Maternal and Child Health Journal (2019) 23:1587–1594
https://doi.org/10.1007/s10995-019-02813-5

The Impact of Adaptive Functioning and Oral Hygiene Practices on Observed Tooth-Brushing Performance Among Preschool Children with Special Health Care Needs

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Published online: 24 September 2019

Abstract

Objectives To investigate the impact of adaptive functioning and oral hygiene practices on tooth-brushing performance among preschool children with special health care needs (SHCN).

Methods A cross-sectional study was conducted in Special Child Care Centers. Children's tooth-brushing performance was assessed by a standardized 13-step pro forma. Information regarding children's socio-economic status, adaptive skills, and oral hygiene practices were collected. Bivariate analysis and ANCOVA were used to explore the potential factors which might be associated with children's tooth-brushing performance.

Results The tooth-brushing assessment was provided to 379 children with SHCN. Approximately 3% of the recruited children performed the whole tooth-brushing procedure independently. The number of tooth-brushing steps practiced by those children was 4.47 ± 3.56. Children who had established tooth-brushing habit before age one practiced more tooth-brushing steps than children who brushed their teeth after age one ($p = 0.029$). When children's age, gender, and socio-economic status were adjusted, children who had established regular tooth-brushing habit or children who had high levels of adaptive skills showed better tooth-brushing performance than their peers. Children who used gauze, cotton swab, or dental floss to clean their teeth practiced fewer key tooth-brushing steps than their peers who had never used additional cleaning approaches ($p = 0.038$).

Conclusions for Practice Children's tooth-brushing performance was associated with adaptive skills and oral hygiene practices. Tooth-brushing training should be provided to children with SHCN in early childhood. For children who had limitations in adaptive functioning, parental assistance or supervision is recommended to guarantee the efficacy and safety of daily tooth brushing.

Keywords Pediatric · Tooth brushing · Adaptive functioning · Special needs · Oral hygiene

Significance

What is already known on this subject? Children with limitations in adaptive functioning have sub-average abilities to perform self-care activities. Brushing of teeth at least twice daily is recommended for children. However, tooth-brushing is a challenging task for children with special health care needs.

What this study adds? Tooth-brushing performance among children with special health care needs need to be improved. When children's age, gender and socio-economic status were adjusted, children's tooth-brushing performance was associated with their adaptive skills and oral hygiene practices.

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Introduction

Children with special health care needs (SHCN) are referred to children who "have or are at increased risk for a chronic physical, developmental, behavioral, or emotional condition and who also require health and related services of a type or amount beyond that required by children generally" (McPherson et al. 1998). Approximately 15.1% of children were estimated to have SHCN, and one in five families were caring for a special-needs child (Caicedo 2014; Glassman 2017). Individuals with SHCN were reported to have poor oral hygiene status and limited access to health-care services (Al-Allaq et al. 2015; Glassman 2017). Oral hygiene maintenance is a challenging task for children with SHCN, as those children are likely to have abnormal tension of facial muscles, poor control of lips or tongue, insufficient gross motor capacity, and subaverage cognitive abilities to understand the importance of oral hygiene maintenance (Al-Allaq et al. 2015; Du et al. 2019; Mays and Heflin 2011; Kim et al. 2017; Zurbriggen et al. 2018).

Adaptive behaviors include "conceptual, social and practical skills that are learned and performed by people in their everyday lives", which encompass a range of behaviors that are "essential for everyday functioning, including daily living skills, social competence, functional communication, leadership, and adaptability" (Schalock et al. 2010; Villarreal et al. 2014). Limitations in adaptive functioning were common among children with SHCN. Due to lower acquisition of adaptive skills, children with SHCN usually rely on family members or caregivers to accommodate their daily living activities, such as brushing teeth, changing bandages, or administering medications (Mays and Heflin 2011; Chi et al. 2014). For children who have severe functional limitations, parents are likely to bear a greater caregiver burden (Chi et al. 2014). The long-term burden can disrupt parents' professional, household, and social roles, resulting in a poorer quality of life (Ausserhofer et al. 2009).

