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RESEARCH **Open Access**

Effectiveness of Exclusive Breastfeeding on Infant Growth Using Android-Based Stimulation Detection Test

Wahyuni[1a*], Irmasanti Fajrin[1b]

[1] Department of Midwifery, Poltekkes Kemenkes Manado, Manado City, North Sulawesi, Indonesia

[a] Email address: wahyuni0891@gmail.com
[b] Email address: irmasantifajrin@gmail.com

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Abstract
The future of the country depends on the optimal growth and development of children. About 10% of Indonesia's population are toddlers, and most of them experience growth and development problems. It is important to stimulate, detect and intervene in child development, including exclusive breastfeeding for 6 months. The aim of this study is to examine the effectiveness of exclusive breastfeeding on infant growth and development using the Android-based Stimulation, Early Detection, and Intervention of Child Growth and Development test. The research method utilized is an analytical cross-sectional observational design with 83 respondents purposively selected and conducted from June to August 2023. The data analysis utilized includes the chi-square test, Phi (Φ), and Cramer's V. The instruments included a checklist form, the mobile application for Stimulation, Early Detection, and Intervention of Child Growth and Development version 1.1, a weighing scale, a height measurement tool, and the Maternal and Child Health Book. The research findings indicate that there is no significant relationship between Exclusive Breastfeeding and Infant Growth (p-value = 0.737, phi/Cramer's V = 0.165). However, there is a significant relationship between Exclusive Breastfeeding and Infant Development (p-value = 0.003, phi/Cramer's V = 0.356). It can be concluded that there is no correlation between Exclusive Breastfeeding and infant growth, but there is a relationship with infant development. Therefore, it is recommended to enhance public education regarding the importance of Exclusive Breastfeeding, and further research to understand the relationship between exclusive breastfeeding and infant development, and to apply the findings for targeted intervention programs, particularly utilizing Android-based apps for easier access to information and support for mothers.

Keywords: Breastfeeding, Growth and Development, SDIDTK Test.

Corresponding Author:

Wahyuni
Department of Midwifery, Poltekkes Kemenkes Manado, Manado City, North Sulawesi, Indonesia
Email: wahyuni0891@gmail.com

1. INTRODUCTION

The first five years of life are crucial for a child's growth. This period is considered significant because it has the potential to influence and shape the course of the child's subsequent development. Stimulation is a way to monitor a child's development and growth, and the Stimulation, Early Detection, and Early Intervention of Child Growth and Development Test is one of the methods that can be used (Soetjiningsih, 2018).

Based on data provided by the WHO in 2017, there was a report indicating that 12% of all toddlers worldwide experienced growth issues (World Health Organization, 2017). The data also specified that the highest prevalence rates were found in the Southeast Asia region, reaching 14.1% (Handayani et al., 2017). Based on data from UNICEF, it was found that more than a quarter of toddlers worldwide (approximately 250 million) failed to reach their developmental milestones optimally. This data placed Asia as the third highest-ranked region after Africa and Europe (UNICEF, 2020).

According to the 2018 Riskesdas data, 4.5% of infants aged 0-23 months (children under two years of age) in Indonesia suffered from severe malnutrition, while 7.2% experienced undernutrition. Among children aged 0-59 months, 3.5% experienced severe malnutrition and 6.7% suffered from stunted growth. However, data from 2020 revealed that 55,283 (1.2%) children under two years of age experienced severe malnutrition, and 186,053 (4.1%) children under two years of age suffered from undernutrition. This data indicates a decrease in the incidence of severe malnutrition in Indonesia between 2018 and 2020 (Kementerian Kesehatan Republik Indonesia, 2021). Around 12.8-16% of Indonesian children under the age of 5 experience delays in overall development, including delays in gross motor, fine motor, language, and social aspects (Farah et al., 2021).

To address this issue, recommendations are provided by the WHO for exclusive breastfeeding for the first six months of a baby's life to ensure optimal growth and health. In Indonesia, 52% of infants under six months have reached the WHO target (50% by 2025) for exclusive breastfeeding, but only a small fraction of mothers continue until the child's second year, resulting in many Indonesian children not receiving adequate nutrition. The use of bottles in feeding increases the risk of disease, as it is difficult to maintain bottle hygiene. Additionally, complementary foods are often not suitable for the nutritional needs of the child (UNICEF, 2020).

