiological subsystem sign/s, presented with a diagnostic outcome of OPD.

4.2. Oromotor skill, oropharyngeal swallowing and clinical signs and symptoms OPD

The participants' oromotor and feeding and swallowing skill is described according to the NNS skills assessment and the clinical signs and symptoms of OPD as noted in the feeding and swallowing assessments. This information was only available for the participants who were assessed in the prospective part of the study, and for the participants who were assessed by the SLT for feeding management in the retrospective part of the study (i.e., NFAS assessments and ST clinical notes; N = 19).

4.2.1. NNS skills

The NNS skills assessment identified clinical signs and symptoms of impaired oromotor skill such as inadequate lip closure (21%; n = 4), reduced sucks per burst (73.7%; n = 14), reduced tongue cupping (52.6%; n = 10) and movement (52.6%; n = 10), reduced sucking strength (68.4%; n = 13), abnormal respiratory patterns (5.3%; n = 1) and reduced sucking endurance (47.4%; n = 9). The results from this subsection suggest that dysphagia was likely to be present in 73.7% (n = 14) of the 19 participants and as such, these participants were unlikely to be ready for oral feeding trials (table 8).

The NNS skills assessment identified that participants of all severities were likely to present with dysphagia, though no statistically significant differences were found between groups ($p = 0.532$). The majority of the participants with a severely abnormal initial aEEG and who were not cooled (83.3%; n = 5) demonstrated impaired oromotor skill and did not undergo the oral feeding assessment on that day. Similarly, 80.0% (n = 4) of the participants with a severely abnormal aEEG and who were cooled, demonstrated impaired oromotor skill, although only 1 participant (20.0%) did not undergo the oral feeding assessment on that day. In contrast, 100% (n = 2) of the participants with a normal initial aEEG and 50.0% (n = 3) of the participants with a moderately abnormal initial aEEG demonstrated impaired oromotor skill, however these participants partook in the oral feeding assessment on that day. The proportion of participants who presented with signs and symptoms indicative that dysphagia was likely to be present at the first NNS skills assessment is indicated in Figure 2.

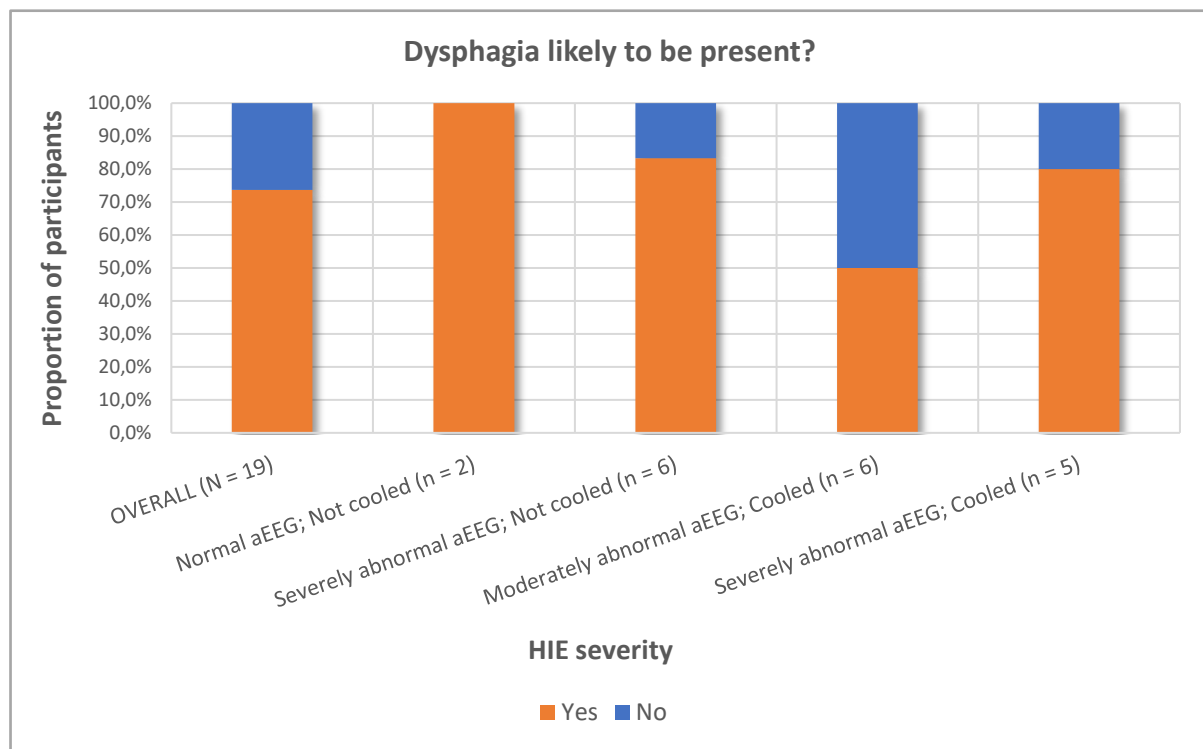


Figure 2. Proportion of Participants who Presented with Impaired Oromotor Skill in the NNS Skills Assessment and thereby, Likely to Present with Dysphagia (N = 19)

Table 8. Signs and Symptoms of Impaired Oromotor Skill in the NNS Skills Assessment

NON-NUTRITIVE SUCKING (NNS) SKILLS (NFAS; ST clinical notes)	OVERALL N = 19			Not cooled		Cooled	
				Normal aEEG n = 2	Severely abnormal aEEG n = 6	Moderately abnormal aEEG n = 6	Severely abnormal aEEG n = 5
	N	(%)	p-value	n	(%)	n	(%)
Clinical Signs							
Inadequate lip closure around finger	4	(21.1%)		2	(100%)	0	(0.0%)
not reported (NR)	6	(31.6%)		0	(0.0%)	2	(33.3%)
< 10 sucks per burst	14	(73.7%)		2	(100%)	3	(50.0%)
Reduced tongue cupping/grooving	10	(52.6%)		1	(50.0%)	4	(66.7%)
Reduced anterior-posterior tongue movement	10	(52.6%)		1	(50.0%)	1	(16.7%)
Reduced NNS strength	13	(68.4%)		1	(50.0%)	5	(83.3%)
Clinical Symptoms							
Abnormal respiratory patterns	1	(5.3%)		1	(50.0%)	0	(0.0%)
NR	6	(31.6%)		0	(0.0%)	2	(33.3%)
Reduced endurance	9	(47.4%)		2	(100%)	2	(33.3%)
NR	6	(31.6%)		0	(0.0%)	3	(50.0%)
Dysphagia likely to be present (NNS skills sub-section only)?	14	(73.7%)	0.532	2	(100%)	5	(83.3%)
NS/oral feeds not assessed?	6	(31.6%)		0	(0.0%)	5	(83.3%)

4.2.2. NS skills/oral feeding assessment

Participants were assessed during breastfeeding (78.9%; n = 15), cup feeding (11.1%; n = 1), breastfeeding supplemented with cup (11.1%; n = 1), and syringe feeding (10.5%; n = 2).

4.2.2.1. The oral phase of swallowing

The NS skills/oral feeding assessment identified clinical signs of OPD within the oral phase of swallowing, such as inadequate lip closure/seal on nipple (26.3%; n = 5), reduced sucks per burst (52.6%; n = 10), delayed sucking responses (36.8%; n = 7), reduced sucking strength (42.1%; n = 8), and poorly coordinated SSB sequences (21.1%; n = 5). The clinical symptoms of OPD observed during the NS/oral feeding assessment included pooling of saliva/secretions (10.5%; n = 2), pooling of the bolus (10.5%; n = 2), excessive anterior spillage during cup feeding/syringe feeding (10.5%; n = 2), and reduced feeding endurance (63.2%; n = 12). The results from this subsection indicated that 78.9% (n = 15) of the 19 participants presented with difficulties in the oral phase of swallowing, with reduced endurance and a reduced number of sucks per burst being the most common oral phase difficulties. The oral signs and symptoms of OPD that were exhibited in the oral feeding assessment are presented in Table 9. The oral feeding assessment identified that participants of all severities presented with difficulties in the oral phase of swallowing.

Table 9. *Clinical Signs and Symptoms of OPD in the Oral Phase of Swallowing*

ORAL PHASE SIGNS AND SYMPTOMS (NFAS; ST clinical notes)	Not cooled					Cooled				
	OVERALL N = 19		Normal aEEG n = 2		Severely abnormal aEEG n = 6		Moderately abnormal aEEG n = 6		Severely abnormal aEEG n = 5	
	N	(%)	n	(%)	n	(%)	n	(%)	n	(%)
<i>Clinical signs</i>										
Inadequate lip closure/seal on nipple	5	(26.3%)	2	(100%)	1	(16.7%)	0	(0.0%)	2	(40.0%)
Not applicable ((n/a) CF/SF)	3	(15.8%)	0	(0.0%)	2	(33.3%)	1	(16.7%)	0	(0.0%)
< 10 sucks per burst cycle	10	(52.6%)	2	(100%)	3	(50.0%)	1	(16.7%)	4	(80.0%)
n/a (CF)	1	(5.3%)	0	(0.0%)	1	(16.7%)	0	(0.0%)	0	(0.0%)
Delayed initiation of NS	7	(36.8%)	2	(100%)	1	(16.7%)	2	(33.3%)	2	(40.0%)
Not reported (NR)	1	(5.3%)	0	(0.0%)	1	(16.7%)	0	(0.0%)	0	(0.0%)
n/a (CF)	1	(5.3%)	0	(0.0%)	1	(16.7%)	0	(0.0%)	0	(0.0%)
Weak/poor NS response	8	(42.1%)	1	(50.0%)	3	(50.0%)	1	(16.7%)	3	(60.0%)
n/a (CF)	1	(5.3%)	0	(0.0%)	1	(16.7%)	0	(0.0%)	0	(0.0%)
Absent NS response	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
Uncoordinated SSB rhythm	5	(21.1%)	0	(0.0%)	2	(33.3%)	2	(16.7%)	1	(20.0%)
<i>Clinical symptoms</i>										
Pooling of saliva/secretions	2	(10.5%)	0	(0.0%)	1	(16.7%)	1	(16.7%)	0	(0.0%)
Pooling of the bolus	2	(10.5%)	0	(0.0%)	2	(33.3%)	0	(0.0%)	0	(0.0%)
Inadequate lip closure with excessive anterior spillage (BF)	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
Excessive anterior spillage (CF/SF)	2	(10.5%)	1	(50.0%)	1	(16.7%)	0	(0.0%)	0	(0.0%)
Reduced endurance	12	(63.2%)	2	(100%)	3	(50.0%)	4	(66.7%)	3	(60.0%)
NR	1	(5.3%)	0	(0.0%)	1	(16.7%)	0	(0.0%)	0	(0.0%)
TOTAL N/n	15	(78.9%)	2	(100%)	4	(66.7%)	5	(83.3%)	4	(80.0%)

Notes: BF: Breastfeeding; CF: Cup feeding; SF: Syringe feeding; NR Not reported

4.2.2.2. The Pharyngeal Phase of Swallowing

The oral feeding assessment identified clinical signs of OPD within the pharyngeal phase of swallowing, such as delayed (10.5%; n = 2) and absent (5.3%; n = 1) pharyngeal swallow responses. The clinical symptoms of OPD observed during the oral feeding assessment included gurgling (10.5%; n = 2), coughing (5.3%; n = 1), and teary eyes (5.3%; n = 1) during or immediately after the swallow. The results from this subsection indicated that 26.3% (n = 5) of the 19 participants presented with pharyngeal phase difficulties. The pharyngeal signs and symptoms of OPD that were exhibited in the oral feeding assessment are presented in Table 10.

Table 10. *Clinical Signs and Symptoms of OPD in the Pharyngeal Phase of Swallowing*

PHARYNGEAL PHASE SIGNS AND SYMPTOMS (NFAS; ST clinical notes)	Not cooled			Cooled	
	OVERALL N = 19	Normal n = 2	Severely abnormal n = 6	Moderately abnormal n = 6	Severely abnormal n = 5
	N (%)	n (%)	n (%)	n (%)	n (%)
<i>Clinical signs</i>					
Multiple swallow attempts to initiate the pharyngeal swallow	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Delayed pharyngeal swallow suspected	2 (10.5%)	0 (0.0%)	0 (0.0%)	2 (33.3%)	0 (0.0%)
Absent pharyngeal swallow	1 (5.3%)	0 (0.0%)	1 (16.7%)	0 (0.0%)	0 (0.0%)
<i>Clinical symptoms</i>					
Gurgling during/after the swallow	2 (10.5%)	0 (0.0%)	1 (16.7%)	1 (16.7%)	0 (0.0%)
Coughing during/after the swallow	1 (5.3%)	0 (0.0%)	0 (0.0%)	1 (16.7%)	0 (0.0%)
Choking during/after the swallow	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Teary eyes during/ immediately after the swallow	1 (5.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (20.0%)
“Wet” respiratory sounds	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
“Wet” vocal sounds	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
TOTAL N/n	5 (26.3%)	0 (0.0%)	2 (33.3%)	2 (33.3%)	1 (20.0%)

4.2.2.3. OPD Outcome

The results from the oral feeding assessment suggested that OPD was likely to be present in 63.2% (n = 12) of the 19 participants (Table 11).

Table 11. *Diagnostic Outcome of OPD in the Oral Feeding Assessment*

DIAGNOSTIC OUTCOME (NFAS; ST clinical notes)	Not cooled						Cooled				
	OVERALL N = 19			Normal aEEG n = 2		Severely abnormal n = 6	Moderately abnormal n = 6	Severely abnormal n = 5			
	N	(%)	<i>p</i> -value	n	(%)	n	(%)	n	(%)		
OPD likely to be present	12	(63.2%)	0.053	2	(100%)	3	(50%)	3	(50.0%)	4	(80.0%)
Full NGT feeds recommended	3	(23.1%)		0	(0.0%)	2	(33.3%)	1	(16.7%)	0	(0.0%)

Notes: OPD, oropharyngeal dysphagia; NGT, nasogastric tube

The oral feeding assessment identified that participants of all severities were likely to present with OPD, though no statistically significant differences were found between groups ($p = 0.053$). The participants with a normal initial aEEG were likely to present with OPD (n = 2), although they were deemed safe to continue with oral feeding trials. Similarly, while the majority (80.0%; n = 4) of the participants with a severely abnormal initial aEEG (and cooled) were likely to present with OPD, they were deemed safe to continue with oral feeding trials. It is likely that all these participants were deemed 'safe' to continue with oral feeding trials because they did not present with clinical signs and/or symptoms of pharyngeal phase difficulties. In contrast, only half of the participants with a severely abnormal initial aEEG (not cooled) and half of the participants with a moderately abnormal initial aEEG were likely to present with OPD. However, 33.3% (n = 2) of the participants with the severely abnormal initial aEEG (not cooled) and 16.7% (n = 1) of the participants with the moderately abnormal initial aEEG were deemed unsafe for the commencement of oral feeding trials. These participants were probably deemed 'unsafe' for oral feeding trials due to the clinical indications of pharyngeal phase difficulties. The proportion of participants who were likely to present with OPD at the first oral feeding assessment is indicated in Figure 3.

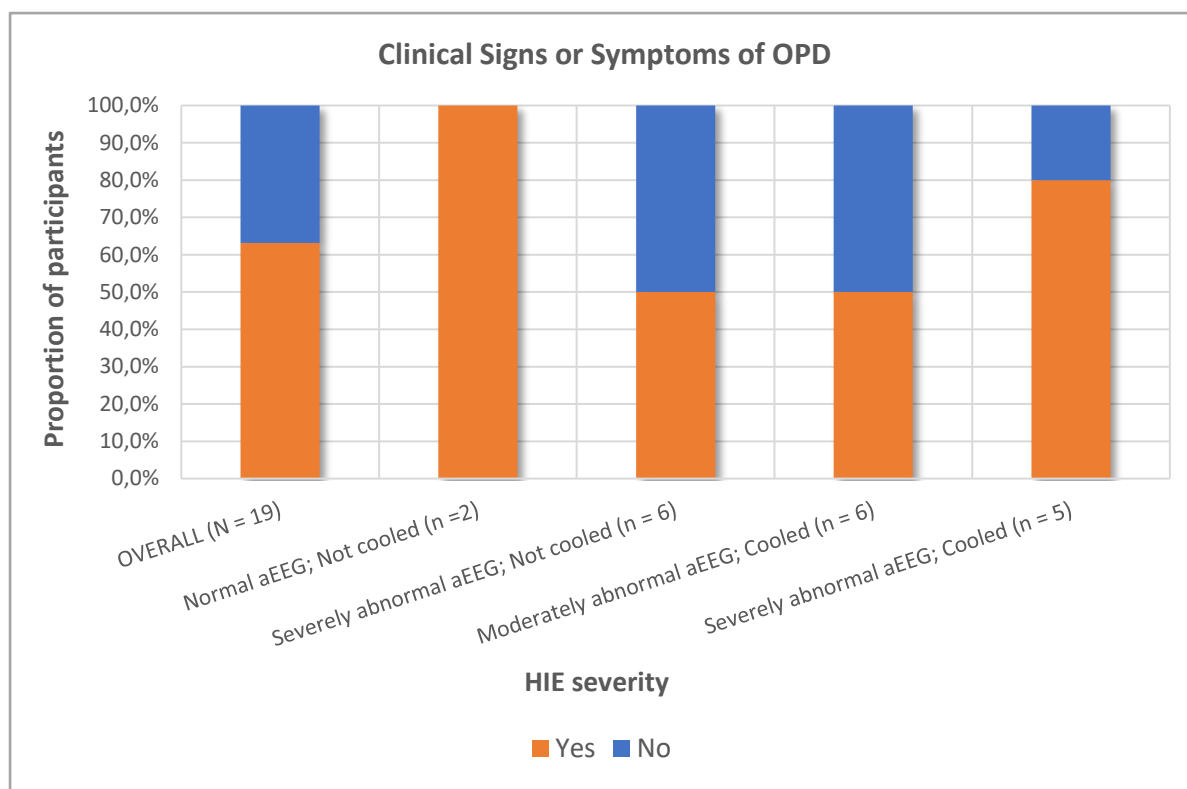


Figure 3. Proportion of Participants who Presented with Clinical Signs and Symptoms of Dysphagia in the oral feeding assessment (N = 19)

4.3. Time taken to reach full oral feeds

The median time for the sample of participants was 5 days until they were able to meet their full intake requirements via oral means (i.e., breastfeeding/cup feeding) with an interquartile range of 4 – 6.8 days and a standard deviation of 4.3 days. Figure 4 demonstrates the group variations in the median number of days until the establishment of full oral feeds.