Tooth decay (dental caries) and periodontal diseases were reported to be the most prevalent dental diseases of mankind (Chapple et al. 2017; Li et al. 2015). Both of them can be initiated or deteriorated by the accumulation of dental plaque. Therefore, plaque control plays a critical role in oral health promotion (McGrath et al. 2019). Among the existing strategies, brushing of teeth at least twice daily is a low cost and widely recommended strategy for plaque control (Collett et al. 2016; Huebner and Milgrom 2015; Pinto et al. 2013; Wong et al. 2013). The benefit of tooth brushing was supported by observational studies and clinical trials (Huebner and Milgrom 2015; Liu et al. 2010; Pinto et al. 2013). Assessing the tooth-brushing performance among children with SHCN could set the foundation for advocating future health promotion activities. Although tooth-brushing frequencies had been investigated in prior studies, few investigations had demonstrated the specific tooth-brushing steps children could practice during a single tooth-brushing session (Ashkenazi et al. 2012; Campanaro et al. 2014; Vaščková et al. 2017; Shaghaghian and Zeraatkar 2017). In this study, a step-based assessment tool was used to assess the tooth-brushing performance among preschool children with SHCN. We aimed to determine how many tooth-brushing steps could be practiced by children with SHCN. Information regarding children's family demographics, adaptive functioning levels, and oral hygiene-related habits were also collected. We hypothesized that children who had high adaptive skills or good oral health-related habits could practice more tooth-brushing steps, while low adaptive skills and unfavorable habits would be inversely related to children's tooth-brushing performance.

Methods

Participants and Study Design

The investigation was designed as a cross-sectional, school-based observational study. Children with SHCN were recruited from Special Child Care Centers (SCCCs) in Hong Kong Special Administrative Region, China, from June 2016 to 2017. Those children were aged 2 to 6 years. They were diagnosed with Down syndrome, autism, cerebral palsy, developmental delay, or other developmental disorders. Children with severe physical disabilities were excluded. Sample size calculation was performed by G*Power 3.1.9.2 at a significant level of 0.05. Ethical approval for the present study was obtained from the local Institutional Review Board of Ethics (IRB HKU: UW 16-012). Invitation letters and information sheet were sent to the SCCCs. Written consent forms were signed by parents.

Data Collection

Children's tooth-brushing performance was observed and evaluated in SCCCs by two investigators, using a 13-step pro forma (McGrath et al. 2017; Zhou et al. 2018). The primary outcome of this study was the number of tooth-brushing steps performed by preschool children with SHCN. The secondary outcome was the average time children spent in a single tooth-brushing session, which was measured in second (s). The recruited children were accompanied by their parents. A set of toothbrush (Colgate® Kids Toothbrush), toothpaste (Colgate® Minions™ Cavity Protection Sparkling Mint Gel, 500 ppm fluoride), cup, basin, paper towel,

and drinkable water was provided to each child-parent dyad. Children were instructed to brush their teeth in front of the investigators, just as the way they practiced in their daily routines. If a specific step was routinely assisted by parents, this step would be practiced by parents during the real-time assessment.

Tooth-brushing steps practiced by children or parents were recorded separately. Only the steps performed by children were analyzed in this study. The duration of tooth-brushing was recorded by a timer. The investigator would stop the timer, if a child showed non-compliant behaviors during the tooth-brushing assessment, for instance, crying, running away, or being distracted by other objects. The recording would continue if the child re-started to brush his/her teeth. In order to avoid over-ingestion of fluoridated toothpastes, if more than a pea-sized amount of toothpaste (American dental association council on scientific affairs 2014) had been dispensed by the observed children, the investigators would take away the extra-amount of toothpaste before children started to brush their teeth. Otherwise, no professional instructions would be provided during the tooth-brushing assessment. After the assessment, a comprehensive tooth-brushing training (including dispensing an age-appropriate amount of toothpaste) was provided to each parent–child dyad.

Questionnaires regarding children's oral hygiene practices and family social-economic status (SES) were completed by their parents. Children's adaptive behaviors were rated by the staff at SCCCs. Assessment of children's adaptive behavior was based on whether a child showed significant limitations in the following domains: conceptual skills (language, reading, writing, time, number concepts), social skills (interpersonal skills, self-esteem, following rules, avoiding victimization), or practical skills (activities of daily living, personal care) (Schalock et al. 2010; Tassé et al. 2016). Each domain was rated as "average or high," "limited (guidance or supervision needed)" or "low" (Zhou et al. 2019).

