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ADVANCING ORAL HEALTH IN EARLY CHILDHOOD: EVIDENCE FROM A COM-B–DRIVEN RANDOMIZED INTERVENTION

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Abstract

Early childhood is a pivotal period for establishing lifelong oral hygiene habits. Despite its preventable nature, dental caries remains one of the most common chronic conditions affecting children worldwide, with significant consequences for physical health, social development, and educational attainment. In Iran, national surveys indicate a high burden of dental disease among preschoolers, with a mean Decayed, Missing, and Filled Teeth (DMFT) score of 5.84 in 5–6-year-olds and over 88% of children showing clinical signs of caries. The development of oral health behaviors in children aged 4–6 is influenced by both physiological limitations and behavioral factors. At this age, children are gaining motor independence but lack the skills and consistency needed for effective oral hygiene. Parents and caregivers therefore play a critical role in establishing, supervising, and reinforcing toothbrushing routines. Variations in parental knowledge, motivation, and capacity can strongly impact children's oral health outcomes. Targeted interventions that address these factors are essential for improving oral hygiene practices in preschool populations and reducing the prevalence of early childhood dental caries.

Keywords: Preschool oral hygiene, Dental caries, early childhood, Parental influence, Iran

Introduction

Early childhood represents a critical window for developing lifelong health habits, including oral hygiene. Globally, dental caries remain one of the most prevalent chronic conditions among children, affecting not only physical health but also social development and educational performance. In Iran, the national oral health survey has revealed alarming statistics, with a Decayed, Missing, and Filled Teeth (DMFT) mean of 5.84 in children aged 5–6, and over 88% of preschoolers showing signs of dental disease. These figures highlight the urgent need for effective public health interventions targeting the youngest population groups.

Oral health issues in children aged 4–6 often stem from both physiological and behavioral factors. While young children are beginning to develop motor independence, their ability to maintain adequate oral hygiene is limited. This responsibility therefore falls predominantly on parents and caregivers, who play a central role in forming, reinforcing, and monitoring brushing routines. However, parental knowledge, motivation, and capability in this domain vary greatly and can significantly influence children's dental outcomes.

Numerous health behavior theories have been developed to guide health promotion strategies. Among them, models such as the Health Belief Model (HBM), the Theory of Planned Behavior (TPB), and the Stages of Change Model have contributed valuable insights into behavior modification processes. However, many of these frameworks lack a comprehensive integration of internal and external influences on behavior. In response, the COM-B model emerged as a pragmatic and dynamic approach that conceptualizes behavior as a product of three

essential components: Capability (C), Opportunity (O), and Motivation (M). This model posits that any attempt to change behavior must address all three elements simultaneously.

The COM-B model has been applied successfully across various health domains, such as smoking cessation, medication adherence, and chronic disease self-management. However, its application in oral health promotion, particularly in early childhood settings, remains relatively unexplored. Behavior formation principles indicate that providing the necessary skills (capability), a supportive environment (opportunity), and intrinsic/extrinsic incentives (motivation) can lead to sustainable changes. Thus, a well-designed intervention based on the COM-B model could have a transformative impact on children's oral health habits.

In this context, our study aimed to assess the impact of an educational package tailored to the COM-B framework on the oral health behavior of preschool children. The intervention included animated videos and structured parent education, which aimed to improve parental understanding, engagement, and motivation. The study compared three groups: those receiving comprehensive COM-B-based education, those receiving a simplified video-only intervention, and a control group with no intervention.

By examining behavioral outcomes (toothbrushing frequency and duration), clinical indices (plaque and gingival health), and parent-reported measures of capability, opportunity, and motivation, this study provides evidence on the feasibility and effectiveness of a behaviorally grounded oral health promotion strategy in early childhood.

Materials and Method

Study design and setting: This was a double-blind controlled educational trial conducted among the parents and children aged 4–6 years in three kindergartens located in Isfahan during the 2022–2023.

Study participants and sampling

Children aged 4–6 years attending private kindergartens in Isfahan who were physically and mentally healthy, had no systemic disease, with both parents alive, were included in this study. The mother should have had at least diploma or a higher education degree. The selection of kindergartens was done in coordination with the Welfare Organization, from the same socio-economic status.

