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A comparison of the Ages and Stages questionnaire-3 (ASQ-3) with the gold standard- Bayley Scales of Infant Development III in South Africa.

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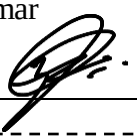
DECLARATION

I, Zaheerah Omar, declare that this research is my own work. It is being submitted in partial fulfilment of the requirements for the degree of Master of Science in Physiotherapy. It has not been submitted before for any other degree or examination at this or any other university.

Zaheerah Omar

Signature: 

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ABSTRACT

Introduction

Globally, over 200 million children in low-middle income countries (LMIC) have disabilities or developmental delay. In South Africa and other LMIC due to the high burden of health-related disorders, early identification of developmental delays is often not prioritised. Assessment tools help us screen and assess if an infant or toddler is reaching their milestones and are developing accordingly.

The Bayley Scales of Infant and Toddler Development (version 3) (BSID-III) has been deemed the "gold-standard" of developmental assessment globally. It has been used worldwide and has been translated into many languages. The Ages and Stages Questionnaire (ASQ-3) is a global, frequently used parental screening tool with good psychometric characteristics and it is considered cost effective and appropriate for developing countries. It has been used in a variety of cultures and countries and literature suggests that it's an appropriate tool to be used cross-culturally.

This study aimed at comparing the results obtained from the ASQ-3 completed by the parent to the BSID-III completed by the physiotherapist.

Method

This study was a cross sectional study, conducted in Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) in South Africa at the neonatal high risk follow up clinic. A total of 60 children aged two months, four months, six months, eight months, ten months and twelve months were assessed. Parents completed the ASQ-3 and the researcher conducted the BSID-III thereafter. Data was collected from both tests and documented. Both assessments were scored so that the subtests from the ASQ-3 and BSID-III results could be compared. The scaled scores of the BSID-III were compared to total ASQ-3 scores. Results were analysed to see if there was a correlation and agreement between that attained by the physiotherapist using the BSID-III and the parent completed ASQ-3.

Results

Sixty infants up to the age of 12 months were assessed using both the ASQ-3 and the BSID-III. A weak non-significant correlation was found between all domains of the BSID and the ASQ. The only significant correlation (0.04) was found between the fine motor domains of both tools. When investigating whether participants were categorised as normal, at risk and delayed on the two tests, there was only a significant difference in categorisation for the language/communication domains (p=0.01).

The sensitivity and specificity of the ASQ-3 was estimated with the BSID-III as the reference method. Sensitivity ranged from 12.5%-42.9% and specificities ranged from 71.1%-93.2%.

Conclusion

In the South African context, the ASQ-3 is a simple and cost-effective screening tool for developmental delay. Despite the BSID-III and ASQ-3 not correlating strongly, the ASQ-3 can be used to identify infants who may need further detailed developmental assessments as it can indicate if they are at risk for developmental delay.

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LIST OF ABBREVIATIONS

ART- Antiretroviral Therapy

ASQ- Ages and Stages Questionnaire

ASQ-2 - Ages and Stages Questionnaire- second edition

ASQ-3 - Ages and Stages Questionnaire- third edition

BDI-II- Battelle Developmental Inventory – second edition

BOTMP- Bruininks-Oseretsky Test of Motor Proficiency

BSID- Bayley Scales of Infant and Toddler Development

BSID-I- Bayley Scales of Infant and Toddler Development- first edition

BSID-II- Bayley Scales of Infant Development- second edition

BSID-III- Bayley Scales of Infant Development- third edition

CAT/CLAMS- Cognitive Adaptive Test/Clinical Linguistic and Auditory Milestone Scale

CDP-PQ- Child Development Review – Parent Questionnaire

CDI- Child Development Inventory

CEO- Chief Executive Officer

CI- Confidence Interval

CMJAH- Charlotte Maxeke Johannesburg Academic Hospital

CNS- Central Nervous System

DDST- Denver Developmental Screening Test

DDST-II- Denver Developmental Screening Test- second edition

DST- Dynamic Systems Theory

EMQ- Early Motor Questionnaire

FN- False Negative

FP- False Positive

GDD- Global Developmental Delay

GMDS- Griffiths Mental Development Scales

HIV/AIDS- Human Immunodeficiency Virus

HREC- Human Research Ethics Committee

ID- Intellectual Disability

IDD- Intellectual Developmental Disorders

IGMST- Infant Gross Motor Screening Test

IQR- Interquartile range

KDI- Kilifi Developmental Inventory

KIDS- Kent Inventory of Developmental Skills

LMIC- Low-Middle Income Countries

MABC-2- Movement Assessment Battery for Children- second edition

MCDI- Minnesota Child Development Inventory

MDAT- Malawi Developmental Assessment Tool

MDT- Multi-Disciplinary Team

MIDI- Minnesota Infant Development Inventory

MSEL- Mullen Scales of Early Learning

NGT- Nominal Group Technique

NICU- Neonatal Intensive Care Unit

NPV- Negative Predictive Value

PARCA-R- Parent Report of Children's Abilities Revised for Preterm Infants

PDI- Paediatric Developmental Impression

PDI- Preschool Development Inventory

PDMS-2- Peabody Developmental Motor Scales

PEDro- Physiotherapy Evidence Database

PEDS- Parents' Evaluation of Developmental Status

PPV- Positive Predictive Value

RTHB- Road to Health Booklet (RTHB)

SASP- South African Society of Physiotherapy

TGMD-2- Test of Gross Motor Development-2

TIMP- Test of Infant Motor Performance

TN- True Negative

TP- True Positive

US- United States

USA- United States of America

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CHAPTER 1- INTRODUCTION

1.1 Background

Globally, over 200 million children in low-middle income countries have disabilities or developmental delay. Early detection of developmental delay is acknowledged as a way of minimising consequences and maximizing developmental outcomes (Van Der Linde, et al., 2015).

In high income countries, early identification strategies are routinely implemented, however, in South Africa and other low-middle income countries, due to the high burden of health related disorders such as HIV/AIDS, infant mortality and tuberculosis, early identification is often not prioritised. These conditions are often the causes of secondary developmental delay and disorders in young children and infants (Van Der Linde, et al., 2015).

Critical development usually occurs during the first few years of one's life. There are tools in place to help us screen and assess if an infant or toddler is reaching their milestones and are developing accordingly in all domains appropriate for their age (Hsiao, et al., 2016). Two of the most commonly used tools are the Bayley Scales of Infant and Toddler Development (BSID -III), which is a developmental assessment tool, and the Ages and Stages Questionnaire (ASQ-3), which is a screening tool (Mackin, et al., 2017).

1.1.1 The Bayley Scales of Infant and Toddler Development- III (BSID-III)

The BSID-III (Appendix I) is an instrument that assesses the developmental level of children between 16 days and 42 months of age. This age range is divided into 17 age groups each consisting of five domains (Cognition, Fine Motor, Gross Motor, Receptive Communication and Expressive Communication) (Steenis, Verhoeven, Hessen and Van Baar ,2015).

Various studies have been conducted globally and have concluded that the BSID-III possesses high reliability, content validity and construct validity (Steenis, Verhoeven , Hessen and Van Baar ,2015). Using the Intraclass Correlation Coefficient, the inter-rater reliability by age group was 0.998 (95% CI: 0.997- 0.999) for the fine motor scale, 0.997 (95% CI: 0.996- 0.998) for the gross motor scale and 0.997 (95% CI: 0.996-0.998) for the cognitive scale (Manandhar, et al., 2016).

Studies conducted in South Africa report that the BSID-III is a valid test to use on South African urban infants (Rademeyer and Jacklin, 2013; Ballot, et al., 2017). In a study conducted in 2015, sensitivities for the BSID-III were found to be relatively low (ranging from 0%-50%), whilst specificities were relatively high (ranging from 92%-96%) across the domains (Veldhuizen, et al., 2015).

The BSID-III has been deemed the "gold-standard" of developmental assessment globally (Rademeyer and Jacklin, 2013; Rubio-Codina, et al., 2016; Kwun, et al., 2015). It has been used worldwide and has been translated into many languages (Steenis, Verhoeven, Hessen and Van Baar, 2015). This assessment tool has shown sensitivity to differences in early childhood developmental outcomes due to interventions in diverse contexts (Rubio-Codina, et al., 2016).

1.1.2 The Ages and stages Questionnaire-3 (ASQ-3)

The ASQ-3 (Appendix H) is a global, frequently used parental screening tool that has been developed and validated in the USA and possesses good psychometric characteristics (Steenis, Verhoeven, Hessen and Van Baar, 2015). The ASQ-3 is a reliable, easy to use and valid parent completed screening tool used to identify potential developmental delays among children aged two months to five years (Hsiao, et al., 2016).

It consists of 21 age groups and includes five developmental domains (Communication, Gross Motor, Fine Motor, Problem Solving and Personal Social) as well as open questions about the general health of the child where parents can indicate any concerns. Each domain contains six questions about milestones appropriate for the age of the child (Steenis, Verhoeven, Hessen and Van Baar, 2015).

The ASQ-3 has been standardised on children in the USA (Squires et al. 2009). This tool is considered cost effective and appropriate for developing countries (Gollenberg et al. 2009; Squires et al. 2009; Visser, et al., 2016). It has been used in a variety of cultures and countries (Brazil, Norway, Korea, Taiwan, India and Ecuador) and literature suggests that it's an appropriate tool to be used cross-culturally (Kyerematen, et al., 2014).

This tool helps to identify low-risk babies who require more in-depth assessments and has been found to be as reliable as standardised developmental tests (Halbwachs, et al.,2013; Mackin, et al.,2017). It is a useful tool for detecting developmental impairments and allows

for ease of assessment and follow-up procedures, especially for people with financial difficulties or those living in remote locations (Halbwachs, et al.,2013).

A previous study conducted in Singapore reported that there was a good concurrent diagnostic agreement between the ASQ-3 and BSID-III with regards to motor development (Agarwal, et al., 2016).

The ASQ-3 has been proven to have a relatively high sensitivity and specificity ranging from 71-82% and 76-84% respectively (Schonhaut, et al., 2013 as cited in Agarwal, et al., 2016). A multinational trial conducted in Asia, Africa, Europe, North- and South-America reports a sensitivity of 88% and specificity of 82.5% (Strehlau, Kuhn, Abrams and Coovadia, 2016).

According to various literature, mothers who have had a history of substance abuse or possess low levels of education are able to use parent completed screening tools and their results often very closely matched the results from a standardised assessment done by a trained professional (Woodward, et al., 2011).

One of the positive points collected from parents involved in carrying out the ASQ-3 is that they felt more included in the monitoring of the child's development, gaining relevant information about the child's development, which also helps them understand the status of the child better (Woodward, et al., 2011). It also makes them feel more included during check-ups and follow up visits, giving them a voice and acknowledging the parents' role with the child.

In clinics and hospitals, not every department can have the BSID-III as it is time consuming, costly and is required to be carried out by a trained individual thus not every physiotherapist can administer the BSID-III whereas with the ASQ-3, a once off purchase canbe made and the tool can then be used (Rubio-Codina, et al., 2016). Although there is a cost involved, it is much cheaper than other tools and assessment time can be cut down from approximately one hour to approximately 15 minutes, and is thus quicker and cheaper than the gold standard BSID- III tool. The two tools have been previously compared and sensitivity was found to be low to moderate with values ranging from 7.3% to 76.9% and specificity ranging from 59.3% to 99.3% (Steenis, Verhoeven, Hessen and Van Baar, 2015).

In recent studies, it is noted that the emphasis has been shifted to screening for disabilities at a younger age, i.e. from birth to two years of age (the first 1000 days) as experiences during this period can have life-long consequences for health and wellbeing (Soleimani, et al., 2016; Moore, Arefadib, Deery, and West, 2017).

1.2 Problem statement

In South Africa, we have many children at risk of developmental delay. With a large influx of patients, developmental screening tools are underutilized in over-burdened, staff-constrained facilities (Strehlau, Kuhn, Abrams and Coovadia, 2016). Despite the BSID-III being the gold standard assessment tool, it is time consuming, costly and is required to be carried out by a trained individual (Rubio-Codina, et al., 2016).

The ASQ-3 is a good alternative as it is quick, easy to administer and interpret, is inexpensive and has been validated for cross cultural use (Rubio-Codina et al., 2016; Van Heerden, et el., 2017). Studies have shown that parents can be a reliable and valid source of providing information about their child's development which can be time saving in a clinical setting (Steenis, Verhoeven, Hessen and Van Baar, 2015; Woodward, et al., 2011). Children are often more comfortable with their parents and when assessments such as the BSID-III is carried out, children can portray different behaviour and skills as it is a strange situation to them as opposed to what their mother may observe them doing at home or in a familiar setting (Steenis, Verhoeven, Hessen and Van Baar, 2015).

Hsiao, et al., 2016 reported that apart from the BSID-I, no other instruments to screen development have been normed among South African children (Hsiao, et al., 2016; Schonhaut, et al., 2013). Although there are few readily available, relatively easy to use, and culturally adaptable developmental assessment tools for young children, there is a need to compare the ASQ-3 with other developmental assessment instruments, such as the gold standard BSID-III for validity of the ASQ-3 in the South African context (Hsiao, et al., 2016).

Many studies comparing the two tools have been carried out in other countries but to date none have been conducted in South Africa. There is contradicting evidence as to whether the ASQ-3 is a suitable tool for low to middle income countries (Hsiao, et al., 2016). Further research needs to be conducted for us to assess if parents in the South African setting are able to relate their child's development upon follow ups.

1.3 Research question

Are the results obtained from the parent's completed ASQ-3 in correlation with the findings of a physiotherapist using the BSID-III in a South African hospital?

1.4 Aim

The aim of this study was to compare the results from the ASQ-3 completed by the parent to the BSID-III completed by the physiotherapist.

1.5 Objectives

The objectives for this study were:

- To determine the development of the child by the physiotherapist using the BSID-III (Appendix I).
- To determine the development of the child from the parent's completed ASQ-3 (Appendix H).
- To compare the results obtained by the physiotherapist using the BSID-III to that of the parent using the ASQ-3.
- To describe the demographic information of the parent and children (Appendix G).

1.6 Significance of the study

Should the answers attained from the ASQ-3 be in alignment with that of the BSID-III in a South African context, we can implement the ASQ-3 and use it as a developmental screener as it is quick, easy, and more cost effective and can be carried out by parents.

CHAPTER 2- LITERATURE REVIEW

2.1 Introduction

This literature review includes information about development, developmental delay, developmental screening and assessment as well as the developmental tools available for assessment and surveillance.

A basic search was done across the following search engines and databases: Google Scholar (https://scholar.google.com/), PubMed (https://www.pubmed.ncbi.nlm.nih. gov /); Physiotherapy Evidence Database (PEDro) (https:// pedro.org.au/); and Research Gate (https://www.researchgate.net/) using keywords to find the relevant articles. In addition to that, references from the original articles were looked at and relevant articles that were available were sought.

Search terms used included 'development', 'developmental delay', 'developmental delay globally', 'developmental delay in Africa', 'developmental delay in South Africa', 'risks of developmental', 'protective factors of development', 'Developmental intervention', 'risks in South Africa', 'Developmental screening', 'Developmental surveillance', 'Developmental assessment', 'Standardised developmental tools', 'Developmental tools in south Africa', 'The Denver Developmental screening tool', 'The road to health booklet', 'The Infant Gross Motor Screening Test', 'The Red Cross War Memorial Children's Hospital developmental screening tool', 'The Ages and stages Questionnaire-3 (ASQ-3)', 'Bayley Scales of Infant Development', 'The Griffiths Mental Development Scales', 'The Kilifi Developmental Inventory'.

Articles in English were reviewed and publications from 2002 to 2021 were included. Some older seminal texts were also included.

