The developmental status of pre-term infants on discharge from a private neonatal intensive care unit in Johannesburg

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Declaration

I, Anna Loyce Nyasha Mlizane declare that this Research Report is my own, unaided work. It is being submitted for the Master of Science in Physiotherapy at the University of Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

Anna Loyce Nyasha Mlizane
Name of candidate

Signature of candidate

On 27 day of September 2025.

Dedication

I dedicate this paper to my parents for always believing in me, my husband for supporting me and my supervisor for realizing my potential.

Abstract

Background

Despite advances in medical management, prematurity is still responsible for 45% of neonatal deaths in South Africa. Premature infants are at risk of developing neurodevelopmental impairments. While there are numerous developmental tests that assess term infants, the Test of Infant Motor Performance (TIMP) can assess the need for neurodevelopmental intervention in infants from 34 weeks gestational age.

Methods

In this quantitative cross-sectional study, 30 infants with a minimal age of 34 weeks were assessed using the TIMP prior to discharge from the hospital. The study took place in a neonatal intensive care unit in a private hospital in Johannesburg, South Africa. Demographic and clinical data was collected.

Results

The mean gestational age was 34.33 weeks (SD 3), the mean birth weight 2.32kg (SD 0.78). The mean age of the preterm infants at testing was 37.33 weeks (SD 2.20) and the average length of stay in the NICU was 21 days. The results indicated the most prevalent condition in preterm infants to be respiratory distress syndrome (n=27) followed by jaundice (n=5) and HIV exposed non infected (n=3). The TIMP scores revealed 34% (n=10) of the infants scored below average, 3% (n=1) scored far below average, this group of infants required a referral for neurodevelopmental intervention. A total of 33% (n=10) infants scored average and 30% (n=9) scored in the low average range. Infants who had low Apgar scores at one minute were significantly more likely to score below average on the TIMP (p=0.03).

Conclusion

Infants born prematurely are at risk of developmental delay and would benefit from a neurodevelopmental assessment as early as 34 weeks gestational age. This could expedite early referral and intervention. Infants with low one minute APGAR scores should be prioritised for developmental assessment and referral.

Key words: Test of infant motor performance, preterm, developmental delay, early intervention

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List of Abbreviations

Apgar:	Appearance, Pulse, Grimace, Activity, and Respiration
BSID:	Bayley Scales of Infant Development
BW:	Birth weight
CA:	Corrected age
CLD:	Chronic lung disease
CP:	Cerebral palsy
C section:	Caesarean section
CVA:	Neonatal stroke
CW:	Current weight
DD:	Developmental delay
GA:	Gestational age
GMA:	The General Movement Assessment
HEU:	Human immune virus exposed unaffected
HIE:	Hypoxic ischaemic encephalopathy
HNNE:	Hammersmith Neonatal Neurological Examination
IVH:	Intraventricular haemorrhage
LMIC:	Low-middle income countries
LOS:	Length of stay
LPI:	Late preterm infants
MAS:	Meconium aspiration syndrome
NBAS:	Neonatal Behavioural Assessment Scale
NBO:	Newborn Behavioural Observations System
NNE:	Neonatal encephalopathy
NNJ:	Neonatal jaundice
NICU:	Neonatal Intensive Care Unit
NVD:	Normal vaginal delivery
PDA:	Patent ductus arteriosus
RDS:	Respiratory distress syndrome
TIMP:	Test of Infant Motor Performance
VLBW:	Very low birth weight

Chapter 1 Introduction

1.1 Background

Prematurity is a worldwide health concern with about 14.8 million infants delivered prematurely each year. Low-middle income countries (LMICs) account for the majority of preterm births, with sub-Saharan Africa and Asia producing more than 81% of all preterm births (Lategan et al., 2022). In South Africa, 20,000 stillbirths are reported in addition to the estimated 23,000 new-born deaths every year. About 45% of the deaths are due to prematurity related problems (Mahwasane et al., 2020). One of the factors that contribute to preterm delivery in South Africa is lack of access to sufficient prenatal care. The required screenings and examinations for identifying and managing risk factors for preterm delivery are frequently not provided to pregnant women in LMICs (Lategan et al., 2022; Mahwasane et al., 2020).

Premature infants have a greater risk of developing disabilities. Developments in medical and surgical management and in technology have improved survival rates of fragile new-borns in neonatal intensive care units (NICUs) across the world. However, the surviving infants are still affected by developmental morbidities (Borges Nery et al., 2019).

Preterm births are usually associated with neurodevelopmental issues, including cognitive and motor difficulties, cerebral palsy (CP), respiratory distress, blindness, and/or hearing loss (Mahwasane et al., 2020). Preterm infants are more likely to develop neurodevelopmental abnormalities compared to their full-term counterparts. The abnormalities include poor quality of movement, a lower handling tolerance, poor self-soothing, increased excitability, increased tone or low tone, and aberrant reflexes (Ross et al., 2017).

There was formerly a belief that infants born between 34 and 37 weeks gestational age had a low risk of morbidity and developmental problems. Yet, research indicates that late preterm infants (LPI) compared to full term infants are more likely to experience neonatal problems and have impaired neurodevelopmental performance (Ramdin et al., 2018). Infants born with very low birth weight are more prone to developmental

issues and often discharged early from hospitals in South Africa with lower weights than they would be in environments with enough resources (Ramdin et al., 2018).

The increased risk of developmental delay associated with prematurity underscores the significance of early detection and intervention for developmental deficits in preterm new-borns. To help them catch up to their full-term counterparts and achieve their full developmental potential, they require developmental evaluations, speech and language therapy, and physiotherapy (Mabrouk et al., 2022).

The Test of Infant Motor Performance (TIMP) assesses motor development of new-borns from 34 weeks gestation age to four months corrected age. It is a simple to use instrument that offers an accurate assessment of the infant's motor skills. The TIMP is especially helpful for screening new-borns who are potentially vulnerable to develop developmental delays and for keeping track of the progress of babies who are getting therapy for motor-related difficulties (Campbell, 2021). The TIMP evaluates the developing head and trunk control and both spontaneous behaviours and elicited movements.

It has been found that the TIMP has excellent clinical utility and evaluative validity, as well as very strong psychometric characteristics. Also, it has been shown to be sensitive to subtle changes in new-borns' motor development (Madayi et al., 2021). The TIMP has been shown to have excellent test retest inter-rater reliability as well as good construct validity (Chiquetti et al., 2020). Peyton et al. (2018) states that the motor outcomes of children between the ages of one and five years have been accurately predicted by the TIMP scores obtained for preterm infants at 12 weeks corrected age. This means that early assessment of infants with the TIMP can be used to identify infants who would benefit from ongoing developmental monitoring and intervention.

Healthcare practitioners with the appropriate training, including paediatricians, occupational therapists, and physiotherapists, frequently administer the TIMP. These specialists are educated to analyse the test results and use the data gathered to highlight the infant's motor development's areas of strength and weakness (Campbell, 2021).

There are several advantages to early detection of developmental impairments in preterm new-borns. The ability to receive early intervention is one of the most crucial aspects, as it increases the likelihood that the child will catch up to peers in terms of developmental milestones (Buys and Gerber, 2021). It also has the added benefit of

reducing the emotional strain and stress on the parents and caregivers of these children. Peace of mind and assistance in better understanding and managing the needs of the baby might result from parents being aware that their child is experiencing developmental difficulties and receiving the necessary support. Another benefit is the ability to access resources and supportive services, such as therapy, early intervention programs, or specific educational services (Buys and Gerber, 2021).

Most other developmental assessment tools are not able to assess children as young as the TIMP is able to. For example, the Bayley Scales of Infant and Toddler development (BSID) can be used from 16 days corrected age and the Ages and Stages Questionnaire from two months. It is also possible to use the Alberta Motor Infant Scale, however research has shown that it is insensitive to detecting motor deficiencies in an infant up to four months old (Chiquetti et al., 2020). The TIMP is therefore one of the few tests that can be administered prior to discharge from NICU especially if the baby was born premature and has not yet reached corrected term age.

1.2 Problem Statement

Ideally, preterm infants should receive developmental screening before discharge from the NICU to identify any potential issues and allow for referral and early intervention if necessary (Chiquetti et al., 2020). However, this does not happen in clinical practice in South Africa and infants are often discharged home without any developmental screening. Although validity and reliability of the TIMP is established it is not clinically used in South Africa. Late identification of developmental delay can have detrimental effects on the long-term development and wellbeing of the children, as well as put a strain on their families financially and emotionally.

The results of this study are hoped to contribute to detecting developmental delays in preterm children as early as possible so that appropriate therapeutic interventions and support may be given to them as soon as possible.

1.3 Aims and Objectives

To establish the motor developmental profile and associated risk factors of preterm infants on discharge from the NICU.

1.3.1 Objectives

I. To determine the clinical profile of preterm infants admitted to the NICU.

II. To determine the developmental profile of preterm infants before discharge from the NICU using the TIMP

III. To determine the association between demographic, clinical factors, and developmental outcome of the preterm infant admitted in the NICU.

1.4 Significance

There is growing evidence that supports the need and benefits of early identification of developmental problems in preterm infants. To evaluate developmental problems in preterm new-borns, the TIMP has become one of the tools utilised. However, most of the existing evidence is geographically skewed with a focus on high income countries. Preterm infants are not routinely screened for developmental delay on discharge from the NICU in many LMICs which may delay their referral and commencement of early intervention. We aim to close this gap by using the TIMP within the South African context.