Children with untreated dental caries in the clinical examination, mouth breathing, or space maintainers were excluded from the study.

Based on a study conducted by Zolfaghari in Tehran[11] in 2021, which compared plaque index in children in two groups (one group receiving educational intervention with videos and a control group), and the formula for comparing the mean between groups, assigning S_1 as 0.4, S_2 as 0.3, and considering a mean difference of 0.3, the sample size for each group was calculated to be 27 individuals. Accounting for a potential loss of samples, the sample size was considered to be 30 in each group. n = (Z1−□/2 + Z1−□)2 (S12 + S22)(□1− □2)2

The multistage sampling was recruited. Initially, three kindergartens with similar socio-economic levels were randomly selected. Then, by using the chance ball, each of the selected kindergartens was randomly assigned to one of the study groups.

These three groups included Group I (intervention including motivating animation and instructional video), Group II (only instructional video), and the control group. Improving oral hygiene behavior in children through the

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COM-B model was targeted in the main intervention group. Figure 1 presents the three main domains of this model and their interconnections. Details of each intervention will be presented in the following part. After coordinating with the kindergarten administrator and obtaining the informed consent from the parents, their children were enrolled in the study.

Data collection tool and technique

Children in all three groups were examined for plaque index and gingival index by one of the authors (NA) who

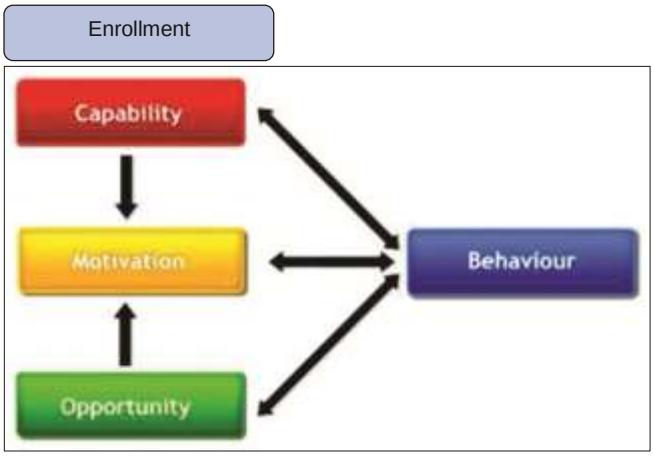

Figure 1: Schematic graph of the main domains of the COM-B model and their interconnections

had received necessary training from the supervisor (BT) and had been calibrated by performing pre-examinations on 10 children in the pediatric department of the Isfahan dental school (intraclass coefficient = 0.88). The plaque index was evaluated based on the Quigley–Hein index,[12] which divides the plaque accumulation on the smooth surfaces into 6° (Grade 0: no plaque, Grade 1: isolated plaque islands, Grade 2: clearly contiguous plaque line at gingival and up to 1 mm, Grade 3: plaque expansion in the cervical third of the tooth, Grade 4: plaque expansion

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to the second third of the tooth, Grade 5: plaque expansion coronal to the cutting edge) on Ramfjord teeth (deciduous: 55, 51, 65, 75, 71, 85). The examination was conducted using a probe and disposable mouth mirror on the kindergartens' chair using natural light.

To evaluate the gum health, the Lobene Gingival Index was used. For the Ramfjord teeth (deciduous: 55, 51, 65, 75, 71, 85), the level of gum inflammation and bleeding were calculated for 4 surfaces of each tooth; finally, a gum index was calculated for each individual (a number between 0 and 3). Clinical interpretation of the results was based on the average scores, categorizing gum inflammation into mild, moderate, and severe for each individual (mild: 0–1, moderate: 1.1–2, severe: 2.1–3).[13,14]

