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Gender gap in tooth brushing among Korean adolescents

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Abstract

Background Previous studies have reported a gender gap in toothbrushing habits. Before the COVID-19 pandemic, the prevalence of tooth brushing after lunch among South Korean schoolboys (29.2%) was approximately half of that among girls (48.5%). During the pandemic, the rate of tooth brushing decreased in both boys and girls. However, the gender gap in toothbrushing decreased by 5.6%, owing to a larger decline in girls. This study aimed to understand the gender gap in toothbrushing before and during the pandemic.

Materials and methods Based on analyses of data obtained from the Korea Youth Risk Behavior Web-based Survey from 2017 to 2022, the nationally representative sample ($n = 341,265$) comprised middle and high school students. Chi-square tests and weighted probit regressions were performed to evaluate differences in the prevalence of tooth brushing after lunch according to socioeconomic factors, health-related behaviors, and mental health conditions. All analyses were performed using Stata (version 18.0, Stata Corp, College Station, Texas, USA), and statistical significance was set to $\alpha = 0.05$.

Results The gender gap cannot be explained by differences in hygiene practices (e.g., handwashing), health behaviors (smoking), parental education, family socioeconomic circumstances, depressive symptoms, or stress. One reason for the decline may be the policy of mandatory mask-wearing in Korean schools during the pandemic.

Conclusions If girls were more motivated than boys to brush their teeth for cosmetic reasons (clean appearance of teeth or fresh breath), this may account for the larger decrease in tooth brushing among girls during the mandatory mask-wearing policy.

Keywords Toothbrushing, Gender role, Adolescent, Covid-19, Sadness

Introduction

Socioeconomic inequalities in oral health have been well documented [1–4]. Indeed, oral health could be viewed as an indicator of a "measure of a just society", as socioeconomically disadvantaged groups experience an imbalanced burden of poor oral health at every stage of life [5]. Although oral health inequalities based on race/ethnicity and social class have been extensively documented, few studies have focused on gender gaps. For example, gender disparities in dental caries and periodontal disease have been reported but are often attributed to biological differences (for

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instance, the influence of sex hormones, or sex differences in salivary composition and flow rate) rather than social determinants [6, 7].

Oral health behaviors, particularly tooth brushing, are important for oral health [8, 9]. Tooth brushing is effective in reducing the level of dental plaque, which is the main risk factor for oral diseases [10]. Women are more likely to practice regular tooth brushing than men. They also exhibit more positive attitudes about dental visits, greater oral health literacy, and engagement in healthier behaviors (e.g., nonsmoking) than males [11]. The knowledge and practice of oral health behaviors tend to be poorer among adult males than females [12, 13]. Socioeconomic factors and cultural norms may interact with sex during dental service usage [14]. Potential gender variations have been recorded in the social and psychological impacts of oral health; women are more likely to endorse the belief that oral health has a greater impact on their quality of life than men [15, 16]. Financial hardship has been linked to poor self-reported oral health, especially among females [17].

Gender differences in oral health behaviors emerge relatively early in the life course. According to data from the Korea pre-pandemic period (2019), for example, the prevalence of tooth brushing after school lunches was 29.2% among boys, approximately half that of the prevalence among girls (48.5%). After the pandemic (2022), the prevalence of tooth brushing decreased in both boys and girls; however, the gender gap persisted (15.4% in boys versus 21.0% in girls) [18]. The total number of visits to dentists and dental hospitals in the first half of 2020 decreased by 16.3% for those aged 0 to 9 years and 9.2% for those aged 10–19 years compared with 2019. Visits for preventive measures have decreased more markedly by 34% for those aged 0–9 years and 31% for those aged 10–19 [19]. In the UK, the use of dental services has recovered to pre-pandemic levels for adults but not for children and the elderly, who are socioeconomically vulnerable, resulting in increased inequality [20].

The number of adults with depression also increased after COVID-19, and individuals with depression were less likely to practice optimal oral health behaviors compared to people who did not suffer from depression [21]. Previous studies have examined the relationship between mental health and oral health [22–24]. The link between poor mental health and poor oral health may be mediated by impaired immune response among individuals who are stressed [22]. Poor mental health may also be associated with difficulties in accessing oral care [25, 26]. Furthermore, mental health has been linked to oral symptoms [27, 28] and oral health behaviors [29], especially in adolescents. Studies also suggested gender differences in trajectories of mental health [30–32].

As COVID-19 has led to many changes in oral health and oral health behavior, it is important to understand the short- and long-term trends. This study aimed to elucidate gender differences in oral health behaviors during and after the COVID-19 pandemic.