1.5 Outline of this Research Report

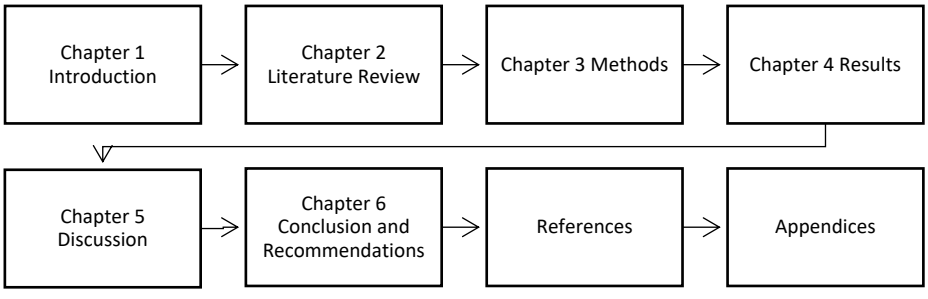

Figure 1.1. Outline of the research report

Chapter 2 Literature Review

2.1 Introduction

This literature review will cover the conditions relating to the developmental status of preterm infants that are admitted in the NICU. This information is aimed to give insight as well as information on the research that has been done in South Africa and worldwide on the matter and aims to identify gaps in research.

An estimated amount of 4 million infants are born premature in Sub Saharan Africa out of an estimated 31 million births annually (Lloyd et al., 2020). Physiotherapy has had an active role in assessing neurodevelopment in children of all ages however it is noted that in South Africa, the research is limited when it comes to the preterm infants. This review will present the current knowledge existing in this field of study.

2.2 Search Strategy

The articles for the literature review were found in PubMed and Clinical key. The search terms used were ‘Prematurity’, ‘Complications of prematurity’, ‘The test of infant motor performance’, ‘Developmental delay’, ‘Benefits of early intervention in preterm infants’, ‘Neurodevelopmental conditions relating to prematurity’, ‘Cerebral Palsy’, ‘The neonatal intensive care unit environment’.

2.3 Developmental delay

Developmental delay is when children do not reach their age predicted milestones due to various reasons that warrant a medical assessment to determine the cause. There are 3 different phases that can be used to classify Developmental Delay. When the current functional age is less than 33% of the chronological age, the situation is considered mild; when it is between 34% and 66% of the chronological age, it is considered moderate; and when it is less than 66% of the chronological age, it indicates a severe delay (Choo et al., 2019). The delay may present as one domain in isolation, or it could be more than one. When the developmental delay consists of two

or more domains it is termed a global developmental delay (Choo et al., 2019; Ohuma et al., 2023).

Strehlau et al (2020) state that about 43% of all children in LMIC were at risk of having developmental delay, according to the Lancet 2010 Global Health study. The children were estimated to be 249.4 million and under the age of 5 and the highest prevalence was Sub-Saharan Africa (Strehlau et al., 2020).

2.3.1 Clinical presentations

2.3.1.1 Neurodevelopmental Impairments

In LMIC, one in three preschool-aged children has neurodevelopmental impairments, with preterm delivery being the primary cause of the delay (Ramdin et al., 2018). Researchers stated that late preterm infants 34 to 37 weeks has a less risk of neurodevelopmental impairments however increased evidence has determined that the late term infants have an increased risk of developing neurodevelopmental impairments compared to full term infants (Ramdin et al., 2018). The immature pre term brain is said to be vulnerable to impairments and thus needs neurological care and monitoring (Soleimani et al., 2020). Extremely pre-term infants' brains (less than 28 weeks gestational age) are at risk of developing intraventricular hemorrhage (IVH) and periventricular hemorrhage (PVH) which can cause major lifelong neurodevelopmental impairments which include cerebral palsy (CP), cognitive delay, blindness, deafness, and behavioral difficulties (Sarda et al., 2021).

Neurodevelopmental care in the NICU is important. It promotes neural growth of the infant, advances physiological stability, assists with behavioral organization, support maturation and sleep rhythms (Soleimani et al., 2020). Neurodevelopmental care should not only stop in the NICU setting but needs to be extended to the home environment especially for low to middle income households where follow up may be difficult due to socio-economic factors (Byrne and Campbell, 2013; Oberg et al., 2012; Soleimani et al., 2020). It is thus important for the parents and caregivers of preterm infants to be taught how to care for the infant and given milestone guidelines to follow when discharged.

2.3.1.2 Cerebral Palsy (CP)

Cerebral Palsy (CP) is a neurodevelopmental impairment that affects the motor function due to injury of the developing brain (Gulati and Sondhi, 2018). It causes abnormalities in the muscle tone and in movement of the body. CP is the most severe condition that affect children born preterm and contributes as the highest cause of disability in children (Novak et al., 2020). It is characterised as a direct insult on the developing brain during or directly after birth and this is more prevalent in infants born at a gestation age of less than 37 weeks. The damage to the developing brain is non-progressive and varies in presentation, it predominantly affects the motor development and may occur with disturbances in cognition, perception, communication, sensation, behaviour and epilepsy (Gulati and Sondhi, 2018).

CP can be categorised as spastic (stiff muscles), dyskinetic (uncontrollable movements), ataxic (poor coordination) and mixed however the most prevalent presentation is spastic CP affecting 80% of the children with CP (Vitrikas et al., 2020). Diagnosis is made between the ages of three to five with observation of the characteristics however early indicators can be assessed as soon as 34 weeks gestational age with tools such as the TIMP. Early intervention for preterm infants during hospitalisation and in first few years of life has proven to have positive effects in improving their neurodevelopmental outcomes. (Dusing et al., 2020; Oberg et al., 2012; Pascal et al., 2018; Spittle and Treyvaud, 2016).

2.4 Factors associated with developmental delay

2.4.1 Prematurity

Prematurity is defined by the World Health Organisation as any child born before 37 full weeks of pregnancy or 259 days after the woman's last menstrual cycle (Vogel et al., 2018). Prematurity is divided into different categories; Extremely preterm which is infants below 28 weeks gestational age (GA), very preterm infants' GA will be between 28 and 32 weeks, lastly the moderate to late preterm infants are those born between 32 to 36 weeks GA (Harrison and Goldenberg, 2016). These categories are important

clinically as they can assist in determining the developmental risks that may affect the infant.

Preterm births occur in 11.1% of all births worldwide and 10% have been reported to be very preterm and 5% extremely preterm (Pascal et al., 2018). Over 60% of an estimated 15 million preterm births are in sub-Saharan Africa and South Asia. Preterm infants' brains experience sensory information that may be proportionate or disproportionate and this encourages a response. It should come with no surprise that disproportionate information has a negative impact on the developing brain. In addition the fetal nervous system develops in the third trimester and due to an early birth, there are disturbances in the process which contributes to most adverse effects of prematurity observed in preterm infants (Soleimani et al., 2020).

Prematurity has become a global problem; it has been found to have morbidity and mortality implications on a global scale. Its burden not only affects the children but affects the mothers, families, and communities at a physical, psychosocial, and economic level. The adverse effects of prematurity can be lifelong and include risk of developmental delay, cerebral palsy, learning impairments and visual disorders. (Harrison and Goldenberg, 2016)

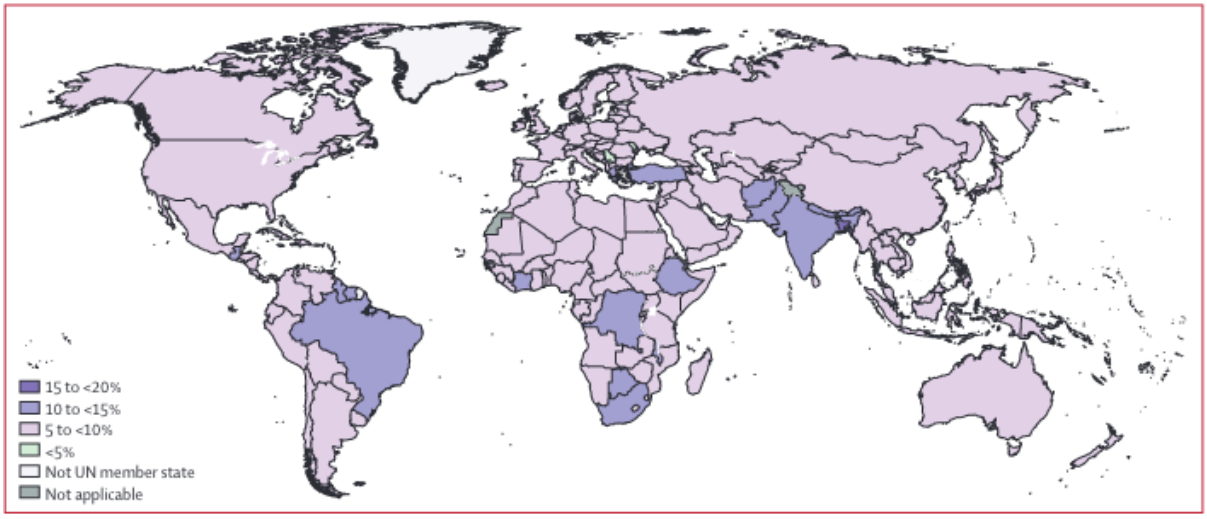

Figure 2.1.1: Estimated national preterm birth rates and numbers in 2020 (Ohuma et al., 2023).

2.4.2 Neonatal Sepsis

Neonatal sepsis is a condition that affects newborn infants and is linked to mortality rates in the first week of life. Worldwide statistics report that 27.5% of neonatal death are related to neonatal sepsis with a total of 20 in every 1000 live births in countries with a high mortality rate (Camargo et al., 2021). The infection is acquired in two ways, the first is via the mother before or during birth and the second is due to organisms from the hospital environment or the community within three to seven days of life, there are incidences of late onset from week one to three months of life (Shane et al., 2017).

Pre-term infants admitted in the hospital have a higher chance of acquiring neonatal sepsis. Complications that may arise from neonatal sepsis include neurological disturbances which is caused by either an ischaemic stroke or ventriculitis. The extent of the neurological damage can be observed with scans and physical examinations by doctors and allied therapists as the child develops. (Camargo et al., 2021)

2.4.3 Respiratory distress syndrome

Respiratory distress syndrome (RDS) is a condition commonly observed in preterm infants, primarily due to insufficient surfactant within the alveoli. Surfactant, a vital substance produced in utero beginning at 32 weeks of gestation, plays a crucial role in maintaining alveolar stability during expiration. As a result of the inadequate surfactant levels present at birth, preterm infants often experience breathing difficulties and RDS, necessitating their admission to the NICU.