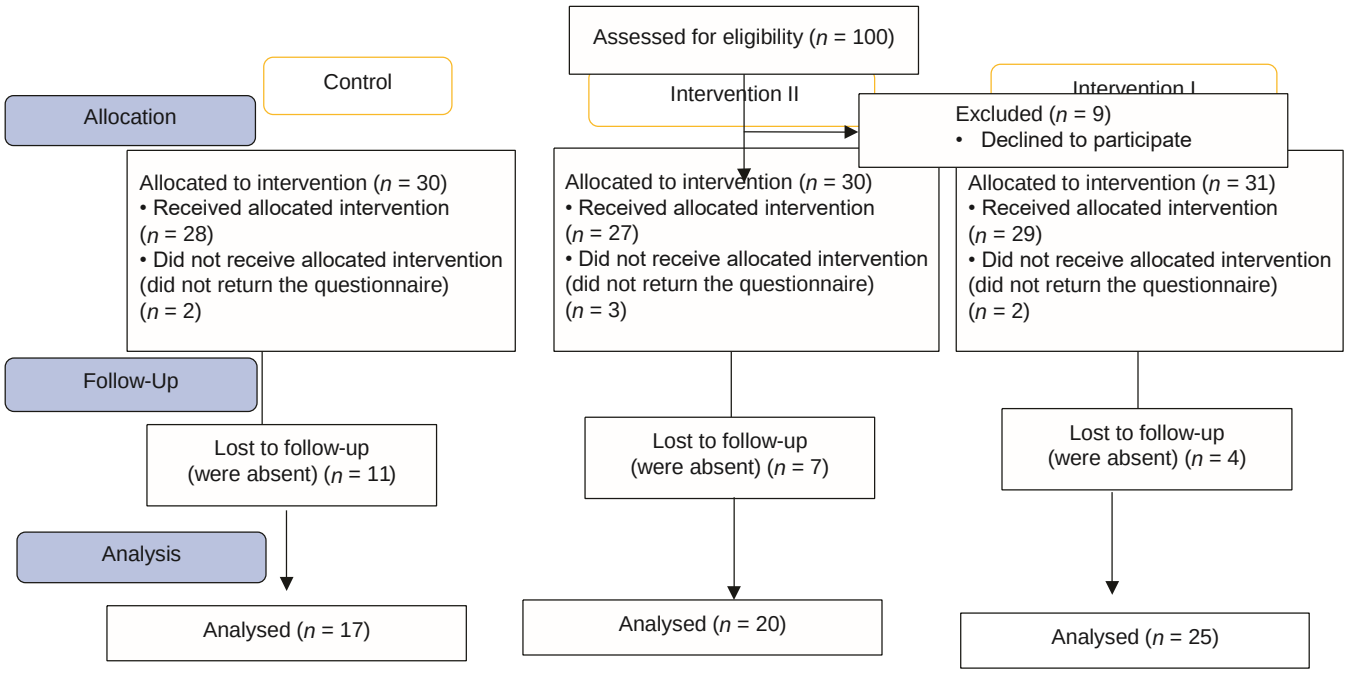

Chart Flow diagram of participants in the study and control group during the trail period

Additionally, a checklist was designed based on the "brief measure of capabilities, opportunities and motivations (COM-B)"[4] for evaluating the baseline status of parents in regard to the three COM-B domains. It was translated in Persian and validated for tooth brushing by the help of an expert panel (one English native editor, three dental public health experts, and one periodontologist). The checklist, which was sent to the parents, was attached to the consent forms. The checklist contained six questions and parents were asked to evaluate their abilities using a VAS (visual analog scale). Other questions included in the

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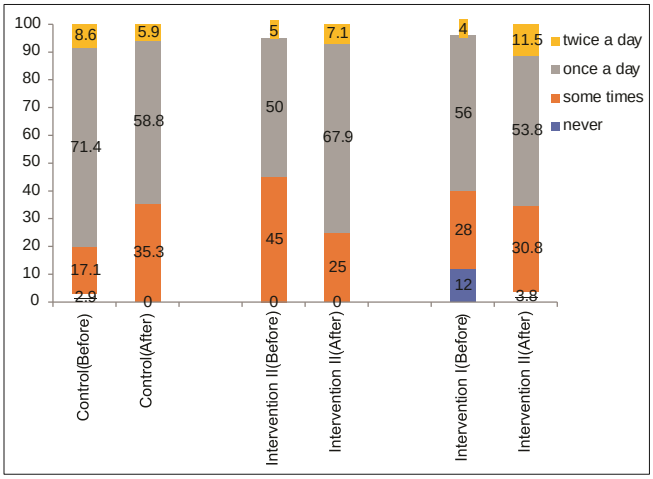

Figure2: Frequency of responses to the question "How often do you brush" based on children report

checklist were about the demographic characteristics of the parents (age, education), the brushing pattern of their child including the duration of brushing, the person who performed it and the frequency of brushing. Some other questions were also designed about the dental flossing and fluoridated-toothpaste use.

