Socio-Demographic Predictors of Neuro-Neurocognitive Development in Breast-Fed and Formula-Fed Infants at Chilenje First Level Hospital in Lusaka

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ABSTRACT

Background: Research on the association between feeding type and child neurocognitive development presents conflicting results, with some studies reporting positive effects while others find no significant impact. Socio-demographic characteristics may help explain these discrepancies. This study aims to examine the socio-demographic factors that predict neurocognitive development in breast-fed versus formula-fed infants

Methods: A cross-sectional study was carried out on 31 six months old singleton infants (21 breastfed, 10 formula-fed) with their primary caregivers attending under five clinics at Chilenje First Level Hospital in Lusaka. Infants' cognitive behaviours, receptive communication, and expressive communication language development were assessed using the Bayley Scales of Infant Development III, the primary caregivers completed a structured questionnaire on socio-demographics. Statistical analysis was conducted using SPSS version 20.

Results: Results demonstrated that breast-fed infants had significant higher mean scores on the cognitive behaviours domain (11.48 vs 7.50, p= .03), and the receptive language domain (8.48 vs 6.50, p= .02). A regression analysis showed that unemployment strongly predicted receptive language and accounted for nineteen percent of variability (r=.44, r^2=.19, p=.01). Unemployment had a moderately positive relationship and accounted for sixteen percent of the variability in expressive language (r=.39, r^2=16, p=.03).

Conclusions: Our study found that breastfeeding significantly enhances certain domains of neurocognition. Breastfed infants exhibited superior cognitive behaviours, receptive and expressive language skills. In addition, six-month-old infants with unemployed primary caregivers performed better in both receptive and expressive language communication.

Keywords: Neurocognitive development, breast feeding, formula feeding, BSID III.

Abbreviations:

AHHI: Annual Household Income

BSID III: Bayley Scales of Infant and Toddler Development, Third Edition

HRA: Hierarchical Regression Analysis

SES: Socio Economic Status

BACKGROUND

Neuro-neurocognitive development is concerned with the study of the biological processes and aspects that underlie cognition, with a specific focus on the neural connections in the brain which are involved in mental processes. It addresses the questions of how cognitive activities, (such as attention, memory, executive functioning, language development, problem solving, reasoning, and many more) are affected or controlled by neural circuits in the brain. Cognitive functions are closely linked to the function of particular areas,

neural pathways, or cortical networks in the brain substrate layers of neurological matrix at the cellular molecular level[1]. Reduction or impairment of cognitive function in one of these areas can lead to a deficit.

There are a number of factors that impact an infant's (cognitive) development such as biological (e.g., child birth weight, nutrition, and infectious diseases), socio-economic (e.g., parental assets, income, and education), environmental (e.g., home environment, provision of appropriate play material, and access to healthcare), and psychosocial (e.g., parental mental health, parent-child interactions, cognitive stimulation, and learning opportunities)[2]. It is important to note that nutrition is a major factor which can impact on infant development as it implicates the complexity of the brain networks[3]. As a source of nutrition in infants, breast milk has overtime been emphasized as its benefits extend well beyond basic nutrition. In addition to containing all the vitamins and nutrients needed, it is packed with disease-fighting substances that protect infants from illnesses, and breastfeeding is modifiable as a health behaviour[4]. However, it is also true that infant formulae have become common over time. Unmodified cow's milk formulae are no longer used in infant feeding, and instead low-electrolyte low-protein formulae are recommended[5]. However safe our present-day products may be, it is important to bear in mind that the quality of baby food is as good as the science and technology at that time.