The primary medical intervention for preterm infants exhibiting respiratory challenges upon birth involves administering surfactant along with supplemental oxygen. Oxygen support can be provided according to the infant's needs through either non-invasive or invasive means. Non-invasive options include the use of nasal cannula or high-flow oxygen, whereas invasive techniques encompass mechanical ventilation. Infants with RDS face an elevated risk of developing bronchopulmonary dysplasia, a lung injury associated with extended reliance on invasive oxygen therapy. (Berkelhamer et al., 2018; Debillon et al., 2021; Liu et al., 2022; Manley et al., 2024; Nakai et al., 2024)

2.4.4 Neonatal Jaundice

Neonatal Jaundice (NNJ) is a condition resulting in increased bilirubin in the blood and results in yellow skin and affects more preterm infants compared to their full-term counterparts. Bilirubin can cross the blood brain barrier which may result in the infant developing various neurodevelopmental issues. Infants identified to have an increased bilirubin levels receive phototherapy to help the breakdown of bilirubin. Phototherapy initiated early has been found to reverse the risk of neurodevelopmental issues associated with NNJ. (Adane et al., 2024; Belay et al., 2023; Muniz et al., 2024; Okulu, 2024)

2.4.5 HIV Exposure

One of the main causes of death for women in their reproductive years worldwide is HIV and AIDS with approximately 17.8 million women affected. Advancement in medicine has made it possible for infants of HIV infected mothers to not pass the infection to their infants during the birthing process. As a result of efforts to prevent transmission from the mother to the child, there are now more HIV-exposed uninfected (HEU) infants. In Sub–Saharan Africa, HEU infants under 6 months have an increased risk of infection and mortality compared to HIV-non exposed infants from unaffected mothers. HEU infants should be observed during the first two years of life as they have a risk of developing neurodevelopmental impairments. (Djoba Siawaya and Maloupazoa Siawaya, 2023; Menbere et al., 2024; Strehlau et al., 2020)

2.4.6 Patent ductus arteriosus (PDA)

The ductus arteriosus is a connection between the pulmonary trunk to the descending aorta and closes within 24 to 72 hours in after birth in newborns. The condition patent ductus arteriosus is due to a defect or incomplete closure on the ductus arteriosus, About 60% of extremely preterm newborns (less than 28 weeks) and 20% to 50% of neonates born before 32 weeks have patent ductus arteriosus. While this condition occurs in preterm infants there is little existing evidence that links it to developmental delay however Backes et al (2022) mentions its association to compromised school aged performance. (Backes et al., 2022; Cambonie et al., 2024; Park et al., 2021).

2.4.7 Neonatal encephalopathy (NNE)

Neonatal encephalopathy (NNE) is condition that causes abnormal brain activity in an infant and can be due to a hypoxic-ischemic event, brain malformations, vascular injuries and more. NNE results in suppression of the respiratory system, reduced responsiveness, abnormal tone and or movements. Over 1 million infants are affected with NNE annually and it is one of the main causes of death in children under the age of five with 42% from sub-Saharan Africa. Therapeutic hypothermia is one of the treatments being implemented globally to prevent disability however there is lack of evidence of its effectiveness in low-income countries. There is a significant chance that infants with NNE will experience neurodevelopmental deficits which include CP, global developmental delay, cognitive dysfunction, epilepsy , and hearing and visual impairments. (Mathew et al., 2022; Mathieson et al., 2024; Mehta et al., 2022; Russ et al., 2021)

2.5 Appearance, Pulse, Grimace, Activity, and Respiration (Apgar) scores

Apgar scores are a standardized measure used assess the need for resuscitation in a newborn. The test is done at 1 minute and 5 minutes after birth and infants that score below 7 are considered to have a low score and are monitored closely. Apgar stands for Appearance, Pulse, Grimace, Activity, and Respiration and are designed to assess cyanosis, hypoperfusion, bradycardia, hypotonia, respiratory depression, or apnea in an infant. The scores taken at 1 minute and 5 minutes have been found to be predictive factors to infant mortality and infant morbidity. Apgar scores are used across the world to assess newborn infants and low scores have indicated an association to poor neurodevelopmental outcomes in full-term and preterm infants. The use of Apgar ratings as a means of identifying infants at risk for neurodevelopmental morbidities is not well supported by research. The infant morbidities associated with a low Apgar scores include CP and need for educational support services however the association decreases with low GA (<28 weeks). (Lin et al., 2022; Sant et al., 2021; Simon et al., 2025)

2.6 Assessment of developmental delay

Preterm infants with adverse outcomes are surviving at higher rates due to improved care and technological developments. Consequently, there is a rising chance of neurodevelopmental deficiencies. Low birth weight, cerebral palsy, and premature birth are risk factors that have an immediate effect on an infant's development and the diagnosis is often late. Due to the immaturity of their neurodevelopmental system, compared to full-term infants, the risk of severe motor issues such cerebral palsy is 20–80 times higher in preterm infants (Ravarian et al., 2023).

2.6.1 Test of Infant Motor Performance (TIMP)

As babies develop, they move to explore their own bodies and their surroundings, which is highly dependent on their motor movement. They focus their eyes and ears toward fascinating stimuli, and this requires head and body movement as well as postural control. and find comfort in themselves. Accurate early evaluation of posture and movement control provides a window into how well an infant performs in the environment as well as provides an opportunity for early intervention which improves the baby’s outcomes. Any delay, regardless of the primary cause, can be captured by the TIMP. It is a valuable tool for clinical trial outcome assessment, useful for planning interventions and evaluating treatment outcomes, and by the time the infant is 4 months old, corrected age (CA), it significantly predicts long-term motor and cognitive outcomes. Additionally, it has been shown to be successful in teaching parents about how preterm infants learn their movement. (Campbell, 2021)

The TIMP is an assessment tool that was developed to assess for developmental delay factors in pre-term infants. The tool can assess infants between 34 weeks (corrected age) and 4 months old. It consists of 42 items that are scored, 13 of which are observed movements and 29 elicited. While the TIMP includes elements that incorporate auditory and visual stimuli, its primary purpose is not to assess auditory or visual functioning directly. These components are used mainly to elicit and observe motor responses, as the test is specifically designed to evaluate postural and selective motor control in infants. (Campbell, 2021; Kvestad et al., 2023; Pietruszewski et al., 2022)

The scores for the items will be used to evaluate if the infant has a low, moderate, or high risk of developmental problems. This tool was created in the United States of America to evaluate preterm newborns' motor development. The TIMP has been found reliable in areas of low resource. However I was unable to find research demonstrating the validity of TIMP in LMIC which highlights a gap in literature and suggests a research need in LMIC. It has been found to have positive reliability and validity in Brazil, Nepal, Iran and Korea with some countries using translated versions to assess preterm infants (Campbell, 2021; Kvestad et al., 2023; Ravarian et al., 2023; Song et al., 2018).

2.6.2 Bayley Scales of Infant and Toddler Development (BSID)

The BSID is a commonly used assessment tool to assess development in 16-day old infants to 42 weeks old toddlers. The BSID measures adaptive behaviour, cognitive, communication, motor, and social-emotional behaviours. The tool was developed in the USA and has been used in low-income countries with some challenges fully adapting it to the settings. In international studies requiring cultural adaptability, the researchers adapted the cognitive, communication and motor only as the other domains presented with complex cross-cultural expectations. The BSID scales has been found to have a good correlation to the TIMP assessment tool in infants. A Kenyan study revealed the BSID III scales useful as a comparative tool between groups compared to defining developmental norms in Kenya. (Kvestad et al., 2022; McHenry et al., 2021)

2.6.3 The General Movement Assessment (GMA)

The General Movement Assessment (GMA) is an assessment tool with a high predictive value of identifying infants with a high risk for CP. It is widely used by health professionals around the world due to its high sensitivity (98%) and specificity (91%). The GMA evaluates the infants quality of movement of their arm, leg, neck and trunk. General movements can be observed from as early and nine to 12 weeks post menstrual age up to the end of six months post term age. These movements are categorised into two; writhing movements which can be observed from birth up to two months and fidgety movements which can be observed from two months post term up

to five months. The GMA had been used in late preterm infants as a predictor for spastic CP. (Tomantschger et al., 2018)

2.6.4 The Neonatal Behavioural Assessment Scale (NBAS)

The Neonatal Behavioural Assessment Scale (NBAS) is a neurobehavioral assessment used by clinicians and carers to assess the behaviour of the infant. This helps the clinicians and carers to observe infants as distinct individuals whose behaviours can be interpreted as meaningful communication of needs, wants, abilities, challenges, and preferences. The NBAS can be used in full term infants up to two months postpartum and in stable preterm infant that are 35 weeks GA. The assessment is made up of 28 behavioural and reflex items which are recorded revealing the infant's social-interactive and neurodevelopmental strengths and challenges. These may include muscle tone, ability to self soothe and the response to human voices or sounds. (Barlow et al., 2018)

2.6.5 Newborn Behavioural Observations System (NBO)

The Newborn Behavioural Observations System (NBO) is system that is based on interactions of the parent and the infant designed to aid parents to be attentive to their baby's abilities. This interaction helps promote a positive relationship between parent and child from birth. The NBO can be done from 36 weeks GA stable infants to three months post term. The assessment focuses observation of the infant and 18 neurobehavioral items with active participation of the parent. The items include acclimatization to stimuli, regulation, motor development and response to voice, face and stress. This observation is known to be baby led and has had positive results in improving parental confidence with new born infants. (Barlow et al., 2018; Yago et al., 2023)

