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Frequent toothbrushing boosts resilience among children in poverty: results from a population-based longitudinal study

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Abstract

Background Poverty negatively impacts beneficial aspects of mental development, such as resilience. Toothbrushing, an oral health behavior, has the potential to protect children's resilience through its anti-inflammatory and self-management effects and may be more effective for children, especially children in poverty. This study investigated whether toothbrushing boosts resilience among children, especially children under poverty, and modifies the association between poverty and resilience using a longitudinal population sample of school children.

Methods Data from the Adachi Child Health Impact of Living Difficulty (A-CHILD Study) were analyzed. A baseline study was conducted in 2015 in which the children were in first grade and followed through fourth grade ($N=3459$, response rate: 80%, follow-up rate: 82%). Poverty was assessed by material deprivation (life-related deprivation and child-related deprivation) and annual household income at baseline. Children's toothbrushing frequency was assessed at baseline and classified into less than twice a day or twice or more a day. Children's resilience was assessed at baseline and follow-up using the Children's Resilient Coping Scale (range 0-100).

Results Children who brushed their teeth twice or more a day in first grade had 3.50 points greater resilience scores in fourth grade than those who brushed their teeth less than twice a day in first grade. After adjusting for confounders, including resilience in first grade, among underpoverty children, those who brushed their teeth twice or more a day in first grade had higher resilience scores [2.66 (95% CI=0.53, 4.79)] than those who brushed their teeth less than twice a day. Among nonpoverty children, toothbrushing frequency in first grade did not significantly correlate with resilience in fourth grade.

Conclusions The beneficial effect of toothbrushing twice or more a day on resilience was more significant among children in poverty than among those without poverty in elementary school in Japan. Health policy focused on frequent toothbrushing may contribute to boosting resilience among children living in poverty.

Keywords Oral hygiene, Mental health, Poverty, Epidemiology, Public health, Behavioral science

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Introduction

According to global epidemiological data, the prevalence of mental health disorders in children and adolescents is approximately 20% worldwide [1]. The long-term negative consequences of child mental health problems, such as low income or prematurity, have been reported [2, 3]. Therefore, it is essential to address the mental health of children. Previous studies have focused on the treatment of negative aspects of mental health, such as depression or anxiety [4]. However, few studies have focused on promoting positive aspects of mental health, such as resilience. Resilience refers to the capacity to rebound from adversity, misfortune, trauma, or other transitional crises and to achieve successful adaptation [5, 6]. Children with higher resilience are less likely to suffer from mental health problems such as depression and anxiety later in life [7, 8].

One of the most critical determinants of resilience is childhood poverty [9]. Given that poverty is a barrier to developing resilience, other modifiable factors need to be elucidated, as poverty per se is difficult to modify. The modifiable factor needs to be an achievable lifestyle because changing a lifestyle does not cost and can be implemented at home. Moreover, it should be easy to understand as parents of childhood poverty may have limited educational attainment.

Oral health behaviors, such as toothbrushing, may be a lifestyle factor to protect children's resilience.

Toothbrushing twice a day is widely recommended to prevent dental problems [10, 11]. A recent epidemiological study showed that toothbrushing less than twice a day is associated with school refusal (refusing or reluctance to attend school or problems staying in school, often causing prolonged absence) in elementary school children [12]. Additionally, routinely brushing their teeth as a healthy lifestyle is beneficial or even crucial to developing children's health practices and self-regulatory capacities [13].

Considering that childhood poverty poses a risk to impaired mental health development [9], which can be partially explained by inflammation [14], the effects of toothbrushing may differ for children in poverty and nonpoverty states. Thus, this study aimed to investigate whether toothbrushing frequency boosts resilience among children, especially children under poverty and modifies the association between poverty and resilience using a longitudinal population sample of school children in Japan.