2.2 What is development?

Development is the course which a child follows in order to progress from dependant infancy to independent adulthood. Normal development is associated with the capability to perform a task at a certain age, relative to the performance of the average child. The ability to conduct a skill for example crawling, is known as a milestone. The normal age for attaining a milestone

varies for each skill. The average age is the age that half of the population of children obtain that skill (Bellman, Byrne and Sege, 2013).

Development is not age determined but rather age related. The progressiveness of development leads to constant variation of what's learned to change in functions of the body and the environment. Differences between individuals are shown as development progresses. The different stages of life (i.e. infancy, childhood, adolescence, middle age, and old age) describes behaviours in a specific age range. Development is self-organizing, dynamic and nonlinear (Clark and Metcalfe, 2002). The first few years are important as vital development in all domains occurs (Grantham-McGregor, et al., 2007).

Child development is a result of interaction between the systems of sensation, movement and perception (Øberg, et al., 2012). The study by Spencer, et al. (2006) concluded that children follow their exclusive path of development. For improvement, infants need to explore wider range of movements, and discover a way to gather the components involved in an action. Spencer, et al. (2006) also stated that each infant's developmental patterns may be different. Each infant develops with a holistic approach incorporating their physical characteristics, environment and movement in order to reach a skill or milestone. Development occurs through exploration and selection (Spencer, et al., 2006).

Neural circuits of the brain are formed in the early years of life, they are strengthened and formed through stimuli and bonding relationships (Venancio, et al., 2019). Early infancy is a vital period as early experiences provide the foundation for brain development and functioning through life (Singh, Jung Yeh and Blanchard, 2017). A child achieves skills needed for activities of daily living through development. Development brings about continuous adjustments to various situations. Development is a merge of psychological, cognitive and behavioural functions formed by some physical and biological characteristics as well as the maturation of the Central Nervous System (CNS) and exposure to different environmental factors (Nikolić, et al., 2016).

In development, previous and future states are connected to the current state. Development of motor skills are a product of the interaction between the constraints (organismic, environmental, and task) that are specific to each individual (Clark and Metcalfe, 2002). When viewing the dynamic systems theory (DST), development is considered a non-linear process. This implies that movement is developed by small, critical changes that could appear

in one sub-system which can cause the whole system to shift. This could result in a new motor behaviour. This shift or change is crucial to the dynamic systems theory's application to motor development (Sauve and Bartlett, 2010).

Feedback processes are based on the child's subsystems interacting with each other. Interactions are between the task, the environment and the child (Øberg, et al., 2012). The dynamic view of development leads to implications for physiotherapy treatments since treatment involves change in finding new, adaptive, movement patterns, just like development is change with the same goal. To promote the best possible treatment, you have to first identify the dysfunctional pattern, followed by a functional goal. With the dynamic systems approach, development is non-linear. Many of the physiotherapy treatments follow the dynamic systems approach. Through this, therapists evaluate the external factors to bring about change in a patient. Therapists try to explore and encourage other patterns to facilitate natural movements and new solutions (Kamm, Thelen, Jensen, 1990).

In terms of the dynamic systems theory, one can either self-organize to produce cohesive patterns or it could be non-linear and sensitive to initial conditions. In the dynamic approach, everyday activities impact developmental change, both external and internal factors of a person (Smith and Thelen, 2003).

2.3 Developmental delay

2.3.1 Definitions of developmental delay

Developmental delay is when children aren't developing or reaching milestones within the expected time frame relevant to their age group (Duby, et al., 2006). Intellectual disability (ID) and global developmental delay (GDD) are characterised by deficits in at least two functional domains during development. ID shows cognitive functional deficits and adaptive behaviours. Both GDD and ID combined are termed intellectual developmental disorders (IDD) (Fieggen, Lambie and Donald, 2019). These conditions may be due to external insults to the developing brain showing earlydevelopmental problems (Fieggen, Lambie and Donald, 2019).

Global developmental delay (GDD) described as a delay in two or more developmental domains of gross/fine motor, social/personal, speech/language and ADLs in children under five years of age (Mithyantha, Kneen, McCann and Gladstone, 2017).

Developmental delay is sub-classified as mild, moderate and severe (Mithyantha, Kneen, McCann and Gladstone, 2017). The domains that are looked at in regards to development are, gross and fine motor, speech and language, cognition, social and personal, and activities of daily living (Mithyantha, Kneen, McCann and Gladstone, 2017). Children developing typically achieve the fundamental patterns in each subdomain (Clark and Metcalfe, 2002).

2.3.2 Epidemiology of developmental delay

Reports on the prevalence of developmental delay vary from country to country and region to region. Globally, over 200 million children in LMICs have disabilities or developmental delay (Van Der Linde, et al., 2015). Reports on Global Developmental Delay (GDD) vary with a prevalence of 1-3% and 2-5%. It is commonly present in children with structural and brain abnormalities (Mithyantha, Kneen, McCann and Gladstone, 2017; Fieggen, Lambie and Donald, 2019). Sub-Saharan Africa accounts for 66% of children with developmental delay (Richter, et al., 2016).

From the systematic review conducted by McCoy, et al (2016), results showed that one in every three children attending pre-school and are living in LMIC fail to meet vital milestones and 16% show setbacks in physical growth. They also reported that children scored low in the cognitive and socioemotional domains in countries such as Chad, Sierre Leone, Central African Republic, Bosnia and Montenegro. Boys scored lower than girls and children from rural areas scored lower than those from urban areas (McCoy, et al., 2016).

Low cognitive and socioemotional development in LMICs has a global prevalence of 32.9% (95% CI 19.7%, 46.3%) (McCoy, et al., 2016). The highest being sub-Saharan Africa (43.8%; 95% CI 30.5%, 57.2%) and South Asia (37.7%; 95% CI 24.3%, 51.1%) and the lowest being the Latin America/Caribbean region (18.7%; 95% CI 5.9%, 32.1%) and the North Africa/ Middle East/Central Asia region (18.4%, 95% CI 6.3%, 31.8%). Sub-Saharan Africa and South Asiaalso account for the most children with low development with an estimate of 29.4 (95% CI 20.4, 38.4) and 27.7 (95% CI 17.9, 38.4) million 3- 4 year olds, respectively (McCoy, et al., 2016).

From this systematic review by McCoy, et al. (2016) containing 99,222 3- 4-year old children living in 35 LMICs, India accounted for the country with the highest number of children with developmental delay followed by China and Nigeria. Nearly 44% of children in sub-Saharan Africa and 38% of children in South Asia have slower development. They have estimated that 49.6% of 3-4-year-old children in LMICs have developmental delay with regards to cognition, socioemotional and physical development. They suggest that more research is required to explore the cross cultural validity and reliability in LMICs of milestones. Another weakness of their study was that the cut off for diagnosing developmental delay was not sufficiently validated (McCoy, et al., 2016).

2.4.1 Risk and protective factors of development

Multiple factors interact to influence a child's development both negatively and positively. Developmental changes are largely influenced by individual experience occurring during the context-specific period. From infancy to adulthood, development is motivated by continuous adaptation to multiple intrinsic and extrinsic factors (Clark and Metcalfe, 2002).

Globally, developmental delay is caused by poverty; malnutrition; poor general health of children, prematurity, low birth weight, infectious diseases, child affected with HIV and poor health care; poor maternal health and well-being, including maternal substance abuse, partner violence, maternal education, maternal stress and depression and genetic factors (Johnson and Marlow, 2006; Grantham-McGregor, et al., 2007; Venetsanou and Kambas, 2009; Gladstone, et al., 2010; Øberg, et al., 2012; Bellman, Byrne and Sege, 2013; Mccoy, et al., 2016; Singh, Jung Yeh and Blanchard, 2017; Van Heerden, et al., 2017; Donald, et al., 2019).

Other factors that may influence development are the child's environment, which includes stimulation at home, interaction with siblings, school setting, the society in which they live, living conditions, family size and socioeconomic status and factors. Ethnic and cultural factors also impact the developmental trajectory of a child, along with the different parenting techniques which vary among social classes and ethnic groups (Grantham-McGregor, et al., 2007; Venetsanou and Kambas, 2009; Bellman, Byrne and Sege, 2013; Rademeyer and Jacklin, 2013).

Factors that contribute towards good child development include clean and safe living environments; breastfeeding and good nutrition; healthy parents; good relationships between

caregiver and infants, which help the child develop basic social and emotional skills; and nurturing environments (Costa and Figueiredo, 2013; McCoy, et al., 2016; Donald, et al., 2019).

2.4.2 Risks in South Africa

In Africa, there are differences between populations with regards to geographic location, socioeconomic status and home language (Ballot, et al., 2017). Children affected with HIV in South Africa are vulnerable to developmental delay (prevalence of 50%). In the absence of ART children infected with HIV are shown to have a gradual decline in motor and cognitive development particularly in the first 18 months of their lives (Potterton, Stewart, Cooper and Becker, 2010; Boyede, Eley and Donald, 2015).

Other risk factors influencing developmental delay in South Africa include prenatal alcohol exposure, iodine deficiency, maternal anemia, malaria, lead exposure, intrauterine growth restriction, enteric disease, maternal depression, maternal exposure to violence, congenital infections and stunted growth (Fieggen, Lambie and Donald, 2019; Donald, et al., 2019; Milbrath, Constance, Ogendi and Plews-Ogan, 2020).

A study conducted by Donald, et al (2019) showed that higher maternal education, higher birth weight, and better socioeconomic status positively affected developmental outcomes. Their research shows that infants with higher birthweights have better cognitive and language outcomes. Previous research showed that low birth weight infants have slower information processing abilities and their ability to recruit, sustain and shift attention and their memory recognition was poorer than normal birth weight infants. The main cause of poor developmental outcomes in low birth weight infants are hypoxic ischemic occurrences in utero. Premature children who receive early intervention have higher cognitive and language score than those who don't receive intervention (Ortiz-Mantilla, Choudhury, Leevers and Benasich, 2008; Donald, et al., 2019). Nurturing, education and caregiver-child relationship has an impact on development (Donald, et al., 2019).

2.5 Developmental intervention

Early intervention is aimed at improving the child's developmental outcomes by minimising or preventing the developmental delays. It also helps associate the child into family life and society. It reduces economic costs and negative social consequences (Nikolić, et al., 2016).

Children's productivity is affected by less learning per year in school and fewer years of schooling. A study by Grantham-McGregor, et al (2007) states that stunting and poverty are associated with decreased years of schooling. It was shown from their study that stunted children learn less in a school year. They also state that results from 51 countries have shown that each year of schooling increases a person's wages by 9.7% on average, thus the economic implications of development are shown. They state that these children often end up less educated, have poorer cognitive function and turn out less productive thus perpetuating the cycle of poverty (Grantham-McGregor, et al., 2007).

Early intervention reduces the effects of developmental delays on the functioning of the child and family and prevents disability. The child should be viewed holistically and a multidisciplinary approach should be encouraged for assessment as well as intervention (Nikolić, et al., 2016).

2.6.1 Developmental screening

Since development is an ongoing process, it needs to be regularly monitored (Milbrath, Constance, Ogendi and Plews-Ogan, 2020). Developmental problems are only detected in half of the children before they start school (Singh, Jung Yeh and Blanchard, 2017).

Developmental screening tools are designed to identify children with possible developmental delay (Duby, et al., 2006). Developmental screening can be carried out by anyone who is trained in early childhood development. Examples of developmental screening tools include the ASQ-3, Brigance Screens, the Parents' Evaluation of Development Status (PEDS); and Developmental Assessment of Young Children (Small, Hix-Small, Vargas-Baron and Marks, 2018).

Developmental screening doesn't result in a treatment plan or diagnosis; it serves to identify the presence and area of developmental delay. Early detection can result in a referral for a full assessment and possible early intervention. Developmental screening tools assess tasks in different manners. There is no globally accepted tool appropriate for all ages and all populations. A systematic review carried out by Mendonca, Sargent and Fetter (2016) investigated the cross-cultural validity of standardised motor development screening and assessment tools. Their study showed that motor developmental screening and assessment

tools developed in first world countries are not necessarily valid for all children globally (Mendonca, Sargent and Fetter, 2016).

Developmental delay detection is simpler and more reliable if a screening test is used. Screening instruments are relatively cheap and brief and the aim is to identify those who need more comprehensive assessments (Nikolić, et al., 2016). Developmental screening is the best way for early identification and optimal development (Singh, Jung Yeh and Blanchard, 2017). Parent reports are screening measures used to identify children needing further assessments. Certain authors are of the opinion that parent reports should not replace standardised tools since standardised tools are the gold standard for outcomes as they provide valid, objective and reliable assessments and scores are standardised (Johnson and Marlow, 2006).

Assessing skills using examiner-administered assessments is expensive, time consuming, fatigues the baby and can underestimate a child's performance as a result of lack of performance at a test. This negatively affects test scores and scores may be skewed if the child isn't comfortable with the examiner and if the examiner hasn't established a good rapport with the child. However, a parent report assessment is cost effective and relies on the caregiver's knowledge of the child (Libertus and Landa, 2013).

A problem may arise with parent completed questionnaires if the parent under or overestimates the child's abilities. However, many studies show that well-structured and designed parent completed developmental questionnaires could accurately provide information about the developmental status of a child. Examples of parent completed developmental questionnaires include the Minnesota Infant Development Inventory (MIDI), the Child Development Review – Parent Questionnaire (CDP-PQ), the Child Development Inventory (CDI), and the Ages & Stages Questionnaire (ASQ) (Libertus and Landa, 2013).

A study by Libertus and Landa (2013) to examine the concurrent and predictive validity of parent's report on motor development compared parent completed questionnaires to examiner administered measures, showed validity of the parent report and they also concluded that parents are able to provide reliable and accurate feedback on their child's development (tool used was the EMQ being compared to the MSEL and PDMS-2). They also recommend that parent report be given more acknowledgement during diagnosis as well as during research assessments (Libertus and Landa, 2013).

A study carried out in Brazil aimed to create and validate an instrument for monitoring

indicators for child development. They wanted an instrument that was different from individual screening tests such as the BSID, Denver and ASQ which restrict access by copyright. They determined that primary caregivers from all socioeconomic levels are able to provide valid information. Interviews with caregivers are easy to apply, are fast, cost effective, easy to complete, don't require much experience to interpret and since parents witness their child's behaviours in different circumstances over time they are more accurate (Venancio, et al., 2019).

2.6.2 Developmental surveillance

Developmental surveillance is a continuous, cumulative and flexible means of identifying children with developmental issues. During surveillance, one should; address parents' concerns about the development of their child, document developmental history, observe the child accurately, identify risk and protective factors surrounding the child and have an accurate record of findings. Unstructured surveillance is directed by casual observation or subjectivity. Structured surveillance is done by using an evidence based screening measure (e.g. the ASQ) to identify if the child needs further assessments (Small, Hix-Small, Vargas-Baron and Marks, 2018).

Screening tools are useful for surveillance and to identify those at risk for developmental deviations from the norm. However, screening tools aren't very useful for diagnosing, especially in identifying subtle impairments, since they were designed as a first-line measure to see who needs more detailed assessments (Johnson and Marlow, 2006).

Developmental surveillance and screening is a continuous process monitoring the child's development by collecting information about the development from multiple sources either by observation from parents or caregivers and relevant standardised parent completed tools such as the ASQ, Parental Evaluation of Developmental Status (PEDS), and the Child Development Inventories (CDI). These tests have good psychometric properties (70-80% specificities and sensitivities), are less time consuming (can be completed by parents in 12-18 minutes) than tests conducted by trained individuals, are cost effective and parents can accurately report on their child's development at intervals (Singh, Jung Yeh and Blanchard, 2017).

2.6.3 Developmental assessment

Developmental assessment is a way of evaluating a child's performance comparable to children of similar age (Bellman, Byrne and Sege, 2013). Identifying developmental delay early is an effective way of preventing secondary complications as well as seeking intervention as soon as possible (Flamant, et al., 2011; Van Der Linde, et al., 2015). Standardised developmental tools provide detailed assessments which enable us to accurately determine abnormality and assess the degree of developmental delays (Johnson and Marlow, 2006).

