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Research Article

Improvements in tooth brushing behavior in children with autism spectrum disorder using mobile dentistry game application: study experimental

Tarisya Permata Putri[1], Anne Agustina Suwargiani[2], Susi Sukmasari[3], Inne Suherna Sasmita[4]

*Correspondence: tarisya21002@mail.unpad.ac.id

[1]Undergraduate Faculty of Dentistry, Universitas Padjadjaran, Bandung, Indonesia
[2]Department of Dental Public Health, Faculty of Dentistry, Universitas Padjadjaran, Bandung, Indonesia
[3]Kulliyyah of Dentistry, International Islamic University Malaysia, Malaysia
[4]Department of Pediatric Dentistry, Faculty of Dentistry, Universitas Padjadjaran, Bandung, Indonesia

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ABSTRACT

Introduction: Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by abnormalities in social interaction, limited interests, and repetitive habits. ASD children have motor, sensory, and communication limitations and difficulties that affect daily activities, namely brushing teeth, therefore education is needed to improve the tooth brushing behavior of ASD children. Education can use the Mobile Dentistry Game Application, namely Pokémon Smile which is one application that can be used to help increase knowledge and education of children with ASD in brushing teeth. The purpose of the study was to analyze improvement in the tooth brushing behavior of children with ASD using the mobile dentistry game application. **Methods:** A quasi-experimental study with 16 children was conducted in November 2024. The study consisted of measuring tooth brushing behavior before using Pokémon Smile, followed by using the game and measuring tooth brushing behavior after using the game. **Results:** There was a significant change with a p-value ($p<0.05$) 0.004. The average score of children's tooth brushing behavior before the use of Pokémon Smile was 5.25 with most behavior levels being very poor and after the use 6.86 with most behavior levels being moderate. There was an increase in the mean score of tooth brushing behavior by 17.05, reflecting a change in the level of tooth brushing behavior of ASD children from the poor category to moderate. **Conclusion:** Tooth brushing behavior of children with autism spectrum disorder (ASD) using a mobile dentistry game application has improved. This improvement is reflected in positive behavioral changes observed after using the application.

KEY WORDS: mobile dentistry game application, health app, visual pedagogy, tooth brushing behavior, autism spectrum disorder, children

Perilaku menyikat gigi pada anak gangguan spektrum autisme menggunakan mobile dentistry game application: studi eksperimental

ABSTRAK

Pendahuluan: *Gangguan Spektrum Autisme (GSA) merupakan gangguan neurodevelopmental yaitu gangguan perkembangan saraf yang memiliki ciri khas berupa kelainan pada interaksi sosial serta minat yang terbatas dan kebiasaan yang repetitif atau berulang. Anak GSA memiliki keterbatasan dan kesulitan motorik, sensorik, dan komunikasi yang mempengaruhi kegiatan sehari-hari diantaranya menyikat gigi sehingga diperlukan edukasi untuk meningkatkan perilaku menyikat gigi anak GSA. Edukasi dapat menggunakan Mobile Dentistry Game Application, yaitu Pokémon Smile yang merupakan salah satu aplikasi yang dapat digunakan untuk membantu meningkatkan pengetahuan serta edukasi anak dengan ASD dalam menyikat gigi. Tujuan penelitian adalah menganalisis perbaikan perilaku menyikat gigi anak dengan GSA menggunakan mobile dentistry game application.* ***Metode:*** *Penelitian berupa quasi eksperimental dengan sampel 16 anak telah dilaksanakan pada November 2024. Penelitian terdiri dari pengukuran perilaku menyikat gigi sebelum penggunaan Pokémon Smile, dilanjutkan dengan penggunaan permainan, dan pengukuran perilaku menyikat gigi setelah penggunaan permainan.* ***Hasil:*** *Terdapat perubahan signifikan dengan p-value ($p<0,05$) 0,004. Rerata skor perilaku menyikat gigi anak sebelum penggunaan* Pokémon Smile *5,25 dengan mayoritas tingkat perilaku sangat buruk dan setelah penggunaan 6,86 dengan mayoritas tingkat perilaku menjadi cukup. Terdapat peningkatan rerata nilai perilaku menyikat gigi sebesar 17,05 mencerminkan adanya perubahan tingkat perilaku menyikat gigi anak GSA dari kategori buruk menjadi cukup.* ***Simpulan:*** *Perilaku menyikat gigi anak dengan Gangguan Spektrum Autisme (GSA) menggunakan* mobile dentistry game application *mengalami peningkatan. Peningkatan terlihat dari perubahan perilaku ke arah positif setelah menggunakan aplikasi.*