Method

Study participants

This study used data from the Adachi Child Health Impact of Living Difficulty (A-CHILD) Study, which began in 2015 for first-grade students attending all public elementary schools in Adachi City, Tokyo, Japan. Figure 1 shows the flow-chart of the participants included in this

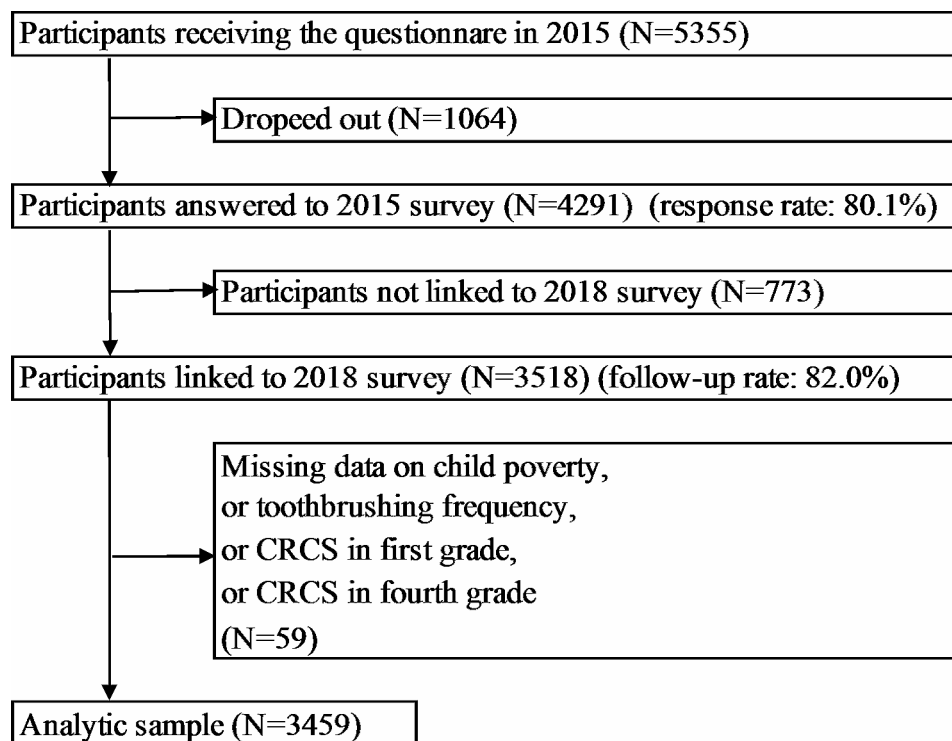


Fig. 1 Flow-chart of study participants

study. In 2015, a questionnaire was distributed to caregivers of all first graders in the city ($N=5355$), and 4291 of them answered the questionnaire [response rate: 80.1%, the average age: 6.65 years (SD: 0.48)]. The questionnaire used for this study has previously been published elsewhere [12, 15–18]. We used the question items of child poverty, toothbrushing frequency, child resilience, and other covariates. In previous studies, the questionnaire on child poverty is used to elucidate the association of child poverty and low self-esteem and to examine the effects of multiple dimensions of child poverty on child behavioral problems [16, 18]. The questionnaire on toothbrushing frequency is used to examine the association of school refusal among elementary school children [12]. The questionnaire on child resilience is used to examine the impact of leaving children at home on their mental health and to examine the associations of home cooking with parent-child interaction and child mental health [15, 17]. The children were followed up until fourth grade in 2018 ($N=3518$, follow-up rate: 82.0%). After excluding 59 participants with missing information on variables related to child poverty, toothbrushing frequency, and child resilience (in first and fourth grades), the data of 3459 children were used for this analysis [the average age: 9.59 years (SD: 0.49)]. This study was approved by the ethics committees of Tokyo Medical and Dental University (M2016-284) and the National Center for Child Health and Development, Tokyo. All caregivers (parents or legal guardians) provided written informed consent to participate in the study. We followed the STROBE guidelines.

Child poverty

In a baseline survey of children in first grade, we assessed three aspects of child poverty: household income, material deprivation, and experience of payment difficulties [19, 20]. The caregivers were asked about their annual household income for the last year. They were also asked about material deprivation and experience of payment difficulty to consider child poverty from the aspect of the entire family environment, not just household economic hardship. Material deprivation was assessed by whether the participants lacked the following materials for financial reasons: books appropriate for their child's age, sports items/toys/stuffed toys for children, a place where children can study, a washing machine, a rice cooker, a vacuum cleaner, heater/heating appliances, an air conditioner, a microwave, a phone (including both landlines and mobiles), a bathtub per household, a bed/mattress per person, or >50,000 yen in savings for emergencies. Experience of payment difficulty was assessed by whether they were unable to pay the following items over the last year: school field trips/extracurricular activities, school textbooks, school lunches, rent, housing loans,

electricity bills, gas bills, water bills, phone bills (including both landlines and mobiles), insurance fees for public pension/national health insurance/public nursing care, or bus/train fees for commuting. We defined child poverty as they apply to any one of the following three categories: (1) annual household income below 3 million JPY, (2) one or more material deprivations, and (3) at least one experience of payment difficulty. This definition is based on the deprivation theory about relative poverty [21].