A short checklist was also designed for children to again ask about their frequency of brushing, who brushed their teeth and the toothpaste used.

Group I or main interventional group: This group received the complete educational package including a 20-min educational video and the motivating animation. The educational video was designed to briefly demonstrate the process of plaque and decay formation, to explain how to mechanically remove plaque using a toothbrush and toothpaste, and to practically demonstrate the steps of brushing teeth on two 5-year-old children using the horizontal and also the roll techniques. During brushing, some information about the fluoridated toothpastes and the way parents could find the content of fluoride were educated.

In addition, the role of parents was explained, stating that for children under 6, brushing should either be done by the parents themselves or under their direct supervision. The validity of this video (which was prepared originally by the authors) was assessed and confirmed by a panel of experts including one health education specialist, two pediatric experts, and two dental public experts using the media evaluation checklists (in terms of the structure and content, including attractiveness, relevancy, acceptability, coherence, accuracy, and clearance) proposed by the Ministry of Health and Medical Education.[15] The video was sent to the parents through a WhatsApp messaging platform created by the administrator of the selected kindergarten.

The second instruction material was an animated video utilized in "Oral Health Promoting Schools" program.[15] The animation content was in the form of children's songs and poetry, conveying messages about how to brush teeth (brushing twice a day from gum to tooth, both front and back surfaces of the teeth), and the use of dental floss and toothpaste. The duration of the animation was 2 min (exactly equal to the recommended brushing time). The face and content validity of the animation has been approved previously.[15] Our expectation was that, this

colorful and attractive animation would be suitable for the age group of 4–6 years, and it could create enough motivation for them to brush their teeth for the full 2 min.

In addition, for our main intervention kindergarten, throughout the WhatsApp messaging platform, parents were allowed to ask their questions regarding the video; also, a reminder message was sent to them every day. The reminder notified parents to show the animation to their children while brushing their teeth. They were also requested to send a 2-min video of their child brushing to the researchers for feedback and identification of areas needing improvement.

Group II or second interventional group: This group just received the educational video through the WhatsApp messaging platform.

Group III: No intervention was implemented in this group.

After 4 weeks, a visit was made to the kindergartens without pre-announcement and the individuals in each group were examined again to record the plaque and gingival indices. To evaluate the effects of the interventions on the oral health behavior of children and abilities of parents, the tooth brushing and the self-assessment brief COM-B checklists were sent again to the parents.

Ethical consideration

A complete description of the intervention, including interactions with parents, child examinations, and the study design, was explained to parents through a written letter, and their informed consents were gained. Also, the complete package (animation and instructional video) was sent to the control and secondary intervention groups after study completion. This study was approved by the Ethics Committee of Isfahan University of Medical Sciences (ethics code: IR.MUI.RESEARCH.REC.1401.246) and also, by the World Health Organization Registry Network (code: IRCT 20160822029476N2).

Statistical analysis

Data were fed into SPSS (IBM SPSS Statistics for Windows, version 26.0.; IBM Corp) and analyzed using analytical tests; the pre- and postclinical indicators and COM-B scores in each group were analyzed using the Paired T-test. For comparisons among the three groups, ANOVA or its nonparametric equivalents were used. The difference in the scores based on parental demographic characteristics was also analyzed using T-test and ANOVA (= 0.05).

Results

Baseline characteristics

At the beginning of the study, 100 informed consents were sent to the parents, from which 91 were signed and returned. However, 84 data were finally collected simultaneously from oral examination and parent questionnaires. After the intervention, the data of 62 participants were collected completely, despite the repeated follow-ups by the project manager and kindergartens' administrators [Figure 1 and Chart 1].

The demographic characteristics of participants (child's gender, parents' education level, parents' age, and number of children) and based on the study groups are presented in Table 1. According to the results, the majority of mothers and fathers had a bachelor's degree or higher, and most of them had only one child. A comparison of

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the demographic characteristics reported no significant differences at baseline between the three study groups [Table 1].