KATA KUNCI: mobile dentistry game application*, visual pedagogi, perilaku menyikat gigi, gangguan spektrum autisme, anak*

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INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by abnormalities in social interaction, limited interests, and repetitive habits.[1] The prevalence of children with Autism Spectrum Disorder (ASD) worldwide has been increasing over time with the prevalence in November 2022 estimated to be 1:100.[2] According to the West Java Education Office (2017), the total number of children diagnosed with Autism Spectrum Disorder (ASD) in West Java was 1,524. The highest prevalence was recorded in Bandung City, accounting for 35% of the total cases in the province.[3] Children with ASD generally experience difficulties in coordinating fine motor, sensory, and verbal and non-verbal communication in daily activities.[4] They also tend to be less able to organize, plan, and complete tasks, thus having difficulty in performing daily routines such as brushing their teeth.[5]

These difficulties and limitations lead to various oral diseases.[6] Diseases that are often found in children with ASD include caries, periodontal disease, oral cavity damage, tooth eruption abnormalities, and trauma.[7] One of the ways that can be done to improve the tooth brushing knowledge of children with ASD is education. One technique that can be used for tooth brushing education for children with ASD is visual pedagogy, which is a method of understanding and recognizing something conveyed through images or actions.[8] Visual media pedagogy can utilize printed images or be delivered through digital devices, such as computers, mobile phones, or tablets. These interactive and user-friendly tools enhance the effectiveness of learning for children with Autism Spectrum Disorder (ASD).[9] Digital tools are favored by people with ASD because they are predictive, consistent, free of social demands, and focused.[10]

The digital tool used in this study is a mobile game application. Studies show that mobile game applications are effective in improving oral health education and behavior.[11] The mobile game used is Pokémon Smile, a game based on Augmented Reality (AR) technology to entertain children while tooth brushing, especially ages 3 and up. The game can detect the child's brushing motion through the camera to evaluate whether the child's brushing behavior is appropriate or not appropriate by guiding the correct brushing technique and rewarding the player by allowing them to "catch" Pokémon. The game is easy to use and engaging, which may encourage children to maintain good oral hygiene habits. While it is engaging and easy to use, its effectiveness may be limited to the accuracy of tooth brushing detection which can vary.

The game can be obtained for free and by anyone, especially for young children who need motivation to brush their teeth. This game was studied in South Korea in 2023 and has proven effective in improving hygiene and interest in brushing teeth in children.[11] The Pokémon Smile game has not been previously studied in Indonesia, nor has its effectiveness been evaluated in children with Autism Spectrum Disorder (ASD). Owing to differences in access to and utilization of advanced technology between Korea and Indonesia, which may influence awareness of dental health and education to affect the use of the game differently.

This game is suitable for children with Autism Spectrum Disorder (ASD) as it provides entertainment, motivation, and engagement by incorporating Pokémon characters into the tooth brushing process. At the end of each session, children who brush their teeth correctly are rewarded with new Pokémon characters, which can be used in subsequent brushing sessions. This reward system helps enhance focus and attention, making the brushing experience more engaging and effective for children with ASD.[12]

Furthermore, this research is anticipated to provide novel insights, as no prior studies have examined the use of Pokémon Smile for children with ASD in Indonesia. Therefore, The purpose of the study was to analyze improvement in the tooth brushing behavior of children with ASD using the mobile dentistry game application.

