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Prevalence of developmental delay and associated risk factors among At Risk Surveillance System children at United Bulawayo Hospitals, Zimbabwe

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Abstract

Globally, 8.4% of children under five years of age have developmental disorders, with sub-Saharan Africa having the highest prevalence. In Zimbabwe, the At Risk Surveillance System (ARSS) follows up on babies with known developmental risk factors for early detection of developmental delay. This study aimed to determine the prevalence and severity of developmental delay in children under the ARSS at United Bulawayo Hospitals (UBH). A descriptive cross-sectional study systematically sampled 160 babies enrolled in the ARSS between 2019 and 2020. The Bayley Scales of Infant and Toddler Development Third Edition (BSID-III) tool was used to assess cognitive, motor, and language domains. Developmental delay risk factors were also noted from caregivers' and patients' files. A prevalence of 83.7% developmental delay was established in our sample, the majority of whom had mild developmental delay. The most important risk factors for developmental delay in all three domains were neonatal convulsions (Adjusted Odds Ratio, aOR, 5.6, p=0.03), Apgar scores of <5 (aOR 2.6, p=0.02), and being a boy (aOR 7.1, p<0.001). Developmental delay of 83.7% is higher than in previous findings because children included in this study had known risk factors for developmental delay, which were similar to those identified by other studies. Children with the most important risk factors need close monitoring as they have a high chance of developmental delay. Children with known risk factors should be closely monitored using the BSID-III, while the rest can be screened using cheaper and faster tools such as the Ages and Stages Questionnaire (ASQ).

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Introduction

Child development is the process by which a child grows from a helpless infant to an independent adult. The ability to perform specific tasks at a given age compared to the performance of the general population at that age is known as normal development. Development is categorized into cognitive, gross and fine motor skills, speech and language, socio-emotional, and behavioral domains. If two or more of these domains are delayed, it is referred to as global developmental delay.[1] Developmental delay is when a child fails to attain expected developmental milestones for their age group.[2] There is strong evidence supporting good outcomes when there is early identification and intervention of developmental delay.[1,3,4] An estimated 30-50% of developmental disorders are identified late, at school-going age, hence making any intervention less effective.[5]

Early childhood development is a major global issue that has to be addressed. In the development of a child, the prenatal and postnatal periods are crucial.[6] Globally, 8.4% of children below the age of five have developmental disorders, 95% of which reside in Low-and-Middle-Income Countries (LMICs). Sub-Saharan Africa has the highest developmental delay prevalence, constituting 73% of the global developmental delay.[7]

Zimbabwe has a disability prevalence of 7%, 25% of which are in children below the age of five.[8] In Bulawayo, Zimbabwe, a

cross-sectional study of 142 At Risk babies with Apgar score of ≤5 at five minutes of life were assessed at one year using The Bayley Scales of Infant and Toddler Development First Edition (BSID-I); 165 were assessed using the Neonatal Neurological Examination (NNE). A 26% developmental delay prevalence was found using the BSID-I scale in children with low Apgar score of ≤5 within the first five minutes of birth, with a Confidence Interval (CI) of 95%.[9]

It is recommended to follow up At Risk (AR) babies, such as preterm babies, after discharge from Neonatal Intensive Care Units (NICU) for developmental screening. Early identification and intervention with therapies (such as physiotherapy, occupational therapy, and speech therapy) are associated with a good developmental outcome.[10] Western-developed assessment tools can be adapted to non-Western countries with good inter-rater and test-retest reliability.[11] The BSID is the gold standard developmental assessment tool and has been tried and tested in Bulawayo in assessing children with low Apgar scores. It was found to be comparable to the NNE tool and correctly classified the level of child development in 94% of the cases.[9] It has been further tested in the black Zimbabwean population and adequately assessed development in HIV-exposed babies in Harare in the domains of motor, language, and cognitive development.[12]

In Zimbabwe, the At-Risk Surveillance System (ARSS) aims to identify children with neurological developmental conditions and disability in the first five months, or the latest twelve months of life. Children who are found to have developmental challenges are referred for early intervention.[13] Dzvukamanja *et al*.[14] reviewed the ARSS in Chimhanda district, Zimbabwe, and found that it was 88% acceptable, affordable, simple (the AR form took an average of 10 minutes to complete), and 97.7% useful.