Nationally in 2020, 66.06% of babies received exclusive breastfeeding, and in North Sulawesi Province, this figure reached 55%, exceeding the 2020 Strategic Plan target of 40%. However, North Sulawesi Province ranks eighth lowest among all provinces surveyed in Indonesia. Meanwhile, the percentage of babies receiving Early Initiation of Breastfeeding (IMD) at the national level is 77.6%, and in North Sulawesi Province, it reaches 57.6%, surpassing the national IMD target of 54% in 2020. However, North Sulawesi Province still ranks third lowest among all surveyed provinces in Indonesia (Kementerian Kesehatan Republik Indonesia, 2021).

There are internal and external factors that influence growth and development. Stimulation factor is an example of an external factor (Rantina et al., 2021). Lack of stimulation can lead to delays in growth and development, even prolonged disturbances (Kementerian Kesehatan Republik Indonesia, 2016). Based on the research findings on factors influencing the growth and development of toddlers, it was generally found that parenting style, parents' education and knowledge, family socioeconomic status, stimulation and support, nutritional intake (energy, protein, and fat), exclusive breastfeeding, history of low birth weight (LBW), habits, and the child's mood are key contributing factors (Sudarman et al., 2024). The research demonstrates that parents' awareness of Growth and Development Checks (GDC) can reduce the risk of overweight and obesity in children. Those who participate in these checks generally have lower BMI and a decreased likelihood of weight issues, highlighting the GDC's vital role in monitoring growth and promoting healthy weight in early childhood (Duan et al., 2021).

It was found that the negative effects of growth delay on the neurological development of low birth weight (LBW) infants can be reduced through appropriate stimulation. The brain development and cognitive functions of infants affected by suboptimal growth can be enhanced through quality stimulation. Furthermore, the benefits of this stimulation are experienced not only by LBW infants but also by all children, including those who are not at high risk. This research indicates that the importance of early stimulation and responsive caregiving can be overlooked if the focus is solely on nutrition. Therefore, a child's optimal development is significantly influenced by both nutrition and positive interactions between caregivers and children (Upadhyay et al., 2022).

The urgency of this research stemmed from the high incidence of growth and development problems among infants in Indonesia, largely due to the low rate of exclusive breastfeeding for infants aged 6–24 months and the limited effectiveness of stimulation practices, which are still predominantly conducted using paper-based methods. However, this study utilized the latest technology through the use of an Android-based application for Stimulation, Early Detection, and Intervention of Child Growth and Development. Preliminary data collected from the Tuminting Community Health Center revealed that there were 468 infants aged 6–24 months recorded between March 2021 and September 2022. The aim of this research was to examine the effectiveness of exclusive breastfeeding on infant growth and development using the Android-based Stimulation, Early Detection, and Intervention of Child Growth and Development test.

2. RESEARCH METHOD

This study employed a cross-sectional observational design and was conducted in the working area of the Tuminting Health Center, Manado City, from June to August 2023. The study population consisted of infants aged six to twenty-four months, with a total of four hundred sixty-eight individuals. The research sample comprised eighty-three respondents selected through a purposive sampling technique. Data collection involved completing a checklist on exclusive breastfeeding status and recording the infant's identity, age, weight, and height. This information was subsequently entered into the mobile-based application for Stimulation, Early Detection, and Early Intervention of Child Growth and Development version 1.1. Developmental assessments for infants were conducted using the Pre-Screening Developmental Questionnaire form embedded within the application. Prior to data collection, ethical approval was obtained from the Ethics Committee of the Manado Health Polytechnic of the Ministry of Health, under approval number KEPK.01/07/103/2023.

The independent variable in this study was breastfeeding status, categorized into Exclusive Breastfeeding (infants who received only breast milk from birth to six months of age) and Non-Exclusive Breastfeeding (infants who received additional foods or drinks other than breast milk within the first six months). Data on breastfeeding status were obtained through a checklist completed by the mother, indicating whether the infant had been given breast milk exclusively or in combination with other substances. The measurement of this variable was conducted using a nominal scale. The dependent variables included infant growth and infant development. Growth status was classified into six categories: severe thinness, moderate thinness, normal, at risk of overweight, overweight, and obese. Growth measurements were obtained by recording the infant's weight and height, which were then entered into the mobile-based application for Stimulation, Early Detection, and Early Intervention of Child Growth and Development to determine growth classification. Infant development was assessed based on three categories: appropriate, questionable, and delayed. Observations of infant behavior during play and interaction were used to evaluate gross motor skills, fine motor skills, language, and social-emotional development. In addition, interviews with parents were conducted to explore developmental milestones not directly observable

during the assessment. The measurement of developmental status used an ordinal scale. Data analysis was performed using the Chi-square test, Mann-Whitney U test, and the calculation of the Phi correlation coefficient (Φ) and Cramer's V.

