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# The accuracy of the denver developmental screening test II in identifying developmental delay in high risk newborns at Charlotte Maxeke Johannesburg Academic Hospital

**Madini, Katlego Babo Boitumelo Jostinah**

**2020**

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# THE ACCURACY OF THE DENVER DEVELOPMENTAL SCREENING TEST II IN IDENTIFYING DEVELOPMENTAL DELAY IN HIGH RISK NEWBORNS AT CHARLOTTE MAXEKE JOHANNESBURG ACADEMIC HOSPITAL

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand,

Johannesburg, in partial fulfilment of the requirements for the degree of Master of Medicine in

the Branch of Paediatrics

Johannesburg 2020

# DECLARATION

I, Katlego Babo Boitumelo Jostinah Madini, declare that this Research Report is my own, unaided work. It is being submitted for the Degree of Master of Medicine in the Branch of Paediatrics at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

_____

Signed on this _20th_day of __August__20__20_in _Modderfontein

# DEDICATION

To the loves of my life, and my No.1 motivations

Takatso “Abraham” Madini

Nkitsi Yekarah Madini

Zoe Madini

Bulawa “Beez-Beez” Madini

# PRESENTATIONS

None

# ABSTRACT

## Background

The Denver Developmental Screening Test II (Denver II) is used to assess the development of high risk newborns at a tertiary hospital in Johannesburg.

## Aim

This article aims at assessing the accuracy of the Denver II in identifying developmental delay in high risk newborns. The Bayley Scales of Infant and Toddler Development III (BSID III) is used as a gold standard test, to determine the level of agreement between the two tests.

## Method

This is a retrospective descriptive study. The study population consisted of both normal and high risk neonates born between 1 July 2013 and 31 December 2015. The results of infants that had both a Denver II and a BSID III were assessed.

## Results

The sensitivity of the Denver II in identifying developmental delay was 14.8% and 44.0% for a BSID III composite score cutoff of <85 ("at risk"), and <70 ("handicapped") respectively. The Denver II had a specificity greater than 90%.for both BSID III composite cutoff values.

The agreement between the results of the two tests were represented by a Kappa value of 0.111 for the BSID III assessed as "at risk" ($p = 0.014$), and 0.423 for the BSID III assessed as "handicapped" ($p < 0.000$).

## Conclusion

The Denver II is not accurate in identifying developmental delay. There is a slight to moderate agreement between the Denver II and the BSID III tests. The Denver II is not a suitable screening test for use in South African infants, and further research is required.

# ACKNOWLEDGEMENTS

Gratitude to Supervisor, Professor Daynia Ballot, and Co-supervisor, Dr Tanusha Ramdin for the mentorship and guidance, as well as to the University of the Witwatersrand Paediatric Research Department (PRINCE Programme) for use of facilities and assistance.

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# ABBREVIATIONS

| | |
|---|---|
| BSID III | Bayley Scales of Infant and Toddler Development Third Edition |
| CMJAH | Charlotte Maxeke Johannesburg Academic Hospital |
| Denver II | Denver Developmental Screening Test Second Edition |
| HIV | Human Immunodeficiency Virus |
| REDCap | Research Electronic Data Capture |
| RTHB | Road-to-Health Booklet |

# *The Accuracy of the Denver Developmental Screening Test II in Identifying Developmental Delay in High Risk Newborns at Charlotte Maxeke Johannesburg Academic Hospital*

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## Abstract

The Denver Developmental Screening Test II (Denver II) is used to assess the development of high risk newborns at a tertiary hospital in Johannesburg.

## Aim.

This article aims at assessing the accuracy of the Denver II in identifying developmental delay in high risk newborns. The Bayley Scales of Infant and Toddler Development III (BSID III) is used as a gold standard test, to determine the level of agreement between the two tests.

## Methods.

This is a retrospective descriptive study. The study population consisted of both normal and high risk neonates born between 1 July 2013 and 31 December 2015. The results of infants that had both a Denver II and a BSID III were assessed.

