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ORIGINAL RESEARCH

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Influence of pretreatment exposure to pediatric dental care using the “Tiny dentist" game on 4–7 years old children's pain and anxiety: a parallel randomised clinical trial

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Abstract

There have been no experiments on interactive modelling through computer games, although there have been a few on modelling a pre-exposure method for managing anxiety among preschoolers. The impact of partaking in a dental simulation game prior to the dental treatment on pain and anxiety in kids aged 4 to7 years during their first appointment was studied. A total of 156 kids who required unilateral pulp therapy and preformed crowns on their mandibular primary molars were enrolled in this double-blind, randomized clinical trial. They were then randomly assigned to intervention and control groups. The intervention group engaged in the game three times/day for 07 days prior to the anticipated appointment. The Wong-Baker Faces Rating Scale (WBFRS) was used to record their pre- and post-operative pain experienced during the dental procedure. Additionally, a finger pulse oximeter was used to record heart rate (HR) at each of the six treatment phases: baseline (the first session, two weeks prior to treatment) and stages 2–6. Playing video games considerably lowered the heart rate. Playing and the treatment period interacted in a major way. On comparing the groups at every time point, the intervention group displayed lower HR during injection, tooth preparation with an air-rotor and biomechanical preparation with endodontic rotary files.The results suggest that engaging in specific dental simulation games prior to the 1st dentist visit could help preschoolers feel less anxious during routine dental operations.

Keywords

Preschoolers; Dental simulation game; Pain; Anxiety

1. Introduction

Children’s dental anxiety is critically relevant because children’s responses to medical necessity are more complex than those of adults and because of the tremendous influence of contextual factors like personality and parental upbringing [1]. The unfamiliarity, unexpected threatening noise, unpleasant smell, the necessity to repeatedly lie on the operatory chair, uneasiness and discomfort all contribute to behavioral resistance in the first visit [2]. Based on the idea that viewing and mimicking others might shape behaviors, pretreatment modeling is one strategy for calming children’s nerves before their first dental appointment. In this method, the child observes dental operations carried out on another individual and is conditioned to exhibit a favorable response to oral procedures [3].

Since unfamiliarity with a new physical interaction can provoke anxiety as a standard response to uncertainty [4], modeling methods can introduce the children to a safe and secure environment especially during first the dental visit. This can be accomplished in two ways: passively, by seeing others (in documentaries, animation films or live modeling) or actively, by engaging in simulation video games [5, 6].

Now that cell phones are so widespread and technologically capable, they may be loaded with realistic simulation games to help calm children’s fears during dental visits. Since there are few studies on playing simulation games using smartphones for pre-exposure to pediatric dental practice [3], this trial examined the influence of playing a smartphone dental simulation game (Tiny Dentist) on pain and anxiety during the first dental appointment in preschoolers. The null hypothesis stated that there would be no significant difference between the two groups with respect to pain and anxiety.

2. Material & methods

The present randomized, parallel, controlled experiment comprised preschoolers who were asked to visit a diagnostic center from 02 February 2022 to 30 October 2022. The participants were 156 preschoolers between the ages of 4 and 7 requiring a pulpectomy on a primary mandibular molar followed by

the cementation of a prefabricated crown. A suitable sample size was determined based on a subjective evaluation after a review of the relevant literature [1, 3] for mean proportion and standard deviation based on results from prior trial and discussion with a statistician using "G" power software (version 3.1; Buchner 1996, Germany) [7]. To be eligible for inclusion, preschoolers had to be prepared to cooperate with the initial evaluation and need at least one elective procedure on their mandibular jaw. The kids in the sample had never experienced hospitalization, orthodontic treatment or any other invasive medical treatment. All the kids had to be proficient in Hindi in order to partake. Kids who required parental attention or had to utilize avoidance behavior control actions were not eligible to participate in the study. Any kid with a systemic or mental ailment was prohibited from taking part. Guardians who were iOS device users were included. In comparison guardians without Android-compatible devices and people needing swift assistance were also excluded. Nonetheless, the kids who were left out of the trial received the appropriate treatment.