Toothbrushing frequency

Caregivers of first-year students responded to the question of how many times a day their children brushed their teeth with the following options: “more than once a day,” “once a day,” and “not every day.” This was then categorized into a binary variable of “twice or more a day” or “less than twice a day” [12].

Child resilience

Child resilience was assessed by the Children's Resilient Coping Scale (CRCS), which was developed to adapt to the Japanese context [15]. It has high internal consistency (Cronbach's $\alpha=0.80$) and sufficient validity [15]. The specific questions asked to the caregivers about their children last month were as follows: (1) to express positive aspects of their future, (2) to try to do their best, (3) to cope well with teasing or mean comments, (4) to greet others properly, (5) to prepare for school, do homework, and help at home on their own without directions, (6) to seek help appropriately when needed, (7) to give up things they want or do things they do not want to do for better results in the future, and (8) to ask questions to learn about what they do not understand. Parents responded to these questions on a 5-point scale from 0 (never) to 4 (very frequently). For the analysis, the total score ranged from 0 to 100. Higher scores indicate a higher level of resilience. The Cronbach's α in our study sample was 0.74.

Covariates

The following covariates were assessed by baseline questionnaire to the caregivers: child's sex, number of parents living at home (two, one, none), number of grandparents living at home (none, one, two or more), number of children in the household (one, two, three, four or more), maternal age (<30, 31–34, 35–39, 40–44, ≥ 45 years old), maternal education (less than high school, junior college or technical school, university or more, others), maternal employment (full/part-time or not working), and caregiver mental health. The caregiver's mental health was assessed by the Japanese version of Kessler 6 (K6) [22] and categorized into two groups based on their scores (5 or more, less than 5) [23]. The higher the score is, the

more likely it is that there is a problem with their psychological state.

Statistical analysis

First, we examined the differences in demographic characteristics between children living in poverty and non-poverished children using Pearson's chi-square test. Next, the interaction effect of toothbrushing frequency and child poverty on resilience was analyzed using multiple regression analysis. Then, because we found an interaction effect between toothbrushing frequency and child poverty, we analyzed the impact of toothbrushing frequency on resilience with stratification by child poverty. Model 1 is a crude model. Model 2 was adjusted for potential confounders (sex, number of parents living at home, number of grandparents living at home, number of children in the household, maternal age, maternal education, maternal employment, and maternal mental condition). Model 3 was additionally adjusted for children's resilience at baseline. All analyses were conducted using STATA version 17.

Results

Table 1 shows the demographic characteristics of the participants at baseline. The percentage of children in poverty in first grade was 23.0%. Among all participants, 1749 (50.6%) were boys, 281 (8.1%) lived in a single-parent family, and 700 (20.2%) had no siblings. Children in poverty tended to brush their teeth less than twice a day, lived in a single-parent family, lived with one or more grandparents, and had many siblings in the household. Their mothers tended to be younger, have less education, be full/part-time working, and have some problems with mental health.

Table 2 shows the associations between Children's Resilience of Coping Scale (CRCS) in fourth grade and child poverty in first grade, including toothbrushing frequency interaction terms in first grade. After adjustment for confounders, the resilience score of fourth-grade children in poverty in first grade decreased by -1.53 (95% CI: -2.91 – -0.15) points compared to that of nonpoverty children. The resilience of children who brushed their teeth twice or more a day in first grade was 3.50 (95% CI: 2.23–4.77) points greater than that of those who brushed their teeth less than twice a day in fourth grade (Model 1). The interaction effect between child poverty and toothbrushing frequency was significant (p value=0.008) (Model 2).