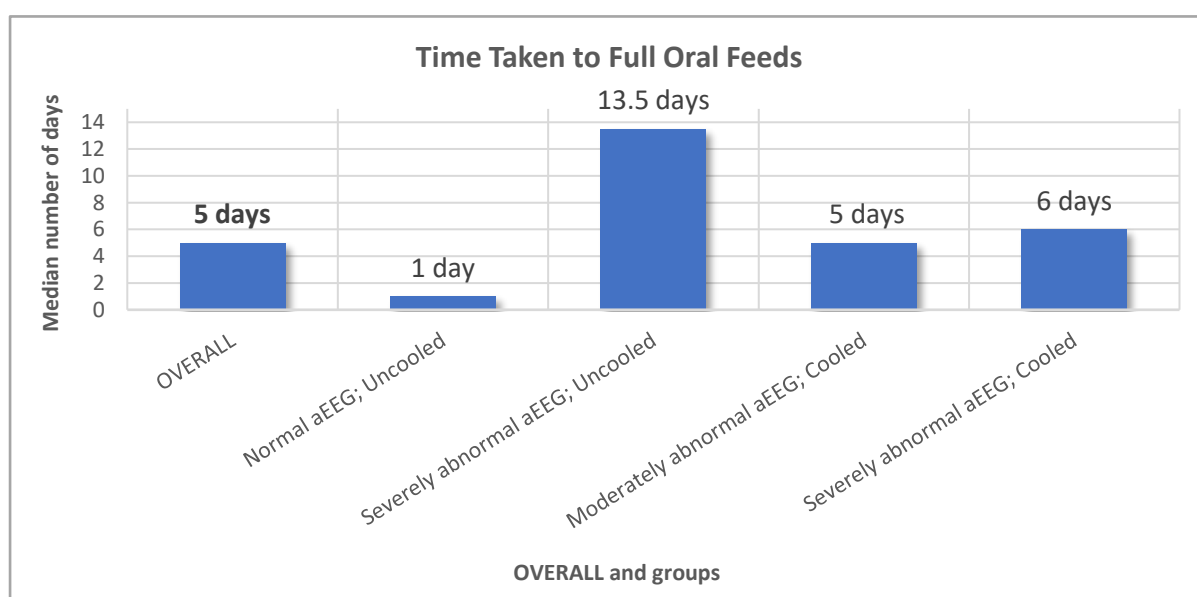


Figure 4. Median Number of Days to Full Oral Feeds

The participants with a normal initial aEEG experienced the shortest time to full oral feeds (1 day), while the participants with a severely abnormal initial aEEG who were not cooled experienced the longest duration to full oral feeds (13.5 days). The median number of days for the sample and for each group to establish full oral feeds, including the interquartile range and standard deviation, is presented in Table 12.

Table 12. *Time Taken to Full Oral Feeds*

	N	Median (days)	IQR (days)	SD (days)	<i>p</i>
OVERALL	50*	5	4 – 6.8	4.3	0.016
Normal aEEG; not cooled	7	1	1 – 6	5.6	
Severely abnormal aEEG; not cooled	4*	13.5	6.3 – 21.5	7.9	
Moderately abnormal aEEG; cooled	26	5	4 – 6	3.6	
Severely abnormal aEEG; cooled	13	6	5 – 7	1.5	

*N = 50 (i.e., 52 – 2): 2 participants were fed via a NGT at the time of discharge

The post-hoc analysis concluded that the participants with a severely abnormal initial aEEG and who did not receive hypothermia treatment, took significantly longer to establish full oral feeds compared with the participants with a normal initial aEEG ($p = 0.042$), and compared with participants with a moderately abnormal initial aEEG ($p = 0.022$). No other statistical differences were found as indicated in Table 13.

Table 13. *Comparison between HIE Groups of Time Taken to Full Oral Feeds*

HIE groups	<i>p</i> -value
Normal aEEG; not cooled vs Severely abnormal aEEG; not cooled	0.042*
Normal aEEG; not cooled vs Moderately abnormal aEEG; cooled	0.143
Normal aEEG; not cooled vs Severely abnormal aEEG; cooled	0.81
Severely abnormal aEEG; not cooled vs Moderately abnormal aEEG; cooled	0.022*
Severely abnormal aEEG; not cooled vs Severely abnormal aEEG; cooled	0.079
Moderately abnormal aEEG; cooled vs Severely abnormal aEEG; cooled	0.071

*Statistically significant at $p < .05$

4.4. Feeding method/s until discharge

Upon admission into the neonatal unit, 98.1% (n = 51) of the sample received enteral nutrition via an NGT or an OGT. On the first day of oral feeding trials, 44.2% (n = 23) of participants were able to meet their full intake requirements via oral means (i.e., breastfeeding/cup feeding), and at discharge, 98% (n = 50) of participants received their full intake requirements orally with the remaining two participants requiring long-term non-oral feeds. Table 14 indicates the modes of intake for the sample on admission, on the first day of oral feeding trials, and at discharge.

Table 14. Feeding Method/s during Hospital Admission

TIME	FEEDING METHOD/S	OVERALL N = 52	Normal aEEG n = 7	Severely abnormal aEEG n = 6	Moderately abnormal aEEG n = 26	Severely abnormal aEEG n = 13
		N (%)	n (%)	n (%)	n (%)	n (%)
Upon admission	Full oral feeds (BF/CF)	1 (1.9%)	1 (14.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
	Oral feeds*; tube t/u	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
	Exclusive NGT/OGT	51 (98.1%)	6 (85.7%)	6 (100%)	26 (100%)	13 (100%)
First oral feed	Full oral feeds (BF/CF)	23 (44.2%)	5 (71.4%)	0 (0.0%)	14 (53.8%)	4 (30.8%)
	Oral feeds*; tube t/u	23 (44.2%)	2 (28.6%)	1 (16.7%)	11 (42.3%)	9 (69.2%)
	Exclusive NGT/OGT	6 (11.5%)	0 (0.0%)	5 (83.3%)	1 (3.8%)	0 (0.0%)
At discharge	Full oral feeds (BF/CF)	50 (96.2%)	7 (100%)	4 (66.7%)	26 (100%)	13 (100%)
	Oral feeds*; tube t/u	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
	Exclusive NGT/OGT	2 (3.8%)	0 (0.0%)	2 (33.3%)	0 (0.0%)	0 (0.0%)

*Oral feeds: may include breastfeeding (BF), cup feeding (CF), and/or syringe feeding

The participant who did not require NGT/OGT feeds upon admission began breastfeeding within the first few hours of life. This participant exhibited a normal initial aEEG and did not undergo therapeutic hypothermia because it was not medically indicated. At the first oral feeding trial, most of the participants who exhibited a normal initial aEEG (71.4%; n = 5) were deemed ready to receive their full intake requirements via oral means. In contrast, the majority of participants who exhibited a severely abnormal initial aEEG and who were not cooled (83.3%; n = 5), had not yet established oral feeding readiness at the time of the first oral feeding trial and were deemed unsafe to continue with oral feeding on that day. Of these, 2 (33.3%) remained unsafe for oral intake at the time of discharge. Figure 5 demonstrates the changes in feeding method/s in the unit over time; namely on admission, at the first oral feeding trial, and at discharge.

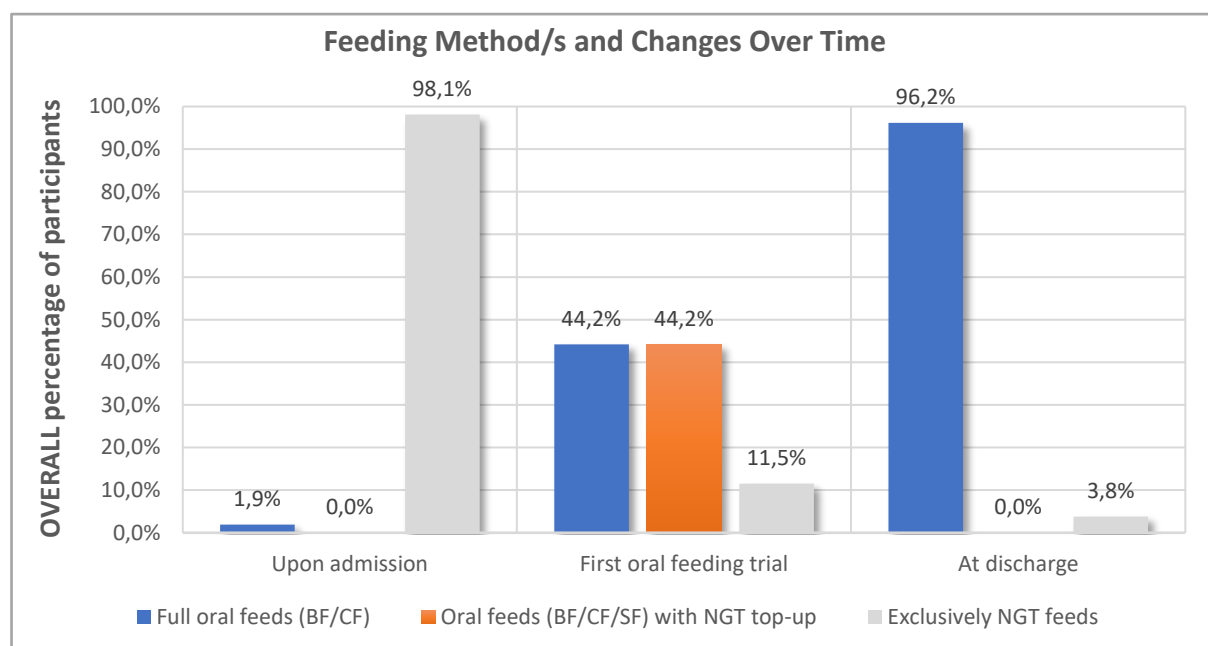


Figure 5. Feeding Method/s until Discharge

5. Discussion

This study described early feeding and swallowing characteristics in a sample of 52 neonates with HIE, including factors related to oral feeding readiness, characteristics of oropharyngeal swallowing and signs and symptoms of OPD, the time taken to reach full oral feeds, and the feeding method at discharge from the neonatal unit. Differences among participants with varied aEEG patterns and therapeutic hypothermia treatment were also considered, and are discussed further in this chapter.

Oral feeding readiness

The median age for oral feeding readiness was achieved on the fourth day of life, with all but one (98.1%; n = 51) of the participants receiving exclusive NGT/OGT feeds up until that time. Malan et al. (2022) reported a similar result with a median age of 5 days for the introduction of oral feeds.

Typically, neonates who are suspected with HIE will be required, according to protocol, to remain nil per mouth upon admission into the neonatal unit. This is because if feeds are introduced too rapidly, these neonates are at risk for developing necrotizing enterocolitis (NEC). Conversely, prolonged enteral fasting may hamper the development of the gastrointestinal tract (Jacobs et al., 2011) and extend the need for parenteral nutrition. Prolonged enteral fasting may also be accompanied by an increased risk for developing a systemic infection due to the reduced functioning of the neonates' immune cells (Morgan et al., 2013). Thus, feeds will typically be initiated at 12 – 24 hours post admission, gradually, and via enteral means until the neonate is deemed medically stable to commence oral feeding trials.

The NICU is faced with the need to provide adequate calories to the newborn, while also ensuring adequate opportunities for oral feeding experiences when deemed medically appropriate (Griffith et al., 2017). Although there are several oral feeding readiness tools available, such as the Earling Feeding Skills Assessment (Thoyre et al., 2005) and the Preterm Oral Feeding Readiness Assessment Scale (POFRAS) (Bolzan et al., 2016), vulnerable neonates may be subject to trial-and-error approaches as these measures are not standardised and they do not provide universally accepted criteria for neonates born at term (Jones, 2012; Pickler, 2004). As a result, health care providers will typically determine a term neonate's readiness for oral feeding trials according to medical stability criteria such as the stability of their vital signs and adequacy of their muscle tone at rest or during simple handling (Ross & Philbin, 2011). The neonate's physiological state, ability to reach and maintain robust alertness for feeding, and the ability to self-regulate, are seldom used as assessment parameters for oral feeding trials (Bertoncelli et al., 2012; Jones, 2012; Pickler, 2004; Wahyuni et al., 2022).

While the participants in this study were deemed medically stable – and therefore ‘ready’ to attempt oral feeding – their oral feeding success during the first NFAS assessment was influenced by their physiological stability (i.e., heart rate and respiratory function), behavioural state organisation, and ability to self-regulate during the oral feed, as discussed in the following sections.

Physiological subsystem

Physiological functioning during oral feeding was reported for the participants who were assessed with the NFAS. The results suggested that physiological instability, namely tachycardia and/or abnormal respiratory patterns, indicated that the participants were not ready to feed orally at that time, similar to reports in the literature (Pickler, 2004; Ross & Philbin, 2011; Wahyuni et al., 2022). As the ability to maintain physiological stability during feeding is a criterion for oral feeding readiness, heart rate variations and respiratory difficulties during feeding are physiological distress responses that may have indicated that the neonate was not ready to attempt oral feeding. Physiological instability during oral feeding may have also indicated a feeding and swallowing difficulty (Arvedson, 2008; Arvedson & Lefton-Greif, 2020), possibly due to inappropriately timed oral feeding (Ross & Philbin, 2011), delayed feeding skill, or impaired swallowing (Viswanathan & Jadcherla, 2020).

Although neonates with congenital heart defects were excluded from the present study, research has found that neonates with cardiac anomalies are likely to experience difficulties in coordinating their breathing and swallowing. Congenital heart defects are associated with reduced tidal volume and increased respiratory rate, which present as reduced respiratory compliance and increased breathing effort (Jadcherla et al., 2008; Latour et al., 2022; Saad et al., 2021). Similarly, respiratory distress during feeding is associated with increased breathing effort, recognised by one or more abnormal respiratory pattern such as nasal flaring or chest retractions (Reuter et al., 2014), and reported to be a common cause of paediatric dysphagia (Arvedson, 2008; Thoyre et al., 2013). The abnormal respiratory patterns observed in the present study – and reported in Malan et al.’s (2022) study – imply that the participants were experiencing a disruption in the typical coordinated activity of sucking, swallowing, and breathing required for safe and efficient feeding. Notably, 21.1% (n = 5) of the participants who underwent swallowing evaluations in this study demonstrated uncoordinated SSB rhythm. Respiratory distress during feeding may, therefore, represent a possible contributing factor to the observed feeding and swallowing difficulties in neonates with HIE. In addition, since the ability to achieve and maintain stability in the other subsystems depends on the smooth and reliable function of the autonomic nervous system, the unstable autonomic nervous system may have infringed on the relative stability of the other subsystems, further interfering with oral feeding as a result (Pickler, 2004; Ross & Philbin, 2011; Wahyuni et al., 2022).

In the present study, a greater percentage of participants with tachycardia and/or abnormal respiratory patterns during feeding presented with a diagnosis of OPD compared with those who demonstrated normal autonomic system functioning. This result is not surprising as feeding has its own physiological demands, making it likely that neonates who are unable to maintain physiological stability become unstable during feeding with an adverse impact on oral feeding success. Thus, as all other aspects of oral feeding are dependent on the neonate's physiological stability (Ross & Philbin, 2011), neonates with tachycardia and/or respiratory complications during feeding are at an increased risk for experiencing fatigue, reduced feeding endurance, behavioural state disorganisation, motor instability, agitation and ultimately, unsafe and inadequate oral intake leading to a prolonged period of enteral feeding and hospitalisation (Arvedson, 2008; Arvedson et al., 2020). In contrast, neonates who can maintain their physiological stability during oral feeding are more likely to present with behavioural state organisation, energy, adequate body posture and tone, and interest in sucking, and as a result, are more likely to demonstrate successful oral feeding (Ross & Philbin, 2011).

Behavioural state organisational subsystem

In addition to autonomic system instability, neonates with HIE frequently present with a reduced level of consciousness and inadequate behavioural state organisation (Sarnat & Sarnat, 1976; Thompson et al., 1997), which have been reported as major contributing factors to poor oral feeding in this population (Krüger et al., 2017, 2019; Malan et al., 2022). More than half of the participants in the sample who demonstrated a non-optimal state of alertness for feeding ($n = 4$; 57.1%), characterised by closed eyes, minimal movement, signs of drowsiness and/or agitation/crying, also presented with a diagnosis of OPD. Similarly, literature has reported that 'unsuccessful feeders' typically spend more than half of their feeding time in sleep states, whereas 'successful' feeders spend less than one-third of their feeding time in sleep states (McCain, 1997).

Drowsiness during feeding is an under-arousal pattern of alertness and indicative that some participants in this study were having difficulty transitioning from unconscious sleep to conscious wakefulness (Karl, 2004), possibly because of their neurological compromise (Pfaff et al., 2008; Volpe, 2012) and the sedative effect of anticonvulsant medications (Mutanana et al., 2020). A crying and irritable state is an overarousal pattern of alertness – an organised response to a heightened level of hunger. However, it was considered to be a disorganised or stressed state in this study as it persisted during the feeding attempt (Jones, 2012; Karl, 2004), possibly due to ill-timed oral feeding (Jones, 2012). A persistent crying or agitated state may result in the neonate becoming 'cut-off' from self or environmental de-stressors, which may further contribute to latching and feeding difficulties. Crying during feeding – with failed caregiver attempts to achieve a neutral-arousal newborn state in preparation for feeding – may also be stressful for the mother, eliciting a parallel physiological response

that causes her milk 'let down' reflex to diminish – further contributing to feeding difficulties (Dewey, 2001; Karl, 2004; Lau, 2001).

In keeping with the Synactive Theory of Development (Als, 1982), the instability and disorganisation of the behavioural system observed in the present study and reported in previous research (Krüger et al., 2017, 2019; Malan et al., 2022) may have interfered with the functioning and stability of the autonomic nervous system and the motor system, and the opportunity to interact with and take in social-emotional information from the environment (Karl, 2004). Neonates who have difficulty regulating their own state may depend on their caregivers to appropriately interpret their needs and assist in regulating their states. Therefore, this study emphasised the importance of recognizing neonatal behavioural states, particularly for oral feeding readiness. Ultimately, under- or over-arousal patterns of alertness during feeding may have indicated that those neonates were not ready to feed orally at that time (Karl, 2004; Thoyre et al., 2005; White & Parnell, 2013).

Research has also indicated that the increased risk of penetration and aspiration in neonates with HIE may be related to inadequate behavioural state organisation and reduced endurance during feeding (Malan et al., 2022). The integration of sucking, swallowing, and breathing while maintaining an appropriate behavioural state for feeding is a highly organised performance skill required for safe oral intake (Bertoncelli et al., 2012; Tamilya et al., 2014). Thus, it could be suggested that the participants who presented with non-optimal states of alertness during feeding – and/or reduced endurance – were at greater risk for aspiration, and thus, particularly vulnerable to potential respiratory sequelae or life-threatening consequences. Clinicians should, therefore, be cognisant of these cues, and decisions regarding oral feeding readiness should be based on careful, individualised assessment while considering signs of instability or stress to reduce the risk of aspiration.

In contrast, no participants who demonstrated an optimal state of alertness during feeding, i.e., quiet alert/active alert, were observed to present with a diagnosis of OPD. This finding was unsurprising because successful and safe oral feeding and swallowing requires active effort on the part of the neonate (Arvedson, 2006; Arvedson & Lefton-Greif, 2020; Delaney & Arvedson, 2008; Lefton-Greif & Arvedson, 2016; Rogers & Arvedson, 2005) and is supportive of adequate functioning and stability of the other subsystems. An optimal state of alertness was, therefore, more likely to aid in achieving feeding success compared with a non-optimal state of alertness (Karl, 2004; Maltese et al., 2017).

Although the study design did not allow for correlations, the idea that a positive relationship may exist between states of alertness and oral feeding success is supported by literature (Als, 1995; Karl, 2004; Pickler et al., 2006). Researchers have primarily investigated this relationship in preterm neonates. However, their findings may be applicable to neonates with HIE as behavioural states by definition

remain consistent throughout the neonatal population. Pickler et al. (2006) concluded that an alert behavioural state during feeding, i.e., optimal state of alertness, was a significant predictor of a high feeding efficiency (i.e., greater number of sucks per minute). In addition, an alert behavioural state has been associated with a better transition to full oral feeding competence (McGrath & Medoff-Cooper, 2002).