Infant development can be used to measure normality and predict future outcomes in children. Typically developing infants follow a certain pattern of development. Deviations from this are common and considered normal in different populations. This means there is a range of normal development[6]. Infants with abnormal development will show deviations from the typical pattern(s) of development. The prevailing consensus from large-scale epidemiological studies is that children who are breastfed perform, on average, higher on tests of cognitive functioning than do children who are exclusively formula-fed, even when factors such as birthweight, gestation duration, and maternal education and socioeconomic status (SES) are accounted for[4]. However, literature has shown that association between breastfeeding and child cognitive function can be largely explained by socio-demographic factors, parental lifestyle, and confounding factors such as maternal intelligence quotient (IQ).

Neurocognitive developmental differences among breastfed and formula fed infants has also been linked to the development of brain structures, magnetic resonance imaging (MRI) scans have shown that breastfed children exhibit increased white matter development in later maturing frontal and association brain regions[7]. These neuropsychological findings are complemented by morphometric brain imaging studies in adolescents, showing volumetric increases in total white matter, sub-cortical grey matter, and parietal lobe cortical thickness in those who were breastfed as infants[7]. Previously of interest in demyelinating diseases such as multiple sclerosis, myelin is attracting new interest as an unexpected contributor to a wide range of cognitive dysfunction. White matter has got its involvement in normal cognitive function, learning and IQ[8]. It remains unknown when structural differences in white matter in humans first manifest and when developmental differences that predict later performance improvements can be detected. Myelination continues for decades in the human brain; it is modifiable by experience and affects information processing by regulating the velocity and synchrony of impulse conduction between distant cortical regions[8].

Statement of the Problem

The potential benefit of breast milk to enhance neurocognitive development had been the focus of numerous studies since Hoefer & Hardy's initial observation in 1929[9]. It was generally agreed that children who were breastfeed were more intelligent. However, the debate remained whether this was a causal relationship or merely an association with favourable parental socioeconomic class and cognition. Additionally, the prevailing consensus from large-scale epidemiological studies was that children who were breastfed perform, on average, higher on tests of cognitive functioning than do children who were exclusively formula-fed, even when factors such as birthweight, gestation duration, maternal education, and SES are accounted for[4]. Further, there was also conflicting literature showing that association between infant feeding and child cognitive function could largely be explained by socio-demographic factors, and other confounding variables[4]. Therefore, this study was conducted to examine socio-demographic factors as predictors of neuro-neurocognitive development between breast-fed and formula-fed infants at Chilenje Fiest Level Hospital in Lusaka.

Aim of the Study

This study aimed to investigate the socio-demographic predictors of neurocognitive development, focusing on cognitive behaviors and both receptive and expressive language development, in infants who were breast-fed versus those who were formula-fed.

Specific Objectives

1. To examine the differences in neurocognitive development including cognition, receptive and expressive language between breast-fed and formula-fed infants.
2. To determine the association between sociodemographic factors and neurocognitive development including cognition, receptive and expressive language among breast-fed and formula-fed infants.

Research Hypothesis

There is no significant difference in cognitive behaviors and language development between breast-fed and formula fed infants. Socio-demographic factors are the significant predictors of cognitive behaviors and language development

Significance of the Study

There was need to carry out a study on neuro-neurocognitive development in infants who are breast-fed and formula-fed, specifically in this part of the world where breast feeding has been on the decline[9]. Findings provided insight into the earliest neurocognitive development with regards to type of feeding, they also provided insights on the effects of socio demographics on neurocognition which are necessary for early identification of neurocognitive deficits and would allow for early management of problems arising in childhood[10].

Theoretical Framework

This research was guided by two underlying theoretical perspectives namely the the Information processing theory by George Armitage Miller[11], and Jean Piaget's theory on stages of neurocognitive development[12]. The information processing theory is a cognitive psychology theory that studies mental processes involved in acquiring, storing, and using knowledge. It focuses on the flow of information as it is passed from one stage to another within a person's mind[13]. The sensorimotor stage, according to Piaget, ranges between 0-2 years, infants are only aware of what is right in front of them. They learn with their senses and motor skills, focusing on what they see and do (visual and physical interactions) within their immediate environment[14].