Statistical Analysis

Data were analyzed using the IBM SPSS Statistics 24.0 (IBM Corp, Armonk, New York). Continuous data were reported in the format of mean and standard deviation. Categorical variables were presented by count frequency and proportions. Reliability of tooth-brushing steps observed by two investigators was analyzed by Intraclass correlation coefficient. Chi square test, Fisher's exact test, Mann–Whitney U test were used to compare proportions and rates when appropriate. Two-sample t-tests were used to compare the means between two groups. Analysis of variance (ANOVA) was used to compare the means among multiple groups, while Kruskal–Wallis H tests were used if un-equal variance existed among multiple groups. ANCOVA was used to identify the potential factors which were associated with children's tooth-brushing performance. Independent variables showing significant associations with the dependent variables were entered into the full models, along with children's age (continuous variable), gender, and SES. All the comparisons were two-tailed, and the statistical significance level was set at 0.05.

Results

Participant Characteristics

A total of 379 children received the tooth-brushing assessment (response rate 97.2%). Those children were aged 3.89 (± 0.97) years, and 71.2% were boys. The majority (93.1%) of the recruited children were presented with limited or low adaptive skills. Low practical skills were reported among 37.2% (141) children, and they entirely relied on parents or other caregivers to accommodate their daily living activities. Limited practical skills were presented among 51.2% (194) children. These children were able to perform self-care abilities under supervision or guidance. The remaining children had average or high practical skills, and they were able to practice simple daily self-care tasks independently.

More than half of the fathers (197) and 39.6% (150) mothers reported that they had received tertiary education, 125 (33.0%) fathers and 106 (28.0%) mothers received secondary education, and the others received lower secondary or primary education. Half of the parents reported that their children had brushed teeth at least twice daily. A quarter of parents used additional methods (gauze, cotton swab, dental floss, toothpick, or mouth rinse) to clean their children's teeth. Besides, 45.9% (174) children had established the tooth-brushing habit before the age of 12 months.

General Tooth-Brushing Performance Observed Among the Recruited Children

Children's tooth-brushing behaviors were assessed by two investigators (inter-examiner reliability: 0.93). The average number of tooth-brushing steps practiced by the recruited children was 4.47 (± 3.56), while the average tooth-brushing duration was 103.23 (± 67.05) s. Most children (84.7%) spent less than 3 min in brushing their teeth. Three of the tooth-brushing steps were related to toothpaste utilization: 32.5% (123) children could hold the tube of the toothpaste, 21.6% (82) children dispensed an appropriate amount of toothpaste onto the toothbrush, and 33.2% (126) children spat out the toothpastes during observation. Approximately 3.2% (12) children accomplished all the tooth-brushing steps, 13.2% (50) children were able to practice all the key

steps independently, and 15.8% (60) children performed zero-step during the observation.

Factors Associated with Children's Tooth-Brushing Performance

The bivariate analysis indicated that children's toothbrushing performance was associated with their adaptive skills and oral hygiene practices. Children with average or high adaptive skills were more likely to accomplish the whole tooth-brushing procedure. When compared to children who had low adaptive skills, children with average or high adaptive skills also spent longer time in tooth brushing ($p < 0.05$). Additionally, children who initiated tooth-brushing habit before age one could practice more tooth-brushing steps than their peers who started to brush teeth after 12 months ($p = 0.029$). Children who brushed their teeth at least twice daily could practice more tooth-brushing steps than their peers who had never or occasionally brushed their teeth (4.98 ± 3.69 vs. 2.79 ± 2.40, $p < 0.05$), Tables 1 and 2.

When children's age, gender, and SES were adjusted, the final models demonstrated that children with average or high adaptive skills were able to practice more tooth-brushing steps than their peers with low adaptive skills ($p < 0.05$). Children with average or high social skills spent more time in tooth brushing, when compared to those children who had low social skills ($p = 0.012$). Likewise, longer tooth-brushing duration was observed among children with average or high practical skills, when compared to those children who had low practical skills ($p = 0.001$). Children's oral hygiene practices were also associated with their tooth-brushing performance. Children who had brushed their teeth regularly were able to practice more tooth-brushing steps than those children who had not established regular tooth-brushing habits ($p < 0.05$). Meanwhile, children who had used gauze, cotton swab, dental floss, toothpick, or mouth rinse practiced fewer key steps than their peers who had never used additional cleaning approaches ($p = 0.038$), Table 3.