Table 3 shows the association of the Children's Resilience of Coping Scale in fourth grade with child poverty in first grade by toothbrushing frequency in first grade among children in Japan. The mean resilience score in fourth grade was 68.0 for children in poverty who brushed their teeth twice or more a day, which

was greater than the 67.6 for nonpoverty children who brushed their teeth less than twice a day (Table 3; Fig. 2). The effect of toothbrushing on resilience was stronger for children living in poverty than for those living in nonpoverty. After adjusting for potential confounders, among nonpoverished children, children who brushed their teeth twice or more a day in first grade had 2.42 (95% CI: 0.95–3.88) points greater resilience scores in fourth grade than those who brushed their teeth less than once a day (Model 2). Among children in poverty, children who brushed their teeth twice or more a day in first grade had 6.39 (95% CI: 3.81–8.98) points higher resilience scores in fourth grade than those who brushed their teeth less than twice a day. After further adjustment for the CRCS score at baseline, among children living in poverty, children who brushed their teeth twice or more a day had 2.66 (95% CI: 0.53–4.79) higher resilience scores than children who brushed their teeth less than twice a day (Model 3). On the other hand, among nonpoverty children, toothbrushing frequency in first grade did not significantly correlate with children's resilience in fourth grade.

Discussion

We found that children who brushed their teeth twice or more daily in first grade had higher resilience scores in fourth grade than children who brushed their teeth once or less in first grade. Additionally, there was a significant interaction effect of child poverty and toothbrushing frequency; that is, the effect of toothbrushing on resilience was greater among underpoverty children.

To our knowledge, the current study is the first to find a positive association between toothbrushing frequency and resilience. This finding is in line with a longitudinal study of A-CHILD data showing an association between toothbrushing frequency in first grade and school refusal in second grade [12]. Other studies have also shown consistent findings on resilience and oral health behaviors; for example, several studies of teenagers have shown that higher toothbrushing frequency is associated with higher self-esteem [24], and toothbrushing less than twice a day is associated with poor mental health, evaluated by a lack of close friends, loneliness, anxiety, suicidal ideation and suicide attempts [25]. Furthermore, although in the opposite direction, a cross-sectional study of first-year medical students in Romania reported that students with higher resilience scores were more likely to floss their teeth, use mouth rinses, and visit dental clinics for check-ups or cleaning, even though they were less likely to brush their teeth. [26] As these studies were conducted in a cross-sectional design, directionality remained uncertain. We add to the literature that children who frequently brush their teeth exhibit increased resilience regardless of their baseline resilience status.

Table 1 Child poverty by demographic characteristics of participants at baseline (N = 3459)

	Total n = 3,459 N (%) or mean (SD)	Child poverty		P-value
		No n = 2,663; 77.0% N (%) or mean (SD)	Yes n = 796; 23.0% N (%) or mean (SD)	
Sex				
Boy	1,749 (50.6%)	1,335 (50.1%)	414 (52.0%)	0.352
Girl	1,710 (49.4%)	1,328 (49.9%)	382 (48.0%)	
Toothbrushing frequency				
less than twice a day toothbrushing	777 (22.5%)	549 (20.6%)	228 (28.6%)	< 0.001
twice or more a day toothbrushing	2,682 (77.5%)	2,114 (79.4%)	568 (71.4%)	
Number of parents living at home				
Two parents	3,152 (91.1%)	2,563 (96.2%)	589 (74.0%)	< 0.001
One parent	281 (8.1%)	85 (3.2%)	196 (24.6%)	
No parents	26 (0.8%)	15 (0.6%)	11 (1.4%)	
Number of grandparents living at home				
No grandparents	3,095 (89.5%)	2,407 (90.4%)	688 (86.4%)	0.002
One grandparent	204 (5.9%)	137 (5.1%)	67 (8.4%)	
Two+ grandparents	160 (4.6%)	119 (4.5%)	41 (5.2%)	
Number of children in the household				
One child	700 (20.2%)	541 (20.3%)	159 (20.0%)	< 0.001
Two children	1,827 (52.8%)	1,479 (55.5%)	348 (43.7%)	
Three children	757 (21.9%)	541 (20.3%)	216 (27.1%)	
Four+	175 (5.1%)	102 (3.8%)	73 (9.2%)	
Maternal age				
< 30	160 (4.6%)	76 (2.9%)	84 (10.6%)	< 0.001
30–34	594 (17.2%)	421 (15.8%)	173 (21.7%)	
35–39	1,218 (35.2%)	961 (36.1%)	257 (32.3%)	
40–44	1,117 (32.3%)	909 (34.1%)	208 (26.1%)	
45+	249 (7.2%)	192 (7.2%)	57 (7.2%)	
Missing	121 (3.5%)	104 (3.9%)	17 (2.1%)	
Maternal education				
Less than high school	1,128 (32.6%)	741 (27.8%)	387 (48.6%)	< 0.001
Junior college or technical school	1,334 (38.6%)	1,083 (40.7%)	251 (31.5%)	
University or more	642 (18.6%)	575 (21.6%)	67 (8.4%)	
Others	22 (0.6%)	10 (0.4%)	12 (1.5%)	
Missing	333 (9.6%)	254 (9.5%)	79 (9.9%)	
Maternal employment				
Yes	2,209 (63.9%)	1,639 (61.6%)	570 (71.6%)	< 0.001
No	1,206 (34.9%)	994 (37.3%)	212 (26.6%)	
Missing	44 (1.3%)	30 (1.1%)	14 (1.8%)	
Maternal mental condition				
K6: <5	2,483 (71.8%)	2,025 (76.0%)	458 (57.5%)	< 0.001
K6: 5+	956 (27.6%)	625 (23.5%)	331 (41.6%)	
Missing	20 (0.6%)	13 (0.5%)	7 (0.9%)	