Each tool views tasks in a different manner. There is no one globally appropriate tool available for every population and all ages, tools are chosen specifically for the population being assessed (Duby, et al., 2006). Although technology has advanced, clinical assessment remains the crucial concept for examination (Mithyantha, Kneen, McCann and Gladstone, 2017). Some developmental assessment tools can be conducted by parents or caregivers whilst others are only to be administered by the appropriate professional (Fischer, Morris and Martines, 2014).

Standardised assessment tools that have been validated in Western countries could have limitations in resource constrained settings. A challenge faced in early identification of developmental delay is lack of availability of tools that can be used across LMICs as well as Western countries (Fischer, Morris and Martines, 2014).

Often, in LMICs, due to the high burden of health related disorders, early identification of developmental delay is often not prioritised (Van Der Linde, et al., 2015). Presently, just a few child developmental assessment tools are utilised in LMICs, most of which are being used for research purposes. These tools are either, a non-adapted, standard Western tool; a translated Western tool or one that had been adapted for cultural equivalence; a combination of translated, as well as adapted items from a number of various Western tools; or, a culturally specific tool designed locally for that specific population (Sabanathan, Wills and Gladstone, 2015).

Many of the tools developed in Western countries may be altered for non-Western countries. However, most often, only translation of the tools is carried out and not adaptation of the tools, which may lead to results being misinterpreted. In some cases, tools are tailored and new items are added to the Western tool. These Western tools may include components that

are unfamiliar to other populations, which may lead to tools providing incorrect results (Gladstone, et al., 2007). Research has demonstrated that it is difficult to develop a culture-free tool with a low cost that can be carried out with minimal training and takes 30 minutes or less (Sabanathan, Wills and Gladstone, 2015).

In South Africa there is limited access to standardised developmental assessment and screening tools, as most instruments are designed and normed in Western countries (Hsiao, et al., 2016). South Africa, like many developing countries use standardised tests developed in Western countries which may render results invalid as it was not designed for them (Rademeyer and Jacklin, 2013). Some of the standardised developmental assessment tools used in South Africa include the Bayley Scales of Infant Development (BSID), the Ages and Stages Questionnaire (ASQ) and the Denver Developmental Screening Test (DDST). Each of these have varying advantages and disadvantages (Rademeyer and Jacklin, 2013; Van Der Linde, et al., 2015; Hsiao, et al., 2016; Ballot, et al., 2017).

2.6.3.1 Characteristics of Standardised developmental tools

1) Test objectivity

   Standardised tools are carried out by those qualified to administer the tool and who are inflexible in the administration and scoring process. The stringent administration criteria ensure objectivity of these results and deviation from protocol could invalidate the scores (Johnson and Marlow, 2006).

2) Norm- referenced scores

   When standardisation of a test is done, a test is conducted with a large group of children for who it was developed. This group forms the normal population or normative sample. A child's score is a comparison to the normative data and can help determine how they are developing compared to the norm (Johnson and Marlow, 2006).

3) Psychometric properties

   During the development of a tool, standardised tools are analysed to assesses the psychometric properties of the tool (Johnson and Marlow, 2006).

   Sensitivity and specificity are used to assess a test against a gold standard.

Sensitivity shows how well a test detects true positives. It measures participants with a positive outcome to what's being tested. Specificity shows how well a test can identify true negatives (how well the test can detect who doesn't have the condition being assessed) (Monaghan, et al., 2021).

Positive Predictive Value (PPV) and Negative Predictive Value (NPV) indicate the amount of positive and negative results that are true positives and true negatives (Monaghan, et al., 2021).

4) Test selection

The standardised tool should be suitable to the age range of the child. When selecting a tool, psychometric properties should be considered and those with good psychometric properties should be selected (Johnson and Marlow, 2006).

There are tools in place to help us screen and assess if an infant or toddler is reaching their milestones and are developing accordingly in domains appropriate for their age (Hsiao, et al., 2016). Although standardised developmental screening tools are valid in the population for which they were developed, they may not be valid for the South African population. These tools are not always very practical in the South African setting with busy clinics and staff constrained settings as they are time consuming, difficult to administer and often require special training and kits before they are administered (Boyede, Eley and Donald, 2015).

Some standardised tools currently used in South Africa will be discussed in more detail.

2.7 Tools

2.7.1 The Ages and Stages Questionnaire-3 (ASQ-3)

The ASQ-3 is a global, frequently used parental screening tool that has been developed and validated in the U.S at the University of Oregon and possesses good psychometric characteristics (Steenis, Verhoeven, Hessen and Van Baar, 2015; Singh, Jung Yeh and Blanchard, 2017). The ASQ-3 is a reliable, easy to use and valid parent completed screening tool used to screen for potential developmental delays among children aged two months to five years (Hsiao, et al., 2016).

The ASQ is cost effective and flexible as it was designed to be carried out by parents and

items on the questionnaire are skills that can be easily identified by the parent. The ASQ format is uniform throughout the 21 age intervals. Five developmental domains are assessed through each domain, i.e. communication, gross motor, fine motor, problem-solving and personal social, as well as open ended questions about the general health of the child where parents can indicate any concerns. Each domain contains six questions about milestones appropriate for the child's particular age. Parents either select 'yes', 'sometimes' or 'not yet' for each scored item. Pictures are included to clarify some items. There are also open ended questions included which are not scored but just view the quality of skills and reveal parent concerns (Steenis, Verhoeven, Hessen and Van Baar, 2015; Small, Hix-Small, Vargas-Baron and Marks, 2018).

It is easy to use with a reading level of fourth to eighth grade and the simple drawings assist in its completion. The ASQ-3 is flexible and can be used in a variety of settings, i.e. hospital setting, clinics, preschool, doctor's office and even home (Singh, Jung Yeh and Blanchard, 2017).

The ASQ-3 has been standardised on children in the USA and is viewed as being cost-effective and suitable for developing countries (Visser, et al., 2016). It has been used in a wide variety of cultures and countries. Literature suggests that it's an appropriate tool to be used cross-culturally and is found to be as reliable as standardised developmental tests (Halbwachs, et al.,2013; Kyerematen, et al., 2014; Hsiao, et al., 2016; Van Heerden, et al., 2017; Singh, Jung Yeh and Blanchard, 2017; Milbrath, Constance, Ogendi and Plews-Ogan, 2020).

The ASQ has successfully been used cross-culturally and translated into various languages. Some of the languages include Spanish, French, Norwegian, Hindi, Norwegian, Dutch, Persian, Arabic, English, Korean, Chinese, and Vietnamese, Afrikaans, Bengali, Brazilian Portuguese, Georgian, Nepalese, Nyanja, Quechua, Sesotho, Spanish, Thai, isiZulu and Turkish. Countries in which its psychometric properties were studied include Australia, Brazil, Canada, Chile, China, Denmark, Ecuador, France, Ghana, India, Iran, Korea, Lebanon, Netherland, Norway, Republic of Macedonia, Spain, Taiwan, Thailand and Turkey. It has been validated in Brazil, Taiwan, Iran, Spain, Canada and India and can successfully be used in low-resource, community based settings and can be effective in identifying children at-risk in LMICs (Van Heerden, et al., 2017).

The study by Singh, Jung Yeh and Blanchard (2017) states that it has good psychometric properties, sensitivity of 87.4% and specificity of 95.7%, test-retest reliability of 92%.

Validity has been tested globally between different communities and cultures (Singh, Jung Yeh and Blanchard, 2017).

A prospective study by Agarwal, et al. (2016) in Singapore on 141 infants has shown the ASQ to have a relatively high sensitivity and specificity ranging from 71-82% and 76-84% respectively (Agarwal, et al., 2016). In the study by Milbrath, Constance, Ogendi and Plews-Ogan (2020), they report that the ASQ's validity varied from 51%-90% with sensitivity of 75% and specificity which ranged between 81% and 92% in previous studies (Milbrath, Constance, Ogendi and Plews-Ogan, 2020).

A study conducted by Hsiao et al. (2016) aimed at testing the appropriateness of the ASQ-3 in South Africa and Zambia. A total of 853 children aged 2-60 months were assessed. The results showed that parental education, employment and preschool involvement linked to higher scores on developmental tests. This emphasizes the impact of socio demographic factors on children's development. The results of this study showed good psychometric properties and the adapted ASQ-3 was shown to be a feasible tool to be used in South Africa. Items in all the domains were shown to be appropriate assess for early development in South Africa (Hsiao, et al., 2016).

A study conducted by Van Heerden et al, (2017) for cultural adaptation, validation and standardization of the ASQ for 2–60-month-old children living in South Africa, deduced that the ASQ-3 is an appropriate tool for the cultural and contextual differences of South African children. The ASQ-3 has been shown to provide accurate developmental status of children in South Africa. Due to the scarcity of trained professionals to screen children's development in LMICs, the ASQ is a feasible instrument to implement. They noted that in the first year of their lives, when assessed with standardised tests of development, South African children scored higher than European and American children. It was suggested that the reason for this is that many of the daily practices of African mothers account for their children's faster development. Some of these practices include feeding on demand, carrying the baby on the mothers back, mother and baby sleeping together, pacifying children immediately when they cry and babies being exposed to a wide social network of family and kin (Van Heerden, et al., 2017).

The ASQ may also be completed by other family members, teachers or those who observe

and know the child well enough to be able to comment on development (Small, Hix-Small, Vargas-Baron and Marks, 2018).

There is contradicting results about the validity of the ASQ and these are due to different editions of the ASQ used, children's age ranges used, country, language, response rate, sample size, risk level of children and reference measure (Veldhuizen, et al., 2015).

The study conducted by Flamant, et al. (2011) in France states that the ASQ is a valid, simple and cost-effective tool to screen for neurodevelopmental outcomes. They also state that the social background of the parent did not change their report of their child's development. Parents are able to accurately complete developmental questionnaires and socio-economic level or maternal education does not alter results (Flamant, et al., 2011).

From the study by Singh, Jung Yeh and Blanchard (2017) the agreement between Developmental Assessment Scale for Indian Infants (DASII) and the ASQ was studied and the sensitivity of the ASQ in revealing developmental delay was 83.3% with a specificity of 75.4%. The correlations were acceptable (r= 0.76-0.80). The agreement between the Battelle Developmental Inventory, 2nd Edition (BDI-II) and the ASQ was also investigated. ASQ was able to identify those who were in need for further investigation. Interobserver reliability was good, with most correlations being over 0.70. The agreement between the paediatrician estimates of development (i.e., Paediatric Developmental Impression (PDI)) and ASQ was 81.8% (Singh, Jung Yeh and Blanchard, 2017).

The findings from the paper by Van Heerden, et al. (2017) suggests that the ASQ culturally and contextually appropriate to be used for South African children. This study also suggests that the ASQ gives a good assessment overall of the development of the child. Although it has been shown be successful in detecting developmental delay in South Africa, researchers from this paper do not recommend the ASQ for clinical assessment of children because children who have developmental delay should be referred for a more intensive assessment to establish the best intervention for the child. This article has also shown the feasibility of the ASQ in developing countries and involving the parents in assessment and treatment of their children as there's a scarcity of trained professionals screening for developmental delay (Van Heerden, et al., 2017).

A study conducted by Milbrath, Constance, Ogendi and Plews-Ogan (2020) compared how adaptable two tools were in South Africa with children in a rural setting. The tools used for comparison were the ASQ and the Cognitive Adaptive Test/Clinical Linguistic and Auditory

Milestone Scale (CAT/CLAMS) (Milbrath, Constance, Ogendi and Plews-Ogan, 2020). The nurses commented on the use of the two tools claiming that the CAT/CLAMS was time consuming, costly and difficult to calculate, whilst with the ASQ they said it was simple, practical and easy to use. However, they stated that the caregivers may have trouble completing the ASQ without assistance due to language barriers. The nurse's state that the ASQ requires parent involvement which is positive. It helps parents understand how play and assessment could impact their child's development. They state that the ASQ needs to be culturally adapted and validated for the population at hand. They also suggest a longitudinal study be carried out to see if the ASQ can track and identify developmental delay in children (Milbrath, Constance, Ogendi and Plews-Ogan, 2020).

This tool has been used successfully cross-culturally in various countries. It has good psychometric properties and has been deemed an appropriate tool to use in the South African context.

2.7.2 Bayley Scales of Infant and Toddler Development

The Bayley Scales of Infant and Toddler Development are considered the gold standard of infant assessment. It has been validated in South Africa and is culturally appropriate without modification yielding results similar to those from the US population (Rademeyer, and Jacklin, 2013; Ballot, et al., 2017; Donald, et al., 2019). The BSID-III is an instrument that assesses the developmental level of children between 16 days and 42 months of age. This age range is divided into 17 age groups each consisting of five domains (Cognition, Fine Motor, Gross Motor, Receptive Communication and Expressive Communication) (Steenis, Verhoeven, Hessen and Van Baar, 2015). The BSID-III provides children with tasks and situations devised to bring about a detectable set of behavioural outcomes that are assessed in the domains (Boyede, Eley and Donald, 2015). The social-emotional and adaptive behavior domains were not included in this study as there is no corresponding subscales on the ASQ-3. It has been used worldwide and has been translated into many languages, such as Dutch, Malay and Korean to name a few (Doh, et al., 2020; Steenis, Verhoeven, Hessen and Van Baar, 2015; Zakaria, et al., 2012).

Studies have shown that Black African children scored higher than children of the US on the BSID I. This prompted Rademeyer and Jacklin (2013) to conduct a study using the BSID-III, the updated Bayley Scales. The scores of the Black African children were still higher than that of the US. A limitation could have been that the US had more children, 1700 whereas

South Africa only had 122 children in their study. The South African children in the study were healthy infants which could be a reason for the difference in results. From this study South African infants have shown to have advanced motor skills (Rademeyer and Jacklin, 2013). Delays may be underestimated in the South African population (Donald, et al., 2019).

Various studies have been conducted globally and have concluded that the BSID-III possesses high reliability, content validity and construct validity (Steenis, Verhoeven , Hessen and Van Baar, 2015). Using the Intraclass Correlation Coefficient, the inter-rater reliability by age group was 0.998 (95% CI: 0.997- 0.999) for the fine motor scale, 0.997 (95% CI: 0.996- 0.998) for the gross motor scale and 0.997 (95% CI: 0.996- 0.998) for the gross motor scale and 0.997 (95% CI: 0.996-0.998) for the cognitive scale (Manandhar, et al.,2016).

The BSID-III takes 30-90 minutes to administer and due to this lengthy administration, it is not commonly used in the clinical setting (Libertus and Landa, 2013). According Gladstone, et al. (2007) two studies tried standardisation in Africa, one of the studies used a translated version of the Bayley scales on Black South African rural infants and the second study was done in a rural Nigerian population with a limited age range (Gladstone, et al., 2007).

A study conducted in South Africa by Ballot, et al. (2017) reported that for most South African children, English is not their home language, therefore for the BSID-III to be conducted, both the child and the assessor had to interact through the mother. They also reported that translating the Bayley assessment into the vernacular to counteract this issue will be expensive and a lengthy process as South Africa has 11 official languages. They concluded that the BSID-III can be used to assess development in inner city South African children (Ballot, et al., 2017).

The revised 3rd edition of the BSID-III is a more comprehensive assessment for children aged 16 days to 42 months. New age standards for cognitive, language and motor development were included. It has more subscales as separate scales for the gross and fine motor performance was developed. It also has scaled and composite index scores. The test also enables the assessment of lower functioning children. The psychometric properties are good, with good validity and reliability. This version corrects all the limitations of the BSID-II (Johnson and Marlow, 2006).