Effects of interventions Gingival and plaque index

Based on the normal distribution test, Shapiro–Wilk, the mean scores of PI, GI before and after intervention were normal, allowing for the use of parametric tests. At the baseline, there were no significant differences (P value = 0.29) between the three groups in total plaque and gingival index mean scores [Table 2]. The plaque index was improved in intervention group II (P value = 0.011) and more noticeable in intervention group I (P value < 0.001). Comparison based on gender reported that girls had a more significant decrease in plaque index, as compared to boys in intervention group I (in girls, the mean was 12.7 ± 3.4 before vs. 6.2 ± 1.9 after, P value < 0.001, and in boys the mean was 9.2 before vs. mean 7.8 after the intervention, P value = 0.3).

COM-B Mean Scores of parents

Table 1: Demographic characteristics of participants at the baseline in total and comparisons based on the study groups (total =84)

Variable		Frequency) percentage)/Mean±SD			Total	Sig.
		Kindergarten C	Kindergarten B	Kindergarten A		
Kids gender	Girl	14 (50)	11 (42.3)	18 (62.1)	43 (51.8)	0.3
	Boy	14 (50)	15 (57.7)	12 (37.9)	41 (48.2)	
Mothers' education	Under diploma	0	0	0	0	0.6
	Diploma	4 (14.3)	4 (14.8)	8 (27.6)	16 (19.5)	
	Bachelor	11 (39.3)	11 (40.7)	11 (37.9)	33 (40.2)	
	Master or higher	13 (46.4)	11 (40.7)	9 (31)	33 (40.2)	
Fathers' education	Under diploma	–	–	1 (3.4)	1 (1.2)	0.5
	Diploma	6 (21.4)	5 (18.5)	10 (34.5)	21 (25.9)	
	Bachelor	11 (39.3)	9 (33.4)	7 (24.1)	27 (33.3)	
	Master or higher	10 (35.7)	12 (44.4)	10 (34.5)	32 (39.5)	
Fathers' age		39.5±4.3	41.2±5	36.8±4	36.8±4	0.5
Mother's age		36.1±3.4	37.6±3.6	40.5±5.3	40.5±5.3	0.4

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Number of children	1.3±1	1.6±0.7	1.6±0.7	1.6±0.7	0.07 Based on the

Kindergarten A=intervention I, kindergarten B=intervention II, kindergarten C=control

Table 2: Comparing the plaque and gingival index before and after the interventions in the three study groups

Groups	Plaque index (before)	Plaque index (after)	Sig. (intragroup comparison)	Gingival index (before)	Gingival index (after)	Sig. (intragroup comparison)
Intervention I	11.2±6.4	6.9±2.3	<0.001	6.1±2.1	6.6±2.7	0.2
Intervention II	11.7±2.6	9.8±3.1	0.011	7.1±2.3	7.4±1.4	0.4
Control	10.8±3	10.5±2.7	0.84	6.7±1.3	6.6±0.7	0.7
Sig. (between groups comparisons)	0.29	<0.001		0.17	0.19	

normal distribution test, Shapiro–Wilk, the mean scores of the total COMB before and after intervention were normal, allowing for the use of parametric tests. At the baseline, the mean COM-B was 44.9 ± 8.8 in intervention group I, while it was 49.8 ± 1.4 and 48.5 ± 1.5 out of 60 in intervention group II and control group, respectively. There was no significant difference between the groups at the baseline (P value = 0.2). After the interventions, the mean total COMB scores had increased in intervention group I, although the differences were not significant (after: 48.9 ± 10.6, P value = 0.06). In intervention group I, the COMB scores in sub-domain of motivation (P value = 0.04) and capability (P value = 0.03) significantly increased [Table 3].

Toothbrushing frequency

At the baseline, there was no significant difference (P value = 0.3) between the groups in toothbrushing frequency and the type of toothpaste used, based on the parents' report [Table 4]. Most of the children (n = 52, 67%) were reported to brush their teeth once a day, and a high percentage of children brushed their teeth alone (n = 30, 39%). Toothpaste was mostly used. More than one-third of the parents (n = 32, 41%) reported the use of fluoride toothpaste, 12% (n = 15.4) were unaware of the fluoride content and about 40% (n = 31) did not use fluoridated paste for their children. In terms of who brushed the child's teeth, there was a significant difference in the control group (P value = 0.001), where parents had a significant role in toothbrushing.