The clinical associate of the diagnostic center enrolled and assigned the participations through simple randomization process by sequentially numbering them. The kids were randomly divided into two sets before getting treatment: 78 control and 78 interventions (the video game was the intervention). The present trial design followed the Consolidated Standards of Reporting Trials (CONSORT) guidelines (Fig. 1). All the participants were Children with odd numbers were enrolled in the intervention group, while the first participant and all subsequent participants were included in the control group. The pediatric dentist and the clinical associate were not informed of the allocations. The youngsters too had no idea about the group allocation.

The dental simulation videogame "Tiny Dentist" (available on iOS and Android) by fantastoonic (Android developer, version 3.7.1) was chosen. It involves role-play. It initially employs tutorials to demonstrate several treatment options to the child before accessing the playing area. The goal of this game is to familiarize kids with fundamental dental procedures. The Entertainment Software Rating Board has certified it as appropriate for all ages, and one can download and play it for free. The videogame offers a kid-friendly graphical user interface that is simple to use. The kids learn the fundamentals of dental hygiene with this app in a fun way [8].

Within the intervention set, 07 days before the process, the game was downloaded onto parent's mobile phones. It was suggested that they permit kids to play the videogame for ten minutes, three times a day for the next 07 days, until the planned appointment. A child was removed from the trial and replaced with a new participant if he or she played more or less than three times per day or missed certain days. Even though they were not included in the study, the preschooler received the scheduled dental treatment.

All appointments were scheduled in the evening by the operator. The participants were first administered topical anesthetic gel and then block anesthetic injections. Around 30 to 45 minutes were spent on the procedure. The process comprised unilateral pulpectomy (1% sodium hypochlorite irrigant and Vitapex as obturating material), followed by prefabricated crown (3M, India) cementation on the lower primary molar. All treatment procedures were carried out based on the "tell-show-do" behavior management approach, and using a bur attached to an air rotor.

The Wong-Baker Faces Rating Scale (W-BFRS) was applied at the preliminary examination session. This scale, used to assess pain, was represented by a sequence of six faces displaying different emotions, each of which was assigned a value from zero to five. Face 0 is a smiling expression that denotes no discomfort, whereas Face 5 is a crying face that denotes the kid's highest suffering and anguish. Prior to the process, the subjects were given a description of the assessment. The subjects were asked to express their emotions in one of the drawings prior to the treatment [9, 10]. This evaluation was conducted again before the child got a present and after the prefabricated crown had been cemented.

The heart rate (HR) is a fundamental and reliable physiological indicator of variations in preschooler's anxiety, so it was monitored [11]. Since it is convenient and easy for children to use, a finger pulse oximeter (Hand held type, Hesley, Mumbai, India) attached to the right index finger. The HR was evaluated at these six time periods: The preschooler was evaluated for the first time (baseline) with his or her parents prior to any intervention. The second measurement was obtained when the young child was placed in the dentist chair (in absence of parents). The next assessment was collected just before the anesthetic injection. The 4th and 5th reading were acquired, respectively, as the cavity was being prepared and the canals were biomechanically prepared by utilizing rotary endodontic files. The suction and pulse oximeter were then taken away. When the dentist's chair was placed back in its upright position, the 6th HR measurement was obtained. The W-BFRS was once more utilized to gauge post-treatment pain. Evaluations were recorded by a single operator who did know about the allocation and the goal of the present trial. After passing all evaluations, the kids were given a prize and released to his or her parents or guardians. No adverse effects were reported during or after the completion of the trial.

3. Statistical analysis

Data obtained was collected and compiled into MS Office excel worksheet & was subjected to various statistical analysis using SPSS version 23.0 for Windows (Armonk, NY, USA: IBM corp) software. Statistical analysis for descriptive statistics was done using Mean and SD for representing quantitative data. All the data showed normal distribution which was checked using Shiparo Wilk test the extent of pre- and post-operative pain for the group was compared using the independent *t*-test. This test was additionally employed to gauge how much pain girls and boys perceived. Chi-square test was utilized for evaluating the impact of gender and playing the simulation game on the post-operative pain minus the pre-operative pain. The HR and ages of the group were compared using the independent-samples *t*-test. To make a comparison of genders, the Chi-Square test was employed. The HRs were compared to the mean resting HR for kids [12] of the same age using an independent *t*-test.