METHODS

This research is quantitative experimental The research subjects were students of SLB Autisma Bunda Bening Selakshahati who were diagnosed with Autism Spectrum Disorder

without co-occurring conditions namely ADHD, anxiety, and depression. The study sample amounted to 16 children using a total sampling technique. The total sampling technique is a sampling method in which the entire population is included as the sample, ensuring that the sample size is equivalent to the population size.[13]

This study consists of several stages, starting from measuring tooth brushing behavior with a questionnaire before using Pokémon Smile by their caregiver, counseling on the use of Pokémon Smile to caregivers, using the game for 5 days every time the child brushes their teeth accompanied by their caregiver, and measuring tooth brushing behavior with the same questionnaire as before using Pokémon Smile for 5 days. This research was conducted in November 2024. Before the study was conducted, the respondent's guardian read the research information and signed the informed consent. Research flow can be seen in Figure 1.

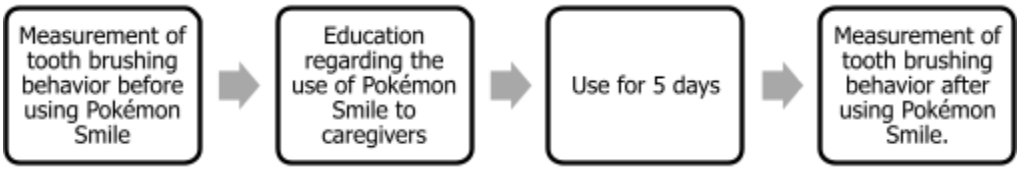

Figure 1. Research flow

Tooth brushing behavior was measured using a questionnaire that included the tooth brushing surfaces contained in the game specifically, on the occlusal surfaces of the upper and lower teeth, the buccal surfaces of the upper, lower, and anterior teeth, and the lingual surfaces of the upper, lower, and anterior teeth. The tooth brushing behavior of children with autism spectrum disorder is not seen from the right technique but is seen from whether all tooth surfaces contained in the game are brushed without seeing the final result of dental hygiene. Subjects will be given a score of 1 if they brush their teeth on the mentioned surfaces and a score of 0 if they do not brush their teeth.

The score obtained will be divided by the maximum score and multiplied by 100, then categorized. A higher total score indicates better tooth brushing behavior, reflecting a more thorough and effective cleaning routine, while a lower score suggests poor brushing habits and inadequate oral hygiene. The measurement of tooth brushing behavior is under the supervision of a professor in pediatric dentistry. The results of tooth brushing behavior before and after using Pokémon Smile were collected and processed descriptively and statistically using SPSS software in the form of tables. The statistical that will be performed is paired t-test to analyze differences in tooth brushing behavior among children with Autism Spectrum Disorder (ASD) before and after using the Mobile Dentistry Game Application.

RESULTS

The research sample amounted to 16 children and the characteristics of the research subjects based on gender can be seen in Table 1.

Table 1. Characteristics of research subjects

Characteristics	n (people)	Percentage (%)
Gender		
Male	15	93,75%
Female	1	6,25%

Table 2. Tooth brushing behavior score before and after the use of pokémon smile

Before Using Pokémon Smile			After Using Pokémon Smile		
Score	**Number of Respondents**	**Percentage (%)**	**Score**	**Number of Respondents**	**Percentage (%)**
0	2	12,5%	3	2	12,5%
2	1	6,25%	4	3	18,75%
3	3	18,75%	6	1	6,25%
4	4	25%	7	6	37,5%
5	2	12,5%	8	1	6,25%
8	2	12,5%	9	2	12,5%
9	1	6,25%	11	1	6,25%
11	1	6,25%	3	2	12,5%
Average Score:	**5,25**		**Average Score:**	**6,86**	

Table 2 shows the tooth brushing behavior score before the use of Pokémon Smile. Table 2 shows that the score of tooth brushing behavior in ASD children before the use of the majority is 4 as many as 4 children (25%). This suggests that before intervention, most ASD children exhibited poor oral hygiene habits, as reflected in their low brushing scores. Table 2 also shows the tooth brushing behavior score after using Pokémon Smile. The results show that the most common score was 7, with six children (37.5%) achieving this score. This indicates an improvement in brushing behavior after using the application. The data shows a significant increase in tooth brushing behavior after using Pokémon Smile. Before the intervention, most ASD children showed poor oral hygiene habits, whereas after using the app, most ASD children achieved higher toothbrushing scores, reflecting better oral hygiene practices. These results suggest that the app can serve as an effective tool to improve oral hygiene in children with ASD.