Table 1 Tooth-brushing steps accomplished by the recruited children

	N	Accomplishment of all steps		Accomplishment of key steps		Accomplishment of zero step	
		% (n)	*p* value	% (n)	p-value	% (n)	p-value
Adaptive skills							
Conceptual skills							
Average or high	52	11.5 (6)	0.001	30.8 (16)	< 0.001	3.8 (2)	< 0.001
Limited	228	2.6 (6)		12.3 (28)		11.8 (27)	
Low	99	0.0 (0)		6.1 (6)		31.3 (31)	
Social skills							
Average or high	59	8.5 (5)	0.018	25.4 (15)	0.001	1.7 (1)	< 0.001
Limited	234	3.0 (7)		13.2 (31)		11.5 (27)	
Low	86	0.0 (0)		4.7 (4)		37.2 (32)	
Practical skills							
Average or high	44	9.1 (4)	0.017	29.5 (13)	< 0.001	4.5 (2)	< 0.001
Limited	194	3.6 (7)		16.0 (31)		5.7 (11)	
Low	141	0.7 (1)		4.3 (6)		33.3 (47)	
Oral-health related behaviors							
Tooth-brushing initiation							
< 12 months	174	3.4 (6)	N.S.	16.1 (28)	N.S.	14.4 (25)	N.S.
≥ 12 months	205	2.9 (6)		10.7 (22)		17.1 (35)	
Tooth-brushing frequency							
Twice or more	191	4.2 (8)	N.S.	16.2 (31)	0.029	12.6 (24)	N.S.
Once daily	125	3.2 (4)		13.6 (17)		16.8 (21)	
Never/occasionally	63	0.0 (0)		3.2 (2)		23.8 (15)	
Additional cleaning							
Yes	98	3.1 (3)	N.S.	11.2 (11)	N.S.	23.5 (23)	0.016
No	281	3.2 (9)		13.9 (39)		13.2 (37)	

Chi square test, Fisher's exact test, Mann–Whitney U test were used to compare proportions and rates when appropriate

Table 2 Tooth-brushing duration and number of tooth-brushing steps practiced by the recruited children

	N	Tooth-brushing duration (s)		Number of overall steps		Number of Key steps	
		Mean (SD)	*p*-value	Mean (SD)	*p*-value	Mean (SD)	*p*-value
Adaptive functioning							
Conceptual skills							
Average or high	52	128.71 (66.99)	0.008	7.08 (3.68)	< 0.001	2.63 (1.91)	0.011
Limited	228	101.63 (65.42)		4.64 (3.40)		1.81 (1.69)	
Low	99	93.56 (68.18)		2.72 (2.87)		1.14 (1.44)	
Social skills							
Average or high	59	135.56 (63.01)	< 0.001	6.39 (3.54)	< 0.001	2.49 (1.79)	< 0.001
Limited	234	104.07 (65.07)		4.83 (3.46)		1.85 (1.71)	
Low	86	78.78 (65.92)		2.17 (2.57)		0.94 (1.37)	
Practical skills							
Average or high	44	151.23 (64.78)	< 0.001	6.86 (3.63)	< 0.001	2.70 (1.86)	< 0.001
Limited	194	107.58 (64.44)		5.12 (3.37)		2.07 (1.71)	
Low	141	82.28 (62.71)		2.84 (3.07)		1.00 (1.37)	
Oral-health related behaviors							
Tooth-brushing initiation							
< 12 months	174	105.05 (67.46)	N.S.	4.91 (3.71)	0.029	1.93 (1.80)	N.S. (0.056)
≥ 12 months	205	101.70 (66.83)		4.10 (3.39)		1.59 (1.63)	
Tooth-brushing frequency							
Twice or more	191	108.57 (66.64)	N.S.	4.98 (3.69)	0.001	1.96 (1.82)	< 0.001
Once daily	125	101.90 (67.95)		4.54 (3.61)		1.83 (1.69)	
Never/occasionally	63	89.71 (65.49)		2.79 (2.40)		0.94 (1.16)	
Additional cleaning							
Yes	98	93.17 (67.34)	N.S.	3.89 (3.69)	N.S. (0.059)	1.38 (1.69)	0.013
No	281	106.74 (66.71)		4.68 (3.49)		1.88 (1.71)	