The association between toothbrushing and resilience can be explained by two possible reasons, which can be inferred from the findings that the benefits of toothbrushing frequency on resilience were pronounced among poor children. First, toothbrushing reduces inflammation and stress, which is more common among children with a low income due to various stresses, such as material hardship, family instability, and harsh parenting [27–30]. Good oral hygiene through toothbrushing

can maintain the oral immune system and prevent oral inflammation, such as gingivitis and periodontal disease [11, 31]. Furthermore, oral inflammation causes systemic inflammation when periodontal pathogens, endotoxins, and proinflammatory cytokines invade the blood circulation. [32, 33]. Inflammatory conditions are negatively associated with resilience; PTSD patients or those who were exposed to adverse childhood experience (ACE) had higher levels of an inflammatory biomarker (IL-6) and

Table 2 Association of Children's resilient of coping scale (CRCS) with child poverty in Japan, including toothbrushing frequency interaction terms (N = 3459)

Variable	Model 1 coefficient (95% CI)	Model 2 coefficient (95% CI)
Child poverty		
No	ref.	ref.
Yes	-1.53 (-2.91, -0.15)	-4.34 (-6.82, -1.86)
Toothbrushing frequency		
less than twice a day toothbrushing	ref.	ref.
twice or more a day toothbrushing	3.50 (2.23, 4.77)	2.45 (0.97, 3.93)
Child poverty x Toothbrushing frequency		
poverty x twice or more a day toothbrushing	-	3.84 (1.03, 6.66)

Notes: Boldface indicates statistical significance ($p < 0.05$)

Both models adjusted for sex, number of parents living at home, number of grandparents living at home, maternal mental condition, number of children in the household, maternal age, maternal education, maternal employment

Table 3 Association of Children's resilient of coping scale (CRCS) with child poverty by toothbrushing frequency among children in Japan (N = 3459)

Child poverty / Toothbrushing frequency	n	CRCS (mean)	Model 1 (crude) Coef- ficient (95% CI)	Model 2 (adjusted) Coefficient (95% CI)	Model 3 (ad- justed) Coef- ficient (95% CI)
no poverty (n = 2,663)					
less than twice a day toothbrushing	549	67.6	ref.	ref.	ref.
twice or more a day toothbrushing	2,114	70.8	3.26 (1.76, 4.75)	2.42 (0.95, 3.88)	0.65 (-0.57, 1.88)
poverty (n = 796)					
less than twice a day toothbrushing	228	62.0	ref.	ref.	ref.
twice or more a day toothbrushing	568	68.0	5.99 (3.40, 8.57)	6.39 (3.81, 8.98)	2.66 (0.53, 4.79)