This study aimed to determine the prevalence and severity of developmental delay in children under the ARSS at United Bulawayo Hospitals. Risk factors that are associated with developmental delay were also to be established.

Materials and Methods

Study design and setting

The design used for this study was a descriptive cross-sectional study carried out at United Bulawayo Hospitals. This hospital was established in 1937. The hospital is one of the largest five central hospitals in Zimbabwe and is in Bulawayo, the second largest city in the country.

Study population

The study population included all babies between two months and five years old who were enrolled in the ARSS at United Bulawayo Hospitals between 2019 and 2020.

Study sample and sampling

A total of 160 babies who met the inclusion criteria were systematically selected from 271 babies who had been enrolled in the ARSS at United Bulawayo Hospitals between 2019 and 2020.

Data collection

A self-developed data collection tool was used to collect information from patient records (birth registers, baby cards), parents/caregivers (for obvious information that may be absent from records, such as the baby's position of birth in the family), and developmental assessment findings. The BSID-III tool was used to assess the development of each child in the following developmental domains: cognitive, motor (both fine and gross), and language (both receptive and expressive) areas. These three domains were adopted from the study in Harare, which also used the BSID-III to assess developmental delay in Human Immunodeficiency Virus (HIV)-exposed and infected children.[12,15] The principal investigator administered the BSID-III, and the research assistant (who was sufficiently trained by the principal investigator) helped file completed research data collection sheets.

Data management and analysis

Statistical package STATA (version 15.0 for Windows) software developed by StataCorp (College Station, USA) was used to clean data for errors of entry and to analyze data. Normally distributed continuous variables were summarized by the mean and Standard Deviation (SD) at a 95% CI. Skewed data was described using the mean and interquartile range. Before running regression models, the analysis followed a pre-determined strategy. The BSID-III measured the early childhood development outcome scores in three developmental domains, which are motor (gross and fine combined), cognition, and language/communication (expressive and receptive combined). The severity of developmental delay was classified based on the flowing BSID-III composite ranges: Normal (≥85), Mild (70-84), Moderate (55-69), and Severe (<55). We used a BSID-III cut-off score of less than 85 to define developmental delay, leading to two categories of developmental delay (score <85) and no developmental delay (score ≥85) as in other studies.[12,16,17] The frequency with percentages was used for categorical data. Categorical variables association (association between risk factors and developmental delay) was tested, and the Chi-square (X^2) test was used. A p-value of ≤0.05 indicated a strong association between the risk factor and developmental delay.

Separate logistic regression for each domain was used to analyze developmental delay outcome data. Odds Ratio (OR) was presented with 95% CI. A complete case analysis approach was used since we had no missing data. Initial models were adjusted for maternal level of education, child sex, and child age (months) since they are factors proven to impact child development outcomes in all three developmental domains. Other covariates, ranging from socio-demographic and environmental factors to maternal and child physical characteristics, were added in blocks. To reduce Akaike Information Criteria (AIC), covariates from each block were picked using the STATA 15.0 "gvselect" command.

Results

Socio-demographic characteristics

All 160 enrolled babies, of whom 94 (58.7%) were males, had completed the BSID-III assessment.

The mean age for the mothers was 30.2 (SD: 5.4) years; 90% were married, while 10% were either widowed or not married. The majority lived in urban areas, with 74.4% staying in high-density suburbs of Bulawayo City.

The mean age of children who completed the BSID-III assessment was 8.6 (SD: 6.4) months. Tables 1 and 2 present the maternal demographics and characteristics of those children completing three domains of the BSID-III (cognition, language, and motor).

Risk factors for developmental delay

Of the 160 babies, a total of 49 (30.6%) were preterm babies, with 47 (29.4%) having been exposed to HIV, 42 (26.3%) having had Apgar scores <5 at both the 1st and 5th minute. A total of 34 (21.3%) were recorded to have experienced severe neonatal jaundice.