2.6.6 Hammersmith Neonatal Neurological Examination (HNNE)

The Hammersmith Neonatal Neurological Examination (HNNE) is an assessment used to identify full term and preterm infants that are at risk of CP. It has been shown to have a significant correlation with a structural MRI and can be utilised in low-resource

situations without access to MRI.The HNNE can be used in infants as early as 32 weeks GA up to 2 months post term. The assessment is based on 34 items that are divided in six categories which are tone, tone patterns, reflexes, spontaneous movement, abnormal neurological signs and behaviour. This tool is standardized and is reliable to use in a NICU settings.(Howard et al., 2023; See et al., 2024; Spittle et al., 2016)

2.7 Early Intervention

Over the years, the evidence in support of early intervention in preterm infants has improved. Early neurodevelopmental intervention is essential in preterm infants that have been identified to have indicators of developmental impairments. The risk of developing impairments increases with a decreased gestational age in the infants (Spittle and Treyvaud, 2016). Research states that there are increasingly high rates of neurodevelopmental impairments observed in preterm infants and to improve the developmental outcomes, early intervention is required throughout the infant's hospital stay in the NICU and after discharge. (Mills et al., 2018; Oberg et al., 2012; Orton et al., 2018; Spittle and Treyvaud, 2016)

Greene and Patra (2016) speak about the importance of early intervention in an American context, they further review that The American Academy of Pediatricians and The National Institute of Child Health and Human Development recognized the need for intervention and encouraged follow up clinics with health care professionals affiliated to the NICU. According to research, 93% of academic NICU's have an established follow up procedure for infants that have been discharged from the NICU (Greene and Patra, 2016). The importance of early intervention in preterm infants is documented in research. In LMIC, it is often difficult to follow up due to socio economic factors however it is our duty as healthcare professionals working in the NICU to educate parents about the importance of early intervention and follow up. (Orton et al., 2018; Petty et al., 2022; Ramdin et al., 2022)

Neuroprotective care is essential for preterm infants' developing brains. The core strategies that are implanted in the NICU are based on the neonatal integrative developmental care model. The core strategies are creating a healing environment,

working with families, handling and positioning, protecting sleep, reducing pain and stress, protecting skin and maximising nutrition. These strategies are implemented in the NICU by ensuring that the environment is quiet and dimmed lighting in between feeding times. Collaboration with families is standard ensuring involvement in the infant's stay in NICU. Infants are handled with care during routine procedures and receive pain relief during painful procedures. Nutritional content of the infant's feeds is highly monitored by a specialised dietician. (Altimier and Phillips, 2016; Parikh and Juul, 2019)

Implementation of neuroprotective care beyond the NICU is based on a continuation of the same core strategies as above. The parents receive education on how to implement each strategy to the best of their abilities from the nursing staff. Skin to skin is one of the foundational cares taught to parents from when the infant is still in the NICU and highly encouraged to continue with at home. Griffith et al. (2022) reports on the importance of a home visit when the infant has been discharged from the NICU though this may be limited in low resource settings.

Post-NICU discharge interventions are essential for reducing unplanned hospital visits, parental stress, and postpartum depression in mothers, as well as for educating parents about infant care and health, boosting parental confidence and competency, improving parent-infant relationships, and fostering emotional and social support. (Griffith et al., 2022)

2.8 Conclusion

An analysis of the literature shows that premature birth complications place infants admitted to the NICU at risk for neurodevelopmental abnormalities. The complications are known to cause effects that affect the infant into adulthood ranging from mild to severe. Early intervention has been recommended in the studies as a way to yield better outcomes in the infant's development. The literature highlights the need for assessing infants for risk of developmental delay is crucial in the administration of early intervention. There was limited evidence in assessment using the TIMP in the NICU in an African setting indicating a gap in literature.

Chapter 3 Methods

3.1 Study Design

A quantitative cross sectional descriptive design was used to conduct this study. This is a type of an observational study that focuses on data from a population at one specific point in time. A cross-sectional study selects subjects from a population that is relevant to the study question, as opposed to case-control studies, which select subjects based on the outcome status or cohort studies, which select subjects based on the exposure status. It is typically quick and affordable to carry out and often yields results that guide the design of other studies. There are rarely any ethical issues in this study type because there is no deliberate exposure of the subjects (Wang and Cheng, 2020). This makes this study design well suited for this research project.

3.2 Study Setting

Study participants were drawn from the neonatal intensive care unit (NICU) of a private hospital in Johannesburg, South Africa. The patients that are admitted to the hospital are those that have scheduled births at the hospital or have been brought by the ambulance due to an emergency. The hospital caters to patients that come from the south of Johannesburg.

3.3 Participants

3.3.1 Source of Participants

The sample of participants we been recruited from a private hospital NICU in Johannesburg, South Africa. The participants were preterm infants admitted to the NICU.

3.3.2 Sample Size

The sample size was determined using the Central Limit Theorem. The Central Limit Theorem (CLT) states “given a sufficiently large sample size, the sampling distribution of the mean for a variable will approximate a normal distribution regardless of that variable’s distribution in the population” (Frost, 2018). Hence, the sample size will depend on how the samples are distributed among the population. According to the CLT, a sample size of 30 participants is sufficient. Thirty participants were recruited for this study.

3.3.3 Sample Selection

Convenience sampling was used. Parents of all infants that met the inclusion criteria and were close to getting discharged from the NICU were invited to participate. Recruitment occurred over a period of five months.

3.3.3.1 Inclusion Criteria

- Preterm infants that are ready to be discharged from the NICU.
- Infants with a corrected age of at least 34 weeks.

3.3.3.2 Exclusion Criteria

- Full term infants.
- Ventilated infants
- Infants that have undergone surgery

3.4 Instrumentation and Outcome Measures

3.4.1 The Test of Infant Performance (TIMP)

The TIMP measures posture, motor control, and movement organization for functional tasks in infants 34 weeks to four months post-partum. It is a norm-referenced assessment. It is a 42-item assessment tool that evaluates movement and postural control in supine, standing positions, prone, and supported seating. It takes approximately 20 to 30 minutes to administer. The TIMP allows preterm infants to be

assessed for age-appropriate or delayed motor development, as well as to predict changes in motor development over time. The test evaluates the child's responses to auditory and visual stimuli as well as their postural control, stability, and alignment of body parts. Kim et al (2011) states that there was a highly significant correlation between TIMP scores and Bayley Scales of Infant Development (BSID) scores. A strong association was found between and the TIMP z-scores at 10 to 15 weeks of age and three BSID subscales at age two years in a study by Peyton et al. (2018). Interpretation of the TIMP results can offer a thorough knowledge of the developmental state of preterm infants. This data can be used to evaluate progress and chart changes over time as well as to help develop interventions and support to help preterm new-borns develop. As a result, preterm new-borns and their families may receive better treatment and have better outcomes (Peyton et al., 2018).

The first part of the test is a two- to three-minute observation of supine spontaneous movement. The test evaluates 13 activities, including the ability to kick, raise the legs off the ground, and centre the head in a midline position. In the second part, the baby is placed in a variety of positions, including tilting upright, side lying, prone, supine, supported sitting, and supported standing.

Every elicited item includes a unique rating scale with four to seven levels that was created using Rasch analysis to represent changes in two-week intervals during the six-month age range that the TIMP can be used for.

The 29 elicited items assessed in the second part analyze the mastery of head control in all spatial orientations and early phases of trunk control development in the baby. The baby’s ability to move freely, roll and righting the body from lateral positions is assessed. The baby has outgrown the TIMP's measuring capacity once he can independently shift his position in space, such as rolling from a supine to a prone position (Campbell, 2021).

3.5 Procedure

3.5.1 Main Study

The infants were recruited from a private NICU in Johannesburg, South Africa. The parents of all NICU infants that were approaching discharge were given an information sheet by the principal investigator a week to two weeks before discharge. This timeline was determined by speaking to the doctors and the nurses as well as observing if the child is off oxygen in combination with the weight gain. Stable preterm infants are discharged from the NICU only when they are coping well on room air, are sucking well, finishing their feeds and are weighing 2000 grams or above.

Giving parents the information sheet and consent form at this time was to make sure they had ample time to settle emotionally from the hospitalisation of their child. The consent form given to the parents was accompanied by the information sheet as well as the contact details of the principal investigator for any further questions.

The assessment was conducted by the principal investigator Miss ALN Mlizane who is certified in using the TIMP assessment. Permission to access files was requested from the Private Hospital ethics board and the head of the unit.

A TIMP assessment was conducted on preterm infants within 24-48 hours before discharge. Each assessment took 20 – 30 minutes.

In the first part of the test, spontaneous movement is observed. In the second part a total of 29 elicited items were observed by the tester to determine the infant's progress toward learning to roll over, move freely when supported while standing, and correct their body from a side-lying position, as well as to demonstrate the earliest stages of trunk control (Campbell, 2021). The assessment was conducted in the infant’s bassinet when the infant was calm and awake.

When the results had been collected the infants that are at risk of developmental delay received a referral for follow up after discharge. The Health Professions Council of South Africa guidelines will be followed as the infants will be referred to their assigned therapists working in the unit. Parents were given information on developmental milestones. The results were communicated to the parents in a private room with sensitivity. A distress protocol was put in place for parents who became distressed

from the results to be referred to the psychologist based at the hospital at which the study was conducted at the cost of the researcher.

3.6 Ethical Considerations

The Human Research Ethics Committee at the University of Witwatersrand granted ethical clearance (M230701) and the Private Hospital group. Information and consent forms were be issued to every parent whose child was eligible to participate in the study. Parents had enough time to decide if they wanted to take part in the research. Participants' parents were advised that they might leave the research at any moment without facing any repercussions. They were made aware that the data gathered for the study would remain anonymous and confidential. The information gathered during this study is to be used exclusively in the study.

Individual results were discussed with the parents, anonymised results will be shared with the unit and will be published and presented.