Tooth-brushing duration was measured in second(s). Two-sample t-test was used to compare the means between two groups. Analysis of variance (ANOVA) was used to compare the means among multiple groups, while Kruskal–Wallis H test was used if un-equal variance existed among multiple groups

Discussion

To the best of our knowledge, this investigation was the first study to assess the tooth-brushing performance among preschool children with SHCN by using a standardized 13-step pro forma. The tooth-brushing assessment tool had been validated in the previous study, and the internal reliability was 0.82 (Zhou et al. 2018). The pro forma covered the whole tooth-brushing procedure (13 steps) in a single tooth-brushing session, including the preparation phase (hold the toothbrush, rinse the toothbrush, hold the tube of toothpaste, and squeeze toothpaste), key tooth-brushing phase (brushing of teeth in different quadrants, also termed as "key steps"), and clean-up phase (spit out toothpaste, rinse, wipe, and put away tooth-brushing supplies) (McGrath et al. 2017; Zhou et al. 2018). The main tooth-brushing characteristics among preschool children with SHCN were identified in this study.

In this investigation, almost half of the preschool children with SHCN had initiated the tooth-brushing habit before the age of 12 months. However, among children without SHCN, less than a quarter of parents reported that their children had established tooth-brushing habit before the age of 12 months (Khadri et al. 2010; Wong et al. 2012). Besides, 25.9% of the recruited parents had used dental floss, toothpick, gauze and cotton swabs to clean their children's teeth. In mainstream kindergartens, only 15.7% children had used additional tooth-cleaning aids (Chen et al. 2017). The above findings indicated that parents who were taking care of children with SHCN had made great efforts to help their children establish appropriate oral hygiene-related habits.

Although parents had spent time and efforts in cultivating appropriate oral hygiene practices for children with SHCN, the unfavorable tooth-brushing performance still existed among those children. By using the 13-step assessment tool, the average number of tooth-brushing steps performed by the recruited children was 4.47 (± 3.56), and only 3.2% children were able to practice all the tooth-brushing steps independently. In terms of toothpaste utilization, only 21.6% of the recruited children were able to dispense the toothpaste onto the toothbrush, and 33.2% of those children had spat out the

Table 3 Key factors associated with children's tooth-brushing performance

	Model 1 (tooth-brushing duration)		Model 2 (number of overall steps)		Model 3 (number of key steps)	
	Estimate (SE)	*p*-value	Estimate (SE)	*p*-value	Estimate (SE)	*p*-value
Adaptive functioning						
Conceptual skills				0.027		
Average or high (1)			2.05 (0.81)	0.012		
Limited (2)			0.36 (0.50)	N.S.		
Low(3)[a]						
Social skills		0.037		0.009		
Average or high (1)	31.35 (12.44)	0.012	1.55 (0.78)	0.049		
Limited (2)	15.86 (8.45)	N.S.	1.58 (0.51)	0.002		
Low(3)[a]						
Practical skills		0.004		0.004		< 0.001
Average or high (1)	43.85 (13.26)	0.001	1.87 (0.72)	0.010	1.61 (0.28)	< 0.001
Limited (2)	9.66 (7.72)	N.S.	1.27 (0.41)	0.002	0.98 (0.18)	< 0.001
Low(3)[a]						
Oral hygiene-related behaviors						
Tooth-brushing frequency				0.001		<0.001
Twice or more (1)			1.73 (0.47)	< 0.001	0.95 (0.23)	< 0.001
Once daily (2)			1.53 (0.50)	0.002	0.85 (0.25)	0.001
Never/occasionally (3)[a]						
Additional tooth-cleaning						
Yes					− 0.39 (0.19)	0.038
No[a]						

Tooth-brushing duration was measured in second (s). Children's age, gender, and SES were adjusted in the ANCOVA final models

[a]Reference category

toothpaste. Moreover, nearly 16% of the participants practiced none of the routine tooth-brushing steps (zero-step) during the observation. Liu et al. (2010) also reported that almost 67% children with profound or severe disabilities were not able to brush teeth by themselves. Thus, most of the children who had SHCN greatly relied on their parents to accomplish the tooth-brushing task in their daily lives.