Note: Boldface indicates statistical significance ($p < 0.05$)

Model 2 adjusted for sex, number of parents living at home, number of grandparents living at home, number of children in the household, maternal age, maternal education, maternal employment, maternal mental condition

Model 3 adjusted for Model 2 + CRCS at baseline

lower levels of an anti-inflammatory biomarker (IL-10), while the resilient group had decreased IL-6 levels and increased IL-10 levels [34–36]. Resilience was also associated with immune function; individuals with greater resilience were less likely to perceive reduced immune

functioning (such as sore throat, flu, cold sores, ear infection, and sudden high fever) [37, 38]. Therefore, toothbrushing may contribute to resilience in poor children through its anti-inflammatory effects and ability to maintain the immune system.

Second, toothbrushing per se develops self-regulation skills [39]. The stronger association between toothbrushing and resilience can be explained by the effect of toothbrushing on developing self-regulation, which is more significant due to the insufficient opportunity for children to develop self-regulation skills due to the shorter parenting time among those in poverty [40–43]. For children in early elementary school, brushing their teeth is one of their most minor favorite tasks [44]. Since toothbrushing is a part of every meal every day, it is possible that children develop self-regulation and perseverance by continuing to brush their teeth daily, even if they dislike it. Therefore, children, especially those in poverty, may benefit from toothbrushing to develop resilience.

Our findings also indicate toothbrushing as a factor modifying the effect of poverty on resilience. Evidence of factors that promote the resilience of children in poverty, with a focus on healthy behaviors other than toothbrushing, has been reported. A study of children (7–17 years old) from low-income families in Oakland, California, revealed that visiting parks for nature exposure improved children's self-reported resilience [45]. In addition, a study conducted with children in Washington State reported that sleep sufficiency partially mediated the association between poverty and mental health [9]. Compared to these factors, toothbrushing behavior is more accessible to practice and less influenced by home and school environment factors because the proximal cause of children's toothbrushing frequency is their intentions. [46, 47].

Several limitations in this study should be noted. First, we relied on caregivers' reports for the variables of children's toothbrushing frequency and resilience, which may have caused common method and social desirability biases. Future studies are needed to assess toothbrushing frequency through objective measurements, such as sensors attached to the lower end of participants' toothbrush grips [48], diary records, and resilience through questionnaires to schoolteachers or children themselves. Second, the baseline response rate was 80%, and the follow-up rate was 82% in this study, which is not low but may have led to sampling and selection bias. Subjects who did not participate in the baseline survey might be more likely to be in poverty, brush their teeth less frequently, and have lower resilience. In addition, we excluded subjects with missing values for poverty, toothbrushing frequency, and resilience variables from this analysis. Comparing the baseline and analytical samples, the analytical samples had a greater percentage of children who were

