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Clinical Evaluation of a newly Developed Smart Phone Oral Hygiene Application for Preschool Children

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ABSTRACT: Background: The relation between oral hygiene and dental caries has been established in many studies, emphasizing the challenge of maintaining optimal oral hygiene in preschool children due to the unstimulating nature of tooth-brushing routines.**Aims:**The study wasfocused on creating and assessing the effectiveness of a new gamified mobile app called "Go Go Brush" to promote oral health in preschool children. **Material and methods:**The study comprised 122 children as a study group and 50 children as a control group, with an age range of four to six years. The study includedthree phasesof application and evaluationof the study group: baseline, one week, and one month after the "Go Go Brush" app use. The app, along with an educational video, was introduced, guiding children in plaque removal. Follow-up visits at one week and one month evaluated the app's oral health impact and assessed plaque and gingival indices.The control group of children followed the same procedures as the study group, except they did not use the mobile application during brushing. Plaque and gingival status were assessed at baseline and then again after one week and one month.**Results**: The "Go Go Brush" app intervention resulted in significant improvements in the plaque index of the study group after one month (0.695±0.25 vs. 0.857±0.32, $p<0.001$). Gingival index improvements were treatment-duration-dependent after one week and one month in the study group (0.615±0.23, 0.325±0.2 vs. 0.942±0.36, $p<0.001$). This reduction is notably greater than the change observed in the control group.**Conclusion:**The study concludes that "Go Go Brush" holds promise for enhancing oral health in preschoolers, showcasing the potential of technology-assisted interventions in early childhood dental care.

Keywords: Dental caries, Gamified mobile phone application, “Go Go Brush”, Preschool children, Technology-assisted oral hygiene interventions.

I. INTRODUCTION:

Oral health promotion is crucial for overall well-being, and dental hygiene influences the incidence of dental disease by creating an environment conducive to cariogenic bacteria growth and plaque formation [1]. The documented role of microbial plaque in dental caries and periodontal disease emphasizes the importance of regular mechanical plaque removal through methods like tooth brushing [2]. Globally, dental caries in children is a prevalent chronic disease and a public health concern, necessitating control measures like restricting sugar intake and maintaining dental hygiene [3, 4]. Oral self-care, including toothbrushing, is vital for quality of life, socialization, and overall health. The challenge of maintaining optimal oral hygiene in children highlights the need for early dental assessments [5]. Childhood tooth brushing, acquired during socialization, becomes ingrained with positive reinforcement, and innovative approaches, like smartphone applications, are emerging for health behavior interventions [6-8].

The widespread use of smartphones and the popularity of games have increased, with over one-third of the global population owning smartphones in 2018. Mobile applications, totaling over 75 billion downloads on Apple and 50 billion on Google Play, play a significant role in various aspects, including healthcare [9, 10]. The term "mobile health" involves using mobile phones and wireless technologies to enhance healthcare, provide easy access to information, promote a rapid response system, and improve patient compliance [11].

Mobile learning, a recent trend in education, particularly in health, has witnessed substantial growth due to the proliferation of mobile devices. Studies indicate that educational mobile applications contribute to motivation and

influence oral health interventions, demonstrating their impact on preventive and restorative care[10, 12-14].

Campos et al. (2019)[12] pioneered the creation and testing of a mobile dental health app specifically designed for preschoolers. Their application, named (1, 2, 3. Brush!), was developed using an interactive children's book flux design process and was compatible with both Android and iOS platforms. Targeting various aspects such as healthy diet, factors promoting tooth decay, oral hygiene practices, bottle feeding, the correlation between primary and permanent teeth, and habits leading to malocclusion, the app was assessed for its effectiveness, efficiency, and user satisfaction. In a separate study by Zolfaghari et al. (2021),[9] a gamified smartphone application was developed to educate mothers about the oral health of their children. The app covered topics such as dental appointments, healthy eating habits, sweets, infant oral hygiene, the impact of fluoride, the use of fluoride toothpaste, and early childhood caries. Through a randomized division of 58 mother-child pairs into simple app (without gamification) and gamified app groups, the study evaluated the impact of the applications on mothers' oral health knowledge and behaviors, as well as their children's oral hygiene, as measured by the plaque index. The findings from both studies contribute valuable insights into the potential of mobile applications as effective tools for enhancing oral health awareness and practices in the preschool population.

This research was undertaken in response to the lack of available applications addressing children's oral hygiene specifically designed for the Arabic language. Additionally, there is a notable scarcity of research dedicated to the oral health of preschool children.