Self-regulation subsystem

A neonate's ability to self-regulate is a representation of their ability to maintain systemic stability when confronted with external stimuli, and is associated with oral feeding success (Maltese et al., 2017; Wahyuni et al., 2022). Thus, the neonates in this study who presented with stress cues and were unable to regulate their state all presented with a diagnosis of OPD. Similarly, Wahyuni et al. (2022) reported that the preterm neonates in their study sample who were unable to self-regulate, had a 1.8 times greater risk of being unable to feed orally ($p = 0.001$). According to the Synactive Theory of Development (Als, 1982; 1995), environmental inputs that are inappropriately timed, and the persistence of those inappropriate stimuli, result in the neonate being unlikely to maintain a stable balance of subsystem interaction, which is observable through disorganisation and signs of stress. This model of development assumes that a neonate is actively and consistently communicating a threshold for sensitivity versus competence through their behaviour. Thus, when multiple stress cues were demonstrated, the neonates were likely to be in a state of tiredness or disorganisation, and communicating that their self-regulating thresholds were overcome by the situation of the oral feeding trial (Maltese et al., 2017; Wahyuni et al., 2022). These neonates were unlikely to be ready for oral feeding at that time because of their inability to respond appropriately to the incoming sensory information and regain a state of equilibrium.

This study highlighted that neonatal feeding is an interactive, developmental task that relies on adequate oral-motor functioning and well-coordinated SSB sequences. Neonates must maintain respiratory and cardiovascular stability during oral feeding – and a robust level of alertness – while interacting with and managing their environment. In addition, and equally important, is the ability of the caregiver or health care practitioner to understand and respond appropriately to behavioural communications and reduce stress responses when required, reinforcing the need for a cue-based approach to oral feeding. By focusing on a behavioural assessment of oral feeding readiness, or on self-regulatory behaviours as indicators for feeding, clinicians can provide neonates with a safe, physiologically driven method for acquiring oral feeding competence while ensuring a positive feeding experience for the neonate and their caregiver.

Oromotor skill, oropharyngeal swallowing and clinical signs of OPD

Sucking and swallowing are important early neurodevelopmental milestones that are intricately linked through the complex interaction of the neonate and their environment, the gastrointestinal tract, cardiorespiratory stability, and central nervous system control and coordination (Jadcherla, 2016). Therefore, clinical feeding assessments can determine a neonate's developmental skill to guide management approaches and predict feeding outcomes. The findings of this study demonstrated that neonates with HIE of all severities are at an increased risk for experiencing feeding and swallowing difficulties, thus, reinforcing HIE as a risk factor for OPD and consequent adverse outcomes (Gulati et al., 2015; Jadcherla, 2016; Krüger et al., 2017, 2019; Malan et al., 2022).

Non-nutritive sucking skills

NNS skill is an indicator of oral feeding readiness and NS. However, NNS has a different and distinct site of neurological activation (Ertekin, 2011; Harding & Cockerill, 2015) and does not require SSB coordination, meaning it is not necessarily predictive of successful oral feeding (Lau, 2016). In addition, the NNS response may differ from the NS response because there are several factors that may influence NNS, such as an aversion to a gloved finger or the features of a pacifier such as its texture or thickness (Zimmerman et al., 2017). The NNS skills assessment does, however, provide insight into the participant's behavioural state and probable oral feeding skill, and subsequently, their readiness for the oral feeding assessment (Amaizu et al., 2008; Harding, 2014). The majority (73.7%; n = 14) of the participants presented with difficulties in NNS – and therefore, oral skills – with 31.6% (n = 6) deemed not ready for the assessment of oral feeding on that day, likely due to the neonates' behavioural and/or oral-motor status (Amaizu et al., 2008).

NNS has been reported to reduce stress responses through its calming effect (Karl, 2004), and NNS during gavage feeding encourages the development of sucking behaviour (Foster et al., 2016; Harding et al., 2012) and improves digestion (Foster et al., 2016). As a result, adequate NNS responses may lead to a reduction in the time needed for neonates to transition from tube feeding to full oral feeding, and from the start of oral feeding to full oral feeding, effectively reducing the length of hospitalisation (Foster et al., 2016; Pinelli & Symington, 2005). Thus, it could be suggested that the impaired NNS responses may have minimised the effect of self-regulation, thereby contributing to the feeding difficulties as a result (Jones, 2012; Wahyuni et al., 2022). Additionally, the findings of the NNS skills assessment indicated that approximately three quarters of the sample were likely to demonstrate feeding and swallowing difficulties at the introduction of oral feeds, implying that the transition to full oral feeds would be delayed and result in a prolonged hospital stay (Foster et al., 2016; Pinelli & Symington, 2005).

Nutritive sucking and oral feeding skills

Oral phase signs and symptoms of dysphagia were documented in 78.9% (n = 15) of the participants assessed. However, fewer participants (63.2%; n = 12) were likely to present with a diagnosis of OPD according to the oral feeding assessment diagnostic criteria. Improvement in the oral feeding assessment diagnostic outcome may have been due to the different dates of assessment for 6 of the 19 participants, enabling time for neurological recovery and subsequent development of oral feeding skill (Shandley et al., 2021).

Short sucking bursts (< 10 sucks per burst) and reduced endurance were the most common oral phase difficulties reported in the participants. These oral phase difficulties were also reported by Krüger et al. (2017, 2019) and Malan et al. (2022) as the most common initial difficulties in their study populations with HIE. Short sucking bursts may be related to difficulties in swallowing leading to ineffective breastfeeding (Arora et al., 2022), while poor endurance – associated with increased pauses and changes in state organisation – is commonly reported to accompany poor feeding performance (Lau, 2020). It is, therefore, notable that 52.6% (n = 10) of participants assessed in the present study demonstrated short sucking bursts and 63.2% (n = 12) showed reduced endurance during feeding.

As endurance is considered a function of clinical state, behavioural organisation, and/or stress, reduced endurance during feeding signalled that these neonates were no longer engaging in the feed actively and safely – possibly leading to poor oral feeding performance (Vandenberg, 2007), including short sucking bursts for some participants. In line with this result, Krüger et al. (2017) reported that the participant with HIE in their study required enteral feeding until day 13 of life due to an inability to compete all feeds orally, perhaps because of reduced endurance (defined as short sucking bursts and staying on the breast for less than a minute). Additionally, Malan et al. (2022) reported that aspiration was observed on the VFSS in their sample of neonates with HIE due to reduced endurance during fatigue testing. Short sucking bursts and reduced endurance during feeding may, therefore, increase the risk for inadequate oral intake, while reduced endurance may increase the risk for aspiration, leading to a prolonged requirement for enteral feeding and an increased hospital stay as a result (American Academy of Pediatrics, 2008).

Weak sucking responses were reported in some neonates (42.1%; n = 8), suggesting that these participants were likely to experience difficulties in latching and milk extraction during breastfeeding (Enrique et al., 2011; Isaac & Choi, 2023; Lau, 2015; Walker, 2011). In light of this, five of these neonates demonstrated inadequate lip closure around the whole nipple during breastfeeding, while the remaining three were cup fed. Although inadequate lip closure during breastfeeding may result in anterior spillage (Arvedson et al., 2020), this was not observed in the present study. This finding may relate to reduced intake due to the weak sucking responses (42.1%; n = 8) and, therefore, an

insufficient bolus mass for an 'excessive' loss of liquid. The findings indicate that sucking and subsequent latching difficulties are among the oral phase difficulties experienced by neonates with HIE and may relate to the abnormal muscle tone that is frequently observed among neurologically compromised neonates (Da Costa et al., 2019; Krüger et al., 2019; Straathof et al., 2022). Abnormal muscle tone may have affected the oral musculature including the ability to latch onto and maintain the maternal nipple, and generate and sustain an adequate suction (Arvedson et al., 2020; Rogers & Arvedson, 2005).

Reduced tongue cupping/grooving and anterior-posterior tongue movement during feeding were noted in 52.6% (n = 10) of participants, possibly negatively impacting oral motor control (Arvedson et al., 2020). Although fewer participants (10.3%; n = 3) were reported to present with reduced tongue shaping and movement in Malan et al.'s (2022) study, it was also documented as a feeding characteristic among neonates with HIE. Tongue cupping/grooving is required to aid the central flow of the milk bolus towards the pharynx, while the anterior-posterior tongue movement creates a propulsion wave for direction towards the oropharynx for the safe initiation of the pharyngeal swallow (Arvedson et al., 2020; Enrique et al., 2011; Isaac & Choi, 2023). Thus, impaired lingual shaping and movement may result in inadequate management of the bolus, which increases the risk for anterior spillage, premature spillage and subsequently, inadequate oral intake or penetration/aspiration. Inadequate management of the bolus may have direct implications for growth and development, and the safety of the swallow (Arvedson et al., 2020).

In the neonatal period, the mechanical acts of latching, sucking, and swallowing are largely automatic and reflexive in nature, and due to the rhythmicity of the SSB process, the motor functions described are primarily driven by central pattern generators (CPGs) located within the brainstem. However, the act of sucking and swallowing is a highly organised process that uses several different areas of the brain. Injuries to multiple brain regions, in addition to the brainstem, may therefore result in feeding difficulties (Shandley et al., 2021). Although limited research exists on the clinical presentation of the feeding and swallowing difficulties that may be experienced by neonates with HIE specifically, it is well known that early neurological injuries may delay or impair the development of these normal feeding reflexes (Arvedson et al., 2020; Da Costa et al., 2019; Jadcherla, 2016; Krüger et al., 2017, 2019; Malan et al., 2022; Martinez-Biarge et al., 2012; Quattrocchi et al., 2010; Shandley et al., 2021). Thus, the poor oral skills indicated in this study, including the poorly coordinated SSB sequences, may be attributed to the nature of neurological injuries in neonates with HIE.

As hypoxic-ischemic injuries do not affect all brain structures at the same time and in the same way, the areas of the brain with higher energy demands will become energy depleted earlier and more rapidly during a hypoxic ischemic insult (Huang & Castillo, 2008). The brain regions typically damaged

due to hypoxic-ischemic injury are essential role players in the swallowing system and include watershed zones, i.e., brainstem tegmentum (Miller et al., 2005), followed by the basal ganglia and thalamus (Martinez-Biarge et al., 2012; Miller et al., 2005; Quattrocchi et al., 2010). Quattrocchi et al. (2010) reported a strong association between oral-motor dysfunction in neonates with HIE and infratentorial lesions on MRI, specifically the brainstem. In addition, as the basal ganglia modulate the final motor response via the thalamus (Mistry & Hamdy, 2008), oral phase difficulties in neonates with HIE have been associated with basal ganglia, thalamic and mesencephalic lesions (Martinez-Biarge et al., 2012). It is unsurprising that a perinatal hypoxic-ischemic injury may have a profound effect on sucking patterns – which could explain the oral phase difficulties observed in the present study.

The pharyngeal phase of swallowing

Hypoxic-ischemic injuries have also been reported to have an adverse effect on the pharyngeal phase of swallowing (Gulati et al., 2015; Jensen et al., 2017), which was also suggested in this study. Five participants (26.3%) presented with clinical signs and symptoms of pharyngeal dysphagia. However, aspiration and other physiological problems that may be present in the pharyngeal phase cannot be thoroughly described or confirmed without an instrumental evaluation of swallowing, e.g., VFSS (Cordier et al., 2023). More participants may have had pharyngeal phase difficulties than suggested by the clinical signs and symptoms demonstrated in this study, given the high number of oral phase difficulties identified, and because research has shown that stimulus induced pharyngoesophageal reflexes are aberrant in neonates with HIE (Gulati et al., 2015; Jensen et al., 2017; Malan et al., 2022). While only two participants (10.5%) in this study sample were suspected of demonstrating delayed pharyngeal swallow responses according to the NFAS assessment, Malan et al. (2022) reported that considerably more neonates with HIE in their study exhibited delayed pharyngeal swallows on the VFSS than were identified on the NFAS. It is plausible that some delayed pharyngeal swallow responses were missed in this study due to the tightly linked, anti-phase relationship between sucking and the pharyngeal swallow (Arvedson, 2008; Jadcherla, 2016), and because delayed pharyngeal swallows constitute one of the most common abnormalities in neonates with dysphagia (Arvedson et al., 2020). Those participants suspected of demonstrating delayed pharyngeal responses on the NFAS may have been at risk for experiencing pooling of the milk bolus in the valleculae and/or pyriform sinuses prior to the closure of the airway, placing them at risk for aspiration before the swallow (Arvedson et al., 2020; Jadcherla, 2016; Viswanathan & Jadcherla, 2020).

Clinical signs of aspiration, namely gurgling (10.5%; n = 2) and coughing (5.3%; n = 1), were not observed frequently. However, the presence of aspiration can only be confirmed via an instrumental assessment (Cordier et al., 2023). In addition, silent aspiration appears to occur more frequently in neonates and children who are neurologically compromised, making the clinical inference more

difficult (Audag et al., 2017; Freitag et al., 2021; Malan et al., 2022). Malan et al. (2022) reported similar findings related to overt indicators of aspiration in the NFAS assessments. They reported that 10.3% (n = 3) and 3.4% (n = 1) of the neonates with HIE in their sample presented with gurgling/coughing and choking, respectively. However, they reported that more participants (31.0%; n = 9) demonstrated penetration and aspiration on the VFSS, and 60.0% (n = 3) of the aspiration events had occurred silently. These findings imply that the mechanisms involved in airway protection in neonates with HIE may be compromised, thereby increasing their risk for aspiration, and that a clinical assessment alone may not be adequately sensitive to identify neonates who are aspirating.

The increased risk for silent aspiration in neonates with neurological impairments may be related to impaired laryngeal sensation. Freitag et al. (2021) demonstrated that children with neurological impairments are at an increased risk for aspiration due to impaired laryngeal receptors required to trigger the airway protective reflexes. They reported that children with neurological impairment had a higher threshold for coughing associated with aspiration compared with that of healthy children, or of children with other co-morbidities but without neurological impairments. In line with this research, neonates with HIE have been reported to present with altered swallowing response sensitivity. Jensen et al. (2017) found that after 5 weeks of maturation, swallowing reflexes were more sensitive to a greater stimulus volume of 0.3 ml compared with 0.1 ml. Thus, it may be that because the bolus size is inadequate in neonates with HIE and OPD, the intake mass per SSB sequence is insufficient to trigger the airway protective reflexes, particularly in the early stages of oral feeding. Therefore, neonates with HIE may face an increased risk of silent aspiration, which may explain the reduced clinical signs of aspiration in the current study and the study by Malan et al. (2022). The relationship between laryngeal sensation and the increased risk for silent aspiration in neonates with HIE requires further investigation.

Although the current study did not investigate the oesophageal phase of swallowing, the increased risk of aspiration in neonates with HIE may also be related to oesophageal dysphagia, which impacts the pharyngeal phase and is represented as OPD symptoms. Pharyngoesophageal manometry studies have revealed that neonates with HIE present with impaired oesophageal responses, including increased skeletal hypertonicity at the UOS and the proximal oesophagus, and dysregulation of LOS relaxation (Gulati et al., 2015; Jensen et al., 2017). This may be due to the hypoxic ischemic injury that affects both afferent and efferent nerve impulse transmission (Gulati et al., 2015). As a result, the smooth transport of the bolus through the pharynx and into the oesophagus is disrupted, which may lead to the pharyngeal pooling of secretions, improper bolus clearance and consequently, an increased risk for aspiration (Viswanathan & Jadcherla, 2020).

A clinical assessment alone may be insufficient to provide a complete and accurate description of the pharyngeal phase of swallowing – an acknowledged limitation of the present study. However, there are risks associated with radiation exposure (Ko et al., 2019), and it is only appropriate to refer neonates for a VFSS when there is concern regarding the safety of their swallow, i.e., pharyngeal signs and symptoms of OPD, and/or a need to define the physiology or anatomy of the upper gastrointestinal tract. Thus, it could be argued that an instrumental assessment was not clinically indicated for most participants in this study sample and, therefore, the results reflect current clinical practice. However, a fiberoptic endoscopic evaluation of swallowing (FEES), which does not involve radiation exposure, may be especially valuable in this population of neonates due to their increased risk for aspiration. Thus, it is recommended that a FEES be included as the standard of care for neonates with HIE and clinically apparent oral phase difficulties. These neonates are more likely to experience aberrant pharyngeal responses and, therefore, increased risk of silent aspiration (Arvedson, 2008; Gulati et al., 2015; Jadcherla, 2016; Jensen et al., 2017; Malan et al., 2022). In addition, an instrumental assessment may be indicated for neonates who experience a prolonged or difficult transition to full oral feeds, or other signs and/or symptoms associated with aspiration, such as respiratory distress.

The presence of difficulties in all three phases of swallowing is reported in literature on neonates with HIE (Gulati et al., 2015; Jensen et al., 2017; Krüger et al., 2017, 2019; Malan et al., 2022). The results of the present study suggest that neonates with HIE are likely to present with oral phase difficulties primarily, namely short sucking bursts, weak sucking responses, impaired lingual shaping and movement, latching difficulties, and reduced feeding endurance. Signs and symptoms of OPD within the pharyngeal phase of swallowing were also present but their description is limited by the nature of clinical assessments. It is also possible that some neonates with HIE who were presenting with pharyngeal phase difficulties, such as an absent pharyngeal swallow response, may have not met the study's medical stability criteria, thereby contributing to the lower number of pharyngeal phase difficulties assessed. The varied signs and symptoms of feeding and swallowing difficulties in neonates with HIE are noteworthy findings, and align with the small body of research on feeding and swallowing in neonates with HIE (Krüger et al., 2017, 2019; Malan et al., 2022).

Time to full oral feeds and feeding method at discharge

Considering the complexity of OPD in neonates with HIE and the possible adverse outcomes, feeding management may necessitate a period of enteral feeding. In the present study, the inadequate lip closure around the whole nipple, weak sucking pressure or variable pressure throughout the feed, reduced sucking cycles, and reduced sucking endurance may have led to a reduced efficiency of milk intake and a reduced volume of milk swallowed (Matsubara et al., 2005). Thus, supplemental enteral feeding was required for 44.2% (n = 23) of participants at the introduction of oral feeds, suggesting

that these participants presented with inadequate oral intake. Furthermore, 11.5% ($n = 6$) of the participants required full enteral feeds at the first feeding trial because of their poor oral phase skills and being deemed unsafe for oral feeding at that time. As neonates with HIE are frequently reported to require short-term enteral feeding due to inadequate oral intake, or to ensure intake without compromising the respiratory system (Krüger et al., 2017, 2019; Malan et al., 2022), the present results are supported in literature.

The feeding and swallowing skills of participants appeared to generally improve during admission as the median time taken to full oral feeds was 5 days, with most participants (96.2%; 50/52) discharged on full oral feeds (breastfeeding and/or cup feeding). Improvements may have been due to improved overall health – including neurological recovery, the effects of neuroplasticity (Medoff-Cooper et al., 2009; Mizuno & Ueda, 2005), and improved subsystem functioning and interaction (Jones, 2012; McGrath, 2004; Pickler, 2004) – and feeding management by the SLT for some of the participants. Malan et al. (2022) also reported that the neonates with HIE in their study presented with an improvement in endurance specifically. As improved endurance has been associated with improved feeding performance (Lau & Smith, 2011), it is probable that the attainment of full oral feeding for most of the participants in this study was also assisted by improved feeding endurance.