**Results**.

The sensitivity of the Denver II in identifying developmental delay was 14.8% and 44.0% for a BSID III composite score cutoff of <85 ("at risk"), and <70 ("handicapped") respectively. The Denver II had a specificity greater than 90%.for both BSID III composite cutoff values.

The agreement between the results of the two tests were represented by a Kappa value of 0.111 for the BSID III assessed as "at risk" ($p = 0.014$), and 0.423 for the BSID III assessed as "handicapped" ($p < 0.000$).

**Conclusion**.

The Denver II is not accurate in identifying developmental delay. There is a slight to moderate agreement between the Denver II and the BSID III tests. The Denver II is not a suitable screening test for use in South African infants, and further research is required.

## Background

There are over 200 million children in low- and middle-income countries worldwide that have developmental delay; the prevalence of which is on the increase due to the recent and continuous advancements in obstetric and neonatal management protocols, resulting in the increased survival of high risk neonates [1]. Owing to the burden on the educational and health services, the American Academy of Paediatrics and many health agencies worldwide recommend developmental surveillance and screening as a means for early identification of infants with disabilities [2]. Thus far, developmental or behavioral screening does not fulfill the epidemiological criteria for effective screening tests [3], and very few screening tools have demonstrated an improvement in developmental outcomes. Even the best screening tests have a relatively low sensitivity and specificity of 70-80%, and recent efforts have looked at implementing alternative programs that can enhance child development without the use of a screening tool [3].

By definition, a screening test should be relatively cheap, easy to perform, simple, and acceptable [3]. In South Africa, the only nationally implemented developmental screening tool is integrated as part of "The Road to Health Booklet (RTHB) and even this tool has been demonstrated to be ineffective to identify developmental delay in infants at risk [1]. The Denver Developmental Screening Test II (Denver II) is one of the best known brief measures of childhood development for ages 2 to 72 months [4]. The Denver II describes childhood development into four domains: Personal-Social, Language, Fine Motor-Adaptive and Gross Motor, and expresses these domains as age norms, similar to that of a growth curve. The Denver identifies a child as being normal or suspect. If the screening test is suspect, further formal developmental testing is recommended.

The Denver II has been standardized in a few different countries, but not yet in South Africa. There has been some research nationally involving this tool, but its potential to be utilized as a reliable screening tool in the South African setting is limited by concerns relating to its validity, sensitivity, specificity and cultural relevance [5]. There have been efforts in research to standardize this tool in a non-western low income country of Africa, such as Ethiopia, with the aim to make it socially and culturally relevant [6]. The Denver II has also been shown to be a useful preschool screening tool to assess for school readiness [7].

Due to its inexpensiveness and ease of use, the Denver II is potentially an ideal screening tool to be used in healthcare facilities across the country.

The Bayley Scales of Infant and Toddler Development Tool III (BSID III) is a well-accepted tool that assesses the development of infants and toddlers of ages 1 to 42 months [8]. The BSID III assesses the cognitive scale, the language scale, the motor scale, the social-emotional scale, and the adaptive-behavioral scale [8]. It takes approximately 60 to 90 minutes to complete, and requires a qualified personnel trained in implementing the tool and interpreting the results. An assessment of one or each of the scales can be done by stepwise implementation of tasks within that scale, to evaluate the child's development. For each scale, a score is assigned for all activities or tasks that the child was able to successfully complete. Each area of development can be evaluated using the scale score, and certain cut-off values used to classify the development. The BSID III reports the individual child's performance for that domain in comparison to a standard population. A score of 100 is average, below 70 is handicapped, and above 130 superior. The BSID III has been used extensively in South African research, and has somewhat been regarded as a gold-standard test with regards to infant and child development [9]. The BSID III has been utilized in studies assessing the development of HIV (Human Immunodeficiency Virus) infected children [10], and to describe the developmental outcome of very low birth weight infants [11]. The BSID III has also been used nationally to assess the development of healthy children in South Africa [12]. Through its involvement in national research, the BSID III is accepted as a reliable tool for assessing development in children in South Africa.