A study conducted by Campbell, et al. (2013) assessed the correlation between the Test of Infant Motor Performance (TIMP) and BSID-III. The intervention was carried out on infants 32 weeks' post-menstrual age. From their study the result was that although there was good

correlation between the BSID-III motor composite and TIMP, the analysis showed divergent results. Based on the results they state that infants won't be identified as delayed in terms of motor development when using the Bayley. They attribute the overestimation of performance to the fact that the 2006 norms for the BSID-IIII were developed in a different way to the previous editions. They state that the 2006 edition was aimed at reflecting the broader population of the U.S and thus included more Latino infants which in turn lowered the overall means of the scaled scores and now enhance the performance of infants. They concluded that despite the commonality between the TIMP and BSID-III, none of the children were identified as delayed by the BSID-III, the TIMP is the preferred tool for assessment of motor performance in infants at risk (Campbell, et al., 2013).

2.7.3 The Denver Developmental screening tool

The Denver Developmental screening tool (DDST) is a standardised tool assessing development in children aged birth to six years. The Denver II assesses four domains of development, namely, linguistic skills, fine motor skills, gross motor skills and personal-social skills (Von Wielligh and Van Rensburg, 2012). The tool was first standardised in 1967 and was called the DDST. In 1992, the revised DDST II version was published (Shahshahani, et al., 2010; Ga and Yi Kwon., 2011).

Research carried out in Tehraan in 2008 on 221 children aged 0-72 months from different socio-economic backgrounds. The aim of this study was to determine the validity and reliability of the Persian version of the DDST-II. The consistency coefficient between DDST-II and ASQ was 0.21 and sensitivity and specificity of DDST-II was 60% and 69% respectively. The test-retest was 90% and the inter-rater reliability was 80-95% and sensitivity of 83% and a specificity of 43%. Their study showed that the Persian version of DDST-II had good validity and reliability (Shahshahani, et al., 2010).

Von Wielligh and Van Rensburg, 2012 reports that no norms of this test are available for South African children (Von Wielligh and Van Rensburg, 2012).

2.7.4 The Malawi Developmental Assessment Tool (MDAT)

Standardisation of tools has been done in many non-western countries using the DDST which has been translated and adapted (Gladstone, et al., 2007). A study conducted by Gladstone, et al. (2007) aimed to create an appropriate developmental assessment tool to be used in rural

Malawi, modified and adapted from Western tools. They used the Denver II, Denver Developmental Screening Test (DDST) and the Griffiths Mental Development Scales (GMDS). They first screened the tools to identify which items were not appropriate to the Malawian children and replaced these items with that which is more culturally appropriate. Most items (58%) were from the Denver II and DDST and only 9% from the GMDS. Eighty-two per cent of the gross motor, seventy-seven per cent of the language and seventy per cent of the fine motor items were translated directly from the Western tests (Gladstone, et al., 2007).

The instrument was considered to possess good content validity and face validity as most items were acceptable for assessing the development of children in the context. For inter-observer reliability, 82% (113/138) of the questions had moderate to good reliability (k.0.4). Intra-observer reliability showed moderate to good reliability (k.0.4) for 75% (106/138) of the questions. Eighty per cent of the items were kept in the revised tool, with some items needing added modifications. Sixty-nine per cent of the new items were kept as opposed to the eighty-six per cent of the DDST or Denver II items, however, many of the new items added were less reliable (Gladstone, et al., 2007).

The tool was able to detect neurodevelopmental delay as well as neuro-disability among the rural African infants. Good content and face validity was exhibited which indicated that the tool is applicable to the sub-Saharan African setting of Malawi. The tool is takes about 30 minutes to administer and is easy to use. Further research is required on this tool. This tool can be used for early identification of neurodevelopmental delays. At present the tool may be more useful for research purposes (Gladstone, et al., 2010).

2.7.5 The Road to Health Booklet

In South Africa, the only screening tool used nationally is integrated as part of the Road to Health Booklet (RTHB). This was an initiative of the Department of Health to advance service delivery to children. The RTHB is a booklet kept by the parents that helps monitor and record immunisation, growth and development of the child. It is given to all parents of new-borns at private and public hospitals by the Department of Health and is checked at follow up visits (Van Der Linde, et al., 2015).

The accuracy of the RTHB's checklist in identifying developmental disabilities is yet to be established, even though this is the most commonly used tool among all health care workers

in the public care sector conducting screening for developmental delays. There is contradicting evidence on the reliability of the RTHB, however, a parent completed screening tool is easier and more likely to be used in a South African setting, due to the staff constrained, overburdened nature of our public hospitals (Van Der Linde, et al., 2015; Otten, 2018; Naidoo, Avenant and Goga, 2018).

The study by Van Der Linde, et al. (2015) investigated the outcomes of the Parents' Evaluation of Developmental Status (PEDS) and RTHB within the South African population, the accuracy of RTHB was to be assessed. The Parents' Evaluation of Developmental Status (PEDS) sensitivity and specificity is higher than the Denver II which is why it was the chosen tool. The PEDS is proven reliable and assists in decision making and the test takes less than 10 minutes. The accuracy of the PEDS in South Africa has been shown and there is sufficient evidence substantiating the reliability, accuracy and validity of the tool which is why it was used to compare to the RTHB checklist (Van Der Linde, et al., 2015).

From the research by Van Der Linde, et al. (2015) the RTHB sensitivity was 25% and specificity was 91%. Those children, who failed the RTHB, also failed the PEDS. The RTHB gross motor, fine motor and language sensitivity was 1% and specificity was 100%. The accuracy of the RTHB against the PEDS is low. A low sensitivity of the RTHB indicates failure to detect developmental delay in children which will result in many children with developmental delays being unidentified. This study shows that further improvement to the RTHB needs to be made. A recommendation of their study was that alternate screening tools be utilized since the accuracy of the RTHB is shown to be meagre and it requires adaptation. A validated tool should be used nationally in South Africa in order to identify at risk children promptly (Van Der Linde, et al., 2015).

A study conducted by Naidoo, Avenant and Goga, 2018 in South Africa revealed that use of the RTHB was suboptimal and that healthcare providers require reminders to utilize the RTHB optimally (Naidoo, Avenant and Goga, 2018).

2.7.6 The Infant Gross Motor Screening Test (IGMST)

The infant gross motor screening test (IGMST) is a gross motor test developed to assess HIV-infected children between six to 18 months of age. Communication with parents is often a challenge in South Africa due to the number of languages spoken and variety of cultures in the country. A gross motor screening tool was thus developed as it is easy to assess and no

equipment is required (Hilburn, Potterton, Stewart and Becker, 2010).

This tool has demonstrated sound psychometric properties; sensitivity of 97.4% and specificity of 85.7%; a positive predictive value (PPV) of 92.7% and negative predictive value (NPV) of 94.7% was found; good inter-rater, test-retest and intra-rater reliability was found. It is a valid and reliable tool to screen for gross motor delay in children infected with HIV (Otten, 2018).

2.7.7 The Red Cross War Memorial Children's Hospital developmental screening tool

The Red Cross War Memorial Children's Hospital devised a screening tool to overcome the absence of sensitive screening tools for developmentally delayed children who are HIV-infected. The tool that they devised is to detect moderate to severe developmental delay in HIV-infected children. This tool was based on the inputs from speech therapists, occupational therapists and physiotherapists in the child development field. For this study, the Bayley Scales was used as it is an international gold standard tool validated for use cross culturally even in South Africa. This study aimed at validating the Red Cross War Memorial Children's Hospital developmental screening tool by comparing it with the BSID-III (Boyede, Eley and Donald, 2015).

The Red Cross War Memorial Children's Hospital developmental screening tool was designed to identify moderate to severe developmental delay in children from nine to 36 months. The domains included are fine motor, gross motor, communication, social and additional sections for warning signs and action taken. The tool was created with the intention of being simple and easy to administer and does not include any special kits or tools. It's a checklist and can take between 5-10 minutes to administer (Boyede, Eley and Donald, 2015).

The results from the study by Boyede, Eley and Donald (2015) showed the Red Cross War Memorial Children's Hospital screening tool to have a sensitivity of 78.6% and specificity of 54.6%. The positive predictive value was 42.3% and negative predictive value was 87.5%. The Red Cross War Memorial Children's Hospital screening tool also favourably compared with the Infant Gross Motor Screening Test which is a local South African screening tool resulting in sensitivity of 97.4% and specificity of 85.7% (Boyede, Eley and Donald, 2015).

2.7.8 The Griffiths III Scales of Child Development

The Griffiths III tool measures the child's overall development, including strengths and needs through five subscales, namely (A) Foundations of Learning, (B) Language and Communication, (C) Eye and Hand Coordination, (D) Personal–Social–Emotional and (E) Gross Motor domains. The maximum age that the Griffiths III can be performed on is six years of age. The Griffiths III helps detect developmental delay and determines if a child is developing age appropriately. The tool is standardised with a normative sample. The results of this test assists the healthcare provider in planning interventions and with decisions about the child's educational management (Jansen, Green, Stroud, and Watson., 2020).

2.8 ASQ and BSID

The domains covered by the BSID-III are similar to those of the ASQ and the BSID-III is commonly used as a reference measure (Veldhuizen, et al., 2015). The agreement between the Bayley Scales of Infant Development II (BSID-II) and ASQ was studied in New York and 40 children were included. This follow up study was conducted at 12 and 24 months of age. Results show a sensitivity of 100% and a specificity of 87%-93% was shown (Gollenberg, et al., 2009).

A study conducted in the Netherlands by Steenis, Verhoeven, Hessen and van Baar (2015) assessed children both the BSID-III and the ASQ-3. Scores of the two scales were compared. Their study showed low to moderate sensitivity values between 7.2%-76.9% and specificity of between 53.2 and 98.4%. The best sensitivity and specificity values were for the older age group being 69.2% and 92.4% respectively. They state that developmental delay may be more apparent with older children and thus easier for parents and professionals to assess (Steenis, Verhoeven, Hessen and van Baar, 2015). A similar result was reported by Agarwal, et al., 2016 in their study with children in Singapore.

In the study conducted by Veldhuizen, et al. (2015), the concurrent validity of the ASQ was examined with respect to the BSID-III. Their results showed that the ASQ and BSID-III fell short in agreement compared to the recommended levels for screening. Sensitivity was 78% and specificity was 82% and there was a high false-positive rate for the ASQ (Veldhuizen, et al., 2015).

Assessment of children with disabilities can be an issue when a standardised test is used as

one often will need to adapt to the test stimuli, administration or scoring procedures. This adaptation is done to minimize the result of a child's disability on their function, and to assess their limits and derive an appropriate intervention. However, with most of the standardised tests, these adaptations are not permitted as it can compromise the norms and standardised scores (Johnson and Marlow, 2006).

A table summarising the properties of the developmental assessment and screening tools currently used in South Africa is presented in Appendix J. The outcome measures reviewed above and in Appendix J were selected as they were the most commonly used in the literature reviewed.

2.9 Conclusion

Developmental delay is a common occurrence in South Africa as various risk factors are prevalent which threaten the development of children. Since development is an ongoing process, it needs to be regularly monitored. Standardised assessment tools are time consuming and costly. An alternative for this is parental reports which are cost effective, quick and are easy to complete and score. Parents are also shown to provide reliable feedback on their child's performance.

Standardised developmental tools provide detailed assessments which assists with determining the degree of developmental delay. Early detection helps prevent secondary complications and allows for early intervention which reduces the effects of developmental delays on the child.

Studies comparing the BSID-III and ASQ-3 show contradicting results and to our knowledge, this is the first comparison carried on the South African population comparing the BSID-III and ASQ-3, as suggested by Hsiao, et al. (2016) (Hsiao, et al., 2016).

CHAPTER 3- METHODOLOGY

3.1 Study design

This study was a cross sectional study. This study design was chosen as we collected all our data at one point in time. We collected the demographic information, completed the ASQ-3 as well as the BSID-III all during one session.

3.2 Location

This study was conducted at the neonatal high risk follow up clinic at Charlotte Maxeke Johannesburg Academic Hospital. The high-risk clinic included children having had Hypoxic-ischaemic encephalopathy, neonatal jaundice, intraventricular hemorrhages, HIV positive and any infant who was admitted to the NICU.
Children are often booked for their follow ups at the clinic after being discharged from hospital. They follow up every 3 months till 2 years of age.

3.3 Participants

Parents of children under one year of age who brought their children to the follow up clinic were invited to participate in our study.

A convenience sample of parent-child dyads who were available and fulfilled the inclusion criteria were included in the study. A total of 60 children aged two months, four months, six months, eight months, ten months and 12 months were assessed. A sample size of 60 was used in order to have 10 participants per age range assessed (Boateng et al, 2018).

3.4 Inclusion criteria

- Children with a corrected age of up to 12 months
- Children who were accompanied by a parent
- Parents who could understand English
- Informed consent received from the parent of the child.

3.5 Exclusion criteria

Children who were very ill or medically unstable were not included in the study. This was determined by the clinic doctor.

3.6 Instrumentation

- The Bayley Scales of Infant and Toddler Development- III (Appendix I) which had been proven to be valid and acceptable and known as the gold standard for the assessment of infant development in the South African setting (Rademeyer and Jacklin, 2013). The researcher was trained to carry out the BSID-III by their supervisor who has years of experience administering it.
- The Ages and Stages Questionnaire-3 (Appendix H) which has been used across the globe and has been proven as a valid source of attaining information even if parents are not educated (Woodward, et al., 2011).

3.7 PROCEDURE

3.7.1 Main study

This study was carried out in the Neonatal high risk follow up clinic at Charlotte Maxeke Academic hospital, Johannesburg, South Africa. The study was conducted from November 2020 and was completed in March 2021.

Parents who accompanied their children to the Neonatal high risk follow up clinic were approached and invited to participate in the study.

Parents were informed verbally about the study by the researcher as they were waiting their turn for their follow- up visits. Information sheets (Appendix E) and consent forms (Appendix F) were handed to the parents who were interested in participating in the study. These were only available in English, however, only parents who could understand English were included in the study. Parents were given some time to read through the documents and the researcher addressed any concerns or questions that the parents had.

Parents who consented were taken to a private room and relevant demographic information was collected from the parent (Appendix G). The ASQ-3 (Appendix H) was given to participating parents for their child's particular age group and they completed it on their own. The study was conducted in English and the researcher was available for any assistance or

queries that the parent had whilst filling out the questionnaire.

Once the questionnaire was completed, it was collected by the researcher. Children were then assessed by the researcher, using the BSID-III (Appendix I). These assessments took place ina quiet room with no distractions. The BSID-III was carried out in the mornings, preferably after baby had a nap and feed, however, it was not always optimal since parents want to leave as soon as they could. The assessments did not affect their usual clinic appointments as they were still seen by the doctor and the rest of the Multi-Disciplinary Team (MDT). Results from both the ASQ and BSID were placed in the patients file so that the rest of the MDT could see the results and to prevent repetition of participants.

A participant number was used, which was written on all their forms instead of a name.

3.8 Data analysis

The data was captured on Microsoft excel then translated using Stata version 15.2.

Data was collected from both tests and documented. Both assessments were scored so that the subtests from the ASQ-3 and BSID-III results could be compared. The raw score of the BSID-III is adjusted to give an age related scaled score so that comparisons across age ranges can be made (Bayley, 2006). The scaled scores of the BSID-III were compared to total ASQ-3 scores. Scaled scores were used because the composite scores combine both the fine and gross motor domains making it difficult to compare to the ASQ-3 directly. The proportion of children falling into the normal, at risk and delayed categories for each outcome measure were compared to see if there was a correlation. There is no universally accepted definition for developmental delay. One method commonly used and employed in this study is that infants with scores of 1SD below the mean are considered ‘at risk’ and infants scoring 2SD below the mean are classified ‘delayed’ (Bayley, 2006). Results were analysed to see if there was a correlation between that attained by the physiotherapist using the BSID-III and the parent completed ASQ-3.