3. RESULTS AND DISCUSSION

Table 1. The Performance of Respondents' Characteristics in the Tuminting Community Health Center Work Area in 2023

Respondents Characteristics	Amount (n)	Percentage (%)
Mother's Age		
<20 years	5	6
20-35 years	70	84
> 35 years old	8	10
Mother's Education		
SD-SMP	13	16
SMA	58	70
College	12	14
Mother's Job		
Housewife	72	87
Civil Servants	1	1
Self-Employed	10	12
Baby's Age		
6-12 Months	55	66
13-24 Months	28	34
Baby's Gender		
Boy	43	52
Girl	40	48
Breastfeeding Status		
Exclusive Breastfeeding	33	40
Not Exclusive Breastfeeding	50	60
Growth		
Severe thinness	3	4
Moderate thinness	6	7
Normal	74	89
At risk of overweight	0	0
Overweight	0	0
Obese	0	0
Development		
Appropriate	63	76
Doubtful	17	20
Deviation	3	4

Table 1 shows that the majority of respondent mothers were aged between 20 and 35 years, totaling approximately 70 individuals (84%). Most of them had a high school level of education, with around 58 individuals (70%). In terms of occupation, the majority were housewives, accounting for approximately 72 individuals (87%). Most of the children were aged 6–12 months, with around 55 individuals (66%), and the majority were male, totaling about 43 individuals (52%). Furthermore, most respondents did not receive exclusive breastfeeding during the first 0–6 months of life, with around 50 individuals (60%). In terms of nutritional status, the majority of the children were classified as having normal nutritional status, approximately 74 individuals (89%), and most were also categorized as having appropriate developmental progress, around 63 individuals (76%).

Table 2. The Relationship between Exclusive Breastfeeding and Infant Growth Using the Android-Based Application for Stimulation, Early Detection, and Early Intervention of Child Growth and Development in the Tuminting Community Health Center Work Area, 2023

Breastfeeding Status	Growth						Total	
	Malnutrition		Undernutrition		Good Nutrition			
	f	%	f	%	f	%	f	%
Exclusive Breastfeeding	2	3	1	1	30	36	33	40
Non-Exclusive Breastfeeding	1	1	5	6	44	53	50	60
Amount	3	4	6	7	74	89	83	100
**p-value* = 0,737	α = 0,05			** Φ = 0,165				

Description: **Mann-Whitney U; **Phi (Φ) dan Cramer's V*

Table 2 illustrates that the majority of respondents (53%) provided their infants with non-exclusive breastfeeding, yet the infants exhibited favorable nutritional status. Based on the results of the Mann–Whitney statistical test, a p-value of 0.737 ($p > \alpha$) was obtained, indicating acceptance of the null hypothesis (H_0) and rejection of the alternative hypothesis (H_1). This result suggests that there is no statistically significant association between exclusive breastfeeding and infant nutritional status in the Tuminting Community Health Center Work Area in 2023. Furthermore, the Phi coefficient and Cramer's V were both calculated at 0.165, indicating a weak association between the categorical variables. The low correlation value, coupled with the high p-value, reinforces the conclusion that there is no meaningful or significant linear or ordinal relationship between exclusive breastfeeding and infant growth.

Table 3. Association of Exclusive Breastfeeding with Infant Development through an Android-Based Early Growth and Development Monitoring Application in the Tuminting Health Center Area, 2023.

Breastfeeding Status	Development						Total	
	Appropriate		Doubtful		Deviation			
	f	%	f	%	f	%	f	%
Exclusive Breastfeeding	31	37	1	1	1	1	33	40
Non Exclusive Breastfeeding	32	39	16	19	2	3	50	60
Amount	63	76	17	20	3	4	83	100
**p-value* = 0,003	α = 0,05			** Φ = 0,356				

Description: **Mann Whitney-U; **Phi (Φ) dan Cramer's V*

Table 3 shows that the majority of respondents (39%) provided non-exclusive breastfeeding, yet their babies demonstrated appropriate developmental progress. The Mann–Whitney statistical test yielded a p-value of 0.003 ($p < \alpha$), indicating that the alternative hypothesis (H_1) is accepted and the null hypothesis (H_0) is rejected. This result suggests a statistically significant relationship between exclusive breastfeeding and infant development in the Tuminting Health Center Work Area in 2023. The Phi coefficient and Cramer's V, both valued at 0.356, indicate a moderate to strong association between breastfeeding practices and infant development within the sample. In other words, these findings suggest that improved breastfeeding practices are associated with better developmental outcomes in infants.