The changes in oral health behaviors after the interventions are demonstrated in Table 4. The direct involvement of parents in toothbrushing was increased in intervention group I (P < 0.001), and the brushing frequency was raised too (P = 0.034). It did not, however, show a significant difference in toothpaste usage before and after the intervention. Meanwhile, in total the percentage of parents using fluoridated paste increased.

The toothbrushing frequency, as reported by the children before and after the intervention, in three kindergartens is shown in Figure 2. According to the results, it seems that in intervention group I, those who never brushed

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Table 3: Comparison of COM-B sub-domains mean (±SD) scores among different study groups

Groups	Subdomains of COM-B	Mean±SD (before)	Mean±SD (after)	Sig.
Intervention I	OP	15.8±4.1	15.8±4.4	0.6
	MOT	14.4±3.4	16.1±3.3	0.04
	CAP	15±3.3	16.9±3.6	0.03
	Total	44.9±8.8	48.9±10.6	0.06
Intervention II	OP	16.7±2.5	16.3±4.7	0.7
	MOT	16.7±2.5	16.5±3.4	0.8
	CAP	16.3±2.6	15.8±3.2	0.6
	Total	49.8±1.4	48.8±6.6	0.6
Control	OP	17.1±2.2	16.4±3.9	0.4
	MOT	15.4±3.1	15.7±2.8	0.7
	CAP	15.9±3.3	16.4±2.8	0.6
	Total	48.5±1.5	48.5±6.3	1

OP=Opportunity, MOT=motivation, CAP=capability

their teeth had a decreased rate of toothbrushing, while those who had brushed twice a day showed a rise. In intervention group 2, the percentage of individuals who brushed their teeth once a day had increased, although the difference was not significant.

From the child's perspective, in intervention group I, the role of parents increased (from 60.9% to 69.2%); also, in intervention group II, the supervisory role increased (from 65% to 82.1%). In the control group, there was no noticeable change [Figure 3].Duration of toothbrushingccording to the results, the duration was increased in intervention groups I (before: 89.4 s, after: 94.2 s) and II (before: 70 s, after: 111 s); however, the differences were not statistically significant (Wilcoxon signed-rank).

on children report

Discussion

This study was aimed to evaluate the effect of a health education package on the oral health status of 4–6-year-old children, as well as the COM-B-related factors among their parents. According to the results, in the main intervention group, the scores of the COM-B index in the domains of motivation and capability were increased among parents and the plaque index was decreased significantly among their children. In girls, the reduction in plaque index was more noticeable.

In a study conducted by Anagnostopoulos et al.,[16] the role of toothbrushing as an effective oral health behavior was emphasized; they reported that toothbrushing frequency was a crucial partial mediator of the oral health behaviors and oral health status. Thus, the greater perceived severity of oral disease and the stronger the

self-efficacy beliefs, the greater the toothbrushing frequency in turn the lower DMFT scores (signifying better oral health). Many efforts have been undertaken to increase the frequency of this behavior among children. Also, according to the clinical evidence-based guidelines, for children under 6, considering the active role of parents in supervision or taking the responsibility of toothbrushing has been highly recommended.[17,18]

To achieve long-term and sustainable improvements in oral health behaviors, the application of behavioral theories has been emphasized.[19] There are different theories such as HBM and planned behavior theory about behavior change, but there is little guidance on how to choose an appropriate theory for a specific behavior. Godarzi et al. in 2019[18] indicated that HBM was an appropriate model to predict the oral health behavior of Iranian students especially regarding the self-efficacy and perceived benefit domains. Research conducted by Carly J Santi Lozoya et al.[20] in 2019 was aimed to evaluate the effect of a smartphone app, based on the theory of planned behavior (TPB), on the oral health behaviors of the parents of preschool children. Parents' behavioral intentions or oral health behaviors did not significantly change after the intervention. In their study, it was revealed that social norms and perceived behavioral control predicted pre-intervention behavioral intentions and post-intervention behavioral change. A systematic review conducted in 2021[21] evaluated five studies using TPB framework, and five ones applying the HBM. All studies confirmed that a prominent means in preschoolers oral-health can rely on the knowledge, attitude, practice, and beliefs of parents.