Continuous data was summarized using median and interquartile range as data was not normally distributed. Categorical data was summarized using frequencies and percentages. Scatter plots were used for the virtual presentation for continuous data. Spearman correlation was used to assessthe linear relationship between the ASQ-3 and the BSID-III domains. The Chi^2 test was used tocompare the child development classification between the ASQ and BSID domains. The percentage agreement of the BSID and the ASQ-3 classification of the

child's development was assessed using the Cohen's Kappa test. Sensitivity and specificity of ASQ-3 was estimated with BSID-III as the reference. A p-value of <0.05 was considered as significant.

Table 3.1: The subscales being compared:

ASQ-3 (Appendix H)	**BSID-III** (Appendix I)
Problem solving	Cognitive
Communication	Language
Fine motor	Fine motor
Gross motor	Gross motor

3.9 Ethical considerations

- Ethical approval was obtained from the University of the Witwatersrand, Human Research Ethics Committee (HREC) (Johannesburg, South Africa), prior to the commencement of the study (Appendix B).
- Permission was sought from the C.E.O of Charlotte Maxeke Academic Hospital, as well as from the head of the Neonatal unit to conduct the study at their facility (Appendix D).
- Written informed consent was obtained from the parent of each participating child. Sufficient information about the study was disclosed to allow participants to decide if they would like to participate in the study and time was given for them to read the information and ask questions (Appendix E & F).
- Participants were allowed to withdraw from the study at any time without any negative implications.
- Researchers ensured that participants' privacy and confidentiality were maintained at all times. The identity of all subjects were protected; details shared by participants were not disclosed.
- All information collected from participants will be stored securely for a period of six

years with access reserved for the researcher and supervisors only for reviewing purposes and will thereafter be destroyed. If the results are published records will be destroyed after two years.

- If any developmental concerns were detected the children were referred to the appropriate department for assessment and relevant treatments. Since the high-risk clinic contains a MDT of the doctors, neonatologists, pediatricians, nurses, dieticians, occupational therapists, speech and language therapists, audiologists and physiotherapists, the referral was a simple process as those who had developmental delay were given a letter stating what was detected and were asked to join the relevant ques in order to see the respective healthcare professionals.

The results obtained from this study will be presented in the next chapter, chapter four.

CHAPTER 4- RESULTS

In this study, the ASQ-3 and Bayley-III were administered to 60 children who met the inclusion criteria. The results obtained are presented in this chapter.

4.1 Demographic information of participants

The demographic characteristics of the participants are summarised in Table 4.1 and 4.2.

4.1.1 Demographic information of the infants

Table 4.1: Summary of the demographic information of the infants (N=60)

Variables	**Categories**	**Frequency (n)**	**Percentage (%)**
Gender of child	Male Female	33 27	55 45
Corrected age of child (months)	Median (IQR)	5.5 (3.5-8)	
Gestational age (weeks)	Median (IQR)	32 (30-40)	

Of the 60 participants, 33 (55%) were males and 27 (45%) were females. The median age of the children was 5.5 months with an interquartile range (IQR) of 3.5-8 months. The median gestational age of children was 32 weeks with an IQR of 30-40 weeks. There were 20 (33.33%) full-term infants and 40 (66.67%) infants who were preterm.

4.1.2 Demographic information of the parents

Table 4.2: Summary of the demographic information of the parents (N=60)

Variables	**Categories**	**Frequency (n)**	**Percentage (%)**
Employment status of the mother	Employed	9	15
	Unemployed	51	85
Educational level of parent	Did not complete matric	23	38.33
	Completed matric	25	41.67
	Tertiary education	12	20
Home language spoken	South African language	47	78.33
	Non-South African language	13	21.67
Age of parent (years)	Median (IQR)	31 (26-36)	

Of the 60 parents, there were 23 (38.3%) parents who did not complete matric, 25 (41.7%) of the parents completed matric and 12 (20%) of them achieved tertiary education. The majority of the parents were unemployed (85%). Most parents (n=47;78.3%) spoke one of the 11 official languages of South Africa whilst 13 (21.7%) were non-South African language speakers. The median age of parents was 31 (IQR= 26-36) years. The parents' age ranged from 18 years to 55 years.

4.2 Developmental status of the infants

4.2.1 Results from the BSID-III

The results from the BSID-III are presented in table 4.3. The scaled score for each section is reported.

Table 4.3: Developmental status according to the BSID-III (N=60)

Domains	**Measures of central tendency**	**BSID-III Scaled score**
Language (receptive + expressive)	Median (IQR)	18 (14-20)
Fine motor	Median (IQR)	10 (8-12)
Gross motor	Median (IQR)	9 (5.5-11)
Cognitive	Median (IQR)	9 (7-11)

The participants generally scored well with scores close to the mean score for the test which is 10. The lowest scores were found in the gross motor domain with scores ranging from 5.5-11.

4.2.2. Results from the ASQ-3

The results for each subsection of the ASQ-3 are presented in table 4.4. The total score for each section is reported.

Table 4.4: Developmental status according to the ASQ-3

Domains	**Measures of central tendency**	**ASQ-3**
Communication	Median (IQR)	55 (45-60)
Fine motor	Median (IQR)	50 (45-60)
Gross motor	Median (IQR)	52.5(40-60)
Problem solving	Median (IQR)	50 (40-60)

On the ASQ the highest scores were in the communication domain with the lowest median scores being in fine motor and problem solving domains.

4.3 Relationship between the BSID-III and ASQ-3 results

To compare the linear relationship of these scores using the Spearman correlation test which ignored normality, the correlation coefficients are shown summarised in Table 4.5. Scatter plots for the BSID-III and ASQ-3 scores for each domain with corresponding fitted values are displayed in Figure 1.

Table 4.5: The correlation analysis of the child's development scores by the using the BSID-III and the ASQ-3

Domains	**Measures of central tendency**	**ASQ-3**	**BSID-III Scaled score**	**Correlation coefficient (p-value)**
Communication/ Language	Median (IQR)	55(45-60)	18 (14-20)	*0.20 (0.14)
Fine motor	Median (IQR)	50(45-60)	10 (8-12)	*0.27 (**0.04**)
Gross motor	Median (IQR)	52.5(40-60)	9 (5.5-11)	*0.17 (0.20)
Problem solving/ Cognitive	Median (IQR)	50(40-60)	9 (7-11)	*0.21 (0.10)

*non-parametric Spearman correlation coefficient as the data was not normally distributed. Interpretation is based on the non-parametric test.

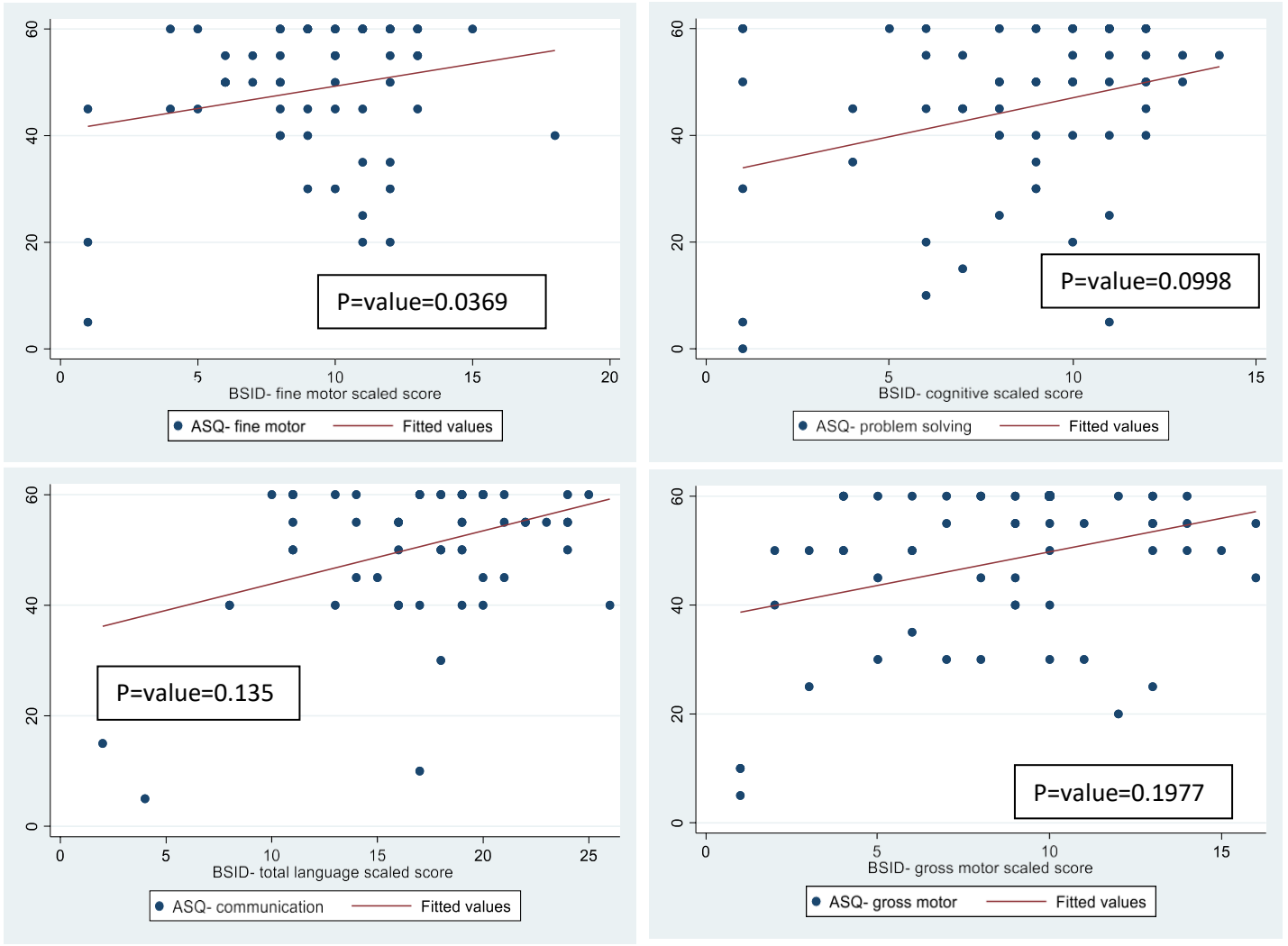

Figure 1: Scatter plot for the BSID-III and ASQ-3 scores for each domain with corresponding Spearman correlation p-values and the fitted line.

Since the data was not normally distributed, the Spearman correlation results will be interpreted. The correlation coefficients for the four domains ranged from 0.17 to 0.27 which indicates a weak positive linear relationship between the scores from the BSID-III and the ASQ-3. However, this linear relationship was not statistically significant for the communication/language (rho=0.20; p=0.14); gross motor (rho=0.17; p=0.20) and problem solving/cognitive domains (rho=0.21; p=0.10) while the linear relationship for the fine motor was statistically significant (rho=0.27; p-value=0.04).

The BSID-III and ASQ-3 scores were further categorised into three groups used to classify child's development (Table 4.6). The classification cut offs defined in the test manuals for each tool were used (Bayley, 2006; Squires and Bricker, 2009).

Table 4.6: Comparing the child development classification (normal, at risk and delayed) between the two methods of assessments.

Child development Domains	**Normal n(%)**	**At risk n(%)**	**Delayed n(%)**	**Chi^2 P-value**
Cognitive (BSID-III)	46 (76.67)	8 (13.33)	6 (10)	
Problem solving (ASQ-3)	45 (75)	4 (6.67)	11 (18.33)	0.25
Column proportion p-value	0.74	0.16	0.10	
Language (BSID-III)	44 (73.33)	12 (20)	4 (6.67)	
Communication (ASQ-3)	55 (91.67)	2 (3.33)	3 (5)	**0.01**
Column proportion p-value	**0.00**	**0.00**	0.55	
Fine motor (BSID-III)	45 (75)	10 (16.67)	5 (8.33)	
Fine motor (ASQ-3)	43 (71.67)	8 (13.33)	9 (15)	0.50
Column proportion p-value	0.63	0.43	0.12	
Gross motor (BSID-III)	38 (63.33)	10 (16.67)	12 (20)	
Gross motor (ASQ-3)	45 (75)	7 (11.67)	8 (13.33)	0.38
Column proportion p-value	0.07	0.32	0.18	

*the bold p-values are significant at 5%

There was no significant difference in the classification of the children as normal, at risk or delayed for the problem solving/ cognitive domain using the two methods (p-value=0.25). The majority of children (75%-77%) were classified as having a normal problem solving/ cognitive development.

There was a significant difference in the classification of the children as normal, at risk or delayed for the language/communication domain using the two methods (p-value=0.01). Though there were more children with a normal language/communication development from each method; the ASQ-3 classified 91.67% children under normal compared to 73.33% using the BSID-III and these proportions were significantly different (p-value=0.00). Similarly, there were more at-risk language/communication development classification of children using the BSID-III (20%) compared to ASQ-3 (3.33%) which was also statistically significant (0.00).

There was no significant difference in the classification of the children as normal, at risk or delayed for the fine motor domain using the two methods (p-value=0.49). The majority of children (72%-75%) were classified as having a normal fine motor development.

There was no significant difference in the classification of the children as normal, at risk or delayed for the gross motor domain using the two methods (p-value=0.38). However, there were more children with a normal gross motor development according to the ASQ-3 which classified 75% children under normal compared to 63% using the BSID-III and these proportions were approaching significance (p-value=0.07).

A dichotomous classification was created by combining the at risk and delayed categories.The infants were thus classified as either Normal or Delayed. The results based on these classifications are summarised in Table 4.7.

Table 4.7: Comparing the child development classification (normal and delayed) between the two methods of assessments

Domains	**Normal** **n(row %)**	***Delayed** **n(row %)**	**Chi** ^{2} **P-value**
Cognitive (BSID-III) Problem solving (ASQ-3)	46 (76.67) 45 (75)	14 (23.33) 15 (25)	 0.83
Language (BSID-III) Communication (ASQ-3)	44 (73.33) 55 (91.67)	16 (26.67) 5 (8.33)	 **0.01**
Fine motor (BSID-III) Fine motor (ASQ-3)	45 (75) 43 (71.67)	15 (25) 17 (28.33)	 0.68
Gross motor (BSID-III) Gross motor (ASQ-3)	38 (63.33) 45 (75)	22 (36.67) 15 (25)	 0.17

*Delayed= delayed + at-risk

There was no significant difference between the method of assessment and the child's classification for the cognitive/ problem solving, fine motor and gross motor development domains (p-value>0.05). In contrast, the language/communication domain showed a significant difference (proportion differences) between the child's classification and the assessment method (p-value=0.01).

The agreement of the ASQ-3 and the BSID-III was also assessed using the sensitivity and the specificity parameters (Table 4.8). The sensitivity and specificity of the ASQ-3 was estimated with the BSID-III as the reference method. The ASQ-3 sensitivity and specificity for problem solving domain was 42.9% and 80.4% respectively; 12.5% sensitivity and 93.2% specificity for the communication domain; 26.7% sensitivity and 71.1% specificity for the fine motor domain; and 31.8% sensitivity and 78.9% specificity for the gross motor domain.

Table 4.8: The sensitivity and specificity of ASQ-3 with reference to BSID-III in the classification of child's development (normal vs delayed)

Domains	**FN**	**TN**	**TP**	**FP**	**BSID-III prevalence (95% CI)**	**Sensitivity % (95% CI)**	**Specificity % (95% CI)**	**PPV % (95% CI)**	**NPV % (95% CI)**	**Chi^2 P-value**
Cognitive/ Problem solving	6	8	9	37	23% (13-36)	42.9% (17.7-71.1)	80.4% (66.1-90.6)	40% (16.3-67.7)	82.2% (67.9-92)	0.08
Language /Communication	2	14	3	41	27% (16-39.7)	12.5% (1.55-38.3)	93.2% (81.3-98.6)	40% (5.27-85.3)	74.5% (61-85.3)	0.60
Fine motor	4	11	13	32	25% (15-37.9)	26.7 % (7.79-55.1)	71.1% (55.7-83.6)	23.5% (6.81-49.9)	74.4% (58.8-86.5)	0.87
Gross motor	7	15	8	30	37% (25-50.1)	31.8% (13.9-54.9)	78.9% (62.7-90.4)	46.7% (21.3-73.4)	66.7% (51-80)	0.35

ASQ=Ages and Stages Questionnaires; BSID-III= Bayley Scales of Infant Development, third edition; CI=confidence interval; PPV=positive predictive value; NPV=negative predictive value; FN=false negative; TN=true negative; TP=true positive' FP=false positive

4.4 Conclusion

In summary the results of this study found that there was a weak positive correlation between the scores of the BSID-III and the ASQ-3. The only significant correlation was in the fine motor domains whilst the language/communication, gross motor and problem solving/cognitive domains were not statistically significant.