Child development assessment outcomes

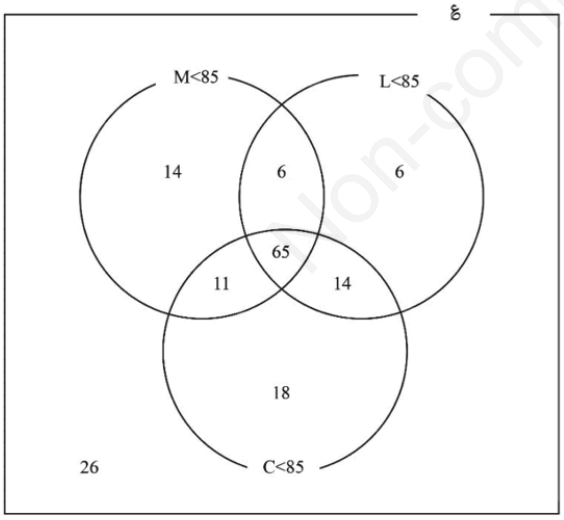
Table 3 shows child development outcomes in the three domains during the first 24 months. On composite scores, girls exhibited higher scores than boys, translating to significantly lower mean score differences for boys than girls. Higher percentages of poor development outcomes (*i.e.,* a composite score below 85) were observed for boys compared to girls.

Child development delay outcome classification by severity

Table 4 shows developmental delay classification by severity for the children in the ARSS at United Bulawayo Hospitals. Girls were significantly more likely to score in the normal category.

Child development delay outcome classification by affected domain

A total of 134/160 (83.7%) children among those assessed were categorized as having developmental delays in at least one domain. The Venn diagram (Figure 1) shows the categorization among the three developmental domains. A total of 96 out of 160 (60.9%) were categorized as having motor delay, 91 out of 160 (56.8%) as having language delay, and 108 out of 160 (67.5%) had a delay in cognitive development. Overall, 96 children from the 160 (60.0%) were classified as having delays in ≥2 domains; the combination of language and cognitive delay was the most common, with 79 children (49.4%). There were 65 children (40.6%) who were delayed in all three domains.



Key: ξ = Total number of babies assessed using BSID-III = 160
M<85 = Set of babies with a composite score of less than 85 in Motor
L<85 = Set of babies with a composite score of less than 85 in Language
C<85 = Set of babies with a composite score of less than 85 in Cognition

Figure 1. Venn diagram showing domains affected by developmental delay.

Table 1. Socio-demographic characteristics of mothers of babies enrolled in the study (n=160).

Variable	
Maternal age in years (Mean, SD)	30.2 (5.4)
Marital status of mother	n (%)
Married	144 (90.0)
Widowed	5 (3.1)
Single	11 (6.9)
Education: secondary and above	n (%)
Mother	
Yes	133 (83.1)
No	27 (16.9)
Father	
Yes	131 (81.9)
No	18 (11.2)
Not indicated	11 (6.9)
At least one parent employed	n (%)
Yes	137 (85.6)
No	23 (14.4)
Medical aid cover for the child	n (%)
Yes	41 (25.6)
No	119 (74.4)
Residential area	n (%)
Urban/High density	119 (74.4)
Low density	32 (20.0)
Rural	9 (5.6)
Maternal mental health status at birth of child	n (%)
Good	157 (98.1)
Poor	3 (1.9)

SD, Standard Deviation.

Table 2. Characteristics of babies who completed Bayley Scales of Infant and Toddler Development Third Edition (BSID-III) developmental assessment (n=160).

Variable	
Child sex	n (%)
Male	94 (58.7)
Female	66 (41.3)
Child age in months (Mean, SD)	8.6 (6.4)
Position of birth in family	n (%)
First	44 (25.5)
Second	61 (38.1)
Third or more	56 (34.4)
Preterm (<37 weeks of gestation): n (%)	49 (30.6)
Mode of delivery	n (%)
Normal vaginal delivery	68 (42.5)
Forceps delivery	9 (5.6)
Vacuum extraction	10 (6.3)
Emergency C-Section	73 (45.6)
Birth head circumference (cm), Mean, [Range]	34.2 [28-54]
Birth length (cm), Mean, [Range]	47.8 [29-58]
Birth weight (grams), Mean [Range]	2718.7 [1020-4150]
Mode of feeding in the first 6 months	n (%)
Exclusive breastfeeding	135 (84.4)
Bottle feeding	19 (11.9)
Solids	6 (3.7)