A systematic approach to understanding individual components or barriers to changing a behavior has led to the development of frameworks that combine multiple theories aiming to guide and simplify the process of developing evidence-based behavior change interventions. One of these frameworks is the COM-B model for behavior change. This model, presented by Michie et al.[22] through combining 19 frameworks, posited that behavior consists of three interrelated factors of capability, opportunity, and motivation. Before engaging in the desirable behavior, an individual must feel capable, both psychologically and physically, must have social and physical opportunities to engage in that behavior, and must have a desire or motivation to engage in it. Any effort to change behavior should aim to address one or more of these components. It also acknowledged that all of these aspects lie within the patient and ultimately rely on patient engagement or clinician-patient rapport to target them.[22] In addition to the cognitive elements of traditional behavior theories, such as patient beliefs (HBM), reflections (PAPM), motivation (SCM, HAPA), and planning (TPB, HAPA), COM-B also addressed non-cognitive determinants.[23]

The COM-B model has been used successfully in

different health-related fields.[4-7] Although it seems that the COM-B model might be promising for behavior change based on its structural model and supporting theories, limited studies have reported its applicability in the field of dentistry. These studies have been mainly focused on oral cancer screening and oral hygiene care in long-term nursing care facilities,[10] changing dentists' behavior regarding the carious tissue removal methods,[9] and reporting suspected abuses by dentists.[24] The effectiveness of an intervention based on COM-B on periodontal patients using cellphone App was tested by Chang et al.[8] However, they did not study whether it led to any changes in clinical outcomes. In another study conducted by Gallagher et al.,[25] a COM-B based

intervention led to a significant increase in oral health knowledge and the use of fluoride toothpaste and interdental cleaning aids among athletes.

Based on the Behavior Change Wheel recommendations,[4] some intervention types are better suited to some COM-B targets. For example, education can be an important starting point to ensure that people understand why it is important to change their behavior and could be involved in capability and motivation domains. Persuasion, incentivization, and coercion could be used to motivate people to take the issue more seriously. Training may help to improve their social skills and involve all the three domains. Modeling by showing examples of good behavior could target the opportunity. Enablement might involve providing support to improve ability to change behavior, so that they can be equipped with the motivation, skills and opportunity.[26]

In the present study, we tried to design our interventions based on the different domains of the COM-B model. There was an instructional video that included necessary basic knowledge points about dental caries, and the role of plaque and oral hygiene in improving mental ability. Also, we demonstrated that two tooth brushing techniques and the use of fluoridated toothpaste could improve oral health behavior; as well, a children's animation that was probably effective in improving reflective motivation and over time automatic motivation due to showing the effect of brushing on character beauty and health in the animation. The results of our study, thus revealed that the motivation and capability domains had a significant improvement. The motivation domain consists of two parts of reflective motivation and automatic motivation. The definition of the first part includes believing that behavior leads to improved health and self-regulation, planning, and decision-making. The definition of the second part encompasses routines and habits, and management of individual anxiety. The capability domain also consists of two parts (physical ability and mental ability). The first part is defined as physical skills and power (ability) to perform behavior, and the definition of the second part entails awareness of behavior and the skill to perform it and knowledge of the time and frequency of performing the desired behavior. It seems, therefore, that the provided video and the motivational animation were successful in improving these two main domains of the COM-B and the expected behavior change among children, which was plaque control, by some means. We did not, however, assess the knowledge change of the parents, but the improvement in the capability domain could be partly justified by increasing the awareness of parents through the educational video.

Making communication with patients through smartphones have opened new opportunities in the development of oral health interventions.[27] Electronic interventions are emerging as alternative to the traditional methods of oral health information dissemination to child caregivers.[28,29] In a study conducted by Zolfaghari et al.,[11] the efficacy of two designed apps (gamified and simple) for the education of mothers in regard to oral healthcare of their preschool children was tested. After 1 month, the oral-health knowledge and practice of mothers and also, plaque control were significantly improved. They indicated that oral health instructions could enhance knowledge and change beliefs that could lead to behavioral or life style changes. They also reported that external motivations such as notifications could reinforce a particular behavior. Other studies conducted by Alqarni et al.[30] and Alklayb et al.[31] also emphasized the effective role of App-based education on the knowledge of the parents of children under the age of 6 years.