When investigating whether participants were categorised as normal, at risk and delayed on the two tests, there was only a significant difference for the language/communication domains whilst the cognitive/problem solving, fine motor and gross motor domains showed no significant differences.

We further categorised the results into normal and delayed (at risk and delayed). As with the previous categorization, there was only a significant difference in the categories in which participants were classified in the language/communication domains. Significantly more children were classified as normal for communication by the ASQ-3 than by the BSID-III.

The results of this study will be discussed in chapter five.

CHAPTER 5- DISCUSSION

In this chapter the results presented in chapter four will be discussed in more detail

5.1 Demographics

5.1.1 Characteristics of infants

The majority of the participants were preterm (66.67%) and males (55%). Previous studies comparing the ASQ-3 to the BSID III also had majority of their participants being males with percentages ranging from 48%-59% (Schonhaut, et al., 2013; Veldhuizen, et al., 2015; Steenis, Verhoeven, Hessen and Van Baar ,2015; Agarwal, et al., 2016).

In a study looking at children in South Africa using the Bayley III as compared to the Bayley normative population, the gender of the children was equally distributed (Ballot, et al., 2017).

These findings are not surprising as the clinic where data was collected caters mainly to infants who were born prematurely and who are followed up post discharge from NICU. The fact that the majority of the infants were male can be explained by the fact that male infants are at higher risk of premature birth (Astolfi and Zonta, 1999).

5.1.2 Characteristics of parents

The majority of the parents had completed matric (41.7%) and a small number of the parents continued to tertiary education (20%). In another study that looked at assessing developmental outcomes using the BSID in South Africa, only 26.1% of parents matriculated and only 9.2% went on to tertiary education (Ballot, et al., 2017). The increase in those gaining tertiary education could possibly be attributed to the “fees must fall” movement, National Student Financial Aid Scheme providing more bursaries and increased access to tertiary education.

Most of the studies conducted in first world countries had lower percentages of parents not completing matric and higher percentages parents attaining tertiary education. To mention a few, a study in Canada only 4% of the parents did not complete matric and 91% of parents went on to attain tertiary education (Veldhuizen, et al., 2015). In another study carried out in the Netherlands, 51.7% of parents achieved tertiary education, 37.7% of parents had completed matric and 10.9% of parents hadn’t completed matric (Steenis, Verhoeven, Hessen

and Van Baar ,2015). The fact that South Africa still lags behind international standards of educational achievement is of concern, particularly as maternal education has been linked to infant developmental outcomes (Donald, et al., 2019).

Despite the level of matric completion coupled with tertiary education in this study, 85% of the parents were unemployed. This is higher than Ballot, et al. (2017)'s study where 64.6% of parents were unemployed (Ballot, et al., 2017). The data for the current study was collected in part during the COVID-19 pandemic. Many people lost their jobs during the pandemic which may be a contributing factor to the high unemployment level. In a study conducted in a first world country (Santiago, Chile) 71% of parents were employed (Schonhaut, et al., 2013). According to statistics, the unemployment rate in South Africa for the first quarter of 2022 was reported to be 63.9% for 15-24 year olds and 34.5% for 25-34 year olds. The official national rate of unemployment is currently 34.5% (Stats SA, 2022).

It is seen that most parent's home language was one of the 11 official languages of South Africa (78.3%) even though Johannesburg is known to have a large migrant population accessing public health care.

5.2 Developmental status

A study that was similar to ours in that they compared the domains of each test had a much larger sample size (587 children) and a bigger age range (children under 2 years). Their results indicate developmental delay on the ASQ was 4.4% for communication, 4.8% for fine motor, 8.5% for gross motor and 6.1% for problem solving (Veldhuizen, et al., 2015). The participants from the current study scored differently from theirs as the results showed much more delay than theirs did. We had for ASQ communication, 8.33%, fine motor 28.33%, gross motor 25%, problem solving 25%. Their study excluded children with sensory impairments and genetic syndromes whereas our study only excluded children who were very ill or medically unstable.

5.2.1. BSID scores and classification

When looking at other studies conducted in South Africa which used the BSID-III, our participants scored better on the BSID-III scores compared to both assessments on the participants of Ballot, et al. (2017). In their study children were assessed at nine to 12 months of age and again at 15 to 20 months of age, delays were found to be the highest for the

cognitive domain and the lowest delays were found in the gross motor domain (Ballot, et al., 2017).

Yu, et al. (2013) whose study was conducted in Taiwan on children aged six, 12, 18 and 24 months of age, reported that the language domain had the highest prevalence of delay whereas our highest number of delays were noted in the gross motor domain (Yu, et al., 2013).

In the current study the cognitive domain had the highest number of children in the normal range, whilst the gross motor domain had the lowest number of participants in with scores in the normal range. This may be attributed to the fact that our participants were from a 'high-risk' clinic with a predominance of premature infants. That is contrary to the findings reported by Rademeyer and Jacklin. (2013) which showed that African infants scored higher in the gross motor domain when compared to children form Western countries (Rademeyer and Jacklin, 2013). One notable difference between the two studies is that this study included children from an at-risk follow up clinic while Rademeyer and Jacklin. (2013)'s participants were healthy children with no known developmental risk factors.

5.2.2 ASQ scores and classification

The domain with the highest scores was the communication domain. This could be because in their normal habitat a child is more confident and free and may do and say more at home than in a confined setting with a stranger. A previous study reports that South African children often score higher in the gross motor and communications domains (Van Heerden, et al., 2017). The reasons for children scoring lower in the fine motor and problem-solving domains may be due to cultural understanding and experiences. For example, although "peek-a-boo" is played in different cultures with a variant, it may not have the same name in all contexts. Without adapting culturally, it may seem as though the parent and child are unable to complete the item (Van Heerden, et al., 2017).

The scores of the problem solving and fine motor domains were the lowest. This could be because parents may not notice the smaller details and take note of finer details whilst their child is playing. A lot of the times parents leave the child playing whilst they are doing chores. Parents may also not be as aware of what to expect from their child in these domains and may not expose them to opportunities to develop these skills

Across Africa, many women carry babies on their backs, fronts and sides as they walk and do

household chores. The close proximity makes babies feel secure and the feeling of the mother's movements and walking are calming. This position also makes the baby more alert to sounds and sights resulting from the mother's activity. Due to the baby being against the mother's body, the mother is more aware of the baby's state, she can respond immediately when her baby is bothered or wants to urinate. This may be a factor contributing to the better communication and gross motor developmental scores (Van Heerden, et al., 2017).

5.3 Comparison between BSID and ASQ results

5.3.1 Associations between developmental domains

The overall agreement between the two tools was moderate (64.165%) with the domains ranging from moderate (58.33%) to good (71.67%). Of all the domains there was only significant agreement between the cognitive domain of the BSID-III with the problem solving domain of the ASQ-3.

Veldhuizen, et al. (2015) found significant agreement in the both the gross motor and language/communication domains whereas we only had significant agreement in the cognitive/ problem solving domains. Their research was similar to ours as sensitivities were uniformly poor, (theirs ranged from 0-50 and ours from 12.5-42.9). Spearman's correlation was used in both studies. For the communication/language domains, their correlation coefficient was 0.44 (ours was 0.195), their gross motor was 0.37 (ours was 0.168), their fine motor was 0.09 (ours was 0.27) and their cognitive/problem solving domains were 0.16 (ours was 0.215) (Veldhuizen, et al., 2015).

Rubio-Codina, et al. (2016) results were only significant for fine motor and communication/receptive language. They looked at children aged 6-18 months which was a bit higher than our age range. They report that when using the ASQ-3, children under 31 months usually perform poorer (Rubio-Codina, et al., 2016).

5.3.2 Correlations between developmental categories

There was a weak correlation between the domains of both tools which was not significant except for the fine motor domains which showed significance at p=0.04. The majority of the children were classified as normal on both the tools in all the domains, with the BSID gross motor domain being the lowest at 63.33% of participants falling into the normal category.

When classified into normal, at risk and delayed, there was a difference between the language and communication domains in both the tools, which also showed the highest percentage of children having normal communication on the ASQ.

However, the BSID-III showed the highest at risk group for language (20%) compared to the other domains. The lowest at risk value was for communication from the ASQ-3 (3.33%). The children scored poorly on the BSID-III (20%) because the test was not administered in their mother tongue. Overall the results suggest that the ASQ may be a good tool for assessing severe delay in children as with the findings of Gollenberg, et al. (2009).

When looking at the results classified into normal and delayed (at risk and delayed combined), we see that the highest percentage of delay is on the BSID-III gross motor domain and the lowest delay is on the ASQ-3 communication domain. The only significant association between the score and the test used is seen in the language and communication domains.

The increased score on normal communication could be due to the language barrier as the assessment was conducted in English. It could also be due to the fact that a child may be tired from waiting and in the normal habitat a child is more confident and free and may do and say more at home than in a confined setting with a stranger.

5.3.3 Sensitivity and specificity

Psychometric properties of the specific domains were investigated, similar to the study of Veldhuizen, et al. (2015). The sensitivity and specificity of the ASQ-3 was estimated with the BSID-III as the reference method. Our sensitivities were uniformly poor (below 70%) and specificities were generally high (above 70%) which was similar to the results of Veldhuizen, et al. (2015). A sensitivity of 70% and higher is indicative of a good screening instrument as the instrument is able to identify at least 70% of children with developmental delay. A specificity of 70% and higher indicates that the instrument is able to identify at least 70% of children performing within their normal range (Gollenberg, et al., 2009; Veldhuizen, et al., 2015). The results of this study suggest that the ASQ-3 may miss some children with developmental delay due to the low sensitivity.

Our results differed from that of Gollenberg, et al. (2009) in that they had high overall sensitivity and specificities. This could be attributed to the fact that their participants were assessed at 24 months old and as seen from Steenis, Verhoeven, Hessen and Van Baar.

(2015)'s research, better sensitivity and specificity values were noted for the bigger age group (Gollenberg, et al., 2009; Steenis, Verhoeven, Hessen and Van Baar, 2015).

Steenis, Verhoeven, Hessen and Van Baar. (2015) found that by using the total scores instead of the scores of each domain, better sensitivity and specificity results were obtained. This could be due to the fact that when looking at the total of scores instead of individual domains, the impact of each item assessed is reduced. The lack of one skill can be compensated for by the others. Their results with regards to sensitivity was low like this study. The domains from the two tools don't always measure the same components. An example of this is on the BSID-III fine motor domains, the item 'transfers block from one hand to the other' is similar to that in the ASQ-3 problem-solving domain. Another example is the item 'screwing lids on and off bottles or jars' appears in the fine motor domain on the ASQ-3 but appears on the cognitive scale in the BSID-III (Steenis, Verhoeven, Hessen and Van Baar, 2015).

Schonhaut, et al. (2013)'s research was similar to that of Steenis, et al. (2015) as they did not look at each domain of the two tools but the overall results. Our results differed from that of Schonhaut, et al. (2013) as they had higher values of sensitivity and specificity respectively (75% and 81%). This could also be attributed to the fact that they did not view the two tools per domain.

A strength of Steenis, Verhoeven, Hessen and Van Baar. (2015)'s study was that their study population was 1244 participants whereas we had 60 participants which is a much smaller study sample. Another advantage is that they had a broad age range (2 weeks – 42 months) whereas we only looked at children till the age of 12 months old. Overall, their scores for sensitivity ranged from very low to adequate (7.3%-76.9%) which is a much wider range than our scores (12.5%-42.9%). Their specificity scores ranged from 53.2%-99.3% which was not too far off from our scores (71.1%-93.2%). Their sensitivity and specificity values were shown to be better for the older age group (18-42 months) whereas all our participants were well below that age range. However, their results differed from ours as they did not compare the results by each domain. The agreement between our research and that of Steenis, Verhoeven, Hessen and Van Baar. (2015) are aligned in the sense that the agreement between the two tools was not optimal. Children also show different behaviours in strange situations such as for the BSID assessment, thus parents may observe them differently at home resulting in them scoring better on the ASQ (Steenis, Verhoeven, Hessen and Van Baar, 2015).

5.3.4 Positive Predictive Value (PPV) and Negative Predictive Value (NPV)

When comparing the ASQ and BSID, Schonhaut, et al. (2013) had a PPV of 47% whilst ours ranged from 23.5-46.7% and their NPV was 9% whilst ours ranged from 66.7%-82.2% which was very high in comparison. The ASQ was good at identifying children with normal development whereas BSID was better at identifying children with delayed development. The BSID identified more children at risk than the ASQ which is opposite of what Schounhaut, et al. (2013) states from their findings. Given the relatively low PPV in our findings and that of Gollenburg, et al. (2009) some children who are classified as being developmental delayed on the ASQ could turn out to be developing normally.

Our false positive values (30-41) were relatively higher than our false negative values (2-7) which also is similar to the results from the research by Veldhuizen, et al. (2015) who reported a high false positive rate among young infants (Veldhuizen, et al., 2015).

5.4 Limitations

It was challenging to recruit participants in the 10-12 months' age range. Follow ups were done in the clinic every three months and many children are lost to follow-up by this age.

Some participants had completed an ASQ-3 with the OT before they saw the researcher, so parents may have had a better idea of what was going to be assessed.

Testing the infants on the same day when they are being assessed at a follow up clinic and after having waited to be seen by the neonatal team prior to the BSID-III being conducted could cause infant's to be tired and hinder their results.

The timing of the assessment with regards to feeds could also have impacted the infant's performance.

The assessment was conducted in English which is a limitation. Assessments conducted in the child's home language could have yielded different results. Since 22% of the sample were non- South African speaking, English being used as the assessing language is a limitation.

Since this was a research report and considering the restrictions of the COVID pandemic, our sample size was fairly small (N=60). A larger sample size could have possibly yielded more accurate results.

A few parents didn't understand the term "chuckle", "high pitched sound" and "gurgling" from the ASQ, which the researcher had to explain to them.

A limitation could be that all our participants were very young and tools may show better results with older children. Veldhuizen, et al. (2015) states that when removing participants under the age of one year from their study, there was an improvement in agreement between the two tools.

5.5 Strengths

A strength of this study is that we didn't limit the participants to delayed or at risk of developmental delay but typically developing children were assessed as well.
The researcher was the only assessor for the BSID-III.

5.6 Recommendations

Those who are unable to read or comprehend English will not be able to utilize the ASQ-3 in the South African context, therefore a recommendation for a follow up study is to translate the questionnaire into more African languages and make it readily available as an interpreter may not always be readily available in a clinical setting.

Future studies could compare total test scores rather than individual domains as recommended by Steenis, Verhoeven, Hessen and Van Baar. (2015) (Steenis, Verhoeven, Hessen and Van Baar. 2015).

Further research with children up to the age of five years and with larger sample sizes is needed to determine the appropriateness of the ASQ-3 across a larger age range.

It could be interesting for future studies to show the age bands and the ASQ-3 scores to see if there is a higher prevalence of 'delayed' results in the younger age bands.

5.7 Conclusion

The ASQ-3 could be used to reduce the number of children requiring full developmental assessments. Even though it does not agree optimally with the BSID-III it can still indicate whether the child is developing typically or atypically and help determine who needs further more detailed developmental assessments.