3.7 Data Management

The information was collected from the medical file of the patient that is stored in a password protected iPad and recorded down on the data collection form. The information collected included the TIMP score which was calculated after the assessment was done. This information was then transferred to an excel document stored in password protected laptop.

3.8 Statistical Analyses

Descriptive statistics including means, standard deviations, frequencies, and percentages were used to summarise the demographic and clinical data. We checked if the data was normally distributed using the Shapiro Wilk test. The relationships between variables were investigated using the two-sample t-test for data that was normally distributed and the Wilcoxon rank-sum (Mann-Whitney) test for data that was not normally distributed (skewed).

Chapter four presents the results of this study.

Chapter 4 Results

The results of the study conducted on thirty participants will be presented below. Interpretation of the results has been done using tables, graphs, and pie charts.

4.1 Participants

Thirty pre-term infants participated in this study. Table 1 summarises the demographics of the infants admitted in the NICU.

Table 4.1: The clinical profile of preterm infants admitted in the NICU (n=30)

Variable	Mean	SD
Gestational Age (weeks)	34.33	3.00
Corrected Age (weeks)	37.33	2.20
Birth Weight (kg)	2.32	0.78
Current Weight (kg)	2.60	0.53
Current length (cm)	45.90	4.40
Head circumference (cm)	33.12	2.00
Apgar 1 minute	7	2
Apgar 5 minute	8	1
Maternal Age (years)	33	5
Length of stay (days)	21	21
Length of O_2 dependence (days)	10	14

The lowest recorded GA was 28 weeks, and the lowest recorded birthweight was 780 grams. There were a total of 16 males and 14 females in the sample. Caesarean section births accounted for about 86% (n=26) of all the births with the remainder 13,33% (n=4) being natural vaginal delivery. The standard deviation for the length of stay is high due to widespread data, the shortest length of stay was three days and the longest was 77 days however the mean indicates the average length of stay in the NICU is 20 days.

Table 4.2: Demographic data as percentages

Variable	Percentage (%)
Male	53.3
Female	46.7
NVD	13.3
C Section	86.7

Table 4.2 shows the percentage population of male compared to females assessed in the NICU. There were slightly more males than females. Given that the majority of the babies were born prematurely, the NVD rate is extremely low when compared to C sections. None of the infants required hypothermia after birth and all infants had kangaroo care during their NICU stay.

Table 4.3: Ventilation and oxygen support

Variable	Percentage (%)
Ventilation	43.3
Non-ventilated	56.7
Oxygen	90
Room air	10

Table 4.3 summarises the infants that were ventilated during their stay in the NICU as well as how many required supplemental oxygen. It further indicates that of all the infants assessed, 90% of them required oxygen support with the remaining 10% coping well on room air from birth and during their stay in the NICU. Ventilation support was required for 43% of the infants.

Table 4.4: Anthropometrics

Variable	Mean	SD
Birth weight (kg)	2.32	0.78
Current weight (kg)	2.60	0.54
Current length (cm)	45.93	4.40
Head circumference (cm)	33.16	2.00
Corrected Age (weeks) at assessment	37.23	2.20
Gestational Age (weeks)	34.33	3.00

Table 4.4 summarises the anthropometrics of the infants assessed. The mean birth weight was 2.35kg, with the mean current weight going up to 2.60kg by discharge. The gestational age averaged at 34 weeks and the corrected age at discharge was 37 weeks. Full term infants are considered to be from 37 weeks gestational age, six full term infants and 24 pre-term infants participated in this study.

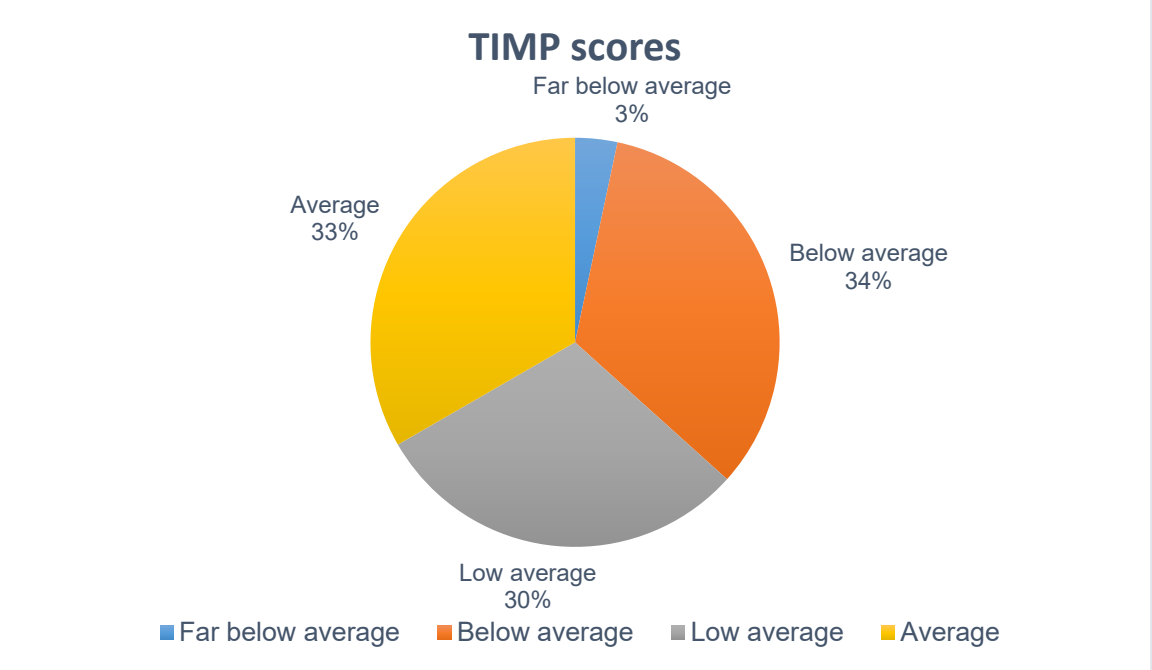

Figure 4.1: The TIMP scores of infants prior to discharge from the NICU

Figure 4.1 summarises the TIMP scores attained by each infant on assessment. From the results, 33%(n=10) of the infants assessed performed below average and 3%(n=1) in the very far below average. These infants' parents were given a referral for a follow up with a physiotherapist and an occupational therapist. The infants that scored in the low average (n=9) and average range (n=10) added up to 63%, these infants performed well within the normal range for their respective ages and their parents were given recommendations to follow up. Overall, the population of infants in the study that required intervention were 35% of the 30 participants.

Table 4.5: Medical conditions (n=30)

Medical Condition	n	Percentages
Respiratory distress syndrome (RDS)	27	90%
Retroviral disease exposed (RVD exposed)	4	13%
Jaundice	5	17%
Meconium aspiration syndrome (MAS)	1	3%
Neonatal sepsis	2	7%
Neonatal encephalopathy (NNE)	1	3%
Congenital hydrocephalus	1	3%
Patent ductus arteriosus (PDA)	1	3%

Every participant, with the exception of one, had at least one of the illnesses shown in the table. The most prevalent condition in this group was RDS (n=27) followed by jaundice (n=5).

4.2 Relationships between key variables

4.2.1 TIMP scores

In order to evaluate the relationship between the TIMP scores and key clinical variables a dichotomous classification of the TIMP scores was developed by combining scores falling within the 'average' and 'low average' ranges grouped together and classified as "average," while scores in the 'below average' and 'far below average' ranges were grouped together as "below average.". This allows comparison of infants with average development with those with below average development by clinical factor.

Table 4.6 shows the initial categories while table 4.7 shows the combined categories.

Table 4.6: **TIMP classification (n=30)**

TIMP category	frequency	percent
Extremely low	1	3.33
Below average	10	33.33
Low average	9	30.00
Average	10	33.33
Total	30	100.00

Table 4.7: **Dichotomous TIMP classification**

TIMP Score	Frequency	Percentage
Below average	11	36.67
Average	19	63.33
Total	30	100.00

Each factor was assessed for normality of data distribution using the Shapiro Wilkes test.

4.2.2 Gestational age

Gestational age was found to be normally distributed and the two sample two test was used to evaluate whether there was difference in gestational age by TIMP category.

Table 4.8: **Gestational age by TIMP category (n=30)**

TIMP Score	Obs.	Mean age (weeks)	Std. error	Std. dev.	P value
Below average	11	33.91	1.05	3.48	
Average	19	34.58	0.65	2.85	0.57
Combined	30	34.33	0.56	3.06	
Difference		-0.67	1.17		

No significant difference was found between the gestational age of preterm infants with below average TIMP scores compared to those with average TIMP scores (p=0.57).

4.2.3 Corrected age

Corrected age at time of assessment was not normally distributed. The two-sample Wilcoxon rank-sum (Mann-Whitney) test was therefore used to evaluate corrected age by TIMP classification as shown in table 4.9.

Table 4.9: **Corrected age by TIMP category (n=30)**

TIMP Score	Observations	Rank sum	expected	P value
Below average	11	209.5	170.5	0.087
Average	19	255.5	294.5	
Combined	30	465	465	

The p value of 0.087 indicates that there is no difference in corrected age by TIMP category.

4.2.4 Birth weight by TIMP category

The difference in mean weight between the below average group and average group is 0.36 kg. Table 4.10 summaries the results. The results suggest an insignificant difference in mean birth weight between the two groups.

Table 4.10: **Birth weight by TIMP category**

TIMP Score	Obs.	Mean weight (kg)	Std. error	Std. dev	P value
Below average	11	2.09	0.27	0.89	0.24
Average	19	2.45	0.17	0.72	
Combined	30	2.32	0.14	0.80	
Diff		-0.36	0.30		

The p value is 0.24 meaning there is no significance difference in birth weight by TIMP category.

4.2.5 Current weight

The weight of the infants on the day of assessment was normally distributed. To ascertain whether there was a difference in current weight by TIMP category, the two-sample t-test was employed.