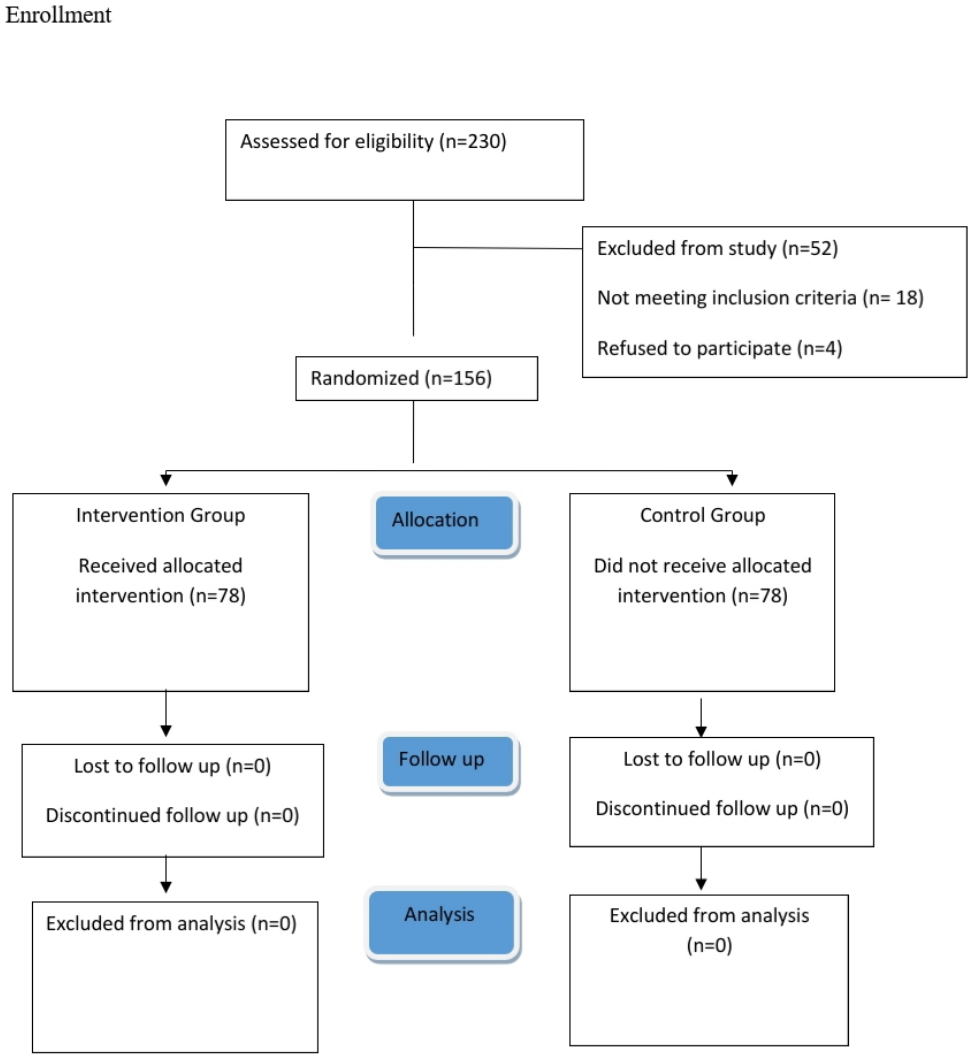

FIGURE 1. CONSORT flow diagram.

4. Results

The average ages (Table 1) of the children in the control and intervention groups were 5.77 ± 4.63 and 5.47 ± 1.12 years respectively ($p = 0.57$). 38 boys and 40 girls in the intervention group and 19 boys and 59 girls in the control group participated in the present trial (Table 2). The preoperative pain was limited to score 5 (5 children), score 1 (2 children) and score 0 (71 children) in the control group (Tables 3 and 4). Whereas, in the intervention group only one child reported with score 5, 4 children with score 1 and 73 of them with score 0 (Tables 3 and 4). The scores of post-operative pain were 2.12 ± 0.46 (range 0–2) in the intervention group and 0.46 ± 0.67 (range 0–3) in the control group. The differences between pre- and post-treatment pains were calculated for each patient and were compared between the groups (Tables 3 and 5).