The aim of the current study is to assess the accuracy of the Denver Developmental Screening Test II in identifying developmental delay in a group of infants, so as to better describe its potential to be used as a reliable screening tool in the South African setting.

## Methods

This was a secondary analysis of an existing database performed at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH). The study population consisted of a group of infants who had attended a developmental follow up clinic. These infants included those with no neonatal problems, as well as those who were admitted to the neonatal unit for various problems.

The Caesarian section rate at CMJAH is relatively high because CMJAH is a tertiary academic institution that receives and manages a variety of complicated high risk pregnancies, some of which result in emergency delivery via Caesarean sections, neonatal resuscitation at birth, perinatal asphyxia, and complications relating to prematurity. The records of infants born between 1st July 2013 and 31st December 2015 were reviewed. Those infants who had both a Denver II and a BSID III assessment were included. Infants with known syndromes such as Trisomy 21 were excluded. Preterm infants had a corrected age calculated by adjusting their chronological age minus the number of weeks or months that he or she was born prematurely. The study infants were seen three monthly at a developmental follow up clinic. The Denver II was assessed at 4 to 6 months corrected age, and a BSID III assessed at 9 to12 months and again at 15 to 18 months corrected age. It was anticipated that a number of infants would be lost to follow up after one year of age, so the Denver II was used mainly as a screening tool during the first few visits following discharge from hospital, and the assessments were not repeated at all subsequent follow-ups. The BSID III gold standard test was used mainly to describe the developmental outcomes of these high risk newborns at an older corrected age. The Denver II and BSID III assessments were performed by either a physiotherapist or a pediatrician trained in neurodevelopmental assessment.

**Statistical analysis**

Information from each follow up visit, including the Denver II and BSID III results, was entered into a computerized database. Data was managed using the Research Electronic Data Capture (REDCap) [13] database, hosted by the University of the Witwatersrand. Data was exported into IBM SPSS 25 for statistical analysis. The Denver II results were reflected as either suspect or normal. The BSID III results were reported using the composite score for each domain. A composite score less than 70 in any of the three domains was considered "handicapped", and less than 85 was classified as "at risk". For the purpose of the primary aim, in infants who had more than one Denver II or BSID II assessment, the first Denver II assessment results and the last BSID III assessment results were used.

Continuous data was described using means and 95% confidence intervals or median and range, depending on the distribution. Categorical data was described using frequencies and percentages. The sensitivity and specificity for the Denver II test was calculated.

The Kappa Statistic was used to determine the agreement between the Denver II and BSID III results. A Kappa value of 1 would indicate perfect correlation and of 0 indicate no correlation between the two tests. The Denver II was compared to the infants identified as at risk, and also those classified as handicapped based on the BSID III score.

## Ethics

The study was approved by the Human Research Ethics Committee of the University of the Witwatersrand: Clearance Certificate number M160712. The study was a retrospective analysis of an existing database, so the need for written informed consent was waived.

## Results

A total of 4426 infants were born between 1 July 2013 and 31 December 2015. Of this number, 353 infants had at least one developmental follow up clinic visit. There were 278 infants that had at least one Denver II assessment and 279 had at least one BSID III assessment. There were 237 infants who had both a Denver II and a BSID III assessment performed during their follow up.

The mean gestational age at delivery of the study infants was 35 weeks (95% CI 34.22 – 35.36). The mean birth weight of the infants was 2 221 g (95% CI 2 107 – 2 335 g). Bag mask ventilation at birth was required in 30.4% (72/237) of the study infants. Perinatal asphyxia with hypoxic ischemic encephalopathy was diagnosed in 18.1% (43/237) of the study infants. The first Denver II was assessed at a mean corrected age of 3.3 months (95% CI 2.9 – 3.6) The last BSID III assessment was performed at a mean corrected age of 17.4 months (95% CI 16.9 – 18.0).

The majority of the infants were male: 125/237 (52.7%). Most infants: 112/237 (47.3%) were delivered by Caesarean section.