Successful oral feeding, defined as consistent weight gain over time while maintaining physiological stability, is one of the main criteria for hospital discharge of high-risk neonates (American Academy of Pediatrics, 2008; Bromiker et al., 2005; Jadcherla, 2016). Research has consistently found that the presence of OPD is the most prevalent barrier to hospital discharge (Attrill et al., 2018; Dziewas et al., 2017; Edwards et al., 2019; Krüger et al., 2017). Although Malan et al. (2022) did not find a statistical association between OPD and the length of hospital stay among neonates with HIE, they suggested that OPD severity plays a role – albeit a lesser role than initially expected – and perhaps the early introduction to oral feeding and the early involvement of the SLT minimised the effect of OPD severity on the length of hospital admission. Statistical inferences regarding the association between OPD and the length of hospitalisation could not be established in this study. As dysphagia services are not readily available across the public healthcare sector in South Africa, the presence of OPD is still likely to increase healthcare utilisation, cost, and associated caregiver stress (American Academy of Pediatrics, 2008; Edwards et al., 2019), impairing the caregiver-neonate dyad and disrupting feeding interaction (Franklin & Rodger, 2003; Jonsdottir et al., 2021; McDonald et al., 2013; Zanardo et al., 2017).

Oral feeding readiness, enteral feeding requirements, time taken to full oral feeds, and the feeding methods used at the time of discharge varied among participants with different severities of HIE. These differences were expected amongst groups because aEEG patterns have proven to provide invaluable information regarding the severity of the encephalopathy and consequent neurological outcomes

(Azzopardi et al., 2008; Chandrasekaran et al., 2017; Hallberg et al., 2010; Orman et al., 2018; Pu et al., 2021; Simbruner et al., 2010; Spitzmiller et al., 2007; Thoresen, 2008; Variane et al., 2022; Weeke et al., 2017), and therapeutic hypothermia has proven to reduce mortality or severe disability in neonates with moderate to severe HIE (Gagne-Loranger et al., 2015). While this method of describing participants with HIE is employed to select neonates for cooling, and considered to be an ideal prognostic tool (Horn et al., 2013a), it is novel in dysphagia research, and as such, limited direct comparisons with other studies that use the traditional 'mild', 'moderate', or 'severe' categorisation of HIE. In addition, the small sample size – particularly with regards to the feeding and swallowing assessments – and the unequal distribution of participants within each group, limited comparisons. However, some patterns in feeding development and difficulties were identified, which may guide future research.

The two participants with a normal initial aEEG presented with clinical signs and symptoms of OPD. However, the time taken to reach oral feeding readiness (1 day) and full oral feeds (1 day) was shorter compared with that of their moderate and severe counterparts, and statistically different compared with participants with a severely abnormal initial aEEG (not cooled) ($p = 0.042$). This suggests that neonates with 'mild' HIE may demonstrate some initial feeding difficulties, thereby constituting 'mild' HIE as a risk factor for OPD. However, as neonates with a normal and maintained initial aEEG pattern typically present with normal neurological outcomes, they may present with earlier developing oral feeding readiness and oral feeding skill, and full oral feeds as a result. This sample size was too small for an accurate representation of feeding and swallowing in neonates with 'mild' HIE, and further research is required.

Participants with a normal initial aEEG did not require therapeutic hypothermia treatment, and the restrictions on oral feeding during treatment did not apply. These neonates were, therefore, likely to be introduced to oral feeding at an earlier time, which may have further contributed to earlier establishment of full oral feeds. Bromiker et al. (2005) reported that when oral feeds were initiated earlier in a group of 70 preterm neonates, their feeding skill developed sooner and full oral feeds were achieved earlier than the preterm neonates of the same post conceptual age introduced to oral feeding two weeks later. Their results highlight the influence of learning and practice, reinforcing the effect of sucking at the breast on the development of feeding skill. Thus, as the participants who presented with a normal initial aEEG were considered to have a 'mild' neurological injury and were likely to be introduced to oral feeding sooner, they were more likely to present with better feeding organisation at an earlier time (Bromiker et al., 2005).

In contrast, the neonates with a severely abnormal initial aEEG trace who did not undergo therapeutic hypothermia treatment experienced the longest median time to oral feeding readiness (12.5 days),

and the longest median time to the establishment of full oral feeds (13.5 days). Furthermore, nearly all the participants in this group were not deemed ready for the oral feeding assessment on that day due to the results of their NNS skills assessment (83.3%; $n = 5$), while two of these participants exhibited limited to no improvement at the time of discharge, necessitating gastrostomy placement. This finding was unsurprising because an early abnormal aEEG has been proven to predict adverse neurological outcomes with high sensitivity and specificity in high-risk neonates who have not undergone therapeutic hypothermia treatment (Bonifacio et al., 2022; Jacobs et al., 2007; Shah et al., 2007; Wilkinson et al., 2007).

Neurologically compromised neonates have been reported to be at increased risk for long-term enteral feeding requirements, with HIE reported as the most common aetiology (Macchini et al., 2018) and OPD as the most common indication (Macchini et al., 2018; Rahnemai-Azar et al., 2014; Sullivan, 2014) due to the brain regions affected (Martinez-Biarge et al., 2012; Miller et al., 2005; Quattrocchi et al., 2010). The fact that only two participants in this study required long-term enteral feeding – two neonates required gastrostomy feeds on discharge – was unexpected. This may have been due to the neuroprotective effect of therapeutic hypothermia treatment in 75% ($n = 39$) of participants resulting in improved neurological outcomes, including feeding and swallowing skill (Bonifacio et al., 2022; Jacobs et al., 2007; Shah et al., 2007; Wilkinson et al., 2007). Another reason for this small number may relate to the strict selection criteria of participants and the medical stability requirement that possibly excluded severely affected neonates.

It was expected that neonates with different severities of HIE would demonstrate varied feeding and swallowing characteristics, with an increased likelihood for OPD in those with more severe HIE. However, this study suggests that the implementation of therapeutic hypothermia may offset this initial ‘severity’ expectation – a finding supported by literature. Thus, as the prognostic value of the aEEG pattern is delayed by 48 hours in those neonates who have undergone therapeutic hypothermia (Azzopardi et al., 2008; Chandrasekaran et al., 2017; Hallberg et al., 2010; Pu et al., 2021; Simbruner et al., 2010; Spitzmiller et al., 2007; Thoresen, 2008; Weeke et al., 2017), the feeding expectation on admission was likely to be altered compared with that of the observed feeding and swallowing skill post cooling treatment. In line with this expectation, the participants who underwent therapeutic hypothermia treatment – those with moderately and severely abnormal initial aEEG – presented similarly with respect to the time taken to oral feeding readiness ($p = 0.050$), and the time taken to full oral feeds ($p = 0.071$). In contrast, the participants with a severely abnormal initial aEEG (not cooled) established oral feeding readiness and subsequent full oral feeds in more than double the time taken by the participants who received therapeutic hypothermia treatment. These findings, while limited, support the neurological benefit of early therapeutic hypothermia management in this population of

neonates (Bonifacio et al., 2022; Jacobs et al., 2007; Shah et al., 2007; Wilkinson et al., 2007). Studies with larger sample sizes across multiple centres will, however, enable more accurate statistical comparisons of aEEG patterns, therapeutic hypothermia treatment, and the feeding and swallowing characteristics that follow.

Clinical implications

Neonates with HIE, regardless of severity, are at an increased risk for feeding and swallowing difficulties and require clinical swallowing assessments, and instrumental swallowing assessments if indicated, by an SLT to accurately identify and manage their feeding and swallowing difficulties. Considering the high incidence of HIE in South Africa, these findings suggest that OPD in neonates with HIE may be an important contributor to pressure on the healthcare system in the country. This study highlights that dysphagia services should be readily available at paediatric healthcare facilities.

All neonates with HIE should be screened for feeding and swallowing difficulties, and referred to the SLT for feeding management once medically stable (Da Costa et al., 2019; Krüger et al., 2017, 2019; Malan et al., 2022; Martinez-Biarge et al., 2012; Quattrocchi et al., 2010). Health care professionals (SLTs, doctors and nurses) should equip primary caregiver/s with the knowledge required to monitor their neonate for possible signs and symptoms of unsafe swallowing given the increased risk of aspiration in this population, particularly in the early stages of oral feeding. As neonates with HIE are at an increased risk for silent aspiration particularly, an instrumental assessment of swallowing – such as FEES – may be required for the accurate diagnosis of aspiration and subsequent management (Malan et al., 2022). However, reduced access to this type of specialised equipment in the South African public health care sector (Horn et al., 2013a; Moyimane et al., 2017), along with limited SLT services (Pillay et al., 2020), presents a challenge to the comprehensive and accurate diagnosis of difficulties in the pharyngeal phase of swallowing. Clinicians must maintain an acute level of awareness when managing feeding and swallowing difficulties in this population of neonates because they are important referral agents and may need to collaborate closely with other health care facilities that offer such services (American Speech-Language-Hearing Association (ASHA), 2023; Health Professions Council of South Africa (HPCSA), 2023; South African Speech-Language-Hearing Association (SASLHA), 2023).

As behaviour is the first way that neonates communicate, adequate care practices can be enforced through observation (Maltese et al., 2017), including oral feeding readiness tools that take the neonate's physiological stress and state, and oral motor skill into consideration. Thus, the findings of this study advocate for the implementation of a contingent caregiving approach to oral feeding, i.e., providing care when the neonate indicates readiness to receive care. Oral feeding initiation and management should, therefore, be undertaken following a careful, individualised assessment of the

neonate's feeding readiness behaviours. Caregivers should also be trained to become keen observers of their newborn's states, and to recognise when stimulation should be increased or decreased to enable accomplishment of developmental tasks, including oral feeding. This approach may enhance stability, organisation and competence, ultimately optimising physiological and behavioural responses to promote transition from tube to oral feeding (Jones, 2012; Karl, 2004; Pickler, 2004).

Although the majority of participants were discharged on full oral feeds, neonates with HIE remain at risk for long-term feeding difficulties. Thus, it is recommended that all neonates with HIE, regardless of severity, attend a high-risk developmental follow-up clinic inclusive of a basic feeding and swallowing screening. This may alert the on-site clinician to possible feeding and swallowing difficulties, thereby enabling an earlier referral to the nearest SLT for further assessment and management. As a result, potential adverse OPD outcomes may be reduced or eliminated (Martinez-Biarge et al., 2012; Tsuda et al., 2022). Considering the high incidence of HIE in South Africa, and its association with an increased frequency of OPD, there is a need to (1) train new graduates in the area of HIE and OPD, and (2) upskill those clinicians already in practice (Schie et al., 2020). This research informs current clinical practice and may contribute to education and training in the field of paediatric dysphagia.

Future research recommendations

Future research should focus on prospective data collection over a longer period to include larger sample sizes with more equally distributed grades of HIE. Although neuroimaging information was available for most of the participants in this study, the relationship between specific patterns of brain injury and OPD was beyond the study scope. However, future research could examine this relationship further to better inform feeding and swallowing outcomes and advance management approaches (Martinez-Biarge et al., 2012; Quattrocchi et al., 2010). Similarly, interventions for OPD among neonates with HIE should be investigated as there is a lack of evidence-based data regarding the direct benefits of feeding management strategies (Lau & Smith, 2011).

Limitations

Although the NFAS is a valid and reliable assessment tool for use within the South African context, clinical assessments are restricted in their identification of the pharyngeal phase of swallowing, and thus, the pharyngeal phase could not be thoroughly described in the present study. It is also worth noting that neonates are typically reported to present with a feeding and swallowing difficulty according to the outcome of the NNS and/or oral feeding assessment. Thus, the NFAS may not reflect clinical practice because a diagnosis of OPD is only made when two or more sub-sections indicate 'yes' for the likelihood of dysphagia, in addition to the 'Oral Peripheral Evaluation' or the 'Clinical Feeding and Swallowing Evaluation' subsection. Furthermore, the NFAS does not take neonates who are cup

or syringe fed into consideration as the observational items are based on breastfeeding skill. This assessment, therefore, did not account for the complete spectrum of possible oral feeding methods that were used in the current study. This was particularly concerning as alternative oral feeding methods, such as paced cup feeds or syringe sips with oral stimulation, were some of the feeding management strategies used to assist with SSB coordination for safer swallowing while ensuring oral feeding practice for the development of feeding skill.

Limitations inherent to the retrospective data collection component included gaps in the information documented and lack of standardisation regarding the information available. Additionally, reliable and detailed feeding and swallowing information in the retrospective component of the study was only available for participants referred for SLT services during admission. However, it is possible – and probable, considering the high-risk population under investigation – that more participants presented with feeding and swallowing difficulties than were indicated by the number of SLT referrals. Though, as there was only one part-time SLT at the research site, it is likely that only the neonates who presented with severe OPD were referred for feeding management. Other study limitations included a small sample size, unequal distribution of participants within each group, and a novel method of HIE categorisation, which limited direct comparison with other studies that used the traditional ‘mild’, ‘moderate’, or ‘severe’ HIE grading systems.

6. Conclusion

The study provided a comprehensive description of the feeding and swallowing difficulties experienced by a sample of neonates with HIE admitted to a regional hospital in the Western Cape, South Africa, using a validated and standardised clinical assessment tool. The findings highlighted that oral feeding readiness is not a static concept but rather multi-factorial and dynamic, requiring assessment prior to every oral feed until full oral feeds are successfully and consistently achieved. The oral phase of swallowing appeared to be primarily affected by HIE. However, this finding may have reflected the nature of the assessment tool and its restricted ability to describe the pharyngeal phase of swallowing. The results of the study align with reports in the literature (Krüger et al., 2017, 2019; Malan et al., 2022) and correspond to motor outcomes related to neurological injuries (Da Costa et al., 2019; Martinez-Biarge et al., 2012; Quattrocchi et al., 2010). Neonates with HIE face an increased risk for inadequate oral intake, aspiration, prolonged enteral feeding, extended hospitalisation and interrupted or reduced feeding interactions. In the context of South Africa's high HIE incidence, the increased risk of aspiration in this population, and the direct cost implications due to an increase in hospital utilisation, the findings promote the role of SLTs in the early identification and management of neonatal feeding difficulties. SLTs and health care professionals working in the field of paediatric dysphagia should be cognisant of the possible feeding and swallowing difficulties experienced by neonates with HIE.

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8. Appendices

Appendix A: Medical Stability Criteria

Participants were considered medically stable by their treating doctor if they met the following criteria for a continuous period of 24 hours (Groote Schuur Hospital, 2019):

- No apnoea
- Axillary temperature maintained at 36.0°C to 37.4°C
- Breathing comfortably with a maximum of 30% oxygen (not on continuous airway pressure (CPAP)) to maintain SpO₂ >95%
- Respiratory rate up to 70 breaths per minute
- Heart rate of >80 to <180 beats per minute
- May be receiving phototherapy, intravenous fluids, and antibiotics

Appendix B: HIE Diagnostic Criteria

For a diagnosis of HIE, the neonate must present with (Groote Schuur Hospital, 2019):

- A. Clinical signs of encephalopathy characterised by:
 - Abnormal level of consciousness
 - Abnormal tone
 - Abnormal primitive reflexes
 - Abnormal breathing and seizures may occur
- B. Evidence of intrapartum hypoxia secondary to an acute intrapartum event e.g., haemorrhage, prolapsed cord, uterine rupture. Intrapartum hypoxia is suggested, but not proven, by one or more of the following peripartum features:
 - An acute intrapartum event
 - Pathological cardiotocograph/foetal heart rate as per The International Federation of Gynaecology and Obstetrics (FIGO) criteria:
 - a. Bradycardia <100 beats per minute
 - b. Reduced or increased variability (normal 5 – 25 beats per minute)
 - c. Sinusoidal pattern
 - d. Repetitive late decelerations (>20 seconds after onset of contraction) or prolonged decelerations (>3 minutes) during >30 minutes of trace or 20 minutes if reduced variability, or one prolonged deceleration >5minutes at any time (decelerations are repetitive when associated with >50% of contractions)
 - Meconium-stained liquor
 - Prolonged second stage (2 hours multiparous, 3 hours primiparous)
 - Need for resuscitation at birth for ≥10 minutes
 - Acidosis on cord or neonatal blood in the first hour of life (defined as pH ≤7.15 and/or base deficit ≥10)

Appendix C: Human Research Ethics Committee (HREC) Approval Letter (Ref. 780/2021)



UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee



Room 45, E-52- Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: hrec-enquiries@uct.ac.za

Website: www.health.uct.ac.za/fhs/research/humanethics/forms

10 December 2021

HREC REF: 780/2021

Ms V Norman

Division of CSD

F-45 OMB

Email: vivienne.norman@uct.ac.za

Student: sam.branfield@gmail.com

Dear Ms Norman

**PROJECT TITLE: FEEDING AND SWALLOWING IN NEONATES WITH MODERATE TO SEVERE
HYPOXIC ISCHEMIC ENCEPHALOPATHY (HIE): A DESCRIPTIVE STUDY-MSC CANDIDATE-MS
SAMANTHA BRANFIELD**

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

This approval is subject to strict adherence to the HREC recommendations regarding research involving human participants during COVID -19, dated 17 March 2020: 06 July 2020 & 01 July 2021.

Approval is granted for one year until the 30 December 2022.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.

(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

The HREC acknowledges that the student: - Ms Samantha Branfield will also be involved in this study.

Please quote the HREC REF 780/2021 in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

HREC/REF 780/2021sa

Yours sincerely



PROFESSOR M BLOCKMAN

CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE

Federal Wide Assurance Number: FWA00001637.

Institutional Review Board (IRB) number: IRB00001938

NHREC-registration number: REC-210208-007

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use: Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2020), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI), and Declaration of Helsinki (2013) guidelines. The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

HREC/REF 780/2021sa

Appendix D: Permission to Conduct Research at MMH: Department of Health (Ref.: WC_202201_032)



STRATEGY & HEALTH SUPPORT
Health.Research@westerncape.gov.za
tel: +27 21 483 0866; fax: +27 21 483 6058
5th Floor, Norton Rose House, 8 Riebeeck Street, Cape Town, 8001
www.capegateway.gov.za

REFERENCE: WC_202201_032
ENQUIRIES: Dr Sabela Petros

University of Cape Town
Anzio Road
Observatory
Cape Town
7925

For attention: Mrs Vivienne Norman, Dr Natasha Rhoda, Ms Samantha Branfield, Ms Janine Joemat

Re: Feeding and swallowing in neonates with moderate to severe hypoxic ischemic encephalopathy (HIE): a descriptive study

Thank you for submitting your proposal to undertake the above-mentioned study. We are pleased to inform you that the department has granted you approval for your research.

Please contact the following people to assist you with any further enquiries in accessing the following sites:

Mowbray Maternity Hospital

DrChantel J Stewart

021 659 5579

Kindly ensure that the following are adhered to:

1. Arrangements can be made with managers, providing that normal activities at requested facilities are not interrupted and the constraints caused by the Covid-19 epidemic above are respected and adhered to.
2. Researchers, in accessing provincial health facilities, are expressing consent to provide the department with an electronic copy of the final feedback (**Annexure 9**) within six months of completion of research. This can be submitted to the provincial Research Co-ordinator (Health.Research@westerncape.gov.za).
3. In the event where the research project goes beyond the *estimated completion date* which was submitted, researchers are expected to complete and submit a progress report (**Annexure 8**) and an updated ethics clearance letter to the provincial Research Co-ordinator (Health.Research@westerncape.gov.za).
4. The reference number above should be quoted in all future correspondence.