The scores of preoperative pains were 0.20 ± 0.54 in girls and 0.8 ± 0.56 in boys ($p = 0.09$). The scores of post-treatment pain were 1.43 ± 0.56 in girls and 0.72 ± 0.56 in boys ($p = 0.10$). The ordinal regression did not show a significant effect for gender ($p = 0.89$) or for playing the simulation game ($p = 0.56$) on delta-pain. Table 6 and Fig. 2 shows that all HR measurements (corresponding to all clinical time points)

TABLE 1. Comparison of age in control and intervention group.

Group	N	Mean (yr)	Std. Deviation	*p*-Value
Age				
Control	78	5.7792	4.63006	0.57
Intervention	78	5.4744	1.12497	

TABLE 2. Distribution of gender in control & intervention groups.

		Groups		*p*-Value
		Control	Intervention	
Gender				
	Males	19	38	0.02*
	Females	59	40	
Total		78	78	

*$p \leq 0.05$. *Statistically significant difference.*

TABLE 3. Intergroup comparison between preoperative and post operative pain between intervention and control groups.

Groups	Mean	Standard Deviation (SD)	*p*-Value
Preoperative pain			
Intervention	0.346	1.236	0.14
Control	0.115	0.602	
Postoperative pain			
Intervention	2.128	0.778	0.01*
Control	0.461	0.677	

*$p \leq 0.05$. *Statistically significant difference.*

TABLE 4. Intragroup comparison of pre-operative pain *vs.* gender in both groups.

Groups		Preoperative			Total	*p*-Value
		Happy (WBFRS-Score: 0)	Pleased (WBFRS-Score: 1)	Crying (WBFRS-Score: 5)		
Control						
Gender	Males	15	2	2	19	0.02
	Females	56	0	3	59	
Total		71	2	5	78	
Intervention						
Gender	Males	36	2	0	38	0.61
	Females	37	2	1	40	
Total		73	4	1	78	
Total						
Gender	Males	51	4	2	57	0.29
	Females	93	2	4	99	
Total		144	6	6	156	

WBFRS: Wong-Baker Faces Rating Scale.

TABLE 5. Intragroup comparison of post-operative pain *vs.* gender in both groups.

Groups		Post Operative				Total	*p*-Value
		Happy (WBFRS-Score: 0)	Pleased (WBFRS-Score: 1)	Normal (WBFRS-Score: 2)	Upset (WBFRS-Score: 3)		
Control							
Gender	Males	0	3	9	7	19	0.86
	Females	1	13	24	21	59	
Total		1	16	33	28	78	
Intervention							
Gender	Males	24	11	3	0	38	0.69
	Females	26	9	5	0	40	
Total		50	20	8	0	78	
Total							
Gender	Males	24	14	12	7	57	0.16
	Females	27	22	29	21	99	
Total		51	36	41	28	156	

Test applied Chi-square test. WBFRS: Wong-Baker Faces Rating Scale.

TABLE 6. Comparison of heart rate (HR; beats/minute) measured at seven time points in both groups.

Time	Group	N	Mean	Std. Deviation	Std. Error Mean	*p*-Value
Baseline						
	Control	78	97.1154	1.32881	0.15046	0.01*
	Intervention	78	94.0128	1.64746	0.18654	
Sitting on dental chair						
	Control	78	101.9744	1.63544	0.18518	0.02*
	Intervention	78	97.1154	1.32881	0.15046	
Injection						
	Control	78	115.8333	2.69881	0.30558	0.04*
	Intervention	78	101.9744	1.63544	0.18518	
High speed (airotor)						
	Control	78	124.7564	2.35866	0.26707	0.01*
	Intervention	78	115.8333	2.69881	0.30558	
Biomechanical preparation						
	Control	78	110.5128	2.75749	0.31222	0.01*
	Intervention	78	102.6282	1.7589	0.19916	
Post-treatment						
	Control	78	102.6282	1.7589	0.19916	0.02*
	Intervention	78	98.1923	1.81665	0.20569	

Test applied Independent t test. $p \leq 0.05$ statistically significant difference.*