CHAPTER 6- CONCLUSION

Apart from the BSID-I, no other instruments to screen development have been normed among South African children (Hsiao, et al., 2016; Schonhaut, et al., 2013). Although there are few readily available, relatively easy to use, and culturally adaptable developmental assessment tools for young children, there was a need to compare the ASQ-3 with other developmental assessment instruments, such as the gold standard BSID-III for validity of the ASQ-3 in the South African context (Hsiao, et al., 2016).

Studies comparing the two tools have been carried out in other countries but none have been conducted in South Africa. There is contradicting evidence as to whether the ASQ-3 is a suitable tool for low to middle income countries (Hsiao, et al., 2016). Research was needed to assess if parents in the South African setting are able to relate their child's development upon follow ups.

This study aimed to compare the results of the parent completed ASQ-3 to the physiotherapist completed BSID-III. If the results had similar outcomes in a South African context, the ASQ-3 can be implemented as a developmental screener as it is quick, easy, more cost effective and can be carried out by parents.

This study was conducted at the neonatal high risk follow up clinic in Johannesburg, South Africa. A total of 60 children aged two months, four months, six months, eight months, ten months and 12 months were assessed. Parents completed the ASQ-3 and the researcher conducted the BSID-III thereafter.

Data was collected from both tests and documented. Both assessments were scored so that the subtests from the ASQ-3 and BSID-III results could be compared. The scaled scores of the BSID-III were compared to total ASQ-3 scores. Results were analysed to see if there is a correlation between that attained by the physiotherapist using the BSID-III and the parent completed ASQ-3.

There was a weak non-significant positive correlation between the two tools, except for the fine motor domain, where the correlation was significant, when using test scores. When categorised as normal, at risk and delayed, there was only a significant difference for the language/communication domains whilst the cognitive/problem solving, fine motor and gross motor domains showed no significant differences in categorisation depending on which tool

was used. When further categorised into normal and delayed (at risk and delayed) categories, there was only a significant difference in the categorisation in the language/communication domains. Our sensitivities were uniformly poor and specificities were generally high. The low sensitivities suggest that theASQ-3 may miss some children with developmental delay.

Despite the weak agreement between the two tools the ASQ-3 could still be used in the South African context to reduce the amount of children requiring full developmental assessments. The ASQ-3 can also suggest who may need further detailed developmental assessments as it can indicate which children are developing typically or atypically. Care should however be taken when interpreting results bearing the limitations identified in this study in mind.

Further research with more participants over a larger age range is needed to investigate the relationship between the BSID-III and the ASQ-3 further.

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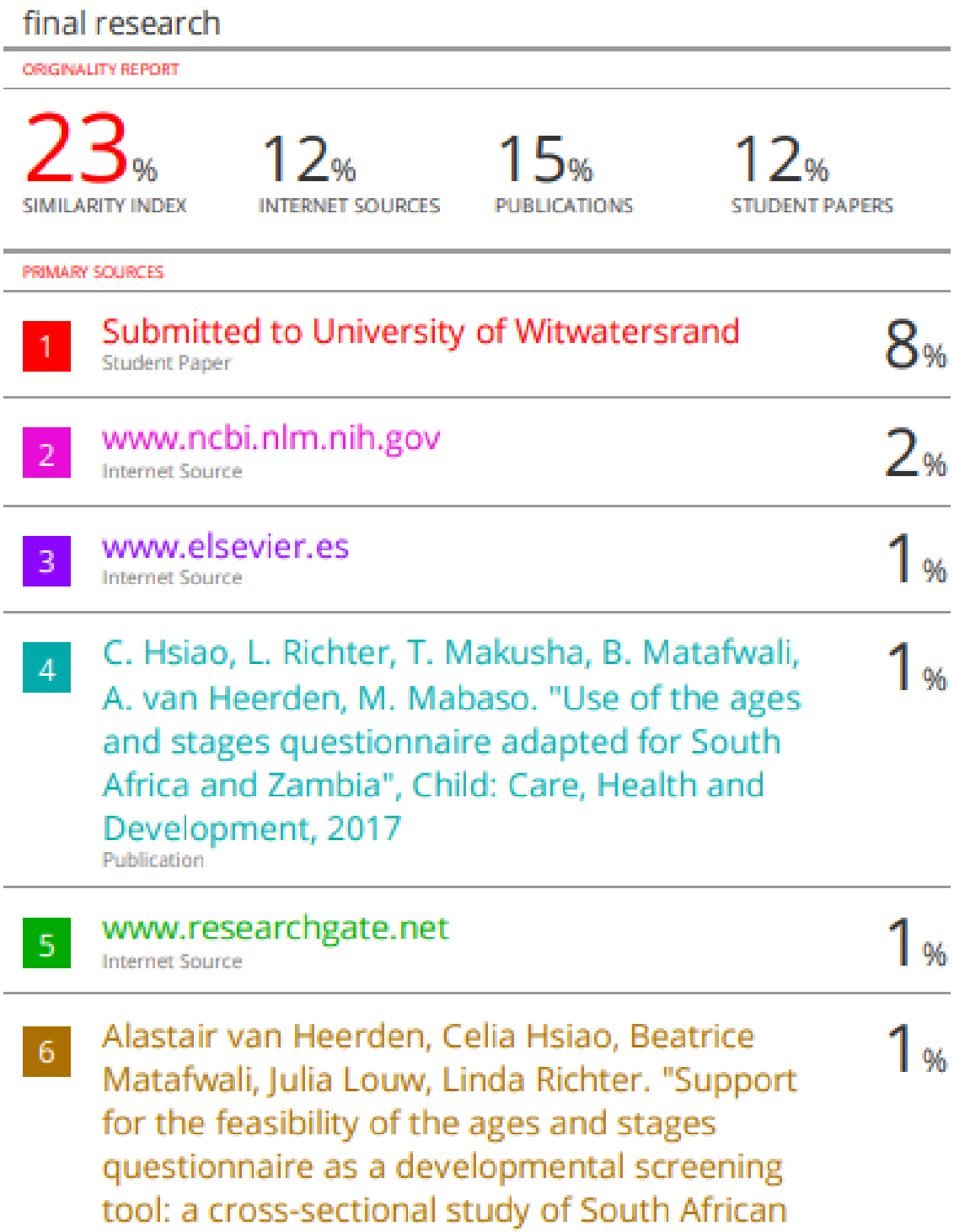
APPENDICIES

APPENDIX A- Turnit in Report



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ORIGINALITY REPORT

23%	12%	15%	12%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to University of Witwatersrand Student Paper	8%
2	www.ncbi.nlm.nih.gov Internet Source	2%
3	www.elsevier.es Internet Source	1%
4	C. Hsiao, L. Richter, T. Makusha, B. Matafwali, A. van Heerden, M. Mabaso. "Use of the ages and stages questionnaire adapted for South Africa and Zambia", Child: Care, Health and Development, 2017 Publication	1%
5	www.researchgate.net Internet Source	1%
6	Alastair van Heerden, Celia Hsiao, Beatrice Matafwali, Julia Louw, Linda Richter. "Support for the feasibility of the ages and stages questionnaire as a developmental screening tool: a cross-sectional study of South African	1%

Turnitin report Zaheerah Omar

Please note that I have checked Ms Omar full plagiarism report. Although the final figure is high at 23% I am satisfied that the majority of items identified are common phrases and terms being identified rather than any significant pieces of work being copied. The one student paper which is identified at 8% is work previously submitted by Ms Omar.

Prof Joanne Potterton (Supervisor)

APPENDIX B- Ethical Clearance certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Miss Zaheerah Omar

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M191018

NAME: (**Principal Investigator**)	Miss Zaheerah Omar
DEPARTMENT:	Physiotherapy Charlotte Maxeke Academic Hospital
PROJECT TITLE:	A comparison of the ages and stages questionnaire-3 (ASQ-3) with the gold standard - Bayley Scales of the Infant Development III in South Africa
DATE CONSIDERED:	25/10/2019
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof J Potterton
APPROVED BY:	CB Penny Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	08/05/2020

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

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. 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.** 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 **October** and will therefore be due in the month of **October** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

10/05/2020
Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

APPENDIX C- Permission letter to the hospital

Date

REQUEST FOR PERMISSION TO CONDUCT RESEARCH AT YOUR INSTITUTION

Dear Sir/Madam

My name is Zaheerah Omar and I am a physiotherapy student at the University of Witwatersrand in Johannesburg. The research I wish to conduct for my Master's report involves "A comparison of the Ages and Stages Questionnaire (III) to the gold standard Bayley Scales of Infant Development (III) among children in South Africa." This project will be conducted under the supervision of Prof. Joanne Potterton (WITS, South Africa).

I am hereby seeking your consent to conduct developmental assessments on patients who attend the Neonatal high risk follow up clinic.

I have provided you with a copy of my research proposal which includes copies of the measurement tools, as well as consent forms to be used in the research process, as well as a copy of the approval letter which I have received from the WITS Research Ethics Committee (Human).

Should you require any further information, please do not hesitate to contact me on, cell: +27 84 351 5894, alternatively email: zaiomar786@gmail.com.

Thank you for your time and consideration in this matter.

Yours sincerely,

Zaheerah Omar

University of Witwatersrand.

APPENDIX D - Permission letter from the CEO of the hospital.

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

CHARLOTTE MAXEKE JOHANNESBURG ACADEMIC HOSPITAL (CMJAH)
Office of the Clinical Director
Enquiries: Ms. TT Mahlangu
Tel: (011) 488-3365
Email: Thandi.Mahlangu4@gauteng.gov
Physical Address: Room 262A,17 Jubilee, Parktown 2193 Postal Address: Private Bag x39, Johannesburg 2000

GP_202005_007

16th November 2020

Dear Z Omar

STUDY TITLE: A Comparison of the ages stage questionnaire (ASQ-3) with the gold standard Bayley scales of infant development III in South Africa

Permission is granted for you to conduct the above-mentioned study as described in your request provided:

1. Charlotte Maxeke Johannesburg Academic Hospital will not anyway incur or inherit costs as result of the said study.
2. Your study shall not disrupt services at the study sites.
3. Strict confidentiality shall be observed at all times.
4. Informed consent shall be solicited from patients participating in your study.

Please liaise with the HOD and Unit Manager or sister in charge to agree on the dates and time that would suit all parties.

Kindly forward this office with the results of your study on completion of the research.

Supported/Not Supported

Dr. PN Africa
Acting Clinical Director
Date: 17/11/2020

Approved/Not Approved

Ms. G Bogoshi
Chief Executive Officer
Date: 18.11.2020

APPENDIX E - Information sheet

Title: A comparison of the Ages and Stages questionnaire (ASQ-3) with the gold standard- Bayley Scales of Infant development III in South Africa.

Good day

I, Zaheerah Omar am doing research on the comparison of the Ages and Stages questionnaire (ASQ-3) with the gold standard- Bayley Scale of infant development (III) in South Africa. Research is just the process to learn the answer to a question. In this study I want to learn whether the information provided by the parent of the child correlates with that of a physiotherapist's assessment. This is a study involving research and not routine care. The study is being done because if the two tests correlate, we can implement the ASQ-3 in a clinical setting and it will save a lot of time and be more cost effective.

I am inviting you to participate in my research study during your clinic/ hospital visit with your child.

You will receive three pieces of information: an information sheet, consent form with demographic details and the questionnaire for your child's particular age group. If you agree to participate in this study you are required to complete the details in the questionnaire and consent form which will be collected by the researcher. This information sheet is for your keeping.

Procedure:

This study will be carried out at Charlotte Maxeke Academic hospital, Johannesburg, South African in the Neonatal high risk follow up clinic.

Parents (and children) who meet the inclusion criteria will be asked to complete the forms, providing us with the relevant information. Parents will complete the questionnaire for their child's particular age group and an assistant will be made available should the parent require assistance or have any queries.

Once the questionnaires are completed, it will be collected by the researcher and participants will be directed to a quiet room with the physiotherapist, where an assessment will be carried out on the infant by a trained physiotherapist, using the Bayley Scales of Infant development (III).

The time required of you for this study is +/- 1.5 hours

[The Bayley Scales of Infant development (III) has five domains (Cognition, Fine Motor, Gross Motor, Receptive Communication and Expressive Communication)]

[The Ages and stages questionnaire- 3 has five domains (Communication, Gross Motor, Fine Motor, Problem Solving and Personal Social) as well as open questions about the general health of the child where parents can indicate any concerns]

Confidentiality:

The information that is collected from this research study will be kept confidential and all data will be stored in a locked cabinet or on a password protected computer, and after a period of 5 years it will be erased and all hard copies will be shredded and discarded. You will remain anonymous, as only your child's age will be used and no names or surnames will be revealed throughout the study. You are welcome to withdraw from this study at any point in the process without reason or consequence.

I thank all participants for your time and contribution towards this study. Participants are welcomed to approach the researcher with any questions or concerns associated with any aspect of this research study.

Contact details of researcher– for further information / reporting of study related adverse events you can e-mail me Zaheerah Omar at 723274@students.wits.ac.za .

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 Professor Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@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

APPENDIX F - Consent form

School of Health Sciences - Department of Physiotherapy

Consent form

I_____(Name) agree that this study has been explained to me and I understand what the study is about. I agree to take part in this study and for my baby to be assessed by Zaheerah Omar. I understand that my information will be kept private and that I can withdraw from the study at any time.

Date:_____Signature of parent: _____

Date:_____Signature of witness: _____

Date:_____Signature of researcher: _____

APPENDIX G - Demographical information

- Age of the child:

  _____

- Age of the parent:

  _____

- Gender of the child:

  _____

- Educational level of the parent:

  _____

- Gestational age

  _____

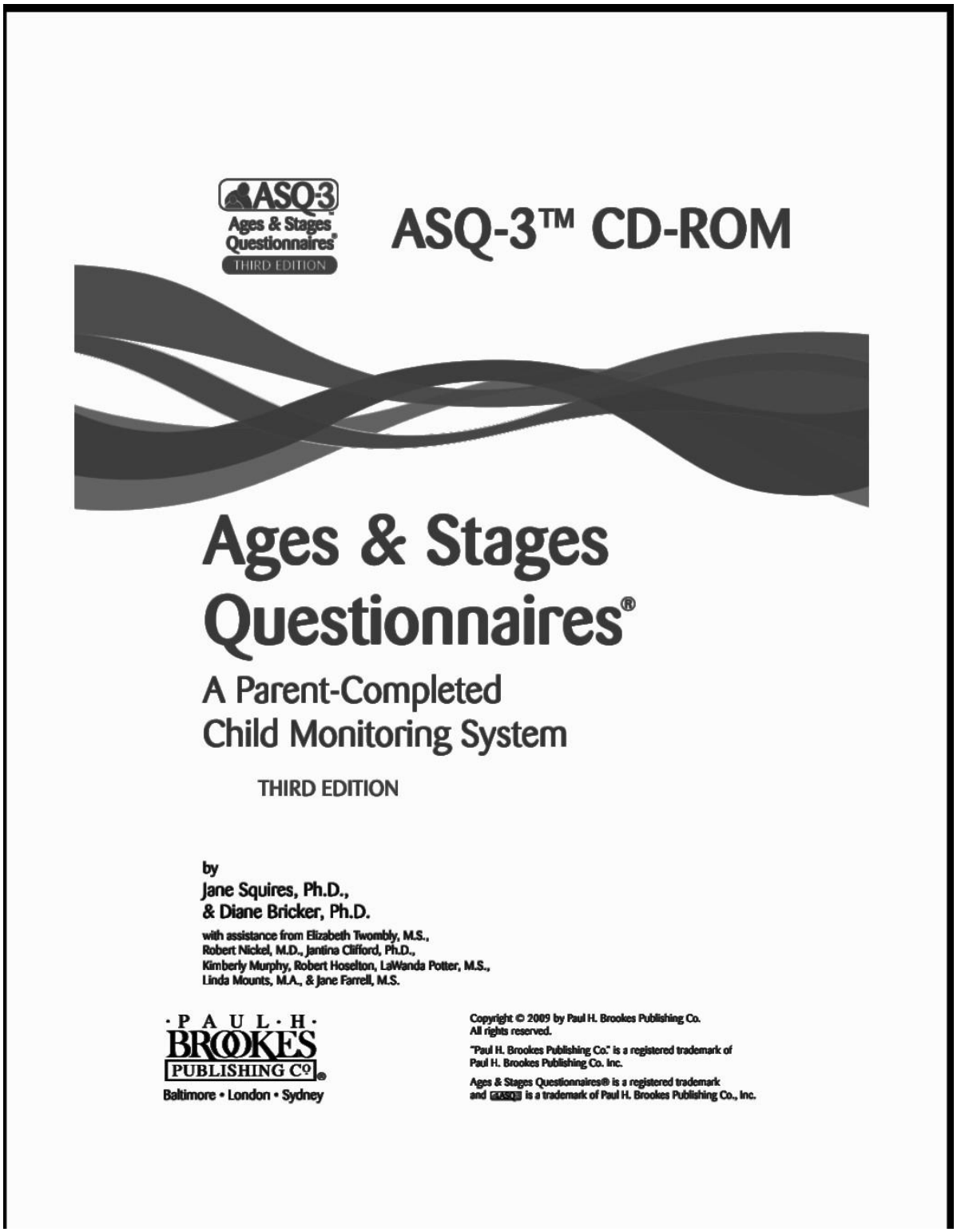
- Employment status

  _____

- Home language spoken

  _____

APPENDIX H – The Ages and Stages Questionnaire-3



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& Diane Bricker, Ph.D.