The potential factors associated with children's tooth-brushing performance were also explored in this study. The main findings of this investigation revealed that children with various levels of conceptual skills, social skills, and practical skills showed significant differences in their tooth-brushing performances, including the number of overall tooth-brushing steps, key tooth-brushing steps, and tooth-brushing duration. When children's gender, age, and SES were adjusted, children with high levels of adaptive skills were able to practice more tooth-brushing steps than those children who had low adaptive skills. Other studies also indicated that children with significant limitations in adaptive skills were facing various obstacles in managing their self-care routines, and most of them had to depend on parents or caregivers to support their daily living activities (Chi et al. 2014; Mays and Heflin 2011; Villarreal et al. 2014). Besides, children's oral hygiene-related habits were also associated with their tooth-brushing performance. Children who had initiated the tooth-brushing habit before age one could practice more tooth-brushing steps than those children who established tooth-brushing habit after age one. Meanwhile, children who had brushed their teeth regularly were able to practice more tooth-brushing steps than children who had not never brushed their teeth.

Considering the benefits of early initiation of tooth-brushing habit, children with SHCN are encouraged to establish regular tooth-brushing habit in their early childhood. However, younger children usually try to hide themselves from tooth-brushing. Non-compliant behaviors (gagging, crying, running away, refusing to open the mouth, biting the toothbrushes, or not able to keep still) were frequently observed among those children (Campanaro et al. 2014; Du et al. 2019; Elison et al. 2014). A cross-sectional study conducted in the Special Child Care Centers stated that 36.9% of the recruited children were scared of tooth-brushing, and almost half of those children did not understand the importance of daily tooth-brushing (Du et al. 2019). Campanaro et al. (2014) claimed that children's noncompliance towards tooth-brushing was one of the most frequent external barriers

reported by the parents who were taking care of children with SHCN. Children with SHCN need parental assistance to maintain good oral hygiene status. However, children's resistant behaviors can make parental assistance extremely difficult to be implemented. Therefore, tooth-brushing training should be provided to young children with SHCN. The early childhood training programs can help those children to improve their tooth-brushing performance, and reduce their parents' caregiver burdens.

There were limitations in this investigation. The main limitation was the real-time observation of children's tooth-brushing behaviors. Children in this study were accompanied by their parents, and they were instructed to perform their routine tooth-brushing activities in front of investigators, just as the way they practiced in their daily life. Our original intention was to collect the first-hand information on children's tooth-brushing routines. However, children with special care needs were presumably more likely to interact with their family members (Zurbriggen et al. 2018). When confronted with dentists (strangers), some children might be nervous, and they were likely to show resistant behaviors during the tooth-brushing assessment. Therefore, the observed tooth-brushing performance might be biased from the routine performance children practiced at home. However, during the tooth-brushing observation, 60 (15.8%) of the recruited children performed zero-step, while parents had reported that 63 (16.6%) of those children had never or only occasionally brushed their teeth at home. The proportion of children who did not brush their teeth during the assessment was similar to that of children who had not brushed their teeth regularly at home. Thereby, the tooth-brushing performance observed by the investigators were feasible to reflect children's routine performance on a certain level. In further studies, tooth-brushing training programs should be advocated among preschool children with SHCN. Those training programs may prevent plaque-induced dental diseases among children with SHCN. Meanwhile, children's self-care ability can be improved by early intervention, and the caregiver burden can be reduced.

Conclusions for Practices

In this cross-sectional study, tooth-brushing performance and its associated factors were investigated among preschool children with SHCN. Based on the main findings, the following conclusions could be addressed: (i) Most of the preschool children with SHCN could not practice the whole tooth-brushing procedure; (ii) A quarter of preschool children with SHCN were using additional cleaning approaches to keep their mouth clean, and the additional tooth-cleaning techniques tended to be used among children who had difficulties in performing key tooth-brushing steps; (iii) Adaptive functioning was associated with children's tooth-brushing performance, and children with higher adaptive skills showed better tooth-brushing performance; (iv) Establishing regular tooth-brushing habits at an earlier age might contribute to better tooth-brushing performance among children with SHCN; (v) Early tooth-brushing training should be recommended to safeguard the oral health status of young children with SHCN.

Acknowledgements We would like to express our deepest gratitude to all the recruited children and their parents for their participation and cooperation. We gratefully acknowledge the staff in the Special Child Care Centers, Ms Cindy YEUNG and Kuen Wai Ma for their excellent assistance in administration of the study. The work described in this paper was fully supported by a grant from the Research Grants Council of the Hong Kong Special Administrative Region, China (Project No. 17118518).

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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