The scores of the opportunity part did not change dramatically in our study. Given the definitions of opportunity (physical opportunity: having access and time to engage in desired behavior, and social opportunity: support from peers, family, and healthcare professionals), it seems that more interventions should have been designed to improve these domains. We limited our interventions to reminders from the research team to show the animation to the children and to ask parents to share the videos of their children with us. Using a disclosing agent might have helped to inform parents about the toothbrushing improvement. In addition, in another study conducted by Lozoya CJ et al.,[20] the effect of a smartphone app, based on the TPB, on the oral health behaviors of the parents of preschoolers was evaluated. This study found that the intervention had no effect on the parents' oral health behavior, including oral health practices and dental attendance. Based on the qualitative phase of Lozoya et al. work, it was revealed that the enforcement of behavior by providers or research teams as a social norm might be a significant predictor of intentions and behavior. Also, Öcek et al.[32] revealed in their study that while their educational program was successful in increasing the knowledge and behavior of mothers in short term, the absence of an effect on the life circumstances led to a decrease in self-efficacy in the presence of obstacles and ended with a lack of positive attitudes. They suggested to support the mothers in their social environment (especially from other members of the family) to follow strategies that will strengthen their ability to overcome obstacles. Anishchuk et al.[33] introduced a novel initiative in which dental hygienists have to support preschool teachers and parents to implement a toothbrushing program for children attending preschools in Ireland and reported its success in improving the parents' knowledge and their practice in three months. Obtaining parental, and community commitments, and establishing supportive policies are also the key steps recommended by the World Health Organization in designing sustainable health promoting settings such as schools.[34]

The observed difference in the plaque scores after the interventions should be related to the differences reported in the tooth brushing patterns as the direct involvement of the parents and the duration of tooth brushing in the main intervention group were increased. In another study conducted by Paulo Melo et al. in 2021,[35] participants were given an educational program on oral health knowledge and behavior. In this study, children 6–12 years of age from Indonesia (N = 2,021) and Nigeria (N = 2,104) were provided with toothpaste and a toothbrush. Children in the intervention group received the 21-day brush day and night program. Ultimately, it was found that the percentage of individuals who brushed their teeth twice a day increased by about 40% ($P < 0.05$) and the proportion of children with adequate timing of toothbrushing significantly increased in both Indonesia and Nigeria (15% and 40%, $P < 0.05$). Additionally, in the study conducted by Wigen et al.,[36] the duration of toothbrushing in preschool children in Norway increased after education. These studies, thus, support the effectiveness of educational programs on toothbrushing patterns.

However, the GI as the other clinical index did not change in our study dramatically. In this relation, a study conducted by Gunpinar et al.[37] revealed that after oral health education programs, changes in gingival index improvement were not significant in one-month follow-up and the significant changes were observable after three to six months. Shirmohammadi et al.[38] also indicated, based on the use of App educational tools, that a long-term (about three months) follow-up was needed to record the significant changes in GI.

One of the other findings of our study was the difference in the impact of education on girls and boys. We observed that in the first intervention group, girls had a significantly greater reduction in plaque, as compared to boys. Another study conducted by Fotouhi Ardakani et al.[39] also reported that positive changes in girls in regard to their oral health behavior were more significant and sustainable than in boys. One possible reason for this could be that girls are more receptive to education at this age or that our animation is more in accordance with the interests of girls.

Limitation and recommendation

Our study, however, faced some design and practical limitations. First of all, there was loss to follow-up, where the individuals were lost, although this was for reasons not related to the method and outcome of the trial. This limitation is usually the case in interventions in kindergartens where children are not obliged to attend every day. Also, our follow-up was limited to a short period not enough to observe the changes in GI and the sustainability of the behavior change. We recommend to design more oral health promotion interventions based on this behavioral model by considering especial interventions based on all of its 6 domains with longer follow-ups.

Conclusion

It seems that designing oral health educational interventions based on the principles of COM-B model might be promising in changing the behavior of the parents of preschool children. However, developing more complex instructions that would give deeper insights into the COM-B elements, especially the opportunity domain, and using the potentials of social networks and mobile Apps in future studies need to be considered more seriously. Structural and regulatory policies of preschool education might be effective in promoting oral health of children by including educational interventions such as the one designed in this study and establishing supportive environments (network of parents, teachers, oral health teams).

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