Breast milk, stands as the most beneficial nourishment for infants due to its provision of energy, protein, micronutrients, and bioactive elements. The act of breastfeeding yields

immediate advantages to the baby's well-being, notably in lessening occurrences of diarrhea and Upper Respiratory Tract Infections. Moreover, it brings about lasting positive impacts on the baby's health and growth, including the reduction of overweight and obesity, as well as enhancement in cognitive development (Jia et al., 2018). In line with this, current reviews have demonstrated compelling evidence that exclusive breastfeeding significantly enhances neurological and cognitive outcomes in infants compared to those fed with formula. Babies who are exclusively breastfed tend to show superior neural development, greater white matter integrity, and improved cognitive performance, suggesting that breast milk plays a vital role in optimizing brain maturation during early life (Chade et al., 2024). However, infant growth and well-being are not solely determined by exclusive breastfeeding status. Recent evidence suggests that maternal capital, which encompasses a mother's physical health, psychological resilience, education, and socio-economic status, also plays a crucial role. Higher maternal capital has been linked to better infant growth outcomes and shorter duration of infant crying, possibly because it enables mothers to breastfeed more frequently and respond more promptly to their baby's needs. These behaviors reflect greater maternal investment and contribute positively to infant development. Interestingly, studies also found that relaxation-based interventions were particularly beneficial for mothers with lower maternal capital, indicating the potential to reduce health disparities related to social inequality (Dib et al., 2023).

The results of this study confirm that there is no significant relationship between exclusive breastfeeding and baby growth. The phi coefficient shows that the relationship between these two variables is weak, indicating that there is no strong relationship, either linear or ordinal, between the two. These findings are consistent with previous research which also showed there was no statistically significant relationship between exclusive breastfeeding and infant nutritional status (Choi et al., 2018). There are several factors influencing exclusive breastfeeding (EBF), including perceptions that health workers themselves do not practice EBF, grandmothers' past feeding practices, misconceptions about breastmilk quality, beliefs favoring formula for faster infant growth, and traditional feeding customs. These cultural beliefs and misunderstandings highlight the need for culturally sensitive breastfeeding support targeting mothers, grandmothers, and fathers (Nsiah-Asamoah et al., 2020). This is also in line with the results of research involving adolescents and linking various factors such as birth weight, exclusive breastfeeding, growth over a certain period, and anthropometric parameters, such as Fat Mass Index (FMI) and Fat-Free Mass Index (FFMI) (Nsamba et al., 2020). The results obtained show that birth weight has a significant influence on FMI and FFMI in adolescence, while exclusive breastfeeding and growth in certain periods do not have a significant influence on these anthropometric parameters (Nsamba et al., 2020). In addition, other studies have also indicated a disconnect between exclusive breastfeeding and infant nutritional status. This can be explained by the fact that exclusive breastfeeding that is not optimal, either in terms of method, quantity or quality, can be the cause. Apart from that, there are many other factors that play a role in influencing the nutritional status of babies, such as education and socio-economic status (Tyas & Saikudin, 2020).

The research results confirm the existence of a positive relationship between exclusive breastfeeding and baby development. The phi coefficient indicates a strong relationship between breastfeeding and infant development in the analyzed sample. This means that the better breast milk is provided, the better the baby's development. These results are consistent with previous research findings highlighting the superiority of breast milk in nutritional and evolutionary contexts. Breast milk contains various bioactive molecules that protect babies from infection and inflammation and support healthy organ growth and immune system. Compared with formula milk, breastfeeding is associated with a reduced incidence of illness and infant mortality, as well as reducing the risk of gastrointestinal, respiratory and allergic diseases (Nuzzi et al., 2021). In North Sulawesi, inadequate breastfeeding practices have been associated with various health problems in infants, including stunting, diarrhea, and acute

respiratory infections (ARI). A study in North Minahasa found that only 44.7% of infants received exclusive breastfeeding, influenced by factors such as early initiation, maternal knowledge, health worker support, and paternal involvement. Infants who are not exclusively breastfed face a higher risk of stunting and infectious diseases, contributing to increased morbidity. These findings highlight the urgent need to promote exclusive breastfeeding to improve infant health outcomes in the region (Punuh & Engkeng, 2021).