II. MATERIALS AND METHODS

Sample population andselection:

The study comprised 122 children as a study group and 50 children as a control group, meeting specific criteria, including normal mental development, an age range of four to six years, and having primary dentition. The sample size determination, conducted at a 5% significance level and 95% study power, utilized G*Power 3.1.9.7 (2020) and was based on the methodology proposed by Rahaei et al. in 2020.[4]Before the intervention, the mean practice score was 13.69 with a standard deviation of 3.89. Following the intervention, the mean practice score rose to 16.02 with a standard deviation of 3.48. The initially calculated sample size of 110 participants was subsequently increased to 172 to account for potential incomplete data and enhance the overall study power.

Ethical considerations:

Participation in the research was optional, and mothers voluntarily signed informed consent forms before their participation. The study received ethical approval from the Mansoura Research Ethics Committee, Faculty of Dentistry, with the code number A03051021.

Application design and development:

The Android application "Go Go Brush" was developed through participatory design meetings involving researchers, programming and design teams, and computer scientists. Informed by a thorough review of the literature, media, and existing mobile applications in the field, the app was designed to motivate children for oral hygiene. Utilizing Kotlin for programming, Firebase Cloud for the database, Google ML Kit for AI, and Unity for games, the app sends nightly reminders for teeth brushing. Pediatric dentists and programming experts reviewed the app, contributing to its refinement. "Go Go Brush" comprises two segmentseducating parents on children's oral health and a gamified section for children, featuring an educational video, camera filters, and a timer. The app incentivizes daily teeth brushing through games and rewards, reinforcing the educational aspect of dental health for children.

Clinical Part:

The initial phase of the clinical component involved a comprehensive examination and demonstration of appropriate toothbrushing methodologies. The researcher initially ensured the child's alignment with the inclusion criteria, and one parent completed the initial questionnaire while providing informed consent. Following this, a disclosing agent was applied to the child's teeth, underscoring the importance of plaque removal through a demonstration using a face mirror. Subsequently, the recommended Fones' circular tooth brushing technique for preschool children was introduced, followed by closely supervised tooth brushing. The child was equipped with a standard toothbrush and fluoride toothpaste, and the researcher supervised the brushing activity for a duration of two minutes. This inaugural visit established a baseline for plaque and gingival index measurements, with the plaque index assessed using a periodontal probe and dental mirror based on the "Löe&Silness" modified dental plaque index.[15] The gingival index was determined

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using the "Löe" modified gingival index.[16]. Subsequently, the gamified application, Go Go Brush, was installed on the parent's mobile device of the study group. The child engaged with an educational animation video demonstrating proper brushing techniques and promoting healthy eating habits, while also experimenting with the application's camera filter. Ultimately, the child and parent were instructed to utilize the application nightly before brushing until the subsequent visit. The second and third visits were conducted to monitor the child's consistent use of the application through the Cap reward system, assess the child's plaque and gingival indices, and evaluate oral health improvements. The third visit, occurring after one month of application usage, appraised the child's oral health status through plaque and gingival indices.

The control group underwent the same steps during brushing procedures, with the only difference being the absence of mobile application usage. Their plaque and gingival status were assessed initially (baseline), and then again after one week and one month.

Statisticalanalysis:

The data was analyzed using SPSS software. Quality data was described using numbers and percentages, while paired groups were compared using the McNemar test. Continuous variables were presented as means and standard deviations. Paired groups were compared using paired t-tests, different groups using independent t-tests, and more than two groups using ANOVA tests. Spearman correlation was used for continuous and ordinal data. Significance was set at 5%, with smaller p-values indicating more significant results.

III. RESULTS

The study investigated the effectiveness of a newly developed oral hygiene smartphone application called Go Go Brush in improving oral hygiene among pediatric patients. 122 child participated in the study group and 50 children in the control group. The plaque index was assessed at three stages: at baseline, after a week of using the app, and after one month of using the app. Tabel (1) reveals a substantial alteration in the average plaque index among participants in the study group following one week and one month of intervention. The mean plaque index score dropped from 2.41±0.28 to 1.16±0.38 after one week and further declined to 0.695±0.25 after one month. This reduction is significantly more pronounced than the decrease observed in the control group, where plaque levels reduced from 2.23±0.33 to 1.95±0.35 after one week, and to 1.78±0.37 after one month.

Table 2 shows a significant change in the average gingival index scores among participants in the study group after one week and one month of intervention. The gingival index was assessed at three stages: at baseline, after a week of using the app, and after a month of using the app. The results showed a significant decrease in the gingival index after using the app. The mean gingival index was 0.942±0.36 before the intervention, 0.615±0.23 after a week of using the app, and 0.325±0.2 after a month of using the app. This decrease was notably greater than the changes observed in the control group during the follow-up assessments.