Information-Processing Theory

The information-processing theory addresses how as children grow, their brains likewise mature, leading to advances in their ability to process and respond to the information they receive through their senses. Attention is a core concept in psychology, and a fundamental component in the information processing models for infant cognition. As a topic of its own right, attention owns to the convergent use of behavioural and psychophysiological measures in the study of infants' response to stimuli[15]. Another component in the infant information processing model is visual habituation- the decline in infant attention to stimulation that is increasingly familiar[16].

Piaget's Theory on Stages of Cognitive Development

According to Piaget, the sensorimotor stage is the first stage in the growth and development. During this stage children have the basic structure of organizing and adapting to their environment and their behaviour tend to be circular and develop an elementary understanding of the things around. It is the stage where an infant acquires language, which enhances their social and intellectual development[14]. This stage is the form of thought or intelligence as observed in the child`s actions, they are constantly experimenting because they don't yet know how things react, they shake or throw things, put things in their mouth, and learn about the

world through trial and error. The later substages include goal-oriented behaviours that leads to a desired result. For instance, the child may cry to see if they will be attended to. Between the ages of 5-8 months, infants begin to realize that an object exists even though they can no longer see it. This critical milestone, known as object permanence, is a sign that the child is developing memory. For example, the infant learns that when you leave, you still exist, and you will be back. They may also look for a toy when it's not with them because they know it still exists. They may also show stranger anxiety or fear of unfamiliar faces as they develop object permanence. They may cry and cling to parents or other familiar faces when strangers are around[14].

METHODS

Research Design

This study used a matched cross-sectional study design with a quantitative approach. The study was also comparative and correlational in nature. This design was appropriate in that this was an observational study in which two existing groups differing in feeding status were compared in neurocognitive development status while also examining the association between sociodemographic factors and neurocognitive development.

Study Site

The study was conducted in Lusaka at Chilenje urban clinic situated at Chilenje First Level Hospital. The study site was representative of infants from diverse backgrounds i.e. SES, giving a platform for many socio demographic factors to be accounted for.

Study Sample

The total sample included 31 infants (20 breast fed and 11 formulae fed). The participants were six months old singleton infants who had been brought for regular under-five clinic services at Chilenje First Level Hospital. This group gave us insight into the earliest neurocognitive development of human beings. Enrolment required that the infant was either exclusively breastfed or exclusively formula fed for the first four months after birth, had no birth defects, no traumatic brain injury, was not malnourished and was within the normal weight range.

Data Collection Procedure

Participants were identified with the help of a nurse who then referred them for participation in the study. After the participants were selected, the primary care givers were informed with a brief outline of the study's purpose and significance and were offered the participant information sheet. Thereafter, they were asked to formalise the exercise by signing an ascent form. Demographic data was gathered from the caregivers. Thereafter, the Bayley scale of infant and toddler development was then administered to the infants in the presence of the caregivers.

Data Collection Instrument

Neurocognitive development was assessed using the Bayley Scales of Infant and Toddler Development, Third Edition (BSID III)[17]. The infants' cognitive behaviours, receptive and expressive language development were measured. The Bayley is a standardized individually administered instrument that assesses the developmental functioning of infants and young children between 1 month and 42 months of age[17]. Its primary purposes are to identify children with developmental delays and to provide information for intervention. The Bayley-III assesses across five domains: Cognitive, Language, Motor, Social-Emotional, and Adaptive Behaviour[16]. For this study, a total number of nineteen test items (items number 16- 34) from the BSID III cognition scale, twelve items (items number 3- 14) from the receptive language scale and the first nine from the expressive scale (items number 1- 9) were used. A child is then given a score of one for each test item they managed to perform and zero for those they could not manage.