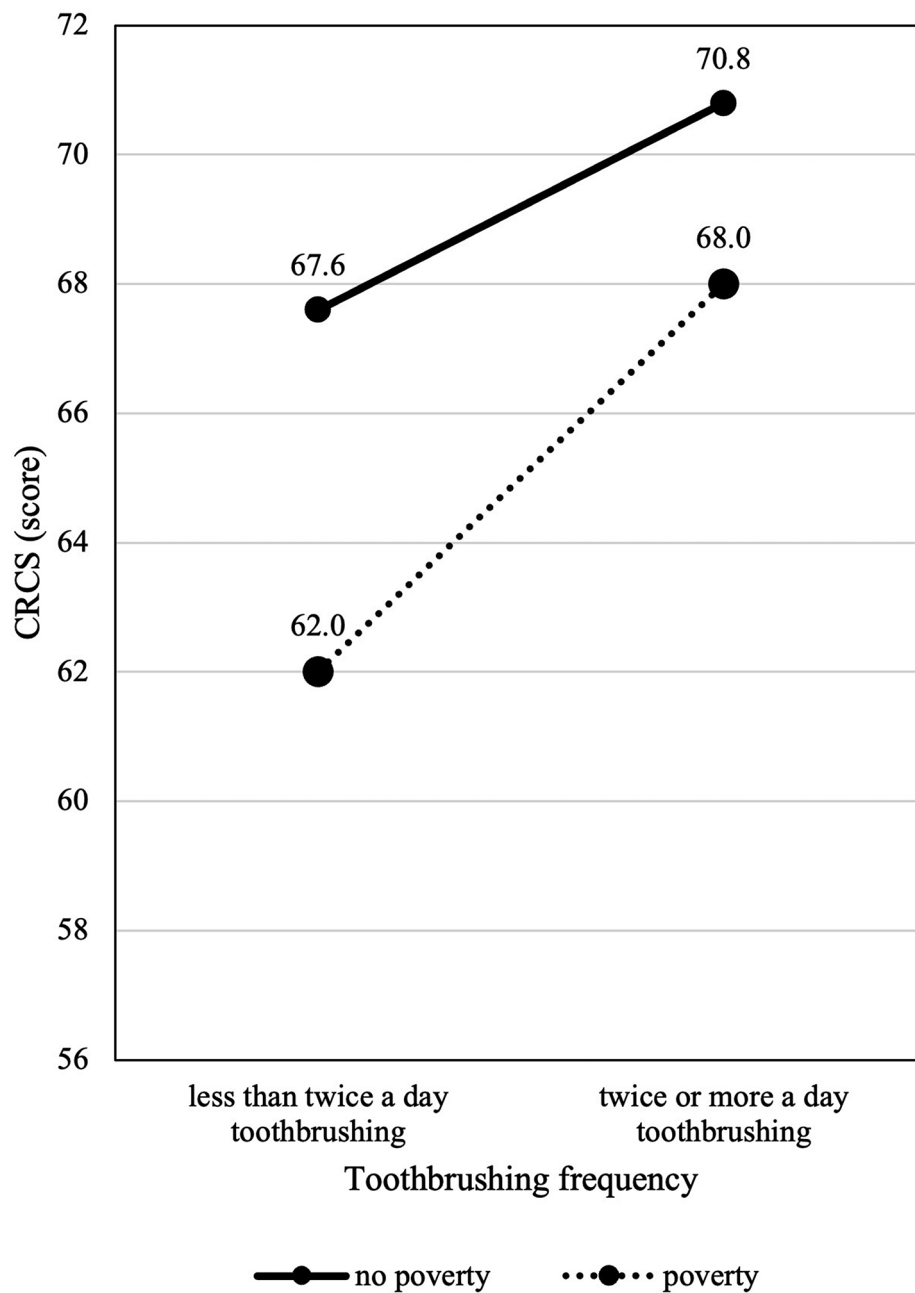


Fig. 2 The mean of Children's Resilient of Coping Scale (CRCS) by child poverty and toothbrushing frequency

not poor, brushed their teeth more than twice a day, and had higher resilience scores in fourth grade. (Appendix Tabel 1) Therefore, the findings may be underestimated. Third, since the participants of this study were children attending public elementary schools in Adachi city, Tokyo, an urban area in Japan, the results may differ for children in other regions or of other ages. Toothbrushing frequency varies by region of residence and tends to be greater in urban areas than in rural areas [49]. There may be regional differences in children's resilience because resilience is also enhanced by communities [50]. Further

intervention studies are needed to examine the causal association between toothbrushing frequency and resilience among children.

Conclusions

This longitudinal study of Japanese elementary school children revealed that the effect of toothbrushing twice or more a day on children's resilience was more significant for children living in poverty. Health policies that focus on the relatively easy-to-improve health behavior associated with toothbrushing frequency have the

potential to contribute to boosting the resilience of children in poverty.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12903-024-04686-9>.

Supplementary Material 1

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Author contributions

AS contributed to the study conception, study design, and formal analysis and drafted the first manuscript, and critically revised the manuscript. YT contributed to the study conception, design, and investigation and drafted and critically revised the manuscript. AI contributed to the data curation and investigation and critically revised the manuscript. TO contributed to the study conception, design, and supervision and critically revised the manuscript. KM contributed to the study conception, design, and supervision and critically revised the manuscript. TF contributed to the study conception, design, investigation, and supervision and critically revised the manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the ethics committee in Tokyo Medical and Dental University (M2016-284) and the National Center for Child Health and Development, Tokyo. All caregivers (parents or legal guardians) provided written informed consent to participate in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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