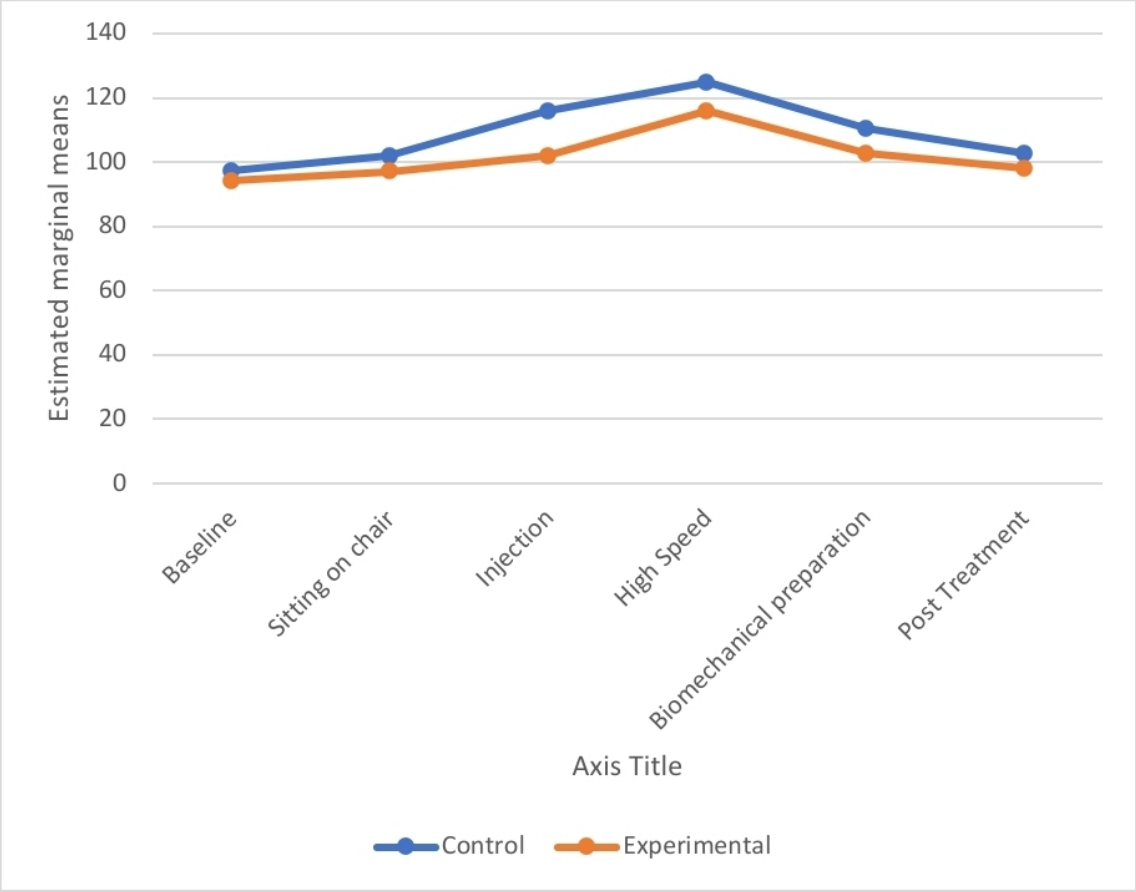

FIGURE 2. Mean heart rate (HR) values (beat/minute) from the baseline tp the end of clinical session.

were statistically significantly lower in the intervention group compared to the control ($p = 0.01$). Independent t-test detected a significant HR-reducing role for the intervention ($p = 0.02$) and for the interaction of the intervention with time ($p = 0.01$), meaning that the pattern of "changes in anxiety over treatment period" differed in the intervention versus the control groups.

5. Discussion

This study's findings corroborated with previous research showing that children's heart rates did not rise much from the baseline resting heart rate until the anesthesia phase, following which it rose in both groups. Playing the "Tiny Dentist" (smartphone video game) prior to treatment considerably decreased this heart rate increased during the injection and cavity preparation with handpiece when compared to the control. Possible explanations for this result include the fact that the child learned and observed the dental procedure being delivered to a virtual patient, and was able to imagine being involved in the oral procedure, all of which helped to reduce or eliminate several known factors associated with the development of anxiety. Compared to the control group, the intervention group experienced significantly less discomfort after playing "Tiny Dentist". Unfortunately, our search for relevant articles turned up very few researches on the topic of using smartphone simulations for pre-visit psychological assessment, so we could only analyze the results in the context of broad underlying principles.