Table 4.11: **Current weight vs TIMP t test**

TIMP Score	Obs.	Mean weight (kg)	Std. error	Std. dev	P value
Below average	11	2.55	0.16	0.54	0.71
Average	19	2.63	0.13	0.56	
Combined	30	2.60	0.10	0.55	
Diff		-0.08	0.21		

A t-test was done, and the p value was 0.71 indicating no significant difference in current weight by TIMP category.

4.2.6 Apgar Scores (1 minute)

Apgar scores at one minute were not normally distributed. The two-sample Wilcoxon rank-sum (Mann Whitney) test was used to determine if there were differences in one minute Apgar scores by TIMP category.

Table 4.12: **One-minute Apgar by TIMP category (n=30)**

TIMP category	Observations	Rank sum	Expected	P value
Below average	11	122	170.5	
Above average	19	343	294.5	0.03
Combined	30	465	465	

This indicates a significant difference in the one-minute Apgar scores of the infants who scored average compared to those below average (p=0.03). These results show that infants with a low Apgar score at one minute are likely to have a below average TIMP score as well.

4.2.7 Apgar scores (five-minute)

Table 4.13: Five minute Apgar by TIMP category (n=30)

TIMP category	Observations	Mean	Std Deviation	P value
Below average	11	8	1.09	0.07
Above average	19	8.6	0.76	
Combined	30	8.4	0.93	

P=0.07 This indicates no significance in five-minute Apgar scores of the infants who scored average compared to those below average.

4.2.8 NICU stay by TIMP category.

The length of stay in the NICU data did not follow a normal distribution. A two-sample Wilcoxon rank-sum (Mann-Whitney) test was used to analyse whether the NICU stay and the preterm TIMP category have an association.

Table 4.14: Length of NICU stay by TIMP category (n=30)

TIMP category	Observations	Rank sum	Expected	P value
Below average	11	199	170.5	0.22
Average	19	266	294.5	
combined	30	465	465	

The results suggest an insignificant relationship between length of stay and TIMP category, with a p-value of 0.22, which is greater than the cutoff of 0.05.

4.2.9 Ventilated infants by TIMP category

Table 4.15: Ventilated infants by TIMP category

Ventilated	Below Average	Average	Total	P value
No	4	13	17	0.13
Yes	7	6	13	
Total	11	19	30	

The p value of 0.13 indicated no significance between the TIMP scores of ventilated and non-ventilated infants. However 54% of the infants who scored below average were ventilated.

4.2.10 Length of time dependent on oxygen

The data for length of time dependent on oxygen was not normally distributed. The two sample Wilcoxon rank-sum (Mann Whitney) test was used to evaluate length of time dependent on oxygen by TIMP category.

Table 4.16: Time on oxygen in days by TIMP category (n=30)

TIMP category	Observations	Rank sum	Expected	P value
Below average	11	193.5	170.5	0.32
Average	19	271.5	294.5	
Combined	30	465	465	

The p value of 0.32 indicated that there was no significant difference in length of oxygen dependence by TIMP category.

4.2.11 Sex

Sex is a categorical variable. Pearson's Chi squared test and Cramer's V test were used to determine the association between TIMP category and sex.

Table 4.17: **Sex by TIMP category**

TIMP Score	Male	Female	Total
Below average	4 (25%)	7 (50%)	11 (37%)
Average	12 (75%)	7 (50%)	19 (63%)
Total	16 (100%)	14 (100%)	30 (100%)

Cramer's V: -0.26

Female infants were more likely than male infants to fall into the 'below average' TIMP category. Pearson's chi2, r= 2.01. The Cramer's V test indicates the strength of association between the TIMP categories and the sex of the infants. The result of the association indicates 26% strength which is considered a weak association (McHugh, 2013).

The average NICU stay for males was less than that of females. Male infants' average NICU stay was 19.62 days and for females was 21.93 days. The length of oxygen dependence also indicates female infants to have needed oxygen for an average of ten days while males were nine days. Lastly female infants had a marginally lower birth weight of 2.25kg compared to the male infants with 2.37kg. These are some variable that may explains why more female infants were prone to developmental delay than males in this study.

4.3 Conclusion

The results of this study found that 37% of the infants scored below average on the TIMP. The statistical analysis found that infants with low one minute Apgar scores are more likely to have developmental delay than those with high one minute Apgar scores.

The findings of this study will be discussed in the following chapter.

Chapter 5 Discussion

The results presented in chapter 4 will be discussed below. Thirty infants were assessed using the TIMP just prior to discharge from NICU.

5.1 Participants

A total of 30 infants participated in the study and were recruited from a NICU in a private hospital in Johannesburg, South Africa. The infants assessed were stable, on room air and assessed while in a calm state 24 hours before being discharged. The sample included 53% male participants and 47% female participants. Every participant was born preterm and spent an average of 21 days in the NICU. The number of male infants is slightly higher compared to females with males being 53.3% of the population. In a study by Ravarian et al. (2023) the ratio for 39% females and 61% males. The sample size of the cohort was chosen to ensure enough statistical power to analyse different variables. This sample was ideal for examining the clinical profile of preterm infants, their developmental profile and associations between the two which provided valuable insights in the study.

5.2 Demographic and clinical picture

5.2.1 Demographic information

Previous research by Madyai et al (2021) used the TIMP assessment on 288 infants who were very low birth weight (VLBW) with mean weight of 1150 grams SD 246 grams and a GA of 29.4 weeks SD 2.8. In this study we assessed a total of 30 infants with the mean weight being 2320 grams SD 780 grams and a GA of 34.3 weeks SD 3.0. This difference can be explained by the selection criteria of the study, in this study we considered every infant admitted in the NICU while the other study selected infants that were born with VLBW. In a study done by Ravarian et al. (2023) the preterm infants were tested at 34 to 46 weeks post menstrual age with a mean age of 35.76 weeks SD 2.10 which is closely similar to this study as infants were tested at a mean of 37.33 weeks SD 2.20.

A systematic review by Pascal et al. (2018) reports a negative association between birth weight and developmental delay; preterm infants with a birth weight of less than 1500 grams are associated with severe to moderate developmental delays. In addition, they report a prevalence of developmental delay of 20% in VLBW infants. Our study could not establish any differences in developmental delays by birth weight. Despite reporting a difference in birth weight of 360 grams between the below average TIMP (2090g) and the average TIMP (2450g) groups, the results was statistically insignificant ($p = 0.24$). This underscores the need to further conduct a study with a relatively large sample size to reassess the relationship between birth weight and developmental delay.

Infants between the ages of 34 weeks and 4 months can be assessed using the TIMP. The studies from Chiquetti et al. (2020), Madayi et al. (2021), and Peyton et al. (2018) assessed infants up to 17 weeks corrected age, while Ravarian et al. (2023) assessed infants similar to the sample in this study, who were between 34 weeks and 42 weeks GA. These studies are consistent with our study as the tool can be used for infants from 34 weeks GA to 4 months CA.

5.2.2 Ventilation and oxygen support

Ventilation and oxygen support is required for preterm infants that have difficulty in breathing. In this study, 90% of the infants required oxygen support with 43.3% of them being ventilated. Oxygen support is a factor that is related to the length of stay in the NICU. The average hospital stay in our study was 21 days and a study by Debillon et al. (2021) had a mean of 36 days hospital stay for preterm infants admitted to the NICU for management of respiratory failure. In their study, Debillon et al. (2021) found that 98.7% of the infants required non-invasive ventilation in the delivery room. Our study reports similar results, which emphasises the importance of oxygen support for infants born preterm.

5.2.3 Appearance, Pulse, Grimace, Activity, and Respiration (Apgar)

One minute Apgar scores of the infants in this study have shown a significance to the infants that are at risk of developmental delay or those who scored below average on the TIMP. In a study done by Lin et al. (2022) higher survival rate in VLBW infants had higher Apgar scores at ten minutes however they did not find them a strong relation to survival in infants born at 24 and 25 GA. An article by Simon et al. (2024) reports that Apgar scores help in identify infants that are at risk of poor neurologic outcomes however not all infants with low Apgar scores will develop CP or a neurologic condition.

This information indicates that even though the Apgar scores were developed and are widely used to determine requirement for respiratory support and resuscitation in neonates, they have indicated some positive relation to infants at risk of developmental delay. While low Apgar scores have been associated with neurodevelopmental delay, the Apgar score alone is not considered a definitive predictor, particularly when assessed in isolation. However, studies by Lin et al. (2022) and Simon et al. (2024) support that the five and ten-minute Apgar scores have a stronger association with long-term neurodevelopmental outcomes compared to the one-minute score. More research is needed in this area as this score, whether it may be one-minute or five-minute Apgar may indicate a need for a neurodevelopmental assessment in preterm infants.

5.2.4 Medical conditions

Our study found that 90% of preterm infants exhibited respiratory distress syndrome (RDS), 17% had jaundice and 13% were exposed to RVD. Our findings are consistent with previous finding by Debillon et al (2021), who reported a 40% prevalence of RDS in infants with a mean GA of 33 weeks. Another study by Nakai et al., (2024) discusses how and increase in GA decreased the incidence of RDS, they report that at 23 weeks GA the incidence is 98% and at 28 weeks GA it decreases to 86%. In our study the incidence of RDS was highly recorded in infants with a mean GA of 37 weeks and 43% of the infants required ventilation support. Debillion et al. (2021) further reports that 44% of the infants with RDS required ventilation support and this result is consistent with our research. Additionally, while Debillon et al. (2021) had 60% of infants born via

C-section our study indicates a higher rate of 87% potentially due to complications and the demographics of our study.

Jaundice is the second most prevalent condition found in preterm infants with 17% of the infants affected. A study from Ethiopia investigating jaundice and its associated factors in neonates recorded 20.5% of the study population presented with jaundice (Belay et al., 2023). This result is consistent with our study. With 13% of all infants exposed to HIV in this study, this is the third most common condition. According to Strehlau (2020), unaffected infants exposed to HIV are at risk for developmental delay and need to be closely watched.