Risk and protective factors for child development

Logistic regression modeling identified risk factors for developmental delay in each of the three domains. Compared to girls, boys were at increased risk of developmental delay in all domains in bivariate analyses, and these associations held when adjusted for confounders in the multivariable model, with cognitive delay (Adjusted Odds Ratio, aOR 4.3; 95% CI 1.8-10.2, p=0.001), receptive language delay (aOR 2.4, 95% CI 1.1-5.3, p=0.034) and motor delay (aOR 4.6, 95% CI 2.1-10.2, p<0.001). Increased age since birth was associated with apparent and significant language and motor delay in both girls and boys. The logistic regression results are depicted in Table 5.

Child physical factors at birth

In the multivariable final model, children with lower birth weight and born through an emergency cesarean section were associated significantly with lower developmental composite scores or higher odds of delay in the motor domain. Children born with a lower weight (<2500 grams) were nearly six times at risk of motor developmental delay (aOR 5.9; 95% CI: 1.7-20.41, p=0.005), while those who had been delivered through an emergency cesarean were more than four times at risk of motor developmental delay when compared to those who were delivered through normal vaginal delivery (aOR 2.4; 95% CI: 1.8-9.5, p=0.001).

Child birth conditions

Child conditions at birth, which were risk factors for lower developmental scores or higher odds of delay, included Apgar scores <5 (both at 1st and 5th minute after birth). This was associated with cognition developmental delay of more than four times (aOR 4.6; 95% CI: 1.4-15.6, p=0.014) compared to children born with normal Apgar scores. Also, these children were more than twice at risk of higher odds of language delay (aOR 2.4; 95% CI: 1.01-5.64, p=0.05) compared to children with normal Apgar score measurements at birth. Increased birth weight was associated with significantly greater scores and lower odds for developmental delays in this sample. Those children who had delivery complications were at very much higher risk of language developmental delay of up to 17 times more (aOR 17.1; 95% CI: 2.8-146.7, p=0.01) compared to children with no delivery complications.

Socioeconomic factors and developmental delay

Good socioeconomic status and older maternal age were protective factors for reduced risk of cognitive delay. Having at least one of the child's parents employed was significantly associated with higher composite scores and reduced risk of cognitive developmental delay (aOR 0.2; 95% CI: 0.04-0.54, p=0.004) compared to children with both parents not employed.

Developmental delay in all three domains

A total of 65 (40.6%) children had developmental delays in all

Table 3. Child development outcome mean composite scores during the first 24 months (n=160).

Developmental subscale	Total n=160	Male n=94	Female n=66	p
Motor				
Mean score (SD)	77.4 (18.9)	73 (18.9)	83.7 (17.2)	0.001
Poor motor outcome, n (%)	96 (60.0)	68 (72.3)	28 (42.2)	
Language				
Mean score (SD)	78.7 (17.0)	75.6 (18.7)	83.1 (13.0)	0.003
Poor language outcome, n (%)	91 (56.9)	63 (67.0)	28 (42.4)	
Cognition				
Mean score (SD)	77 (16.4)	74.3 (17.2)	80.9 (14.6)	0.006
Poor cognitive outcome, n (%)	108 (67.5)	72 (76.6)	36 (54.6)	

SD, Standard Deviation.

Table 4. Child development delay outcome classification by severity according to composite score.

Developmental subscale	Total n=160	Male n=94	Female n=66	p
Motor		n (%)		
Normal (≥85)	64 (40.0)	26 (27.7)	38 (57.6)	0.001
Mild delay (70-84)	40 (25.0)	26 (27.7)	14 (21.2)	
Moderate delay (55-69)	36 (22.5)	27 (28.6)	9 (13.6)	
Severe delay (<55)	20 (12.5)	15 (16.0)	5 (7.6)	
Language	n (%)			
Normal (≥85)	69 (43.1)	31 (33.0)	38 (57.6)	0.001
Mild delay (70-84)	43 (26.9)	29 (30.8)	14 (21.2)	
Moderate delay (55-69)	33 (20.6)	19 (20.2)	14 (21.2)	
Severe delay (<55)	15 (9.4)	15 (16.0)	-	
Cognition	n (%)			
Normal (≥85)	52 (32.5)	22 (23.4)	30 (45.5)	0.006
Mild delay (70-84)	62 (38.8)	38 (40.4)	24 (36.4)	
Moderate delay (55-69)	46 (28.7)	34 (36.2)	12 (18.2)	
Severe delay (<55)	-	-	-	