Breastfeeding may also benefit long-term cognitive outcomes. Recent evidence shows a small but positive effect on IQ in later childhood. While some studies suggest a potential protective role in reducing conduct disorders and enhancing executive function, current evidence is limited and inconclusive. Further research is needed due to possible confounders and reliance on maternal recall, which can introduce bias (McGowan & Bland, 2023).

Breast milk also plays an essential role in neurological development. According to research, breastfed infants exhibit increased cortical thickness and improved functional connectivity in the brain's language and cognitive processing areas compared to formula-fed infants (Pehlevan et al., 2023). WHO's recent global health guidelines highlight that exclusive breastfeeding for six months, followed by complementary feeding until age two, greatly benefits child development. Compliance leads to a 0.4 SD improvement in overall development, a 0.6 SD increase in height-for-age, and a 67% lower risk of stunting. These findings emphasize the importance of adhering to WHO feeding recommendations to support better growth and reduce stunting, reinforcing their role in child nutrition and public health programs (Wallenborn et al., 2021).

According to research findings, breast milk emerges as the best nourishment for newborns owing to its capacity to offer comprehensive nutrition and numerous bioactive health components. Breastfeeding correlates with enhanced infant well-being and immune system maturation, resulting in fewer occurrences of gastrointestinal ailments and reduced mortality rates in comparison to infants fed with formula. Apart from supplying vital nutrients for the developing infant, breast milk serves as a reservoir of commensal bacteria, which enhances the baby's health by hindering the attachment of pathogens and promoting the colonization of beneficial microbes in the gastrointestinal tract (Lyons et al., 2020). The gut microbiota holds significance in human growth and development, with the human gut microbiome playing a crucial role in both health and disease. This role commences during the prenatal period and persists throughout childhood (Ihekweazu & Versalovic, 2018). Moreover, there is evidence indicating the significance of microbiota in brain function and development. Hence, characterizing microbiota not only holds potential as a diagnostic or even preventive measure for forecasting NEC (Necrotizing enterocolitis) but can also function as a biomarker for monitoring, and potentially as a target for influencing brain development (Niemarkt et al., 2019). The primary element within breast milk responsible for encouraging the growth of particular bifidobacteria is HMO (human milk oligosaccharides). The emergence of a primarily bifidobacterial gut microbiota is observed in infants who are breastfed (Vandenplas et al., 2020). A variety of biologically active constituents found in breast milk aid in the growth, well-being, and development of infants. Breast milk supplies a diverse array of breast milk epithelial cell-derived extracellular vesicles (MEV) for the infant's benefit (Melnik et al., 2021).

In relation to infant development, longitudinal studies on Kangaroo Mother Care (KMC) have shown substantial benefits in promoting not only breastfeeding success but also growth and neurodevelopment in preterm infants. Early initiation of KMC is particularly advocated in neonatal intensive care settings, including in China, where its adoption among parent-infant pairs has proven effective in improving developmental and breastfeeding outcomes. These findings underscore the importance of integrating early skin-to-skin contact and supportive breastfeeding practices as part of comprehensive neonatal care to enhance both short- and long-term health outcomes (Wang et al., 2021).

Based on previous research, an Android-based application was developed to help parents track and understand their toddlers' development and health. Using the waterfall method, the app underwent analysis, design, coding, and testing, with blackbox tests confirming its smooth functionality. User feedback from questionnaires showed strong agreement that the app is effective for monitoring toddler growth and serves as a reliable source of health information for parents (Syahputri et al., 2019). In addition, prior studies also revealed a significant association between the use of the Stimulation, Early Detection, and Early Intervention of Child Growth and Development application and its effective implementation, with a reported p-value of 0.003. On average, the implementation level was categorized as fairly high, reaching 70%. As such, the application was designed to be more user-friendly and visually engaging, with the goal of improving ease of use. Furthermore, the application serves as a valuable tool for health education by providing accessible information related to the monitoring of child growth and development (Windiyani et al., 2023).

4. CONCLUSION

The conclusion of the study shows that although there is no significant correlation between exclusive breastfeeding and the baby's growth, there is a significant relationship with the baby's development, in line with the expectations in the "Introduction" chapter. Thus, this research succeeded in achieving its objectives. The projected development of the results of this research includes further research to understand the mechanism of the relationship between exclusive breastfeeding and infant development, as well as the application of research results as a basis for more targeted intervention programs in increasing the understanding and practice of exclusive breastfeeding, especially by utilizing Android-based application technology to provide information and support that is more easily accessible to mothers.

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