with assistance from Elizabeth Twombly, M.S.,
Robert Nickel, M.D., Jantina Clifford, Ph.D.,
Kimberly Murphy, Robert Hoselton, LaWanda Potter, M.S.,
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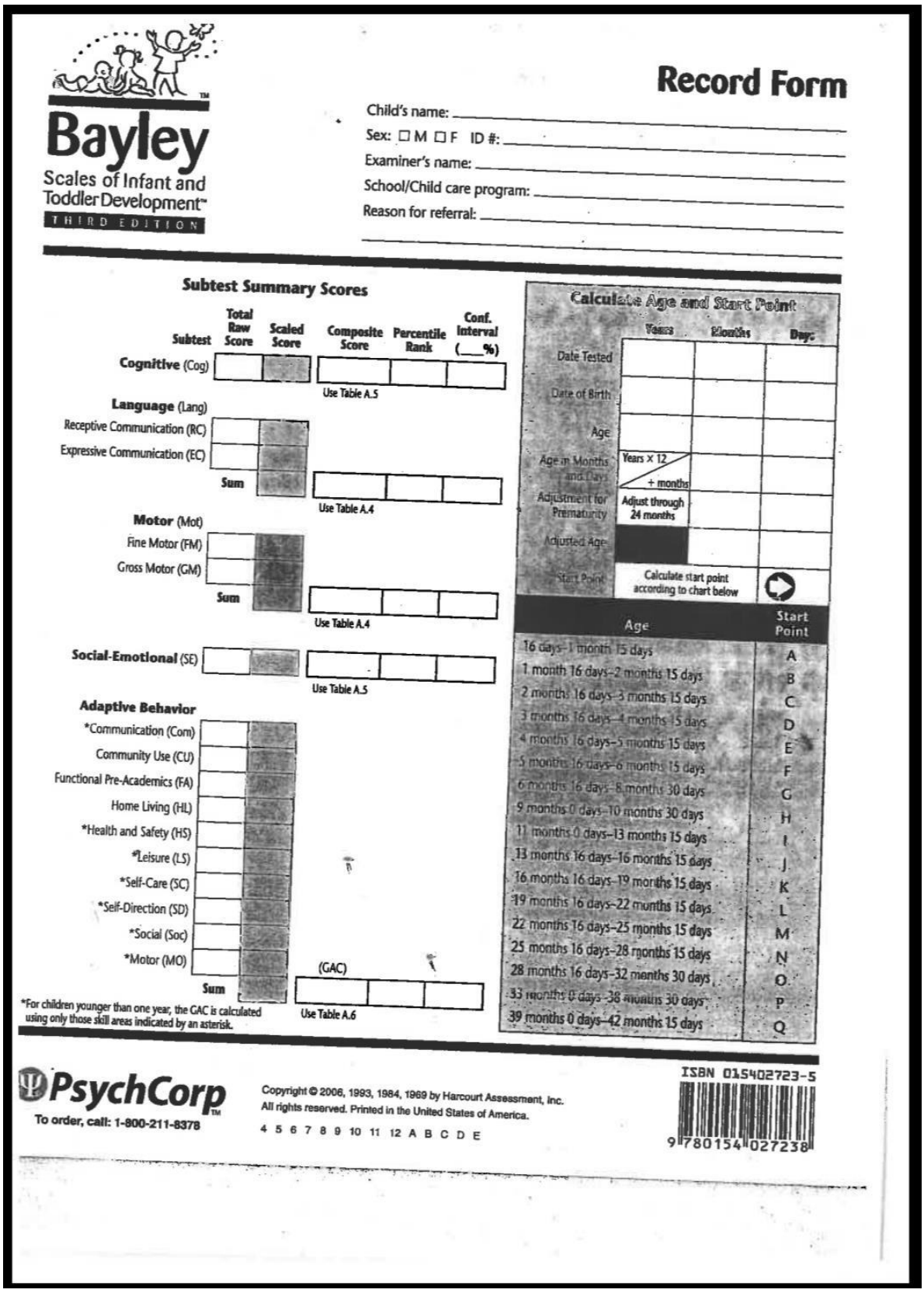
APPENDIX I – The Bayley Scales of Infant Development –III



Bayley
Scales of Infant and Toddler Development™
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Record Form

Child's name: _____
Sex: ☐ M ☐ F ID #: _____
Examiner's name: _____
School/Child care program: _____
Reason for referral: _____

Subtest Summary Scores

Subtest	Total Raw Score	Scaled Score	Composite Score	Percentile Rank	Conf. Interval (___%)
Cognitive (Cog)					
			Use Table A.5		
Language (Lang)					
Receptive Communication (RC)					
Expressive Communication (EC)					
Sum					
			Use Table A.4		
Motor (Mot)					
Fine Motor (FM)					
Gross Motor (GM)					
Sum					
			Use Table A.4		
Social-Emotional (SE)					
			Use Table A.5		
Adaptive Behavior					
*Communication (Com)					
Community Use (CU)					
Functional Pre-Academics (FA)					
Home Living (HL)					
*Health and Safety (HS)					
*Leisure (LS)					
*Self-Care (SC)					
*Self-Direction (SD)					
*Social (Soc)					
*Motor (MO)					
Sum			(GAC)		
			Use Table A.6		

*For children younger than one year, the GAC is calculated using only those skill areas indicated by an asterisk.

Calculate Age and Start Point

	Years	Months	Days
Date Tested			
Date of Birth			
Age			
Age in Months and Days	Years x 12 + months		
Adjustment for Prematurity	Adjust through 24 months		
Adjusted Age			
Start Point	Calculate start point according to chart below		

Age	Start Point
16 days–1 month 15 days	A
1 month 16 days–2 months 15 days	B
2 months 16 days–3 months 15 days	C
3 months 16 days–4 months 15 days	D
4 months 16 days–5 months 15 days	E
5 months 16 days–6 months 15 days	F
6 months 16 days–8 months 30 days	G
9 months 0 days–10 months 30 days	H
11 months 0 days–13 months 15 days	I
13 months 16 days–16 months 15 days	J
16 months 16 days–19 months 15 days	K
19 months 16 days–22 months 15 days	L
22 months 16 days–25 months 15 days	M
25 months 16 days–28 months 15 days	N
28 months 16 days–32 months 30 days	O
33 months 0 days–38 months 30 days	P
39 months 0 days–42 months 15 days	Q

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APPENDIX J- Summary of developmental assessment tools

Tool	Purpose and age range	Domains measured	Psychometric properties
The Denver Developmental screening tool	Assesses the motor development in children aged zero to six years (Von Wielligh and Van Rensburg, 2012).	Linguistic skills, fine motor skills, gross motor skills and personal-social skills (Von Wielligh and Van Rensburg, 2012).	Good content validity, face validity and inter-observer reliability. Intra-observer reliability showed moderate to good reliability (k.0.4) (Gladstone, et al., 2007).
The Road To Health Booklet	An initiative of the Department of Health to advance service delivery to children. The RTHB is a booklet kept by the parents to monitor and record growth and development of the child (Van Der Linde, et al., 2015). Birth to 5 years of age is assessed.	Gross motor, fine motor and language (Van Der Linde, et al., 2015).	Sensitivity of 25% and specificity of 91% (Van Der Linde, et al., 2015).
The Infant Gross Motor Screening Test (IGMST)	It is a gross motor test used to assess HIV-infected children between six to 18 months of age (Hilburn, Potterton, Stewart and Becker, 2010).	Gross motor (Hilburn, Potterton, Stewart and Becker, 2010).	Content validity of 80% agreement; concurrent validity of Kappa 0.85; sensitivity of 97.4% and specificity of 85.7%; a positive predictive value (PPV) of 92.7% and negative predictive value (NPD) of 94.7%; good inter-rater, test-retest and intra-rater reliability. It is a valid and reliable tool to screen for gross motor delay in children infected with HIV (Otten, 2018).
The Kilifi Developmental Inventory (KDI)	Assesses physical and cognitive skills aged 6 months to 6 years (Abubakar, et al., 2008; Mathe, 2011; Fischer, Morris, and Martines, 2014; Kitsao-Wekulo, et al., 2016).	Locomotor, Eye-Hand Coordination and Executive Function (Mathe,2011).	Sensitivity of 89% and a specificity of 91%. Concurrent Validity, r (87) = 0.80 (Abubakar, et al., 2010).
The Red Cross War Memorial	detects moderate to severe developmental	fine motor, gross motor,	sensitivity of 78.6% and specificity of 54.6%. The positive predictive value was

Children's Hospital developmental screening tool	delay in HIV-infected children aged 9 to 36 months (Boyede, Eley and Donald, 2015).	communication, social and additional sections for warning signs and action taken. (Boyede, Eley and Donald, 2015).	42.3% and negative predictive value was 87.5% (Boyede, Eley and Donald, 2015).
The Griffiths Mental Development Scales—Revised (Griffiths Scales)	assesses children from birth to 23 months (baby scale) and 24 months to 8 years for the extended scale (Johnson and Marlow, 2006).	Locomotor, Personal—Social, Hearing and Language, Eye and Hand Coordination, and Performance (Johnson and Marlow, 2006).	The psychometric properties are poor, with reports of the test—retest reliability being poor for the first year and inter-scorer reliability and validity not being provided (Johnson and Marlow, 2006).

Tool	Description
The Mullen Scales of Early Learning (MSEL)	This is the preferred tool to use in children with Autism spectrum disorder. It looks at 5 domains (Gross Motor, Fine Motor, Visual Reception, Receptive Language, Expressive Language) and is normed for children between 0-68 months of age. Its takes between 15-60 minitues to be carried out (Libertus and Landa, 2013).
the Peabody Developmental Motor Scales (PDMS-2)	This tool is used to assess gross and fine motor development. It takes between 45-60 minutes to complete (Libertus and Landa, 2013).

The Child Development Inventory – CDI	The CDI was created from the Minnesota Child Development Inventory – MCDI which was created to collect data from parents on the developmental status of children between 1-6 years of age. The CDI was adjusted for children aged 15-78 months old. 270 items are assessed in the following groups, Social, Self Help, Gross Motor, Fine Motor, Expressive Language, Language Comprehension, Letters, and Numbers. In the section on general development, parents note problems and concerns pertaining to vision, hearing, health, eating, sleeping, toilet training, motor coordination problems, speech and language problems, behaviour problems, attention problems and emotional problems. Sensitivity was shown to be 50% and specificity of 86% with a positive predictive value of 50% and negative predictive value of 76% (Nikolić, et al., 2016).
The Minnesota Infant Development Inventory – MIDI	The MIDI is another tool to have been developed from the MCDI. The MIDI was designed to assess children from birth to the age of 15 months in regards to gross motor, fine motor, language, comprehension, and personal-social domains. It has a high sensitivity of 58% and specificity of 77% (Nikolić, et al., 2016).
The Preschool Development Inventory (PDI)	The PDI is a standardised tool developed for children aged 3-5 years to detect health, developmental or behavioural problems. Domains looked at are motor, language, self-help and social behaviour. There are 3 more sections in which parents are able to describe the child, provide their observations and report and concerns or problems that the child may have. Gender is acknowledged in this tool with the development of certain skills. The PDI is however the least sensitive to motor variations in development and the occurrence of socio-emotional problems. It has a sensitivity of 68% and specificity of 88% with a positive predictive value of 41% (Nikolić, et al., 2016).

The Test of Gross Motor Development-2 – TGMD-2	This is a standardised tool developed to measure gross motor development for children between the ages of 3-10 years. It takes 15-20 minutes. 12 gross motor skills are assessed consisting of 2 subtests. The first is locomotor (run, gallop, hop, leap, horizontal jump, and slide) and the second focuses on object control ways (two-hand strike, stationary bounce, catch, kick, and overhand throw). Motor sequence is closely monitored as opposed to the execution of the task. The TGMD-2 is also used to assess speech and language disorders, developmental coordination disorders, attention deficit hyperactivity disorder, autistic spectrum disorder visual impairments and intellectual disability (Nikolić, et al., 2016).
The Movement Assessment Battery for Children – Movement and Movement ABC-2	These were derived from the Test of Motor Impairment (TOMI) and the Oseretsky Scales for the Motor Capacity of Children. These tools assess basic motor development and is helpful when detecting problems of functional integration or with problems in primary school. The age range for these tests are 4- 12 years of age. Three categories of movement are assessed (manual dexterity, ball skills, and balance skills (static and dynamic). It takes 20-30 minutes to conduct. The movement ABC-2 is for children aged 3-16 years old. It is a valid and reliable tool to assess movement as well as assess the effectiveness of intervention (mainly used for children with developmental coordination disorder) (Nikolić, et al., 2016).
The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP)	The BOTMP is an assessment tool used to assess fine motor and gross motor development. The revision of this instrument is The Bruininks-Oseretsky Test of Motor Proficiency. Both tests are used to detect mild-moderate motor coordination problems. The first version was for ages 4-15 years while the second version is for children aged 4- 21 years. Domains in the Bruininks-Oseretsky Test of Motor Proficiency are fine motor precision, fine motor integration, manual dexterity, bilateral coordination, balance, running speed and agility, upper-limb coordination and strength. It takes 45-60 minutes to conduct. This test has to

	be carried out by a trained individual (Nikolić, et al., 2016).
The Test of Infant Motor Performance (TIMP)	The TIMP was developed in 2001 for the use in Neonatal Intensive Care Units and early intervention programs for premature children and those at risk for developmental delay. It is a test assessing motor function in children aged 34 weeks postmenstrual age to 17 weeks corrected age (Campbell, et al., 2013).
The Mullen Scales of Early Learning (MSEL)	The MSEL assesses fine motor, visual reception, receptive language, expressive language and gross motor components in children from birth to 68 months of age. Its quick to conduct and requires a trained individual to conduct it. The psychometric properties are adequate, however, the normative data was standardised 15-23 years ago and is now outdated (Johnson and Marlow, 2006).
The Battelle Developmental Inventory II (BDI-II)	The BDI-II assesses personal-social, adaptive, motor, communication and cognitive domains from birth to 8 years of age. It can be conducted by individuals without training, that being said, result interpretation needs to be done by a trained individual. The BDI-II can be adapted through its guidelines for those with physical, visual, or hearing impairments, without compromising the tests normative values. The psychometric properties are better than that of the first edition (Johnson and Marlow, 2006).