Yours sincerely

PROF. V ZWEIGENTHAL
DIRECTORATE: HEALTH INTELLIGENCE
DATE: 25 May 2022
CC

Appendix E: Permission to Conduct Research at MMH: MMH Research Committee



Mowbray Maternity Hospital Research Committee

Enquiries: Dr. C Stewart / N R Rhoda
Head of Clinical Unit Obstetrics / Neonatology
12 Hornsey Road, Mowbray, 7700
Email: Chantal.stewart@westerncape.gov.za
Email: Natasha.rhoda@wct.ac.za
Telephone: +2721659 5578 / 5562

TEMPLATE FOR REQUESTING FACILITY APPROVAL FOR RESEARCH STUDIES

STUDY TITLE:

Title: Feeding and swallowing in neonates with moderate to severe hypoxic ischemic encephalopathy (HIE): a descriptive study

PRINCIPAL INVESTIGATOR:

...Samatha ...Branfield... ..(Principal-Investigator)

..... (Co-Investigator)

SUPERVISOR:

Vivian Norman (Primary), Janine Joemat (secondary), Natasha Rhoda (secondary)

CLINICAL DEPARTMENT (X):

Obstetrics and Gynaecology ☐
Pharmacy ☐

Neonatology ☒
Nursing Education ☐

DATE OF DEPARTMENTAL APPROVAL: 04/02/2022.....

HREC APPROVAL NUMBER (Letter attached): FHS HREC- REF : 780/2021.....

NHRD REGISTRATION NUMBER: WC_202201_032

WESTERN CAPE APPROVAL STATUS:

APPROVED	X PENDING	NOT APPLIED FOR
----------	-----------	-----------------

THE PROTOCOL SYNOPSIS IS ATTACHED:

X YES	NO
-------	----

12 Hornsey Road, Mowbray, 7700

tel: +27 21 659 4959 fax: +27 21 685 2991

Private Bag X7, Mowbray, 7705

www.westerncape.gov



THE STUDY METHOD IS MAINLY:

RECORD REVIEW	PATIENT INTERVIEWS	STAFF INTERVIEWS	CLINICAL TRIAL
x	x	x	

The Principal investigator must provide information regarding impact on the facility as follows:

DESCRIPTION	YES/NO	If Yes, Provide details
1. Additional load on nursing	no	
2. Support services	no	
3. Consumables	no	
4. Laboratory tests	no	
5. Equipment	no	
6. Space	no	
7. Communications	no	
8. Additional OPD visits	no	
9. Admission of patients	no	
How will the sites be prepared to participate in your research?	Evaluation during routine care of HIE baby on the unit	



10/02/2022

SIGNED:

Appendix F: HREC Approval of Protocol Amendment



UNIVERSITY OF CAPE TOWN
UNIVERSITEIT VAN KAAPSTAD

**HUMAN RESEARCH
ETHICS COMMITTEE**

06 JUL 2022

FACULTY OF HEALTH SCIENCES
HEALTH SCIENCES FACULTY
UNIVERSITY OF CAPE TOWN



FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

Form FHS006: Protocol Amendment

HREC office use only (FWA00001637; IRB00001938)		
☒ Approved	☒ Type of review: Expedited	☐ Full committee
This serves as notification that all changes and documentation described below are approved.		
Signature HREC Chairperson / Designee		Date
6/7/22		
Note: All Major amendments must include a Cover Letter and a local PI Synopsis justifying the changes for the amendment. Please note that incomplete amendment submissions will not be reviewed. Please email this form and supporting documents (if applicable) in a combined pdf-file to hrec-enquiries@uct.ac.za with subject line: FHS006 + (HREC Reference number). The latest forms are found on our website. http://www.health.uct.ac.za/fhs/research/humanethics/forms Please also clarify your plan for research-related activities during COVID-19 lockdown.		
Comments from the HREC to the Principal Investigator:		
Note: The approval of this protocol amendment does not grant annual approval. Please complete the FHS016 / FHS017 form for annual approval at least one month before study expiration.		

Principal Investigator to complete the following:

1. Protocol information

Date (when submitting this form)	5/7/2022	
HREC REF Number	780/2021	
Protocol Title	Feeding and swallowing in neonates with moderate to severe hypoxic-ischemic encephalopathy: a descriptive study	
Protocol Number (if applicable)		
Principal Investigator	Vivienne Norman	
Department / Office Internal Mail Address	Health and Rehabilitation Sciences, F45 Old Main Building, Groote Schuur Hospital, Main Road, Observatory, 7925	
1.1 Is this a major or a minor amendment? (see FHS006h1p) Major (tick box) Minor (tick box)	☒ Major	☐ Minor
1.2 Does this protocol receive US Federal funding?	☐ Yes	☒ No



1.3 If the amendment is a major amendment <u>and</u> receives US Federal Funding, does the amendment require full committee approval? Note: Any protocol amendments for Full Committee Review MUST be submitted on the monthly HREC submission dates. (Please email an electronic copy to hrec-enquiries@uct.ac.za)	☐ Yes	☐ No
1.4 Did the initial study require UCT No-Fault Insurance	☐ Yes	☒ No

2. List of Proposed Amendments with Revised Version Numbers and Dates

Please itemise on the page below, all amendments with revised version numbers and dates, which need approval.
This page will be detached, signed and returned to the PI as notification of approval. Please add extra pages if necessary.

- Extension of inclusion criteria to include neonates with mild HIE and not only those with moderate to severe HIE.
- Add a retrospective folder review pre-dating this prospective study to increase the dataset.

These changes have been indicated in the summary of amendments with rationales, and noted in the revised version of the proposal dated 5 July 2022.

3. Protocol status (tick ✓)

☒	Open to enrolment
☐	No participants have been enrolled
	Closed to enrolment (tick ✓)
☒	Research-related activities are ongoing
☐	Research-related activities are complete, long-term follow-up only
	Research-related activities are complete, data analysis only

4. Proposed changes will affect: (tick ✓ all the categories that apply)

Protocol	
☒	Study objectives, design (including investigator's brochure, clinical activities, study length)
☐	Study instruments, questionnaires, interview schedules
☒	Sample size
☒	Recruitment methods
☒	Eligibility criteria (inclusion and exclusion criteria)
☐	Drug/device (composition, amount, schedule, route of administration, combination with other drugs/devices, safety information)



☒	Data collection/ analysis
☐	Principal Investigator. (Please attach revised conflict of interest and PI declaration statements. Refer: sections 7 and 8.4 in the New Protocol Application Form FHS013)
☐	Consent form and information sheet
☐	Recruitment materials (e.g. advertisements)
☐	Administrative (e.g. change in sponsor's name, change in contact information)
☐	Other. Please specify:
<i>*Note: Amendment changes involving study length, sample size, additional sites and eligibility criteria (i.e. inclusion of minors and /or pregnant woman) need to be declared to the Insurance office. Please liaise via fhs.sponsorship@uct.ac.za regarding the required documentation and information to be submitted to obtain an updated UCT No-fault Insurance Certificate- it should be included herewith</i>	
4.1 In your opinion, will there be any increase in risk, discomfort or inconvenience to participants?	
☐ Yes ☒ No	
If yes, please provide a detailed justification/explanation:	

4.2 What follow-up action do you propose for participants who are already enrolled in the study?	
☐	Inform current participants as soon as possible
☐	Re-consent current participants with revised consent/assent forms (append)
☒	No action required
☐	Other. Please describe:

5. Detailed description of the change(s)

Please attach, for each amendment, a summary of all changes which clearly indicates: i. Old wording (e.g. ~~strikethrough~~ text, CHANGED FROM and CHANGED TO) ii. New wording (e.g. <i>italicized</i>, bold, tracked) iii. Detailed rationale/ justification/ explanation for each change
--



6. Ethics Review for Amendment Levy – cost including vat

Amendment Review Costs including VAT

Please tick amount to be billed:

Submission Type	Description	New fee (Vat incl.)	tick ✓
Research funded solely from UCT departmental/ divisional/group budget	Major/ Minor Amendments	R0,00	☐
Non-sponsored student research for degree purposes at UCT/Other Universities & Colleges	Major/ Minor Amendments	R0,00	☒
Protocol amendment - Major (FHS006 Form)	Clinical Trial & International Grant Funded Research - Any changes to the protocol that requires Full Committee review	R8 000,00	☐
Protocol amendment - Major (FHS006 Form)	Clinical Trial & International Grant Funded Research - Any change to the protocol that requires Expedited review that does not require Full Committee Review	R5 000,00	☐
Protocol amendment - Minor (FHS006 Form)	Clinical Trial & International Grant Funded Research - Minor amendments, administrative changes that do not affect study design e.g. changes to informed consent form, changes in study staff, etc.	R2 250,00	☐
Protocol amendment - Major (FHS006 Form)	National grant funded research - Any change to the protocol that requires Full Committee review	R7 000,00	☐
Protocol amendment - Major (FHS006 Form)	National grant funded research - Any change to the protocol that requires Expedited review that does not require Full Committee review	R2 500,00	☐
Protocol amendment - Minor (FHS006 Form)	National grant funded research - Minor amendments, administrative changes that do not affect study design e.g. changes to informed consent form, changes in study staff, etc.	R1 000,00	☐

NB: Protocols funded by UCT (e.g. departmental funding / student research) and by certain grant funding organizations (e.g. MRC, NRF, CANSA,) are exempt from these charges.

Please provide details for Invoicing, either complete section 1 or 2 :

1. Invoice billing – Directly to Sponsor

Sponsor's name	
Billing Address of Sponsor:	
Vat Number:	
Contact person:	
Telephone number:	
Email Address:	

2. Internal Journal Billing:

Fund Number:	
Cost Centre Number:	



Account Holder Name:	
Division of Account Holder:	

7. Amendment Submission checklist (tick ✓)

7.1 Please tick that all the documents are attached before submitting to the HREC. NB: Incomplete submissions will not be processed	
☒	Latest FHS006 form completed with all sections completed as per our website
☒	Cover Letter
☒	PI Justification/ Summary for the reasons for the amendment
☒	Protocol - Track changes & Clean Copy (where necessary)
☐	Informed Consent Forms (ICF), if applicable (Any changes made to ICF tracked & clean copy)
☐	Any other additional documentation in support of amendment
☐	Updated no fault insurance certificate (if applicable)

Please email this form and supporting documents (if applicable) in a combined pdf-file to hrec-enquiries@uct.ac.za with subject line: FHS006 + (HREC Reference number). The latest forms are found on our website.

8. Signature

My signature certifies that I will maintain the anonymity and/ or confidentiality of information collected in this research. If at any time I want to share or re-use the information for purposes other than those disclosed in the original approval, I will seek further approval from the HREC.	
Signature of PI	Date 5/7/2022

Appendix G: Permission to Conduct Retrospective Data Collection at MMH: MMH Research Committee



Mowbray Maternity Hospital Research Committee

Enquiries: Dr. C Stewart / N R Rhoda
Head of Clinical Unit Obstetrics / Neonatology
12 Hornsey Road, Mowbray, 7700
Email: Chantal.stewart@westerncape.gov.za
Email: Natasha.rhoda@uct.ac.za
Telephone: +2721659 5578 / 5562

TEMPLATE FOR REQUESTING FACILITY APPROVAL FOR RESEARCH STUDIES

STUDY TITLE:

Title: Feeding and swallowing in neonates with hypoxic ischemic encephalopathy (HIE):
a descriptive study

PRINCIPAL INVESTIGATOR:

...Samantha ...Branfield... (Principal-Investigator)

..... (Co-Investigator)

SUPERVISOR:

Vivienne Norman (Primary), Janine Joemat (secondary), Natasha Rhoda (secondary)

CLINICAL DEPARTMENT (X):

Obstetrics and Gynaecology ☐
Pharmacy ☐

Neonatology ☒

Nursing Education ☐

DATE OF DEPARTMENTAL APPROVAL: 06/07/2022.....

HREC APPROVAL NUMBER (Letter attached): FHS HREC- REF : 780/2021.....

NHRD REGISTRATION NUMBER: WC_202201_032

WESTERN CAPE APPROVAL STATUS:

X APPROVED	PENDING	NOT APPLIED FOR
------------	---------	-----------------

THE PROTOCOL SYNOPSIS IS ATTACHED:

X YES	NO
-------	----

12 Hornsey Road, Mowbray, 7700

tel: +27 21 659 4959 fax: +27 21 685 2991

Private Bag X7, Mowbray, 7705

www.westerncape.gov



THE STUDY METHOD IS MAINLY:

RECORD REVIEW	PATIENT INTERVIEWS	STAFF INTERVIEWS	CLINICAL TRIAL
x	x	x	

The Principal investigator must provide information regarding impact on the facility as follows:

DESCRIPTION	YES/NO	If Yes, Provide details
1. Additional load on nursing	no	
2. Support services	no	
3. Consumables	no	
4. Laboratory tests	no	
5. Equipment	no	
6. Space	Yes	Data extraction from folders to be conducted in the research office at MMH
7. Communications	no	
8. Additional OPD visits	no	
9. Admission of patients	no	
How will the sites be prepared to participate in your research?	Evaluation during routine care of HIE baby on the unit; Availability of the research office key	

SIGNED: 26/07/2022

Appendix H: Informed Consent Form

 DHRHS Department of Health and Rehabilitation Sciences FACULTY OF HEALTH SCIENCES	Divisions of Communication Sciences and Disorders, Nursing and Midwifery, Occupational Therapy, and Physiotherapy F45 Old Main Building, Groote Schuur Hospital, Observatory, Cape Town, 7925 Tel: +27 (0) 21 650 3002
---	---

TITLE: Feeding and swallowing in neonates with hypoxic ischemic encephalopathy (HIE): a descriptive study

PRINCIPAL INVESTIGATOR: Vivienne Norman

CONTACT NUMBER: 083 414 7928

EMAIL ADDRESS: vivienne.norman@uct.ac.za

HUMAN RESEARCH ETHICS COMMITTEE (HREC) REFERENCE NUMBER: 780/2021

Dear parent,

You and your baby are invited to participate in a research study and this information letter is to help you decide if you would like to take part.

ABOUT ME:

My name is Samantha Branfield, and I am a qualified Speech-Language Therapist (SLT). I have four years of clinical experience and more specifically, three years' experience working largely with feeding and swallowing disorders in neonatal intensive care/high care units. I am currently doing my master's through the University of Cape Town (UCT) and Vivienne Norman, Dr. Natasha Rhoda and Janine Joemat are my supervisors.

WHAT IS THIS RESEARCH ALL ABOUT?

I am doing a study to see how babies whose brains didn't get enough oxygen at birth feed, as sometimes these babies struggle to breastfeed, or they might not be able to swallow well. We want to find out more about how these babies learn to feed and swallow so that we, and other doctors and health workers, can help other babies with the same problem feed safely, and to help their mothers to feed them safely.

WHY HAS YOUR BABY BEEN INVITED TO PARTICIPATE?

You and your baby are invited to participate in this research study because your baby had a lack of oxygen during birth and now s/he might struggle to feed.

WHAT WILL YOU AND YOUR BABY HAVE TO DO?

If you do decide to participate in this study, you may have to answer some questions about your baby's feeding. I will then watch while you/the nurse feeds your baby during the usual feeding time and in the same way that s/he usually feeds e.g., with breast/cup/syringe. This will happen 2-3x/week and it will take about 30 - 40 minutes each time. I will stop observing feeds when your baby is able to complete a full cup or breastfeed without difficulties and/or falling asleep during the feed, or when you and your baby have been discharged from the hospital.

HOW WILL THIS STUDY BENEFIT YOU AND YOUR BABY?

If your baby does not have a feeding problem, this research will not have a direct benefit for you or your baby as there will be no therapy required and therefore no referrals necessary. However, if your baby is struggling to feed, I will pick it up earlier and refer your baby to the Speech-Language Therapist sooner, which may improve feeding.

WILL I OR MY BABY BE HARMED DURING THIS STUDY?

NO, I will first talk to your baby's doctor to make sure that s/he is healthy enough to participate in this study. If you do decide for your baby to participate, you/the nurse will feed her/him in the same way as you/the nurse usually would while I watch, so nothing that I will do will hurt you or your baby.

To minimise COVID-19 and other infection risks, I will follow the Infection Prevention and Control measures of the neonatal unit and the National Department of Health. This includes screening for COVID-19 symptoms before entering the hospital, always wearing a mask, wearing gloves and an apron when I am busy with the assessment, and sanitizing my hands before and after every feeding assessment and handling medical files and/or equipment.

WILL I BE PAID?

You will not be paid for participating in this study, but it also won't cost you anything as it will be conducted here, at Mowbray Maternity Hospital (MMH).

DO I HAVE TO SAY YES?

You do not have to say yes. Before deciding whether to participate, you may ask questions about anything you do not understand. You do not have to give an answer today as I will be back tomorrow to follow up. If you do not want to participate, that is okay. You do not have to give a reason and your

baby's medical care will not be affected. If you do decide to participate but later start to feel uncomfortable and want your baby to stop taking part in this study, you may do so without giving a reason which will also not affect your baby's medical care.

WILL I HAVE ACCESS TO MY BABY'S RESULTS?

If you do decide to participate, I will give you the results of your baby's feeding assessment after each assessment. You may ask questions throughout the study, and I will answer them happily. I will also give you my contact number if you would like to find out more at the end of the study.

WHO ELSE WILL HAVE ACCESS TO MY BABY'S RESULTS?

Your baby's name will be replaced with a reference number and stored on a computer in a password protected folder. This reference number will be used on all assessment forms. All assessment forms will be stored in a locked cupboard and as your baby's name will not be on these forms, only I, my research assistant and my supervisor will be able to identify your baby's results. Your baby's name will not be used on the final research report. After completion of the research, the information will be kept safely with UCT for a minimum of 5 years.

The UCT Faculty of Health Sciences Human Research Ethics Committee can be contacted on 021 406 6338 if you have any questions regarding your baby's rights and welfare as research subjects in this study.

You will receive a copy of this information form for your records.

Thank you for your time. Please do not hesitate to contact me should you require any further information.

Research contact details:

Ms. Samantha Branfield
Speech-Language Therapist
MSc Student
Cell: 083 393 5294
Email: sam.branfield@gmail.com

Vivienne Norman
Primary supervisor
Division of Communication Sciences and Disorders
Department of Health and Rehabilitative Sciences
University of Cape Town
Cell: 083 414 7928
Email: vivienne.norman@uct.ac.za

Dr Natasha R Rhoda

Co-supervisor

HCU Neonatal Medicine

Mowbray Maternity Hospital

Office: 021 659 5562

Cell: 076 319 0597

Email: natasha.rhoda@uct.ac.za

Janine Joemat

Co-supervisor

Chief Executive Officer

Mowbray Maternity Hospital

Office: 021 659 5544

Email: Janine.Joemat@westerncape.gov.za

**Please sign on the next page if you agree for your baby to take part in this study*

TITLE: Feeding and swallowing in neonates with hypoxic ischemic encephalopathy (HIE): a descriptive study

PRINCIPAL INVESTIGATOR: Vivienne Norman

RESEARCHER: Samantha Branfield

HREC REFERENCE NUMBER: 780/2021

Declaration by participant

By signing below, I (*name and surname*) _____ agree for my baby to take part in this research study entitled: "A description of feeding and swallowing characteristics in neonates with hypoxic ischemic encephalopathy (HIE)". I declare that:

- I have read/had read to me and understand this informed consent form and it is written in a language in which I am fluent and comfortable.
- I understand that providing consent for my baby to be a part in this research is voluntary and I have not been forced to give consent.
- I understand that I will not be paid for my participation.
- I understand that if I feel uncomfortable at any stage during this research, I have the right to withdraw my consent without being discriminated against or my baby's medical care being affected.
- I understand that the researcher will not identify my baby or me by name in any reports using the information obtained from this research.
- I have had a chance to ask questions and I have had all my questions answered to my satisfaction.
- I have been given a copy of this information form.