three domains. Of these, most were boys, 54 (83.1%). Neonatal convulsions (aOR 5.6; 95% CI: 1.2-25.7, p=0.03), an Apgar score of <5 at both 1st and 5th minute after birth, (aOR 2.6; 95% CI: 1.1-5.8, p=0.02) and being a boy, (aOR 7.1; 95% CI: 3.2-15.7, p<0.001) were risk factors for developmental delay in all the three domains.

Discussion

A substantial prevalence of at least one domain of developmental delay among the three domains has been reported in this sample in 83.7% of participants, much higher than in previous studies. This can be explained by the fact that all of the children included in this study were known to have development risk factors. Different settings could have also contributed to the differences, as our study was done in Bulawayo, a unique setting compared to previous studies. The child-nurturing environment is known to contribute to child development.

On classification for severity of developmental delay, significant delay (moderate and severe combined) in motor development was observed in 35% of this sample, which is lower than 77.5% reported by Baillieu and Potterton[16] in HIV-infected children.

Table 5. Associated risk and protective factors for developmental domain outcome for composite score.

	Cognition		Language		Motor	
	Unadjusted OR [95% CI]' p	Adjusted OR [95% CI], p	Unadjusted OR [95% CI], p	Adjusted OR [95% CI]' p	Unadjusted OR [95% CI] p	Adjusted OR [95% CI] p
A priori factors						
Child sex: boy	2.7 [1.4–5.4] p=0.004	4.3 [1.8-10.2] p=0.001	2.8 [1.4-5.3] p=0.002	2.4 [1.1-5.3] p=0.034	3.5 [1.8-6.9] p<0.001	4.6 [2.1-10.2] p<0.001
Child age			1.1 [1.05-1.2] p<0.001	1.1 [1.05-1.2] p<0.001	1.1 [1.01-1.13] p=0.014	1.1 [1.01-1.15] p=0.023
Physical factors						
Head circumference			1.2 [1.1-1.4] p=0.007	1.1 [0.98-1.32] p=0.075		
Birth weight (<2500 g)					2.5 [0.96-6.74] p=0.06	5.9 [1.7-20.4] p=0.005
Delivery mode						
Vacuum extraction					2.5 [0.6-10.4] p=0.215	2.4 [0.5-11.4] p=0.288
Emergency C-Section					2.8 [1.4-5.7] p=0.004	4.1 [1.8-9.5] p=0.001
Risk factors at birth						
Both Apgar scores <5	2.1 [0.9-4.8] p=0.078	4.6 [1.4-15.6] p=0.014	2.3 [1.1-5.0] p=0.029	2.4 [1.01-5.64] p=0.05		
Severe prematurity (birth weight <1500 g)	0.1 [0.03-0.4] p=0.001	0.1 [0.04-0.6] p=0.006	0.2 [0.1-0.7] p=0.011	0.3 [0.1-1.4] p=0.118		
Term baby with delivery complications			11.3 [1.4-88.9] p=0.021	17.1 [2.8-146.7] p=0.01		
Socioeconomic factors						
At least one parent working	0.47 [0.2-1.1] p=0.095	0.2 [0.1-0.5] p=0.004				
Maternal age	0.8 [0.7-0.8] p<0.001	0.8 [0.7-0.9] p<0.001				

OR, Odds Ratio; CI, Confidence Interval.