5.3 The TIMP scores

The TIMP scores indicate the need for developmental intervention for preterm infants using their corrected age. The study results indicate that 34% of the infants were in need of early developmental intervention. Most of the infants (66%) admitted in the NICU scored within the average range and did not require early intervention however the parents were advised to monitor developmental milestones.

The TIMP has been researched to be an indicator in predicting cognitive, language and motor outcomes for high risk preterm infants in relation to the BSID III at 2 years old (Peyton et al., 2018). In their study a total of 154 high risk preterm infants were assessed between the ages of 10 to 15 weeks corrected age using the TIMP assessment tool and was followed up at two years using the BSID III test. It was found that the TIMP z scores assessed at 10 to 15 weeks corrected age was significantly associated to the BSID scores taken at two years of age.

A study done in Brazil indicated a positive reliability and validity of the TIMP on 650 infants assessed with the TIMP and the AIMS. The results indicated the TIMP indicated appropriate reliability, content, construct, and discriminant validity to assess preterm infants (Chiquetti et al., 2020). The TIMP assessment tool has been found to have good cross-cultural adaptation in Persian infants where it was translated and used to assess 170 preterm infants in Iran. Validity and reliability to identify motor delays in preterm infants was found to be high in the Persian version of TIMP (Ravarian et al., 2023). Madayi et al (2021) used the TIMP to assess VLBW preterm infants in

Singapore and they identified risk factors of developmental delay which enabled them to recommend targeted early intervention to yield a better developmental outcome.

5.4 Relationships between key variables

The dichotomous classification of TIMP results indicates 37% of the infants scored below average in the TIMP and required early neurodevelopmental intervention while 63% scored within the average range. There was no significance differences found between the TIMP scores and all but one of the variables assessed. The variable that showed a significant difference was TIMP scores and Apgar scores at one minute with a p value of 0.03. Individually the variables have implications on the neurodevelopment of the preterm infant however there is limited research of them being analysed against TIMP scores. The statistical analysis indicated that all infants that were admitted in the NICU should be screened for neurodevelopment regardless of what their clinical data looks like.

5.5 Conclusion

The purpose of this study was to determine the motor developmental profile and risk variables related to preterm infants who were discharged from the NICU at a Johannesburg private hospital. The TIMP was used to evaluate developmental problems in preterm new-borns. The study highlights the effectiveness of TIMP as an assessment tool for aiding early detection of developmental delays and administration of interventions. Our findings indicated that 34% of our sample required intervention. In addition, we found evidence that collaborates with previous literature confirming some of the clinical and demographic factors that are associated to developmental delay; these include gestation age, birth weight and Apgar scores. The study underscores the need for all infants to get a developmental screening before discharge from the NICU ‘s across South African hospitals.

Chapter 6 Conclusion and Recommendations

6.1 Conclusion

This study aimed to investigate the developmental profile of preterm infants admitted in the NICU in a private hospital using the TIMP. The findings revealed a clinical profile and developmental profile of the preterm infants. Analysis indicated the associations between the two, one significant finding was that low Apgar scores at one minute are related to risk of developmental delay. There were no associations found between the variables analysed. The TIMP scores indicated that 34% of the infants needed early intervention as they scored below average.

While the study provided valuable insights, its limitations include a small sample size and focus on only one hospital in the private sector. Future studies could explore a larger sample size and recruiting participants from the private and the public hospitals across different geographical regions in South Africa. Ultimately this research offers information on the developmental status of preterm infants and an insight in the use of the TIMP in a South African setting, highlighting the need for further research into the subject.

6.2 Clinical / Practical Recommendations

The study recommends all infants admitted to the NICU to undergo a neurodevelopmental assessment and parents to be educated on their child's neurodevelopment and what to observe at home. If the infants fall in the below average of a neurodevelopmental assessment, I recommend the parents be given a referral or a set appointment for follow up at an appropriate time with a neurodevelopmental therapist. I believe this early intervention in the rehabilitation of the infant will yield better results and will ensue the infant or child have proper support structures in their journey that is life.

6.3 Recommendation for Future Research

This study examines the developmental profile of preterm infants admitted in a private NICU, with the aim of identifying infants that could need early intervention. It provides evidence on the efficacy of TIMP as an assessment tool for early childhood developmental delays within the context of South Africa. Future research could benefit from addressing the limitations of this study by investigating gaps that remain unexplored. For instance, the study sample size was 30 infants; we recommend a larger sample size of preterm infants, recruited from both private and public hospitals. While the current study focused on subjects that were about to leave the hospital, future studies could consider an assessment of preterm infants covering the duration of their admission in the NICU and monitor for any changes in their TIMP scores.

In addition to this, this study found a positive a positive corelation between Apgar scores and low TIMP scores., Previous research suggests low Apgar scores are indicators of a risk of developing neurologic conditions (Lin et al., 2022; Simon et al., 2025). It is recommended that a study be done on the effectiveness of Apgar scores as an indicator of preterm infants who may be considered for a neurodevelopmental assessment before discharge in the NICU.

6.4 Strengths and Limitations

The study focussed on preterm infants at a private hospital in Johannesburg and recruited 30 participants. While this provides building blocks for understanding the effectiveness of TIMP as a tool, the study findings cannot be generalised to South Africa and developing world at large. The small sample size also makes it difficult to detect meaningful differences in TIMP scores across a range of demographic variables. Recruiting larger samples across different provinces, covering both private and public hospitals could have enriched our analysis, but this was not feasible given the time and financial constraints.

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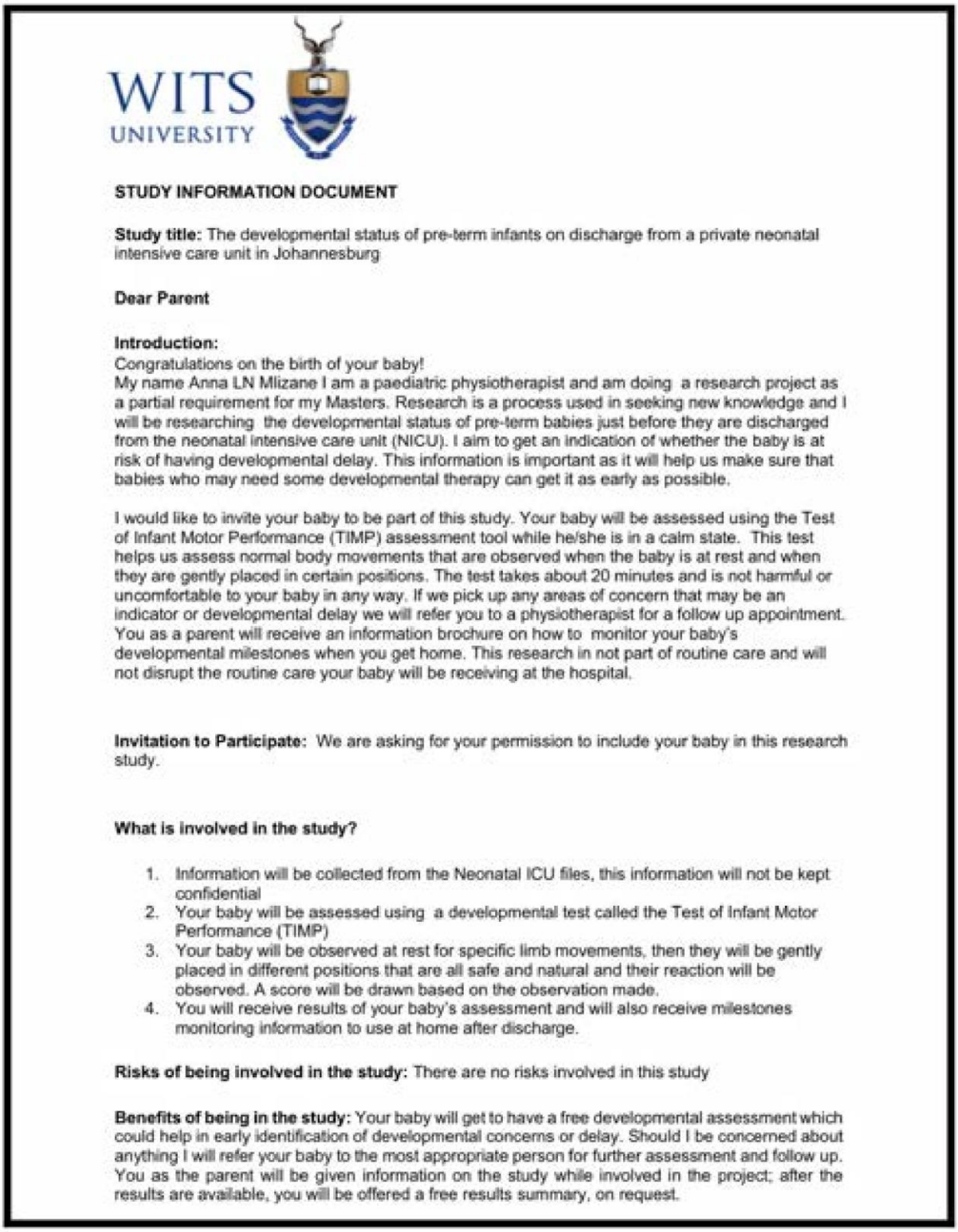
Appendix

Appendix A: Information sheet



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STUDY INFORMATION DOCUMENT

Study title: The developmental status of pre-term infants on discharge from a private neonatal intensive care unit in Johannesburg

Dear Parent

Introduction:
Congratulations on the birth of your baby!
My name Anna LN Mlizane I am a paediatric physiotherapist and am doing a research project as a partial requirement for my Masters. Research is a process used in seeking new knowledge and I will be researching the developmental status of pre-term babies just before they are discharged from the neonatal intensive care unit (NICU). I aim to get an indication of whether the baby is at risk of having developmental delay. This information is important as it will help us make sure that babies who may need some developmental therapy can get it as early as possible.