Signed at (*place*) _____ on (*date*) _____

Signature of participant

Signature of witness

Declaration by researcher

By signing below, I (*name and surname*) _____ declare that:

- I explained the information in this document to _____.
- I encouraged her to ask questions and took adequate time to answer them.
- I am satisfied that she adequately understands all aspects of the research as discussed above.
- I did/did not use an interpreter.

Signed at (*place*) _____ on (*date*) _____

Signature of researcher

Signature of witness

Declaration by interpreter

By signing below, I (*name and surname*) _____ declare that:

- I assisted the researcher (*name of researcher*) _____ to explain the information in this document to (*name of participant's mother*) _____ using the language medium of isiXhosa/Afrikaans.
- We encouraged her to ask questions and took adequate time to answer them.
- I conveyed a factually correct version of what was relayed to me.
- I am satisfied that the participant's mother fully understands the content of this informed consent form and has had all her questions answered satisfactorily.

Signed at (*place*) _____ on (*date*) _____

Signature of interpreter

Signature of witness

Appendix I: Criteria for Undergoing Therapeutic Hypothermia Treatment

This criterion is implemented at MMH based on recommendations in the Total Body hypothermia (TOBY) international cooling study (Azzopardi et al., 2008). Neonates suspected with HIE must fulfil ALL of the categories in A, B, and C to qualify for cooling and unless indicated otherwise, are cooled for a continuous period of 72 hours. The categories are as follows:

Category A

1. ≥ 36 weeks gestation
2. Birth weight of ≥ 1800 grams
3. Cooling can be commenced before age 6 hours

Category B

4. First hour blood gas (cord/infant/arterial/capillary/venous): pH ≤ 7 or base deficit ≥ 16
5. A blood gas (umbilical cord or any infant blood) within 60 minutes of birth showing acidosis with a pH of ≤ 7 or base deficit ≥ 10 mmol/l; with a history of a perinatal event (i.e., cord prolapse/rupture, uterine rupture, shoulder dystocia, maternal trauma/haemorrhage/arrest) or foetal bradycardia < 100 beats per minute or pathological CTG
6. A 5-minute Apgar score of < 7 (only if early gas is not available)
7. A need for any type of positive pressure ventilatory assistance at 10 minutes (i.e., mask/intubation/neopuff)

Category C

8. Clinical signs of encephalopathy (i.e., lethargy, stupor, coma, seizures or a Thompson Score ≥ 7) and if seizures are absent, one or more of the following: hypotonia, abnormal reflexes or an abnormal suck
9. Abnormal CFM before age 6 hours (i.e., DNV, CLV, burst suppression, flat trace, seizures)

Appendix J: Prospective Data Collection Form

CASE HISTORY									
Participant ref. number:							Today's date:		
BIOGRAPHICAL INFORMATION									
Date and time of birth:									
Gestational age:									
Birth weight (grams):									
Sex:			Female				Male		
BIRTH AND MEDICAL HISTORY									
Apgar scores:						(1m)	(5m)	(10m)	
Relevant delivery information:									
Respiratory status									
Oxygen requirement/s until comfortable in room air (r/a) (i.e., CPAP, HFO ₂ , NPO ₂):						(date)			
						(date)			
						(date)			
Breathing comfortably in r/a on day (/date):									
Has the participant experienced apnoea? If yes, how frequent?						Yes		No	
Neurological health									
Did the participant receive therapeutic hypothermia treatment?						Yes		No	
Has the participant experienced seizures during admission? If yes, how frequent? If yes, what medication was administered?						Yes		No	
CFM patterns during admission (aEEG):						(aEEG)		(date)	
						(aEEG)		(date)	
						(aEEG)		(date)	
						(aEEG)		(date)	
						(aEEG)		(date)	
Thompson Scores	Day Date	D0	D1	D2	D3	D4	D5	D6	D7
	Limb tone								
	LOC								
	Visible fits								
	Posture								
	Moro								
	Grasp								
	Suck								
	Respirations								
	Fontanelle								
	TOTAL								
Head scan results:		(date)		(VI left)		(VI right)		(Results)	

Additional medical conditions						
Sepsis:	CRP ≥ 10 :	Yes		No		
	Blood culture:	Positive		Negative		
Have any other medical conditions been diagnosed? If yes, please specify:		Yes		No		
BASIC FEEDING HISTORY						
Was the participant fed via a NGT/OGT upon admission?		Yes		No		
1 st oral feeding trial (Document if prior to NFAS ax.)	Trialled on day (/date):					
	Feeding method/s used:	BF	CF	SF	NGT t/u	Excl. NGT
	Volume (ml):					
	Tolerance report:					
What was the feeding method timeline/progression until discharge (d/c) (date; method; tolerance report)?						
When was the NGT/OGT removed?						
Weight (on full oral feeds):		(date)		(grams)		
		(date)		(grams)		
		(date)		(grams)		
		(date)		(grams)		
		(date)		(grams)		
Referrals						
Was a referral made to the Speech-Language Therapist? If yes, on day (/date):		Yes		No		
Were any instrumental assessments conducted? If yes, specify assessment type and result/s:		Yes		No		
DISCHARGE (D/C)						
Date of d/c:						
Feeding method at d/c:		BF	CF	Excl. NGT		

FEEDING AND SWALLOWING ASSESSMENTS													
Participant ref. number:													
MEDICAL / HIE STATUS													
CFM pattern upon admission:								CNV	DNV	CLV	B/S	f/t	
Thompson score upon admission:													
Therapeutic hypothermia treatment received?								Yes		No			
NFAS RESULTS													
		ASSESSMENT 1				ASSESSMENT 2				ASSESSMENT 3			
Date:													
Day of life (age):													
Current feeding method/s (before ax.):		BF	CF	NGT t/u	Excl. NGT	BF	CF	NGT t/u	Excl. NGT	BF	CF	NGT t/u	Excl. NGT
Feed time intervals:													
Last recorded weight:													
Receiving ST?		Yes		No		Yes		No		Yes		No	
(Take note before/during/after feed)													
Respiratory status:		HFO ₂	NPO ₂	r/a		HFO ₂	NPO ₂	r/a		HFO ₂	NPO ₂	r/a	
SpO ₂ (%):		Before	During	After		Before	During	After		Before	During	After	
Feeding method/s in ax.:		BF	CF	SF		BF	CF	SF		BF	CF	SF	
Volume (ml):													
Duration of feed:													
NFAS Section A & B:		Yes		No		Yes		No		Yes		No	
NFAS Section C:		Yes		No		Yes		No		Yes		No	
NFAS Section D:		Yes		No		Yes		No		Yes		No	
NFAS Section E:		Yes		No		Yes		No		Yes		No	
NFAS Section F:		Yes		No		Yes		No		Yes		No	
NFAS Diagnostic outcome:		Yes		No		Yes		No		Yes		No	
		ASSESSMENT 4				ASSESSMENT 5				ASSESSMENT 6			
Date:													
Day of life (age):													
Current feeding method/s (before ax.):		BF	CF	NGT t/u	Excl. NGT	BF	CF	NGT t/u	Excl. NGT	BF	CF	NGT t/u	Excl. NGT
Feed time intervals:													
Last recorded weight:													
Receiving ST?		Yes		No		Yes		No		Yes		No	
(Take note before/during/after feed)													
Respiratory status:		HFO ₂	NPO ₂	r/a		HFO ₂	NPO ₂	r/a		HFO ₂	NPO ₂	r/a	
SpO ₂ (%):		Before	During	After		Before	During	After		Before	During	After	
Feeding method/s in ax.:		BF	CF	SF		BF	CF	SF		BF	CF	SF	
Volume (ml):													
Duration of feed:													
NFAS Section A & B:		Yes		No		Yes		No		Yes		No	
NFAS Section C:		Yes		No		Yes		No		Yes		No	
NFAS Section D:		Yes		No		Yes		No		Yes		No	
NFAS Section E:		Yes		No		Yes		No		Yes		No	
NFAS Section F:		Yes		No		Yes		No		Yes		No	
NFAS Diagnostic outcome:		Yes		No		Yes		No		Yes		No	

Appendix K: Retrospective Data Collection Form

CASE HISTORY											
Participant ref. number:							Today's date:				
BIOGRAPHICAL INFORMATION											
Date and time of birth:											
Gestational age:											
Birth weight (grams):											
Sex:			Female				Male				
BIRTH AND MEDICAL HISTORY											
Apgar scores:						(1m)		(5m)		(10m)	
Relevant delivery information:											
Respiratory status											
Oxygen requirement/s until comfortable in room air (r/a) (i.e., CPAP, HFO ₂ , NPO ₂):						(date)					
						(date)					
						(date)					
Breathing comfortably in r/a on day (/date):											
Was apnoea experienced? If yes, how frequent?						Yes		No			
Neurological health											
Did the participant receive therapeutic hypothermia treatment?						Yes		No			
Were seizures experienced during admission? If yes, how frequent? If yes, what medication was administered?						Yes		No			
CFM patterns during admission (aEEG):						(aEEG)		(date)			
						(aEEG)		(date)			
						(aEEG)		(date)			
						(aEEG)		(date)			
						(aEEG)		(date)			
Thompson Scores	Day Date	D0	D1	D2	D3	D4	D5	D6	D7		
	Limb tone										
	LOC										
	Visible fits										
	Posture										
	Moro										
	Grasp										
	Suck										
	Respirations										
	Fontanelle										
	TOTAL										
Head scan results:		(date)		(VI left)		(VI right)		(Results)			
Additional medical conditions											
Sepsis:		CRP ≥10:				Yes		No			
		Blood culture:				Positive		Negative			

Was the participant diagnosed with a LRTI while in hospital? If yes, on day (/date):		Yes		No		
Were any other medical conditions diagnosed? If yes, please specify:		Yes		No		
BASIC FEEDING HISTORY						
Was the participant fed via a NGT/OGT upon admission?		Yes		No		
1 st oral feeding trial	Trialled on day (/date):					
	Feeding method/s used:	BF	CF	SF	NGT t/u	Excl. NGT
	Volume (ml):					
	Tolerance report:					
What was the feeding method timeline/progression until discharge (d/c) (date; method; tolerance report)?						
When was the NGT/OGT removed?						
Weight (on full oral feeds):		(date)		(grams)		
		(date)		(grams)		
		(date)		(grams)		
		(date)		(grams)		
		(date)		(grams)		
Referrals						
Was a referral made to the Speech-Language Therapist? If yes, on day (/date):		Yes		No		
Were any instrumental assessments conducted? If yes, specify assessment type and result/s:		Yes		No		
DISCHARGE (D/C)						
Date of d/c:						
Feeding method at d/c:		BF	CF	Excl. NGT		

SPEECH-LANGUAGE THERAPY ASSESSMENT/MANAGEMENT						
<i>(Only applicable to the participants who were seen by the SLT - complete for every SLT assessment)</i>						
Participant reference number:		Date:				
		ST ax. number:				
MEDICAL / HIE STATUS						
CFM pattern upon admission:		CNV	DNV	CLV	B/S	f/t
Thompson score upon admission:						
Therapeutic hypothermia (TH) treatment received?	Yes			No		
Supplementary oxygen (if required):	HFO ₂		NPO ₂		r/a	
Increased WOB, decreased SATS (general)?	Yes			No / NR		
Last weight recorded (grams):						
FEEDING & SWALLOWING						
NON-NUTRITIVE SUCK						
Aversion/resistance to non-food (i.e., oral stimulation, utensils)?	Yes			No / NR		
Biting down on finger?	Yes			No / NR		
If yes, bite easily released?	Yes		No / NR		n/a	
Was a suck initiated?	Yes			No / NR		
Timely initiation of suck?	Yes			No / NR		
Adequate sucking strength?	Yes			No / NR		
Attempted tongue cupping/grooving?	Yes			No / NR		
Anterior-posterior tongue movement/attempted tongue stripping?	Yes			No / NR		
Abnormal tongue movement (i.e., tongue thrust)?	Yes			No / NR		
Overall tongue movement?	Adequate		Reduced / limited		NR	
Burst cycles of approximately 10-20 sucks/burst?	Yes			No / NR		
If <i>not</i> , how many sucks/burst were reported?			NR		n/a	
Overall outcome: Was dysphagia present?	Yes			No		
Deemed ready for oral feeding ax.?	Yes			No		
NUTRITIVE SUCK / ORAL FEED						
Date:						
What feeding method/s were utilised prior to ax.?	BF	CF	SF	NGT t/u	Excl. NGT	
What feeding method/s were used for ax.?	BF		CF		SF	
Volume (ml):						
State of alertness during feed:			NR			
Oral skills / signs & symptoms of OPD						
Aversion or refusal of feeds (e.g., turning head away)?	Yes			No / NR		
Did the participant demonstrate sensory awareness?	Yes			No / NR		
Did the participant establish a latch?	Yes		No / NR		n/a	
Did the participant maintain adequate lip closure around the whole nipple during BF?	Yes		No / NR		n/a	
Biting/munching?	Yes		No / NR		n/a	
Was a suck initiated?	Yes		No / NR		n/a	
Adequate sucking strength?	Yes		No / NR		n/a	
Burst cycles of approximately 10-20 sucks/burst?	Yes		No / NR		n/a	
If <i>not</i> , how many sucks/burst were reported?			NR		n/a	

Coordination:	SSB (BF/SF)?	Good	Poor	NR	n/a	
	Swallow-breathe (CF)?	Good	Poor	NR	n/a	
Was a swallow initiated?		Yes		No / NR		
Oral phase symptoms of OPD						
Pooling of saliva / secretions?		Yes		No / NR		
Pooling of the bolus?		Yes		No / NR		
Anterior spillage?		Yes		No / NR		
Pharyngeal signs & symptoms of OPD						
Was the pharyngeal swallow triggered?		Yes		No / NR		
Was a delayed pharyngeal swallow response suspected?		Yes		No / NR		
Absent pharyngeal swallow response?		Yes		No / NR		
Gurgling during / after the swallow?		Yes		No / NR		
Coughing during / after the swallow?		Yes		No / NR		
Choking during / after the swallow?		Yes		No / NR		
'Wet' respiratory sounds?		Yes		No / NR		
Physiological signs & symptoms of OPD						
Increased respiratory rate?		Yes		No / NR		
Increased respiratory effort / signs of abnormal respiratory patterns?		Yes		No / NR		
Desaturation?		Yes		No / NR		
Apnoea?		Yes		No / NR		
Additional signs & symptoms of OPD						
Tires, fatigues during feed (i.e., reduced endurance)?		Yes		No / NR		
Longer mealtimes >30min, slow feeds, not completing feeds?		Yes		No / NR		
Crying, distressed during feed?		Yes		No / NR		
OVERALL diagnostic outcome						
Was OPD present?		YES			NO	
What feeding method/s were recommended post-ax?		BF	CF	SF	NGT t/u	Excl. NGT
Additional comments:						

Appendix L: Supporting Literature for Prospective and Retrospective Data Collection Forms: Case History Items

ITEM	RATIONALE
Participant reference number	To ensure participant confidentiality (World Medical Association, 2013).
BIOGRAPHICAL INFORMATION	
Date of birth	To record the participant's age.
Time of birth	In addition to the participant's date of birth, neonatal age (day of life) is calculated according to the time of birth, i.e., before or after 12:00pm. Thus, time of birth was also documented to accurately record the participant's age.
Birth weight	To monitor weight loss/gain during the course of admission. It was also important to note if the participant was small for his/her gestational age (<2500g) as these participants were at a greater risk for feeding difficulties (World Health Organization, 2014).
Sex	To further describe participant characteristics.
BIRTH AND MEDICAL HISTORY	
Apgar scores	The Apgar score is used to assess a newborn's medical status, and subsequently, the need for medical intervention and/or resuscitation. This was therefore an important inclusion item as it gave the researcher an indication of the participant's initial cardiovascular, respiratory and/or neurological status (Gutbir et al., 2020).
Relevant delivery information	Delivery information was documented as it related to the diagnosis of HIE.
Respiratory status - O₂ requirements - apnoea	To give the researcher an indication of the participant's physiological stability (Barlow, 2009).
Neurological health	
Therapeutic hypothermia (TH)	TH is the medical intervention that is typically used for term asphyxiated newborn's with moderate to severe encephalopathy. TH has proven to reduce or eliminate adverse sequelae that may follow a hypoxic-ischemic injury and therefore, an important factor to document (Gagne-Loranger et al., 2015).
Seizures	HIE is reported to be the most common cause of neonatal seizures (Glass et al., 2016) which may worsen

	neurodevelopmental outcomes, including feeding and swallowing (Wusthoff et al., 2011). Thus, the documentation of seizures provided insight into the participant's neural functioning and highlighted which participants were at an increased risk for OPD.
Seizure medication	Fatigue is a common side effect of seizure medication (Mutanana et al., 2020) and therefore, an important factor to account for with respect to the timing of the feeding and swallowing assessments.
CFM patterns (aEEG)	As the development of normal feeding and swallowing reflexes appear to be affected in full term neonates with HIE, their specific feeding and swallowing difficulties were likely to vary depending on the degree of neurological involvement (Krüger et al., 2017, 2019; Malan et al., 2022; Thompson et al., 1997). The aEEG is an objective measure of continuous neurological assessment (Britton et al., 2016) and therefore, deemed a reliable measure of 'severity' assessment. Thus, initial aEEG patterns were used to group medically similar participants together to address the aims of the research (de Vries & Hellström-Westas, 2005; Glass et al., 2013; Orman et al., 2018; Variane et al., 2022).
Thompson scores	As the Thompson score utilises clinical signs of encephalopathy to grade the severity of HIE, it provided a clinical picture of participants (Thompson et al., 1997) and therefore, relevant to record.
Head scan results	Brain scan results were documented as it provided further insight into the severity of the hypoxic-ischemic injury.
Additional medical conditions	
Sepsis	Sepsis has been documented to be the leading cause of neonatal mortality and morbidity, especially in lower- and middle-income countries (Seale et al., 2014) and thus, relevant in the present study. Subtle changes in the respiratory status of a newborn, temperature instability, or feeding problems may be the first sign of an infection. As pneumonia is often the presenting infection, respiratory symptoms may be present including apnoea, nasal flaring, and intercostal retractions (Simonsen et al., 2014); symptoms that may also indicate a feeding difficulty and possibly interfere with SSB coordination during oral feeding (Arvedson, 2006; Isaac & Choi, 2023). Cardiac symptoms may also occur such as desaturation and bradycardia (Simonsen et al., 2014); symptoms that may also indicate a feeding difficulty (Thoyre & Carlson, 2003). Additionally, sepsis can result in lethargy (Singh et al., 2022), similar to that of HIE (Sarnat & Sarnat, 1976;

	Thompson et al., 1997; Volpe, 2012), which may also interfere with oral feeding (Krüger et al., 2019). The presence of sepsis is therefore an important consideration in observations related to oral feeding and swallowing performance.
LRTI (only applicable on retrospective form)	LRTIs have been linked to persistent aspiration and thereby, a possible symptom of OPD (Arvedson et al., 2020; Sheikh et al., 2001).
Other medical conditions	Any other medical conditions not described above will be documented here as there may be additional confounding variables associated to the participant's oral feeding and swallowing performance.
BASIC FEEDING HISTORY	
NGT/OGT feeds - insertion to removal, i.e., duration	To indicate the period in which participants were unable to meet their full intake requirements via oral means.
Day of 1 st oral feeding trial - Feeding method - Volume - Tolerance	To provide insight into oral feeding readiness.
Feeding timeline - Feeding method/s (incl. d/c) - Volume - Tolerance report	To follow the participant's feeding delay/progress over the course of hospitalisation.
Weight (<i>on full oral feeds</i>)	To follow the participant's growth pattern and subsequently, his/her oral feeding performance.
Referrals	
SLT	A referral to the SLT highlighted which participants were experiencing feeding and swallowing difficulties.
Instrumental assessment (<i>i.e., VFSS</i>)	A referral for an instrumental evaluation of swallowing was documented as this would have indicated which participants were demonstrating a concern regarding the safety of the swallow (DeMatteo et al., 2005).
DISCHARGE (d/c)	
Date of d/c	Earlier research has consistently found that OPD is associated with the length of hospital stay (Attrill et al., 2018; Dziewas et al., 2017; Edwards et al., 2019; Krüger et al., 2017). Thus, the date of d/c was documented to indicate the duration of hospitalisation as this may have been related to feeding and swallowing difficulties.