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Statistical Analysis

The data was analysed using SPSS version 20.0. Descriptive statistics were primarily used to generate socio demographic factors. Independent samples t tests were used to compare the performances of the two groups on the Bayley scales of cognition, receptive and expressive language. Pearson correlation was used to estimate the association between sociodemographic factors and child performance. Regression analysis was performed to examine the sociodemographic predictors of neurocognitive development, more specifically the sociodemographic factors that predict infants' cognition, receptive and expressive language was measured.

Ethical clearance and consideration

The study was approved by the National Research Authority, the University of Zambia Biomedical Research Ethics Committee, the Republic of Zambia Ministry of Health, and the Chilenje First Level Hospital Administration. At all stages of the study from data collection and data analysis ethical considerations such as confidentiality were carefully followed. Participants gave written consent after receiving a briefing from the researcher about the research. The primary caregivers were also informed that they were free to withdraw their infant from the assessment.

RESULTS

Socio Demographics of Primary Caregivers

All the caregivers were the infants' biological mother. Caregiver age ranged between 20 to 43 years (Mean = 26.9 years; SD = 4.7 years), and almost half (45%) had attained a tertiary education. Most of the primary caregivers (42%) were unemployed and most of them (84%) were married. About a third of the participants (35%) earned ZMW 51,000 or above as their annual family income. More than half the infants assessed were first born children (54.8%).

Table 1: Social Demographic Characteristics of Respondents

	N	Percentage (%)
Age Group of Primary Care		
20-25yrs	13	42
26-30yrs	11	35
31-35yrs	6	19
36-40yrs	0	0
41-45yrs	1	3
Gender of assessed Infant		
Female	14	45
Male	17	55
Marital Status of Primary Care Giver		
Married	26	84

Never married	5	16
Education Level of primary care giver		
Primary level	7	23
Secondary level	10	32
Tertiary	14	45
Employment Status of Primary Care Give		
Fulltime employment	9	29
Unemployed	13	42
Self employed	8	26
Part time employment	1	3
Annual Household Income		
under ZMW 10,000	9	29
ZMW 10,000 to 20,000	8	26
ZMW 21,000 to 30,000	3	10
ZMW 31,000 to 40,000	0	0
ZMW 41,000 to 50,000	0	0
ZMW 51,000 and above	11	35
Type of Delivery		
Natural birth	21	68
Caesarean birth	10	32
Type of Feeding Practiced		
Formula feeding	10	32
Breast feeding	21	68

Neurocognition of Breastfed vs Formula Fed Infants

Type of feeding significantly affected a child's cognitive behaviours (t (17.3) = 2.35, p = .03) Breast-fed infants reported higher levels of cognitive behaviours (11.48) compared to formulae-fed infants (7.50). The mean difference between the two groups was (3.98) and the 95% confidence interval for the estimated population mean difference was 0.51 (lower) and 7.44 (upper). Type of feeding significantly affected a child's receptive language development (t (29) = 2.41, p = .02). Breast-fed infants reported higher levels of receptive language development (8.48) compared to formula-fed infants (6.50). The mean difference between the two groups was (1.98) and the 95% confidence interval for the estimated population mean difference was 0.3 (lower) and 3.65 (upper). Table 2 summarizes the above results.

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Table 2 Independent samples t-test (type of feeding vs. infants' performance on the Bayley)

		t	M	MD	SD	df	p	95% Confidence Interval	
								Lower	Upper
Cognitive behaviours	Formula fed		7.5		4.5			0.51	7.44
	Breast Fed	2.35	11.5	3.98	4.37	29	.03		
Receptive language	Formular fed		6.5		2.17			0.3	3.65
	Breast fed	2.41	8.48	1.98	2.11	29	.02		
Expressive language.	Formula fed		4.5		1.84			-1.05	2.72
	Breast fed	.90	5.33	0.83	2.61	29	.32		

****p = .05. M = mean. MD= Mean Difference, SD = Standard Deviation.**

Sociodemographic Factors that Predict Neurocognitive development (Regression Analysis)

A regression analysis showed that only one socio-demographic variable demonstrated a significant relationship with neurocognitive development. Unemployment strongly predicted receptive language and accounted for nineteen percent of variability (r=.44, r^2=.19, p=.01). Unemployment had a moderately positive relationship and accounted for sixteen percent of the variability in expressive language (r=.39, r^2=16, p=.03).