Similarly, for cognitive developmental delay, a lower proportion was observed in significant developmental delay, with 28.7% compared to over 50% reported in other studies.[16,17] These differences could be attributed to the inclusion of several risk factors in this study compared to other studies that included HIV alone as a risk factor. Infection by HIV contributes to developmental delay, which is multifactorial due to the impact of the virus itself, exposure to ARVs, the condition of the caring mother, and many others.[12,18]

In our sample, key factors associated with developmental delay in all three domains at <24 months of age included male gender, having experienced neonatal convulsions, and having an Apgar score of <5 both at 1st and 5th minute after birth. Our findings are similar to the related literature, highlighting some of the risk factors for developmental delay in the three developmental domains. The risk factors were similar to those identified by Donald *et al*.[19]

Boys performed poorly compared to girls, who had significantly lower composite scores in all three developmental domains. Correspondingly, boys had an increased risk of developmental delay in each of these developmental delays.[19] This is similar to our study findings and other studies that explored developmental performance in children exposed to developmental delay risk factors at birth, as described in a large multicountry study assessed over a period of time.[20]

Neonatal seizures were associated with delayed development in all three domains (40.6% had delayed development in all three domains in our study). Seizures are known to contribute to developmental delay.[21] Similarly, another study that looked at developmental delay in children with neonatal seizures found that 43% had global developmental delay.[22]

Apgar scores of <5 both at 1st and 5th minute after birth were associated with developmental delay in all three domains. It was associated with cognitive developmental delay more than four times. They were also more than twice at risk of language developmental delay. Low Apgar scores of ≤5 define birth asphyxia,[23] which is a known cause of Hypoxic-Ischemic Encephalopathy (HIE), which causes damage to the immature brain, leading to neurological problems.[24,25]

Children with severe neonatal jaundice significantly contributed to developmental delay in our sample. This is similar to the findings from other studies.[21,26,27]

HIV exposure was found in 29.4% of our sample. Babies showed significant developmental delay in our sample. This is well supported by other studies in sub-Saharan Africa, which concluded that HIV exposure contributes to child developmental delay. However, developmental delay is more in HIV-infected babies compared to HIV-uninfected babies born to HIV-infected mothers because neonatal infections are known causes of developmental delay.[12]

Babies who had delivery complications were at a very high risk of language developmental delay, up to 17 times more compared to children with no delivery complications. Delivery complications such as difficult labor are fully established causes of developmental disorders due to the bearing they have on fetal distress and asphyxia.[28-30] In a similar study conducted in India, a high developmental delay odds ratio was also reported in babies with a history of delivery complications.[25]

Lower birth weight was associated with increased delay in motor and language in both boys and girls. The weight contribution is similar to the study findings by Abdel Khalek *et al*.,[26] in which very low birth weight was associated with developmental delay.

Older maternal age was associated with a significant reduction in cognitive development delay in our study. This supports evidence from the literature that vulnerability to developmental challenges is reduced with increasing maternal age from 15 to 35 years. This age-related advantage lapses beyond 35 years.[31,32]

The importance of social determinants in childhood development is fully described.[33-36] Our findings are similar to those of Donald *et al*.[19] in the South African population, who observed that good socioeconomic standing was protective against poor developmental delay. The socioeconomic status in our study tallies with the typical African population from similar studies in Sub-Saharan Africa.

This study's most important risk factors were low Apgar scores of <5 in the first five minutes, neonatal convulsions, and being a male child. These differed from Abdel Khalek *et al*.[26] in the Egypt study investigating developmental delay in children born with AR factors. They discovered that babies with cyanosis (OR 16.391), low birth weight (OR 6.147), parental consanguinity (OR 5.489), first birth order (OR 4.048), urban residence (OR 3.702), and neonatal jaundice (OR 2.518) had significantly higher odds of developing delayed milestones in the logistic regression model. This can be attributed to different settings.

Conclusions

The majority of children in the ARSS presented with developmental delays in all three domains. Children exposed to risk factors had a higher chance of having developmental delays. Children with the most important risk factors (boys with low Apgar scores and/or neonatal convulsions) should be closely monitored in the ARSS. They should be assessed using meticulous tools such as the BSID-III as they have a high chance of having a developmental delay in all three domains. The findings of this study support the need for ongoing developmental monitoring and assessment of infants at UBH. The inclusion of an interdisciplinary rehabilitation team is strongly recommended to effectively address developmental delays in motor, language, and cognition.

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