Table (1) The mean plaque scores of the study and control groups at baseline and after one week and one month:

Plaque Index score	Study Group Mean ± SD	Control Group Mean ± SD	Independent t-test	P value
Baseline	2.41±0.28	2.23±0.33	t=2.32	0.06
After 1 week	1.16±0.38	1.95±0.35	t=19.63	≤0.001*
After 1 month	0.695±0.25	1.78±0.37	t=22.29	≤0.001*
Repeated ANOVA	F=50.049 p ≤0.001*	F=47.69 p ≤0.001*	-	-
Post hoc LSD test	P1≤0.001* p2≤0.001* p3≤0.001*	P1≤0.001* p2≤0.001* p3≤0.001*	-	-

P1: Before intervention vs. after brushing teeth. P2: Before intervention vs. After 1 week. P3: Before intervention vs. after 1 month. *: Significant at p ≤0.05

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Table (2): The mean gingival scores of the study and control groups at baseline and after one week and one month:

Gingival index score	Study Group Mean ± SD	Control Group Mean ± SD	Independent t-test	P value
Baseline	0.942±0.36	0.982±0.45	t=2.52	0.06
After 1 week	0.615±0.23	0.958±0.22	t=11.71	≤0.001*
After 1 month	0.325±0.2	0.708±0.43	t=21.42	≤0.001*
Repeated ANOVA	F=61.412 p ≤0.001*	F=81.4 p ≤0.001*	-	-
Post hoc LSD test	P1≤0.001* p2≤0.001* p3≤0.001*	p1= 0.735 p2≤0.001* p3≤0.001*	-	-

P1: Before intervention vs. after brushing teeth. P2: Before intervention vs. After 1 week. P3: Before intervention vs. after 1 month. *: Significant at p ≤0.5

IV. DISCUSSION

Children are more prone to developing dental caries, due to their limited understanding of oral hygiene and the difficulties they face in maintaining regular brushing habits. Therefore, it is crucial to consider both their motivation to consistently practice good oral hygiene and their level of physical dexterity when developing interventions to promote oral health among children. [17]

Gamification can be employed to encourage individuals to engage in activities they might otherwise avoid, such as brushing their teeth. Gamification can also make oral health education more enjoyable and engaging for children.[18] With the growing trend of using educational tools that are more relevant to real-world experiences for the target audience, modern technology can provide children with access to health information through mobile learning applications that incorporate games.[19]

Digital natives, or children who have grown up surrounded by technology, are already familiar with multimedia and interactive games. These games can be used to effectively convey oral health information in a way that resonates with children.[20, 21] However, there are limited app-based games specifically designed for preschoolers that focus on dental health education. The available options are primarily entertaining rather than truly informative.[22, 23]

This study developed a gamified mobile application aimed at encouraging proper oral hygiene among children, and supporting the Arabic language. This innovative application integrates gamification elements with rewards and knowledge-based content tailored to both parents and their children. The app's content was carefully crafted and refined under the guidance of experts.

Previous studies have not developed or utilized an application specifically designed for oral hygiene education among children and supporting the Arabic language. [24-27] This oversight in the field of research is concerning, particularly given the high prevalence of oral health problems among children in Arab-speaking countries. A culturally sensitive application tailored to these children and available in their native language could serve as a valuable tool for improving oral health outcomes. To address this knowledge gap, the development of an application that focuses on oral hygiene for children and supports the Arabic language was the primary objective of this study.

The mobile software was created as an Android app, in line with previous research,[2, 4, 9] because Android smartphones are more widely available and affordable than iPhone devices among the target population, which is predominantly made up of middle-class and lower-class families. Alkilzy et al.'s [27]software was compatible with both Android and iOS smartphones, increasing its inclusiveness, in contrast to Herrera et al.'s [28]app, which was limited to iPhone users, hence narrowing the study's scope.

There is no one ideal way to evaluate a child's oral hygiene when it comes to measuring dental plaque and gingival condition. This explains the reasons for using a modified version of the Löe[16] modified gingival index and the Silness&Löe[15] plaque index, which are quick and simple methods of evaluating plaque in children without being very expensive or time-consuming and require a lot of their participation.

The study found that the children's plaque index score in the study group decreased significantly after using the Go Go Brush app. It fell from 0.857±0.32 after baseline brushing to 0.695±0.25 a month after the intervention. This decline was noticeably bigger than what the control group experienced. This suggests that the app is effective in improving children's oral hygiene. The results are consistent with other studies that have found that mobile apps can be effective in improving oral hygiene in children.[9, 27]

The study also investigated that the children's gingival index score improved significantly in the study group after using the Go Go Brush app. It decreased from 0.942±0.36 before the intervention to 0.325±0.2 a month after the intervention. In the control group, the gingival index decreased from 0.982±0.45 to 0.708±0.43 after one month of using the app. This decline was not as great as what the study group observed. This suggests that the app is effective in improving children's gum health. The results are consistent with other studies that have found that mobile apps can be effectivein improving gingival health in children. [27, 29]

V. CONCLUSION

The study's findings indicate that the newly developed smartphone application "Go Go Brush" has the potential to improve oral health among preschool children. These findings highlight thepotential of technology-based oral hygiene interventions in early childhood dental care.

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