Table 3 Regression analysis (socio- demographics Vs infants' performance on the Bayley)

	Cognitive behaviour			Receptive Language			Expressive Language		
	r	r^2	p	r	r^2	p	r	r^2	p
Employment status	.2	.04	.27	.44	.19	.01	.39	.16	.03
Education level	.12	.02	.51	.07	.00	.7	.27	.08	.13
Marital status	.11	.01	.54	.05	.00	.8	.03	.00	.89
Annual House Hold Income	.09	.00	.65	.11	.01	.55	.01	.00	.97
Birth order of infant	.13	.02	.48	.05	.00	.65	.35	.12	.06

****p= .05 Employment status was represented at five dummy levels with unemployed as the reference group.**

DISCUSSION

This study aimed to investigate the socio-demographic predictors of neurocognitive development in breastfed versus formula-fed infants, with objectives including examining differences in cognition, receptive, and expressive language between the groups, and determining the association between sociodemographic factors and neurocognitive development. The study found that breast-fed infants had significantly higher mean scores on the cognitive, receptive and expressive domains. Our research found that breast-fed infants had superior performance in certain neurocognitive domains, specifically cognitive behaviors and receptive language communication, compared to formula-fed infants. These results are consistent with Tawia's findings, which indicated higher IQ scores in preschoolers who were breastfed during infancy[17]. However, our study goes further by specifying the exact facets of neurocognition affected, providing deeper insights into the brain pathways influenced by feeding type.

Our regression analysis for the second objective indicated that unemployment had significant associations to both receptive and expressive language communication. This differs from earlier studies, which showed significant associations with maternal IQ and educational attainment in school-aged children [4, 18,19]. These findings imply that socio-demographic factors may impact neurocognitive development during a crucial developmental period, potentially influenced by the child's age.

The findings of this study have significant implications for both primary caregivers and healthcare professionals. By engaging in discussions about the associations between sociodemographic factors and neurocognitive development, caregivers can gain a deeper understanding of their crucial role. It is particularly important to encourage caregivers to spend more time with their six-month-old infants, as this can foster improved neurocognitive outcomes. Additionally, the study highlights the importance of reinforcing breastfeeding programs in under-five clinics, as these initiatives can play a vital role in enhancing neurocognitive development in newborns. A major strength of this study is its inclusion of a diverse population, including both breast-fed and formula-fed infants. Additionally, the studied population is representative of infants from both feeding types practiced in Zambia. However, a notable limitation is the small sample size of 31 participants, which restricts the generalizability of our results to the entire Zambian population. Despite this limitation, our study serves as a foundational basis for larger, more extensive research in the future.

The findings of this study have important implications for primary caregivers and healthcare professionals. Engaging in discussions about the association between sociodemographic factors and neurocognitive development can help caregivers understand the critical role they play. Specifically, caregivers should be encouraged to spend more time with their six-month-old infants to foster better neurocognitive outcomes. Furthermore, the study underscores the need to reinforce breastfeeding programs in under-five clinics, as these initiatives can significantly enhance neurocognitive development in newborns.

CONCLUSION

This study has demonstrated that breast-fed infants exhibit greater responsiveness in cognitive behavior and receptive language domains compared to their formula-fed peers. Additionally, it has shown that there is an association between sociodemographic factors and neurocognitive development among breast-fed and formula-fed infants. Specifically, six-month-old infants with unemployed primary caregivers performed better in both receptive and expressive language communication domains. The study supports the need to reinforce breastfeeding programs for newborn babies in the under-five clinics to enhance neurocognitive development.

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