Table 3. Level of tooth brushing behavior before and after using Pokémon Smile

Before Using Pokémon Smile			After Using Pokémon Smile		
Behavior Level	**Number of Respondets**	**Percentage (%)**	**Behavior Level**	**Number of Respondets**	**Percentage (%)**
Very Good	2	12,5%	Very Good	3	18,75%
Good	2	12,5%	Good	1	6,25%
Simply	0	0%	Simply	6	37,5%
Bad	2	12,5%	Bad	1	6,25%
Very Bad	10	62.5%	Very Bad	5	31,25%
Total	**16**	**100%**	**Total**	**16**	**100%**

Table 3 shows the level of tooth brushing behavior before the use of Pokémon Smile and the level of tooth brushing behavior of ASD children before the use of the majority is very bad, indicating insufficient or inadequate oral hygiene practices. This highlights the need for an effective intervention to improve brushing habits in this population. Data show that before the implementation of Pokémon Smile, children with ASD demonstrated lower levels of correct tooth brushing behavior, highlighting the need for engaging and structured interventions. Table 3 shows the level of tooth brushing behavior in ASD children after using Pokémon Smile. Findings revealed that the majority of children demonstrated "adequate" levels of toothbrushing behavior. This improvement indicates that the intervention had a positive influence on the oral hygiene practices of children with ASD.

Table 4 shows the results of the normality test showed a *p*-value > α (0.05) in each group. The before group showed a *p*-value = 0.253 > 0.05 and after *p* = 0.188 > 0.05. Based on these values, the data is normally distributed, and a paired sample t-test is performed. The results of the paired sample t-test can be seen in Table 4. Table 4 shows that the average value of tooth brushing behavior in ASD children before using Pokémon Smile was 41.47 and the average value of tooth brushing behavior in ASD children after using Pokémon Smile was 58.52.

Table 4. Statisticals test results

Normality Test		Paired Sample Test Comparing Mean Values				Paired Sample T Test Results			
Tooth Brushing Behavior	Normality Test Value (Shapiro-Wilk)	Paired Sample Test	Mean	SD	N	Paired Sample Test	t count	t table	*p*-valu
Before	0,253	Value Before	41,47	27,96	16	Value Before and	3,428	2,131	0,004
After	0,188	Value After	58,52	20,98	16	After			

Significant p value <0.05.

This shows a difference in the average value of tooth brushing behavior in ASD children before and after using Pokémon Smile which has increased by 17.05. Table 4 shows a significant change with a t count 3.429 greater than t table 2.131 and *p*-value 0.004 smaller than α (0.05), therefore H_0 is rejected and H_1 is accepted which means there is a significant difference in tooth brushing behavior in ASD children before and after tooth brushing education using Pokémon Smile.

DISCUSSION

Characteristic data regarding the gender of the research subjects, namely children diagnosed with autism spectrum disorders without a dual diagnosis at SLB Autisma Bunda Bening Selakshahati, showing that most respondents are male gender. This is related to the prevalence of autism spectrum disorders which is greater in men than women, namely 3:1.[1] The results presented indicate that before using Pokémon Smile, the average tooth brushing behavior score among children with ASD was 5.25.

Notably, the highest score was achieved by male participants, suggesting a potential difference in brushing behavior between genders. This is in line with previous research which says that ASD children's difficulties in coordinating fine motor, sensory, and impairments in verbal and non-verbal communication cause children with ASD to have difficulty socializing and difficulty training independence in daily routine activities, one of which is brushing teeth[5]. Most ASD children exhibited very poor tooth brushing behavior, with 10 children (62.5%) classified in this category.