Appendix M: Supporting Literature for ‘Prospective Data Collection Form’: Feeding and Swallowing Assessment Items

ITEM	RATIONALE
Participant reference number	To ensure participant confidentiality (World Medical Association, 2013).
MEDICAL/HIE STATUS	
CFM; Thompson score; TH	To summarise ‘HIE severity’ together with a summary of the feeding and swallowing assessment outcomes.
FEEDING & SWALLOWING EVALUATIONS	
Day of life	To record the participant’s age on the day of the assessment.
Current feeding method/s	To record whether the participant had commenced oral feeding trials prior to the NFAS assessment.
Feed time intervals	To plan for the feeding and swallowing observation.
Respiratory status	To give the researcher an indication of the participant’s respiratory status prior to and/or during the assessment. If the participant was deemed physiologically stable for the feeding assessment to begin, his/her respiratory rate was monitored during the course of the assessment. Any changes in the participants respiratory pattern during oral feeding may have interfered with his/her SSB coordination and consequently, put him/her at risk for aspiration (Arvedson, 2006; Barlow, 2009; Isaac & Choi, 2023). Thus, any changes in breathing would have signalled a feeding and swallowing difficulty with an increased risk for aspiration and as a result, the oral feed should be discontinued.
SpO ₂ (%)	SpO ₂ is reported to be at the foundation of endurance, maintenance of body tone, oral-motor control, and SSB coordination during feeding thus, a symbol of the participant’s physiological stability prior to and/or during the NFAS assessments. A stable SPO ₂ indicated that the neonate was able to regulate his/her physiological processes and the feed could continue safely. Alternatively, oxygen desaturation indicated that the neonate’s physiological regulation was exceeded, and the feeding assessment should either not begin or be terminated (Thoyre & Carlson, 2003). Thus, SpO ₂ (before, during, and after oral feeding) was an important vital sign to monitor throughout the feeding assessment.
Volume (ml) (CF/SF)	To record the percentage of feed completed.

Duration of feed	To record if the feed was completed in an adequate amount of time (≤ 30 minutes). This was important to note as prolonged oral feeding may put the neonate at risk for weight loss due to an energy imbalance (i.e., calories in < calories out) and signal a delay in oral feeding development (Yang, 2017).
NFAS diagnostic outcomes	To provide an overview of the NFAS sub-section and overall diagnostic outcomes. This section enabled the researcher to summarise the participant's feeding and swallowing performance and subsequently, the presence/absence of OPD over time (Viviers et al., 2016).

Appendix N: Supporting Literature for ‘Retrospective Data Collection Form’: Speech-Language Therapy Assessment/Management Items

ITEM	RATIONALE
Participant reference number	To ensure participant confidentiality (World Medical Association, 2013).
MEDICAL/HIE STATUS	
CFM; Thompson score; TH	To collapse ‘HIE severity’ together with a summary of the feeding and swallowing assessment outcomes.
Respiratory status - O₂ requirement on the day of assessment - Increased WOB, decreased SATS (general)	To give the researcher an indication of the participant’s respiratory status prior to the assessment. This enabled the researcher to establish a baseline and subsequently, assess changes in respiratory patterns during oral feeding if reported on.
FEEDING & SWALLOWING EVALUATIONS	
This section addressed the main aim of the study. It enabled the researcher to make inferences based on normally developing feeding responses or, on signs and symptoms representing oral and pharyngeal phase difficulties. Non-nutritive sucking (NNS) characteristics and nutritive sucking (NS) characteristics were evaluated according to the neonate’s willingness to actively engage if reported on, sucking strength and tongue movement, burst cycles, and suck-swallow ratio.	
NNS	
Aversion/resistance to non-food	An aversion or resistance to oral stimulation is a behavioural response that may have indicated that the neonate was not ready for oral intake. This item therefore provided insight into the participants oral feeding readiness (Maltese et al., 2017).
Oral skills - Sucking response - Tongue movement - Burst cycles	The NNS assessment was utilised as an indicator of oral feeding readiness (Pickler, 2004) and to provide insight into various features of the sucking response that cannot be observed in its entirety in the NS/oral feeding assessment, i.e., tongue cupping, anterior-posterior tongue movement.
NS/ORAL FEED	
Date	To document if the date differed to that of the NNS skills assessment.
Feeding method/s prior to ax.	To determine the feeding profile of participants prior to the assessment. For example, full NGT feeds would have indicated that the participant has been unable to meet their nutritional requirements via oral means.

Feeding method/s assessed	To determine which oral skills were applicable to each participant, i.e., latching was not applicable to the participants who were cup fed.
Volume (ml)	To record the percentage of the total prescribed feed completed or alternatively, the volume whereby feeding and swallowing difficulties were demonstrated.
State of alertness during feed	To determine the participant's readiness for feeding orally, i.e., drowsiness during feeding would have been a distress response and increased the likelihood of feeding and swallowing difficulties being experienced (Karl, 2004).
Oral skills / signs & symptoms of OPD	
Aversion or refusal of feeds	To indicate oral feeding readiness.
Oral skills - Sensory awareness - Latching; lip closure - Sucking response - Burst cycles - SSB/SB coordination - Initiation of swallow	A delay in oral skills may hinder bolus formation and put the neonate at risk for prolonged feeding times, anterior spillage, premature spillage and consequently, increase the risk for slow weight gain or weight loss and aspiration (Arvedson et al., 2020). This section enabled the researcher to document the presence/absence of typically developing oral feeding skills. As a result, the researcher was able to determine the presence/absence of dysphagia and subsequently, describe the oral phase of swallowing in neonates with HIE.
Pooling of saliva / secretions	In neurological conditions, the aetiology of excessive saliva in the oral cavity relates to weakness or poor coordination of bulbar or facial musculature. Rather than excessive saliva production, it may have been the result of ineffective swallowing mechanisms, reduced swallowing frequency, poor lip seal, and ineffective saliva control (Marks et al., 2001; Merello, 2008). Thus, the pooling of saliva / secretions was documented as it may have correlated to the presence of OPD.
Pooling of the bolus	Pooling of the oral bolus is a symptom of OPD that may be observed in neonates with neurological involvement (Garg, 2003; Jensen et al., 2017).
Anterior spillage	Anterior oral spillage of the bolus is a symptom of OPD that may be observed in neonates with neurological involvement (Garg, 2003; Jensen et al., 2017).
Pharyngeal signs & symptoms of OPD - Pharyngeal swallow response - Overt indicators of ?aspiration	Although the pharyngeal phase of swallowing cannot be thoroughly described or confirmed without an instrumental evaluation of swallowing (i.e., VFSS) (Cordier et al., 2023), clinical signs and symptoms of OPD such as coughing/choking during or after the swallow may have indicated that the mechanisms responsible for airway protection were compromised (Arvedson et al., 2020). Thus, this section enabled the researcher to make

	inferences about the presence of pharyngeal difficulties thereby addressing the aims of the research.
Physiological signs & symptoms of OPD - Respiratory rate - Abnormal respiratory patterns - Desaturation - Apnoea	Physiological signs such as respiratory distress, desaturation, and apnoea were included as respiratory problems are frequently reported in neonates with HIE (Malan et al., 2022; Rainaldi & Perlman, 2016; Sarnat & Sarnat, 1976; Shalak et al., 2003; Szakmar et al., 2019; Thompson et al., 1997) which may contribute and/or indicate a feeding and swallowing difficulty (Arvedson, 2008; Gewolb & Vice, 2006; Pinnington et al., 2000).
Additional signs & symptoms of OPD - Reduced feeding endurance - Prolonged mealtimes - Distress signals during feeding	Poor feeding endurance, or distress signals during feeding, has been reported to accompany poor feeding performance (Lau, 2020). Thus, behavioural changes during the oral feed would have indicated that the participant was no longer engaging in the feed actively and safely (Als, 1982, 1995; Vandenberg, 2007). Additionally, prolonged oral feeding may put the neonate at risk for weight loss due to an energy imbalance (i.e., calories in < calories out) and signal a delay in oral feeding development (Yang, 2017).
OVERALL diagnostic outcome	To determine the significance of the presenting feeding and swallowing difficulties and thereby, to address the aims of the research.

Appendix O: Neonatal Feeding Assessment Scale (NFAS)



NEONATAL FEEDING ASSESSMENT SCALE (NFAS)

Participant ref. number:	Ax. no:
Patient name:	Date of birth:
Gestational age at birth:	Current adjusted age:
Birth weight:	Current weight:
Diagnosis:	
Date of assessment:	
Examiner:	

SECTION A: FUNCTIONING OF PHYSIOLOGICAL SUBSYSTEMS		
(Dieckman, Brownstein & Gausche-Hill, 2000; Henning, 2002; Hodgman, Hoppenbrouwers, & Cabal, 1993)		
A.1. Observation of heart rate		
Instructions: Observe the infant's heart rate if the infant is attached to a cardiac monitor during feeding, if not proceed to A.2. Complete the relevant items for the infant's current adjusted age.		
A.1a Infant attached to cardiac monitor	YES	NO
32 – 39 weeks		
A.1.1 Normal heart rate (120 – 170 beats per minute)	YES	NO
A.1.1.1 Tachycardia (>170 beats per minute)	YES	NO
A.1.1.2 Bradycardia (<120 beats per minute)	YES	NO
40 weeks – 2 months 3 weeks post term		
A.1.2.1 Normal heart rate (100 – 150 beats per minute)	YES	NO
A.1.2.2 Tachycardia (>150 beats per minute)	YES	NO
A.1.2.3 Bradycardia (<100 beats per minute)	YES	NO
3 – 4 months post term		
A.1.3.1 Normal heart rate (90 – 120 beats per minute)	YES	NO
A.1.3.2 Tachycardia (>120 beats per minute)	YES	NO
A.1.3.3 Bradycardia (<90 beats per minute)	YES	NO
SCORE SECTION A.1: If bradycardia/tachycardia present indicate YES for the likelihood of dysphagia to be present		
OUTCOME SECTION A.1: Dysphagia likely to be present	YES	NO

A.2. Observation of Respiratory function				
Instructions: If the infant is attached to a respiratory monitor <i>during feeding</i> complete the items relevant to current (adjusted) age, as well as subsection A.2c. If the infant is <i>not attached to a monitor</i> , complete only subsection A.2c.				
A.2a Infant attached to respiratory monitor		YES	NO	
32 – 39 weeks				
A.2.1 Normal breathing rate (40 – 70 breaths per minute)		YES	NO	
A.2.1.1 Tachypnoea (>70 breaths per minute)		YES	NO	
A.2.1.2 Apnoea (absent breathing efforts for > 15 seconds)		YES	NO	
40 weeks – 2 months				
3 weeks post term				
A.2.2 Normal breathing rate (35 – 50 breaths per minute)		YES	NO	
A.2.2.1 Tachypnoea (>50 breaths per minute)		YES	NO	
A.2.2.2 Apnoea (absent breathing efforts for > 15 seconds)		YES	NO	
3 – 4 months post term				
A.2.3 Normal breathing rate (35 – 45 breaths per minute)		YES	NO	
A.2.3.1 Tachypnoea (>45 breaths per minute)		YES	NO	
A.2.3.2 Apnoea (absent breathing efforts for > 15 seconds)		YES	NO	
A.2c Signs of abnormal respiratory patterns during feeding				
A.2.4.1 Laboured/noisy breathing		YES	NO	
A.2.4.2 Obligatory mouth breather		YES	NO	
A.2.4.3 Non-obligatory mouth breather		YES	NO	
A.2.4.4 Stridor		YES	NO	
A.2.4.5 Rib cage flaring		YES	NO	
A.2.4.6 Sternum depression/retraction		YES	NO	
A.2.4.7 Irregular/shallow breathing		YES	NO	
A.2.4.8 Intercostal retractions (related to Respiratory Distress Syndrome)		YES	NO	
SCORE SECTION A.2: If tachypnoea/apnoea present in items A.2.1-A.2.3.2, select YES for the likelihood of dysphagia being present. If items A.2.1-A.2.3.2 not scored, select NOT APPLICABLE (N/A). If YES was selected for any item/s in subsection A.2c, indicate YES for the likelihood of dysphagia being present.				
OUTCOME SECTION A.2.1-A.2.3.2: Dysphagia likely to be present		YES	NO	N/A
OUTCOME SECTION A.2c: Dysphagia likely to be present		YES	NO	
COMBINED OUTCOME SECTION A: If one YES obtained in a sub-section, select YES for likelihood of dysphagia being present.				
OUTCOME SECTION A: Dysphagia likely to be present		YES	NO	

SECTION B: STATE OF ALERTNESS DURING FEEDING

(Als, 1982; Brazelton, 1973; Nugent, Keefer, Minear, Jonhson & Blanchard, 2007; Prechtl & Beintema, 1964; Wolff, 1959)

Instructions: Observe the infant's state of alertness during feeding. Select YES only once in this section, and score the remaining items NO.		
B.1.1 Stage 1 – Deep sleep	YES	NO
B.1.2 Stage 2 – Light sleep	YES	NO
B.1.3 Stage 3 – Drowsy	YES	NO
B.1.4. Stage 4 – Quiet alert	YES	NO
B.1.5 Stage 5 – Active alert	YES	NO
B.1.6 Stage 6 – Alert agitated	YES	NO
B.1.7 Stage 7 – Crying	YES	NO
SCORE SECTION B: Optimal state of alertness for feeding is indicated by a YES for either item B.1.4 or B.1.5. Items B.1.1-B.1.3 and B.1.6-B.1.7 reflects non-optimal states of alertness for feeding. A non-optimal state of alertness could likely contribute to a feeding problem.		
OUTCOME SECTION B: Non-optimal state of alertness during feeding	YES	NO
<i>COMBINED SCORE FOR SECTION A & B:</i>		
Section A	YES	NO
Section B	YES	NO
SCORE OBTAINED SECTION A & B OVERALL: If both sections obtained YES responses, indicate YES for the likelihood of dysphagia being present.		
OVERALL OUTCOME SECTION A & B: Dysphagia likely to be present	YES	NO

SECTION C: STRESS CUES DURING FEEDING		
(Als, 1982; Brazelton & Nugent, 1995; Hall, 2002; Karl, 2004)		
Instructions: Observe the infant during feeding and note down the stress cues the infant displays. Circle either YES or NO for all items in Section C.		
State related stress cues		
C.1.1 Staring	YES	NO
C.1.2 Panicked, worried or dull look	YES	NO
C.1.3 Silent/weak cry	YES	NO
C.1.4 Dozing	YES	NO
C.1.5 Startle	YES	NO
Motor related stress cues		
C.1.6 Twitching limbs	YES	NO
C.1.7 Hypextension of limbs	YES	NO
C.1.8 Fluctuating tone	YES	NO
C.1.9 Increased stiffness (arching/finger splays/fisting)	YES	NO
C.1.10 Excessive diffuse movements	YES	NO
Mild autonomic stress cues		
C.1.11 Gasping	YES	NO
C.1.12 Sighing	YES	NO

C.1.13 Sneeze	YES	NO
C.1.14 Sweating	YES	NO
C.1.15 Hiccup	YES	NO
C.1.16 Trembling jaw/limbs	YES	NO
Moderate autonomic stress cues		
C.1.17 Startling	YES	NO
C.1.18 Straining/Squirming	YES	NO
C.1.19 Averting gaze	YES	NO
C.1.20 Facial grimacing	YES	NO
C.1.21 Increased floppiness	YES	NO
C.1.22 Increased stiffness	YES	NO
C.1.23 Falling asleep during feeding	YES	NO
C.1.24 Crying during feeding	YES	NO
Severe autonomic stress cues		
C.1.25 Coughing	YES	NO
C.1.26 Gagging	YES	NO
C.1.27 Skin colour changes	YES	NO
C.1.28 Apnoea	YES	NO
C.1.29 Irregular respiration	YES	NO
C.1.30 Spitting up	YES	NO
C.1.31 Arching back	YES	NO
C.1.32 Breath holding	YES	NO
C.1.33 Bradycardia	YES	NO
C.1.34 Continued excessive crying	YES	NO
C.1.35 Choking	YES	NO
SCORE SECTION C: If YES selected for 3 or more items, then indicate YES for the likelihood of dysphagia being present.		
OUTCOME SECTION C: Dysphagia likely to be present	YES	NO

SECTION D: GENERAL MOVEMENT & MUSCLE TONE SCREENING		
(Clark, 2009; Van Haastert et al., 2006)		
Instructions: Observe the infant's muscle tone at rest and during handling for feeding. Complete all items in the section relevant to the infant's current (adjusted) age.		
32 – 39 weeks AT REST		
D.1.1 Normal resting posture (full flexion of all limbs not yet present, relatively adequate muscle tone/flexion in lower limbs; partial flexion in upper limbs)	YES	NO
D.1.2 Extremely floppy/extended resting posture (all limbs)	YES	NO
D.1.3 Extremely stiff resting posture (arched head & neck/arched back)	YES	NO

32 – 39 weeks DURING FEEDING		
D.1.4 Normal resting posture (full flexion of all limbs not yet present, relatively adequate muscle tone/flexion in lower limbs; partial flexion in upper limbs)	YES	NO
D.1.5 Extremely floppy/extended resting posture (all limbs / froggy position)	YES	NO
D.1.6 Extremely stiff resting posture (arched head & neck/arched back)	YES	NO
40 weeks term – 4 months post term AT REST		
D.2.1 Normal fully flexed resting posture of all limbs	YES	NO
D.2.2 Extended resting posture of all limbs (froggy position)	YES	NO
D.2.3 Stiff resting posture (arched head & neck/arched back)	YES	NO
40 weeks term – 4 months post term DURING FEEDING		
D.2.4 Normal fully flexed posture of all limbs maintained at midline	YES	NO
D.2.5 Floppy/extension of limbs/difficult to maintain midline flexion	YES	NO
D.2.6 Extremely stiff (arched head & neck – hyperextension pattern/arched back – shoulder retraction or elevation pattern)	YES	NO
SCORE SECTION D: If normal posture is indicated at rest and during feeding, then dysphagia is not likely to be present. Then select NO. If abnormal posture is noted at rest and during feeding or only during feeding, then dysphagia is likely to be present. Then select YES.		
OUTCOME SECTION D: Dysphagia likely to be present	YES	NO