Our results corroborated with studies conducted by Akyuz *et al*. [13] and Milgrom *et al*. [14], who reported that the administration of anesthesia and the preparation of the cavity were the most stressful procedures for the children. Significant reductions in anxiety were found in various trials evaluating the influence of pretreatment modeling on dental anxiety utilizing video or live environments, which is consistent with our findings [15–20]. Live parental modeling was proven to lower children's anxiety more than tell-show-do in a study by Farhat-McHayleh *et al*. [5]. This is due to the fact that providing kids with information to help them mentally prepare, lessens the negative impacts of worry they may feel in the future [19]. However, few studies revealed no significant differences between the tell-show-do approach and filmed modelling [20]; this might be because of differences in study design, sample size, film resolution and length, participant age and culture, and the nature of the study's clinical context. The findings of this study are consistent with those of Meshki and colleagues [21], who found that playing particular simulation games before a first dental visit could lessen anxiety. There was no change in the pain experienced by pretreatment playing in the same study, contradicting the results of the current trial. When comparing the tell-show-do strategy versus the smartphone game usage for controlling anxiety in kids aged 4–10, Tahersoltani A. and colleagues found that the smartphone game method was more effective [8].

Since previous research has shown that children are most difficult to manage between the ages of 4 and 6, this trial focused on kids in that age range [22–24]. The current study measured pain and anxiety with subjective and objective measures (such as heart rate and the Wong-Baker Faces Scale). Many previous types of research had employed these same variables, but they had yet to yield conflicting results. Multiple studies have found that heart rate is an accurate indicator for tracking anxious states [21]. We took multiple readings over the course of the trial and averaged them out to assess the variable's change over the course of treatment.

Besides the fact that the patient is a child, the fact that they will need to get an anesthesia injection prior to undergoing invasive dental operations is a major contributor to their increased fear. In both groups, the heart rate rose noticeably from the resting phase. Since the preschooler cannot find any experience of injection in the game environment, and because they visualize the oral procedure as not painful for him or them, even in little amounts, they are unprepared for the injection experience.

Meshki *et al*. [21] conducted the most similar prior research, which examined how a dental simulation game affected patient's perceptions of anxiety and pain. There were fifty kids in the sample. Prior to the treatment session, the experimental group had played the game for fourteen days. Playing the game decreased anxious feelings throughout therapy, as seen by the findings. The independent variables were the Wong-Baker face score and the number of times heart rate was monitored. The study compared the game's long-term impacts on the child's psychology to those of the conventional method but did not measure the game's immediate effects during therapy. Raising the sample size would have allowed for more accurate and trustworthy results. Continued practice with the game improves the child's attitude toward therapy. Since it is simple for children aged 4–7 years to indicate the level of pain they experienced during treatment by pointing to the appropriate shape on the Wong-Baker Faces scale, this method was adopted in the current trial.

Children of the 21st century may be more receptive to pretreatment exposure and modeling by playing video games than watching movies or observing live models. The reason is that playing video games is a fun and rewarding activity for kids [25]. Unlike traditional computer games, free mobile apps have many advantages, including greater accessibility and the lack of specialized technology (like Virtual Reality goggles) required to play. Because of this, future research should evaluate the game's efficacy relative to other means of relieving stress and anxiety.

There were constraints to this current experiment. The participant's actions throughout the study period could not be tracked. It has been suggested that a standard smartphone model (with equivalent screen sizes, light and sound levels) be used for all participants to guarantee a more uniform intervention. However, the current design preferred generalizability because people in clinical settings do not all have the same cell phones and may prefer different illumination and sound settings. An application tailored to pretreatment exposures should be the focus of future research.

6. Conclusions

Within the confines of this study's constraints, it was discovered that playing specific smartphone simulation video games dramatically decreased dental anxiety (assessed through heart

rate) and pain in kids having their first dentist visit at all phases of invasive oral treatment (pulpectomy).

Hence, such games may be recommended to the parents or suggested by clinicians as a technique for behavior modification, as they can effectively alleviate pain and anxiety in children.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

AUTHOR CONTRIBUTIONS

MV and PBSR—Conceived & designed the analysis; MV, PBSR and KS—Collection of data; MV, TS and BS—Contributed data or analysis tool; MV, PBSR, KS, TS and BS—Drafting of manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Parents and/or guardians were informed about the study and told to sign a consent form. The ethics council of Navneet Jain Health Center (Mumbai, India) gave its consent for the study to be carried out (NJHC/2021-32).

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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