The high percentage of children with very poor behavior levels (62.5%) reflects that although children can be instructed and understand instructions, their cognitive, fine motor, and sensory limitations, as well as their verbal and non-verbal communication barriers, have a significant impact on their ability to carry out routines independently.[4] The unprecedented learning of tooth brushing is also one of the main factors contributing to the low level of tooth brushing behavior.

Children only learn to brush their teeth during self-help classes using media such as cards. In previous research, it was said that digital materials have been proven to have a greater impact on children compared to printed materials which are less interactive so that children find it difficult to accept the learning.[14] Mobile devices, including computers, tablets, and smartphones, are widely utilized and favored by individuals with ASD due to their predictability, consistency, absence of social demands, and ability to provide a focused and controlled environment for attention.[10] ASD children at SLB Autisma Bunda Bening are learning about tooth brushing which is expected to change the behavior of ASD children in brushing their teeth for the better even though they have been routinely accustomed to brushing their teeth twice a day.

The results show a positive shift in the level of tooth brushing behavior among ASD children after using Pokémon Smile. This positive shift happens because ASD children have been learning about brushing their teeth using the Pokémon Smile game educative media. Integrating play into the learning process is an effective approach to enhancing oral health

behaviors in children. Therefore, a mobile game application that combines educational and interactive play elements proves to be an effective tool, as it allows children and caregivers to engage with it conveniently at any time and in any location.[15]

The results of this study support preceding research that shows the effectiveness of Pokémon Smile in improving tooth brushing behavior, especially in preschool children[11]. In contrast to previous studies, this study focuses on children with ASD, who face greater challenges in motor, sensory, and communication. The main difference lies in the target population and evaluation approach. Whereas the preceding study measured the tooth-brushing habits of normal children, this study showed that the Pokémon Smile app was also effective in improving tooth-brushing behavior in ASD children through AR technology, although the app was not specifically designed for them.

Previous research stating that educational games are effective and recommended to improve education and behavior to maintain oral health is proven.[15] This data shows that learning to brush teeth using mobile dentistry game applications can improve the focus of ASD children, which is reflected in the increase in the average tooth brushing behavior score from 5.25 to 6.86. In addition, the results reveal that this method helped ASD children brush their teeth better, as seen from the change in behavior category from mostly poor to fair. This effectiveness is supported by the live-action features and Augmented Reality technology contained in the Pokémon Smile game. This technology offers direct visual guidance, which facilitates the learning process for children with ASD. Children with ASD often experience discomfort in social settings and may become easily stressed when their environment changes. By providing a structured and controlled learning environment, this technology enhances their engagement and supports skill development in a more comfortable and adaptive manner.[10]

The results of this study are in line with the research of Cihak *et a*l.,[16] which shows that AR-based interventions are very effective in improving the behavior of ASD children in brushing teeth. Previous research has shown that augmented reality, such as that used by Pokémon Smile, has a positive impact on ASD children's learning due to its ability to provide visual elements that can attract attention and improve focus. Cihak *et al.*[17] research even found that AR-enabled children learn a series of tasks, such as brushing their teeth. Different from previous studies that emphasize self-directed learning through AR, this study uses the Pokémon Smile application that combines AR with digital games. This makes the approach more practical and fun for ASD children. Similarly, Zheng et al., found that the use of augmented reality (AR) significantly enhanced tooth-brushing skills in children with ASD by offering an interactive and immersive technology-based learning experience. AR facilitates the acquisition of tooth-brushing skills by providing real-time feedback and visual cues, making the learning process more engaging and comprehensible.