The Denver II results compared to the BSID III groups “at risk’ and “handicapped” are shown in Tables 1 and 2. Firstly, the Denver II results are compared to the BSID III results in the group assessed using a composite score of below 85 as “at risk”. Secondly, the Denver II results are compared to the BSID III results in the group assessed using a composite score of less than 70 for “handicapped”.

**Table 1: Denver II compared to "at risk" infants identified on BSID III (<85)**

| | | BSID III Result | |
|---|---|---|---|
| | | **Normal (149)** | **At risk (88)** |
| **Denver II Result** | **Normal** | 141/149 (94.6%) | 75/88 (85.2%) |
| | **Suspect** | 8/149 (5.3%) | 13/88 (14.8%) |

**Table 2: Denver II compared to "handicapped" infants identified on BSID III (<70)**

| | | BSID III Result | |
|---|---|---|---|
| | | **Normal (212)** | **Delayed (25)** |
| **Denver II Result** | **Normal** | 202/212 (95.3%) | 14/25 (56%) |
| | **Suspect** | 10/212 (4.7%) | 11/25 (44%) |

The accuracy of the Denver II and its agreement to the BSID III is represented in Table 3.

**Table 3: The accuracy of the Denver II in identifying developmental delay**

| BSID III | Sensitivity of the Denver II | Specificity of the Denver II | Kappa Value | P value |
|---|---|---|---|---|
| 'At Risk" | 14.8% | 94.6% | 0.111 | 0.014 |
| "Handicapped" | 44% | 95.3% | 0.42 | <0.001 |

## Discussion

This study conducted in Johannesburg, South Africa, evaluated the accuracy of the Denver II as a screening tool to identify infants that were "at risk" or "handicapped". The results of the Denver were compared to the BSID III. Although the Denver II was highly specific, the sensitivity was poor. The Denver II over-estimated the presence of delay in normal infants, and underestimated the delay in infants with developmental delay. The sensitivity of the Denver II improved somewhat in the group of infants classified as "handicapped" on the BSID III, indicating that this is a more reliable test for identifying infants with significant developmental

problems. There are several possible reasons for the poor performance of the Denver II in this study.

Firstly, it is possible that the Denver II may have been a more accurate screening tool in a group of high risk infants with a higher prevalence of handicap, rather than the heterogeneous study group. That is to say that the Denver II may not be suitable for developmental screening in a population of normal infants.

Secondly, the Denver II's poor performance may relate to the different ages at which the Denver II and BSID III assessments were done. Perhaps, comparing the results of the Denver II and BSID III tests performed at the same corrected age at follow up, would have given a better reflection of the accuracy of the Denver or in identifying development delay.

Thirdly, there has been some concern that developmental assessments performed at a very young age is less predictive of later outcome [14].

The poor correlation of the Denver II with the BSID in the present study are in agreement with reports of other screening tools. The Bayley III Screening Test [15] and the Ages and Stages Questionnaire [16] have also been poorly predictive of the BSID III assessment.

## Conclusion

This present study shows that the Denver II is not accurate in identifying developmental delay in a group of infants in Johannesburg, South Africa. This poor performance by the Denver II could be due to inadequacies in the test itself, or factors relating to how the results of the two tests were compared.

## Limitations

It is possible that the classification of "at risk" and "handicap" in the present study could have influenced the performance of the Denver II. In this study, the BSID III classification of "at risk' or "handicap" referred to a composite score in any of the three domains, rather than global delay in all domains. It would be expected that the Denver II would be more accurate in identifying infants with global delay.

The results of the Denver II performed at 4 to 6 months corrected age were compared to the BSID III results performed at 9 to 12, and 15 to 18 months corrected age. Perhaps, comparing

the results of the two tests performed at the same corrected age would have given a better reflection of the accuracy of the Denver II in identifying developmental delay.

**Competing Interests**: None declared

**Patient consent:** Not required

**Ethics approval:** The study was approved by the Human Research Ethics Committee of the University of the Witwatersrand.

**Acknowledgement and thanks:** Supervisors, PRINCE programme and mentors.

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