I would like to invite your baby to be part of this study. Your baby will be assessed using the Test of Infant Motor Performance (TIMP) assessment tool while he/she is in a calm state. This test helps us assess normal body movements that are observed when the baby is at rest and when they are gently placed in certain positions. The test takes about 20 minutes and is not harmful or uncomfortable to your baby in any way. If we pick up any areas of concern that may be an indicator or developmental delay we will refer you to a physiotherapist for a follow up appointment. You as a parent will receive an information brochure on how to monitor your baby's developmental milestones when you get home. This research in not part of routine care and will not disrupt the routine care your baby will be receiving at the hospital.

Invitation to Participate: We are asking for your permission to include your baby in this research study.

What is involved in the study?

1. Information will be collected from the Neonatal ICU files, this information will not be kept confidential
2. Your baby will be assessed using a developmental test called the Test of Infant Motor Performance (TIMP)
3. Your baby will be observed at rest for specific limb movements, then they will be gently placed in different positions that are all safe and natural and their reaction will be observed. A score will be drawn based on the observation made.
4. You will receive results of your baby's assessment and will also receive milestones monitoring information to use at home after discharge.

Risks of being involved in the study: There are no risks involved in this study

Benefits of being in the study: Your baby will get to have a free developmental assessment which could help in early identification of developmental concerns or delay. Should I be concerned about anything I will refer your baby to the most appropriate person for further assessment and follow up. You as the parent will be given information on the study while involved in the project; after the results are available, you will be offered a free results summary, on request.

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Participation is voluntary: refusal to participate will involve no penalty or loss of benefits to which you and your baby are entitled. You may discontinue participation at any time without penalty, or loss of benefits; that there is no requirement to provide a reason for withdrawing and any data collected on such a person will be destroyed, unless you specifically consent to its retention.

Confidentiality: Normally personal information will be treated in the strictest confidence and will only be available to me as the Principal Investigator (PI) and my Supervisor. No individual will be identified by name. The only exceptions - and all of them are rare - would normally be:

1. Personal information may be disclosed if required by law
2. the Human Research Ethics Committees of the University may exceptionally require personal data to respond to a formal complaint, or for a compliance audit

No individual will be identified by name in any report or publication arising out of the study. All data collected in the course of the study will be securely retained for two (2) years if a scientific publication arises from the study, and six (6) years if there is no publication. Thereafter it will be destroyed accordingly.

Contact details of researcher/s:
Anna LN Mlizane, Principal Investigator, telephone no. 0739500272, or by e-mail at annaloycem@yahoo.com

Prof Joanne Potterton, Supervisor, on telephone no. 0117173702, or by e-mail at joanne.potterton@wits.ac.za

Outputs

The study will yield a developmental profile for infants admitted in the NICU prior discharge as well as indicate the need for a developmental assessment for NICU infants across the country before discharge. At your request the output of this study will be shared with you once completed.

Contact details of HREC administrator and chair

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee"). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.
If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Prof Paul Ruff, who may be contacted on telephone number 011 717 2301, or by e-mail on paul.ruff@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Thank you for reading this Study Information Sheet.
Date:

Appendix B: Consent form

WITS UNIVERSITY

PARENT CONSENT FORM

The developmental status of pre-term infants on discharge from a private neonatal intensive care unit in Johannesburg

1. I have been given an Information Sheet which explains the nature and processes involved in this study, which is attached hereto;
2. I was given time to read it, or had it read to me, in the language I best understand;
3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory;
4. I believe I fully understand why the study is being conducted and what the intended outcomes will be;
5. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about the hospital for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained
6. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

I _____ herby agree for my child _____ to participate in the study described to me in the information sheet.

I am aware of what the study entails and that there will not be any additional risks experienced during the assessments. I understand that the results will be anonymous, and my private information will be kept confidential. I understand that there are no monetary rewards for my participation and that my participation is voluntary.

Signature of participant's parent: _____
Contact details of parent: _____
Next of kin contact details: _____
Email address: _____

Signature of researcher: _____

Contact details:

Anna LN Mlizane, Principal Investigator, telephone no. 0739500272, or by e-mail at annaloycem@yahoo.com

Prof Joanne Potterton, Supervisor, on telephone no. 0117173702, or by e-mail at joanne.potterton@wits.ac.za

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za.
Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Appendix C: Ethical clearance certificates

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Miss Anna Mlizane M230701 MED21-11-090

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M230701 MED21-11-090

NAME: (Principal Investigator)	Miss Anna Mlizane
STUDENT/STAFF NO:	721937
DEGREE:	MSc Paediatric Physiotherapy
DEPARTMENT:	School of Therapeutic Sciences Physiotherapy Netcare Alberton Hospital
PROJECT TITLE:	The developmental status of pre-term infants on discharge from a private neonatal intensive care unit in Johannesburg
DATE CONSIDERED:	11/08/2023
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof J Potterton
APPROVED BY:	Paul Ruff Prof P Ruff, Chair, HREC (Medical)
DATE OF APPROVAL:	22/11/2023 **EXPIRY DATE:** 22/11/2028

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report** in July each year until study is closed. Failure to submit annual report will result in ethics clearance certificate suspension. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in July and will therefore be due in the month of July each year. Unreported changes to the application invalidate the clearance given by the HREC (Medical). Email signed copy of this ethics clearance certificate prior to commencing with the study hrec-medical.researchoffice@wits.ac.za

Principal Investigator Signature

28/11/2023
Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Tel: + 27 (0)11 301 0000
Fax: Corporate +27 (0)11 301 0499
76 Maude Street, Corner West Street, Sandton, South Africa
Private Bag X34, Benmore, 2010, South Africa
www.netcare.co.za

RESEARCH OPERATIONS COMMITTEE FINAL APPROVAL OF RESEARCH

Approval number: UNIV-2023-0053

Ms Anna Mlizane

E mail: annapaedsphysio@gmail.com

Dear Ms Mlizane

RE: THE DEVELOPMENTAL STATUS OF PRE-TERM INFANTS ON DISCHARGE FROM A PRIVATE NEONATAL INTENSIVE CARE UNIT IN JOHANNESBURG

The above-mentioned research was reviewed by the Research Operations Committee's delegated members and it is with pleasure that we inform you that your application to conduct this research at Netcare Alberton Hospital, has been approved, subject to the following:

i) Research may now commence with this FINAL APPROVAL from the Netcare Research Operations Committee.

ii) All information regarding Netcare will be treated as legally privileged and confidential.

iii) Netcare's name will not be mentioned without written consent from the Netcare Research Operations Committee.

iv) All legal requirements regarding patient / participant's rights and confidentiality will be complied with.

v) All data extracted may only be used in an anonymised, aggregated format and for the purposes of this specific study as specified in the proposal. The data may under no circumstances be used for any other purpose whatsoever.

vi) The research will be conducted in compliance with the GUIDELINES FOR GOOD CLINICAL PRACTICE IN HUMAN PARTICIPANTS IN SOUTH AFRICA (2016).

vii) Netcare must be furnished with a STATUS REPORT on the progress of the study at least annually on 30th September irrespective of the date of approval from the Netcare Research Operations Committee as well as a FINAL REPORT with reference to intention to publish and probable journals for publication, on completion of the study.

viii) A copy of the research report will be provided to the Netcare Research Operations Committee once it is finally approved by the relevant primary party or tertiary

Directors: J du Plessis R H Friedland, K N Gibson, C Grindell

Company Secretary: C Vikisi

Reg. No. 1996/006591/07

institution, or once complete or if discontinued for any reason whatsoever prior to the expected completion date.

ix) Netcare has the right to implement any recommendations from the research.

x) Netcare reserves the right to withdraw the approval for research at any time during the process, should the research prove to be detrimental to the subjects/Netcare or should the researcher not comply with the conditions of approval.

xi) APPROVAL IS VALID FOR A PERIOD OF 36 MONTHS FROM DATE OF THIS LETTER OR COMPLETION OR DISCONTINUATION OF THE ~~TRIAL~~ STUDY, WHICHEVER IS THE FIRST.

- This approval granted applies strictly to the proposal as stipulated in the original application received.
- Should any amendments or variation to the materiality of the content of the research study become necessary during the course of the study, the principal investigator/researcher must apply for approval of these amendments/changes to the Netcare Research Operations Committee, prior to implementation.
- Any extension of the duration, and / or site, and / or investigators of the authorisation granted in this approval must be applied for in writing timeously for consideration by the Netcare Research Operations Committee in order to ensure continuity of the study/research.

We wish you success in your research.

Yours faithfully

1/12/23

Prof Dion du Plessis
Full member: Netcare Research Operations Committee & Medical Practitioner evaluating research applications as per Management and Governance Policy

Dr Shannon Nell
Chairperson: Netcare Research Operations Committee
Netcare Hospitals (Pty) Ltd
Date: 06/12/2023

Appendix D: Turnitin report

A Mlizane 721937 Research Report submission

ORIGINALITY REPORT

15%	12%	11%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	wiredspace.wits.ac.za Internet Source	1%
2	www.science.gov Internet Source	1%
3	www.frontiersin.org Internet Source	1%
4	www.nature.com Internet Source	<1%
5	researchspace.ukzn.ac.za Internet Source	<1%
6	era.ed.ac.uk Internet Source	<1%
7	scholarscompass.vcu.edu Internet Source	<1%
8	Submitted to UNICAF Student Paper	<1%
9	ujcontent.uj.ac.za Internet Source	<1%
10	worldwidescience.org Internet Source	<1%
11	www.scirp.org Internet Source	<1%
12	Submitted to Riga Stradins University Student Paper	<1%

Appendix E: The test of infant motor performance

Item number	Score	Item number	Score
1		22	
2		23	
3		24	
4		25	
5		26	
6		27	
7		28	
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21		42	