The findings of this study are also consistent with the existing literature of Narzisi *et al*.,[18] demonstrating the effectiveness of digital interventions in enhancing behavioral outcomes among children with ASD, particularly in facilitating the acquisition of proper oral hygiene techniques. Children with ASD often face challenges that hinder their ability to maintain oral care; however, digital interventions provide a more accessible and comprehensible learning experience by delivering visual information in a structured and efficient manner. Additionally, a study by Krishnan *et al*.,[19] aimed to evaluate the effectiveness of two sensory-based interventions—visual pedagogy and a mobile-based application are also in line with this study which demonstrated that these digital intervention tools serve as effective educational tools for enhancing oral health education and subsequently improving oral hygiene outcomes in this population.

Previous research used the Applied Behavior Analysis (ABA) method with picture card media to improve dental health knowledge in ASD children.[20] This approach involves repetition, chaining, and gradual reduction of dependency, which can feel boring to children. In contrast, this study adopts a digital method that incorporates AR technology and interactive characters to capture children's attention and increase motivation. Another study that used audiovisual methods to improve ASD children's tooth brushing skills.[5] The study said that the audiovisual

method can improve ASD children's tooth brushing skills as well as using Pokémon Smile, but, the study did not present statistical analysis, so the conclusion is descriptive. In this study, the paired sample t-test showed the significance of the difference in tooth brushing behavior using Pokémon Smile.

The results of the normality test for the value of tooth brushing behavior of ASD children before and after using Pokémon Smile. Based on statistical calculations using the Shapiro-Wilk test the number of small samples is less than 50, totaling 16 samples. Data before using Pokémon Smile showed a normality test value of 0.253 > 0.05 and data after using Pokémon Smile showed a normality test value of 0.188 > 0.05. Based on the test results, the data is normally distributed.

Hypothesis testing was conducted using a paired sample t-test because the data were normally distributed. The test results showed that the average value of tooth brushing behavior in ASD children before using Pokémon Smile was 41.47, while the average value of tooth brushing behavior in ASD children after using Pokémon Smile was 58.52. This average increase of 17.05 reflects a change in the level of tooth brushing behavior of ASD children from poor to moderate.

The existence of a significant difference in the tooth brushing behavior of ASD children before and after using Pokémon Smile can be seen from the results of the paired sample t-test. The test results show a calculated t value of 3,429, which is greater than the t table of 2,131. The *p*-value obtained from the paired sample t-test is 0.004, the *p*-value obtained is smaller than the significance level α (0.05), therefore H_0 is rejected and H_1 is accepted, which means there is a difference in tooth brushing behavior in ASD children before and after tooth brushing education using Pokémon Smile. The data shows a statistically significant difference in tooth brushing behavior among ASD children before and after education using Pokémon Smile, indicating that this educational method is effective and beneficial in improving their tooth brushing habits.

This study has several limitations that should be considered for future development. The sample was limited to children who could follow instructions and did not have a co-occuring conditions, which may not fully represent the broader population of children with ASD. Consequently, further research with a more diverse sample is necessary to obtain a more comprehensive understanding of tooth brushing behavior in ASD children using the mobile dentistry game application. Additionally, the cross-sectional data collection method used in this study does not assess the long-term effects of the application, as this research serves as an initial study providing baseline data for future investigations.

To address these limitations, the researchers propose several recommendations. First, future studies should include a more diverse sample of ASD children to gain deeper insights into their tooth brushing behavior when using the mobile dentistry game application. Second, this study serves as preliminary research and is expected to be used as a database for further research on the use of mobile dentistry game applications for ASD children. Lastly, a longitudinal study design is recommended to evaluate the long-term impact of mobile dentistry game applications on the oral hygiene and dental health status of children with ASD. Future research should incorporate both behavioral assessments and clinical evaluations, such as DMFT (Decayed, Missing, and Filled Teeth Index) and OHIS (Oral Hygiene Index-Simplified), to provide a more comprehensive understanding of the application's effectiveness in improving oral health outcomes.

CONCLUSION

Tooth brushing behavior of children with autism spectrum disorder (ASD) using a mobile dentistry game application has improved. This improvement is reflected in positive behavioral changes observed after using the application. Implications of this study suggest that tooth brushing skills in children with ASD should be addressed and improved in order to assist them in establishing better oral hygiene routines.

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