SECTION E: ORAL PERIPHERAL EVALUATION			
(Arvedson & Brodsky, 2002; Chapman Barr, 2001; Hall, 2001; Swigert, 2010)			
E.1 Oral reactions			
Instructions: The oral reactions should preferably be elicited BEFORE feeding if the infant presents with relatively adequate state regulation and appears alert.			
Permanent reactions	Stimulus & Appropriate expected response	Present	Absent
E.1.1 Transverse tongue reaction	Stroke sides of tongue. Response: Tongue moves to the side that has been stimulated.	YES	NO
E.1.2. Sucking	Stroke tongue or touch hard palate. Response: Tongue should push little finger up against hard palate with good strength.	YES	NO
Temporary reactions	Stimulus & Appropriate expected response	Present	Absent
E.1.3 Phasic bite	Stimulate the gums by stroking the upper/lower gums. Response: Rapid rhythmical up and down movement of the jaw.	YES	NO
E.1.4 Tongue protrusion	Touch tongue tip. Response: Anterior tongue protrusion beyond the border of the lips.	YES	NO
E.1.5 Rooting reaction	Stroke cheek or corner of mouth. Response: Head move toward side of stimulus and mouth opens.	YES	NO

	{Rooting reaction starts to integrate (diminish) by 3 0 6 months of age.}		
E.1.6 Santmyer reflex	Administer a puff of air to the perioral area in the face of an alert non-crying infant. Response: Infant should swallow	YES	NO
E.1.7 Palmomental (Babkin) reflex	Bilateral pressure to the palms. Response: Mandibular depression & suckling movements of the tongue.	YES	NO
SCORES SECTION E.1: If the sucking reflex is absent dysphagia is likely to be present. Select YES.			
SECTION E.1: Dysphagia likely to be present		YES	NO

E.2 – E.5 Oral structure & function			
Instructions: Observe oral structure and function AT REST or where indicated DURING FEEDING.			
E.2 LIPS			
E.2.1 Symmetrical appearance		YES	NO
E.2.2 Lips touch when gums are together		YES	NO
E.2.3 Closure maintained <i>at rest</i>		YES	NO
E.2.4 Closure maintained around nipple <i>during feeding</i>		YES	NO
<i>E.2.5 Upper lip tone at rest</i>			
E.2.5.1 Normal appearance		YES	NO
E.2.5.2 Stiff / retracted		YES	NO
E.2.5.3 Floppy / inactive		YES	NO
<i>E.2.6 Upper lip tone during feeding</i>			
E.2.6.1 Normal appearance		YES	NO
E.2.6.2 Stiff / retracted		YES	NO
E.2.6.3 Floppy / inactive		YES	NO
<i>E.2.7 Lower lip tone at rest</i>			
E.2.7.1 Normal appearance		YES	NO
E.2.7.2 Stiff / curled in towards lower gum		YES	NO
E.2.7.3 Sagging		YES	NO
<i>E.2.8 Lower lip tone during feeding</i>			
E.2.8.1 Normal supportive appearance		YES	NO
E.2.8.2 Stiff / curled in towards lower gum		YES	NO
E.2.8.3 Sagging		YES	NO
<i>E.2.9 Structural deviations of the lips</i>			
E.2.9.1 Bilateral cleft lip		YES	NO
E.2.9.2 Unilateral cleft lip		YES	NO
E.2.9.3 Other (i.e lip pits etc.)		YES	NO

E.3 CHEEKS		
E.3.1 Age appropriately absent fat pads (32 – 39 weeks old infant) OR Fat pads present (40 weeks – 4 month old infant)	YES	NO
E.3.2 Stiffness during feeding	YES	NO
E.3.3 Inactivity / sagging during feeding	YES	NO
E.4 PALATE		
E.4.1 Intact hard palate	YES	NO
E.4.2 Cleft of the hard palate	YES	NO
E.4.3 Intact soft palate	YES	NO
E.4.4 Cleft of the soft palate (incl submucous cleft)	YES	NO
E.4.5 Intact uvula	YES	NO
E.4.6 Bifid uvula	YES	NO
E.5 TONGUE		
E.5.1 Normal size <i>at rest</i>	YES	NO
E.5.2 Macroglossia	YES	NO
E.5.3 Microglossia	YES	NO
E.5.4 Ankyloglossia	YES	NO
E.5.5 Normal muscle tone <i>at rest</i>	YES	NO
E.5.6. Protruded / thick appearance <i>at rest</i>	YES	NO
E.5.7 Retracted / bunched appearance <i>at rest</i>	YES	NO
E.5.8 Normal muscle tone / movement <i>during feeding</i>	YES	NO
E.5.9 Inactive / protruded tongue during feeding	YES	NO
E.5.10 Stiff / retracted tongue during feeding	YES	NO
E.5.11 Structural deviations of the tongue	YES	NO
<i>E.5.12 Abnormal movement patterns</i>		
E.5.12.1 Tongue thrust	YES	NO
E.5.12.2 Limited movement	YES	NO
E.6 JAW		
E.6.1 Normal appearance of the jaw	YES	NO
E.6.2 Micrognathia (small lower jaw)	YES	NO
E.6.3 Maxillary hypoplasia (midfacial retrusion)	YES	NO
E.6.4 Prognathism (protruded)	YES	NO
E.6.5 Retrognathism (retracted)	YES	NO
<i>E.6.6 Abnormal movement patterns</i>		
E.6.6.1 Jaw clenching	YES	NO
E.6.6.2 Jaw thrusting	YES	NO
SCORE SECTION E.2-E.6: If YES was selected to indicate any structural or physiological abnormality likely to impact on any of the stages of swallowing, select YES for the likelihood of		

dysphagia being present.		
OUTCOME SECTION E.2-E.6: Dysphagia likely to be present	YES	NO

E.7 Observation of cranial nerve function to indicate symptoms of possible dysfunction (Chapman Barr, 2001; Hall, 2001; Henning, 2002)		
Instructions: This section is to be completed based on the observation of oral structure and function "at rest" or "during feeding"(*). Item E.7.1.4 should be scored based on the elicitation of the rooting response in item E.1.5.		
E.7.1 CN V Trigeminal nerve dysfunction		
E.7.1.1 Reduced mandibular movements*	YES	NO
E.7.1.2 Failure to initiate sucking*	YES	NO
E.7.1.3 Weak lip seal*	YES	NO
E.7.1.4 Asymmetric reaction during rooting response	YES	NO
E.7.2 CN VII Facial nerve dysfunction		
E.7.2.1 Facial asymmetry	YES	NO
E.7.2.2 Reduced facial movements (at rest/when crying)	YES	NO
E.7.2.3 Weak lip seal*	YES	NO
E.7.3 CN IX Glossopharyngeal nerve dysfunction		
E.7.3.1 Failure to initiate sucking*	YES	NO
E.7.3.2 Suspected delayed swallow response*	YES	NO
E.7.3.3 Nasopharyngeal penetration (unrelated to structural deficit of hard/soft palate)*	YES	NO
E.7.4 CN X Vagus nerve dysfunction		
E.7.4.1 Absent voicing when crying (suspected vocal fold paralysis)	YES	NO
E.7.4.2 Weak cry (suspected vocal fold paresis)	YES	NO
E.7.4.3 Hypemasal cry	YES	NO
E.7.4.5 Suspected delayed swallow response*	YES	NO
E.7.4.6 Weak/poor sucking*	YES	NO
E.7.5 CN XII Hypoglossal nerve dysfunction		
E.7.5.1 Reduced tongue movements*	YES	NO
E.7.5.2 Weak/poor sucking*	YES	NO
SCORE SECTION E.7: If YES selected for any item in this section, indicate YES for the likelihood of dysphagia being present.		
OUTCOME SECTION E.7: Dysphagia likely to be present	YES	NO
OVERALL OUTCOME SECTION E:		
E.1	YES	NO
E.2 – E.6	YES	NO
E.7	YES	NO
SCORE OBTAINED SECTION E OVERALL: If a score of 2 OR more YES responses are obtained		

indicate YES for the likelihood of dysphagia being present.		
OUTCOME SECTION E OVERALL: Dysphagia likely to be present	YES	NO

SECTION F: CLINICAL FEEDING & SWALLOWING EVALUATION		
(Arvedson & Brodsky, 2002; Darrow & Harley, 1998; Rudolph & Thompson Link, 2002; Swigert, 2010)		
Instructions: Only complete the sections relevant to the infant's current (adjusted) age for section F.1.1 – F.1.4.		
F.1.1 – F.1.2 Non-nutritive sucking (NNS) skills		
F.1.1 NNS characteristics of the preterm infant (32 – 39 weeks)		
Instructions: Use a pacifier/your little finger to stimulate a suckling response. For item F.1.1.1 the approximate number of suckles before a pause occurs, should be counted.		
F.1.1.1 Burst cycles of approximately < 10 sucks before pausing	YES(0)	NO (1)
F.1.1.2 Adequate endurance throughout the feeding session	YES(0)	NO (1)
F.1.1.3 Adequate lip closure around finger/pacifier	YES(0)	NO (1)
F.1.1.4 Attempted tongue cupping/grooving against finger/pacifier	YES(0)	NO (1)
F.1.1.5 Anterior-posterior tongue movement present during suckling	YES(0)	NO (1)
F.1.1.6 Adequate sucking strength	YES(0)	NO (1)
F.1.1.7 Coordinated suck-swallow-breathe rhythm	YES(0)	NO (1)
F.1.1.8 Normal breathing pattern with no catch-up breathing	YES(0)	NO (1)
SCORE OBTAINED SECTION F.1.1.: If a score of 2 or more is obtained, indicate YES for the likelihood of dysphagia being present.		
OUTCOME SECTION F.1.1: Dysphagia likely to be present	YES	NO
F.1.2 NNS characteristic of the term (40 weeks) to four month post term infant		
Instructions: Use a pacifier/your little finger to stimulate a suckling response. For item F.1.2.1 the approximate number of sucks before a pause occurs, should be counted.		
F.1.2.1 Burst cycles of approximately 10 - 20 sucks before pausing	YES(0)	NO (1)
F.1.2.2 Adequate endurance throughout the feeding session	YES(0)	NO (1)
F.1.2.3 Adequate lip closure around finger/pacifier	YES(0)	NO (1)
F.1.2.4 Attempted tongue cupping/grooving against finger/pacifier	YES(0)	NO (1)
F.1.2.5 Anterior-posterior tongue movement present during suckling	YES(0)	NO (1)
F.1.2.6 Adequate sucking strength	YES(0)	NO (1)
F.1.2.7 Coordinate suck-swallow-breathe rhythm	YES(0)	NO (1)
F.1.2.8 Normal breathing pattern with no catch-up breathing	YES(0)	NO (1)
SCORE OBTAINED SECTION F.1.2: If a score of 2 or more is obtained, indicate YES for the likelihood of dysphagia being present.		
OUTCOME SECTION F.1.2: Dysphagia likely to be present	YES	NO
F.1.3 – F.1.4 Nutritive sucking (NS) skills		
F.1.3 NS characteristics of the preterm infant (32 – 39 weeks)		
Instructions: Ask the mother/caregiver/nurse to feed the infant. Observe the infant for the duration		

of the feeding session.		
F.1.3.1 Burst cycle of approximately < 10 sucks before pausing	YES(0)	NO (1)
F.1.3.2 Adequate endurance throughout the feeding session	YES(0)	NO (1)
F.1.3.3 Adequate lip closure/seal on nipple/bottle teat	YES(0)	NO (1)
F.1.3.4 Timely initiation of sucking	YES(0)	NO (1)
F.1.3.5 Adequate sucking strength	YES(0)	NO (1)
F.1.3.6 Coordinated suck-swallow-breathe rhythm	YES(0)	NO (1)
<i>F.1.3.7 Clinical signs of possible aspiration during feeding:</i>		
F.1.3.7.1 Gurgling	YES(1)	NO (0)
F.1.3.7.2 Coughing	YES(1)	NO (0)
F.1.3.7.3 Choking	YES(1)	NO (0)
F.1.3.7.4 Teary/watery eyes	YES(1)	NO (0)
<i>F.1.3.8 Avoidance behaviour during feeding:</i>		
F.1.3.8.1 Tongue thrust	YES(1)	NO (0)
F.1.3.8.2 Jaw clenching	YES(1)	NO (0)
F.1.3.8.3 Jaw thrusting	YES(1)	NO (0)
F.1.3.8.4 Lip retraction on presentation of nipple/bottle teat/small cup/syringe	YES(1)	NO (0)
F.1.3.8.5 Arching of the back & neck (extension pattern)	YES(1)	NO (0)
F.1.3.8.6 Turning the head away from the breast/bottle/cup/syringe	YES(1)	NO (0)
SCORE OBTAINED SECTION F.1.3: If a score of 2 or more is obtained, indicate YES for the likelihood of dysphagia being present.		
OUTCOME SECTION F.1.3: Dysphagia likely to be present	YES	NO
F.1.4 NS characteristics of the term (40 weeks) to 4 month post term infant		
Instructions: Ask the mother/caregiver/nurse to feed the infant. Observe the infant for the duration of the feeding session		
F.1.4.1 Burst cycle of approximately 10 - 20 sucks before pausing	YES(0)	NO (1)
F.1.4.2 Adequate endurance throughout the feeding session	YES(0)	NO (1)
F.1.4.3 Adequate lip closure/seal on nipple/bottle teat	YES(0)	NO (1)
F.1.4.4 Timely initiation of sucking	YES(0)	NO (1)
F.1.4.5 Adequate sucking strength	YES(0)	NO (1)
F.1.4.6 Coordinated suck-swallow-breathe rhythm	YES(0)	NO (1)
<i>F.1.4.7 Clinical signs of possible aspiration during feeding:</i>		
F.1.4.7.1 Gurgling	YES(1)	NO (0)
F.1.4.7.2 Coughing	YES(1)	NO (0)
F.1.4.7.3 Choking	YES(1)	NO (0)
F.1.4.7.4 Teary/watery eyes	YES(1)	NO (0)
<i>F.1.4.8 Avoidance behaviour during feeding:</i>		
F.1.4.8.1 Tongue thrust	YES(1)	NO (0)

F.1.4.8.2 Jaw clenching	YES(1)	NO (0)
F.1.4.8.3 Jaw thrusting	YES(1)	NO (0)
F.1.4.8.4 Lip retraction on presentation of nipple/bottle teat/small cup/syringe	YES(1)	NO (0)
F.1.4.8.5 Arching of the back & neck (extension pattern)	YES(1)	NO (0)
F.1.4.8.6 Turning the head away from the breast/bottle/cup/syringe	YES(1)	NO (0)
SCORE OBTAINED SECTION F.1.4: If a score of 2 or more is obtained, indicate YES for the likelihood of dysphagia being present.		
OUTCOME SECTION F.1.4: Dysphagia likely to be present	YES	NO
F.2 Behavioural response to feeding method & NNS stimulation		
Instructions: Observe the infant's acceptance of pacifier/little finger during NNS stimulation as well as during feeding.		
F.2.1 Infant accepts nipple/bottle teat/syringe/small medicine cup	YES(0)	NO (1)
F.2.2 Infant accepts pacifier/finger	YES(0)	NO (1)
<i>F.2.3 Negative behavioural responses during feeding or NNS stimulation</i>		
F.2.3.1 Refusal by turning the head away from source of feeding or pacifier/finger	YES(1)	NO (0)
F.2.3.2 Arching of the back and neck (extension pattern) to avoid feeding	YES(1)	NO (0)
F.2.3.3 Emesis after feeding	YES(1)	NO (0)
SCORE OBTAINED SECTION F.2: If a score of more than 0 is obtained, indicate YES for the likelihood of dysphagia being present.		
OUTCOME SECTION F.2: Dysphagia likely to be present	YES	NO
F.3 – F.4 Symptoms of Oropharyngeal dysphagia		
Instructions: Completing this section is based on the clinician's interpretation of the observation of respiration during feeding, oral function, cranial nerve function, NNS stimulation and feeding.		
<i>F.3 Oral symptoms</i>		
F.3.1 Delayed initiation of sucking	YES(1)	NO (0)
F.3.2 Poor/weak sucking response	YES(1)	NO (0)
F.3.3 Absent sucking response	YES(1)	NO (0)
F.3.4 Uncoordinated tongue movement during NNS and NS	YES(1)	NO (0)
F.3.5 Inadequate lip closure with excessive anterior spillage during feeding	YES(1)	NO (0)
F.3.6 Multiple swallow attempts to initiate pharyngeal swallow response (feel for multiple tongue base retractions without appropriate hyolaryngeal elevation in an attempt to swallow)	YES(1)	NO (0)
<i>F.4 Pharyngeal symptoms</i>		
F.4.1 Gurgling during/after swallowing	YES(1)	NO (0)
F.4.2 Coughing during/after swallowing	YES(1)	NO (0)
F.4.3 Choking during/after swallowing	YES(1)	NO (0)
F.4.4 Teary eyes during/immediately after swallowing	YES(1)	NO (0)
F.4.5 "Wet" respiratory sounds	YES(1)	NO (0)

F.4.6 "Wet" vocal sounds	YES(1)	NO (0)
F.4.7 Suspected delayed pharyngeal swallowing response	YES(1)	NO (0)
F.4.8 Absent pharyngeal swallowing response	YES(1)	NO (0)
SCORE OBTAINED SECTION F.3-F.4: If a score of more than 0 is obtained, indicate YES for the likelihood of oropharyngeal dysphagia being present.		
OUTCOME SECTION F.3-F.4: Dysphagia likely to be present	YES	NO
<i>OVERALL OUTCOME SECTION F:</i>		
F.1.1 – F.1.2	YES	NO
F.1.3 – F.1.4	YES	NO
F.2	YES	NO
F.3 – F.4	YES	NO
SCORE OBTAINED SECTION F OVERALL: If a score of 2 OR more YES responses are obtained indicate YES for the likelihood of oropharyngeal dysphagia being present.		
OUTCOME SECTION F OVERALL: Dysphagia likely to be present	YES	NO

CALCULATING DIAGNOSTIC OUTCOME			
SECTION A & B	Dysphagia likely to be present	YES	NO
SECTION C	Dysphagia likely to be present	YES	NO
SECTION D	Dysphagia likely to be present	YES	NO
SECTION E	Dysphagia likely to be present	YES	NO
SECTION F	Dysphagia likely to be present	YES	NO
SCORING INSTRUCTION: If a score of 3 or more YES responses obtained in the section outcomes above, indicate YES for the final diagnosis of oropharyngeal dysphagia likely to be present. However, at least one of the 3 YES responses required for reaching the final diagnosis of oropharyngeal dysphagia being present, must either be obtained in SECTION E or F.			
Diagnostic outcome	Oropharyngeal dysphagia likely to be present	YES	NO

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Appendix P: Permission Letter from the University of Pretoria for the Use of the NFAS



Faculty of Humanities

Fakulteit Geesteswetenskappe
Lefapha la Bomotheo

Department of Speech-Language Pathology and Audiology



12 March 2021

To whom this may concern

PERMISSION FOR THE USE OF THE NEONATAL FEEDING ASSESSMENT SCALE

(Viviers et al., 2017)

In response to the request sent on the 27th of February 2021, I hereby grant permission to Me Vivienne Norman and her colleagues at the University of Cape Town, to use the Neonatal Feeding Assessment Scale (NFAS; Viviers et al., 2017) in a masters study. The NFAS was developed and validated in a PhD study at the University of Pretoria and therefore remains intellectual property of the institution. Permission is therefore granted based on the premise that appropriate acknowledgement and reference will be made to acknowledge the authors and university in publication.

From the University of Pretoria, we wish you best of luck with your endeavours.

Warm regards,



Prof. Jeannie van der Linde

Head: Department Speech-Language Pathology and Audiology