Materials and methods

Study design and participants

We analyzed tooth brushing rates after lunch according to sex among middle and high school students using data from the Korea Youth Risk Behavior Web-based Survey (KYRBS) [33, 34] from 2017 to 2022. The target population for the survey was nationally representative of all public and private middle- and high-school students aged 12–18 years in South Korea. The survey design was based on multistage cluster sampling. The sampling framework was stratified into 117 regions and school districts. A sample of 400 middle schools and 400 high schools was allocated to participate every year. Schools were the primary sampling units (PSUs) in the first stage of sampling, and one classroom from each grade was selected as the secondary sampling unit. All students in the sampled classes were eligible to participate in the study. Students completed a self-administered anonymous questionnaire in a computer laboratory at their school between June and July. The probability of being selected was approximately 15% for middle- and high school and 2% for middle- and high school students in Korea. The item nonresponse rate was within 2%; therefore, the results were calculated without nonresponse substitution. The response rate of participants ranged from 92.2% in 2022 to 95.8% in 2017. The sample size ranged from 51,850 in 2022 to 62,276 in 2017. The characteristics of the schools and the numbers of male and female students in all classes were used to select classes and develop sample weights.

Study variables

The general characteristics discerned from the surveys included sex; grade of school, area, subjective income level, education and nationality of the parents, health-related behaviors such as consumption of fruit, soda, sweet drinks, breakfast, and fast-food, doing aerobic physical activity, drinking, smoking, washing hands before lunch, obesity, and sealant use, and mental health (feelings of stress or sadness). Categorizations of independent variables are summarized in Table 1: socioeconomic factors, health-related behaviors, and mental health conditions. The rate of tooth brushing after lunch served as the dependent variable. The Korea Centers for Disease Control and Prevention

Table 1 The weighted percentage of the study population, Korean middle- and high-school adolescents from 2017 to 2022

	N	Total	boys	girls	
Total	341,265	100.0	51.9	48.1	
Socioeconomic factors					
School					
Middle	177,489	48.5	48.3	48.7	
High	163,776	51.5	51.7	51.3	
Area					
City	149,313	42.4	42.3	42.4	
Province	191,952	57.6	57.7	57.6	
Subjective income level					
Average	303,677	88.8	86.9	90.9	***
Above average	37,585	11.2	13.1	9.1	
Father's education					
High school	69,604	30.0	29.7	30.3	
College and more	151,946	70.0	70.3	69.7	
Father's nationality					
non-Korean	1,275	0.5	0.5	0.4	*
Korean	272,686	99.5	99.5	99.6	
Mother's education					
High school	80,841	34.6	33.2	36.0	***
College and more	146,473	65.4	66.8	64.0	
Mother's nationality					
non-Korean	5,966	1.8	1.8	1.9	
Korean	270,214	98.2	98.2	98.1	
Health-related behaviors					
Having breakfast					
~5 times per week	122,154	35.7	34.3	37.2	***
6 + times per week	219,105	64.3	65.7	62.8	
Eating fruit					
~6 times per week	275,111	80.3	80.3	80.4	
once + a day	66,128	19.7	19.7	19.7	
Having soda & sweet drink					
~once a day	322,669	94.6	93.6	95.6	***
Twice + a day	18,596	5.4	6.4	4.4	
Eating fast-food					
~2 times per week	260,030	75.8	74.2	77.4	***
3 + times per week	81,235	24.3	25.8	22.6	
Doing physical activity					
~4 days per week	289,796	85.5	79.2	92.3	***
5 + days per week	51,469	14.5	20.8	7.7	
Drinking alcohol last month					
No	295,227	86.2	84.3	88.1	***
1 + days	46,038	13.8	15.7	11.9	
Smoking last month					
No	322,963	94.4	92.2	96.9	***
1 + days	18,362	5.6	7.8	3.1	
Obesity					
No	292,781	86.1	83.2	89.2	***
Yes	48,484	13.9	16.8	10.8	
Washing hands with soap before lunch at school last week					
Not usually	170,913	51.0	46.3	56.1	***
Usually	170,352	49.0	53.7	43.9	
Having sealant last year					
No	247,635	72.3	75.7	68.7	***

Table 1 (continued)

	N	Total	boys	girls	
Yes	93,630	27.7	24.4	31.3	
Mental health conditions					
Feeling stress usually					
No	66,055	19.1	24.3	13.5	***
Yes	275,210	80.9	75.7	86.5	
Feeling sad or despair over two weeks last year					
No	249,929	73.2	78.3	67.7	***
Yes	91,336	26.8	21.7	32.3	
COVID-19 period					
No (2017 ~ 2019)	179,619	52.2	52.3	52.0	
Yes (2020 ~ 2022)	161,646	47.8	47.7	48.0	

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

reports tooth brushing every year [34]. It is an important indicator of oral health, influenced by both school and peers. The other indicator, toothbrushing before bedtime, reflects influences in the home environment.

Statistical analysis

Analysis with sampling weights was applied because the KYRBS uses two-stage stratified cluster sampling [35]. Chi-square tests were conducted to evaluate differences in the prevalence of tooth brushing after lunch according to socioeconomic factors, health-related behaviors, and mental health conditions. Weighted probit regressions were performed for common binary outcomes [36], with Model 1 fully adjusting for covariates, and Model 2 incorporating interaction terms for sex × socioeconomic status or sex × mental health because these factors could act differently by sex. Variance inflation factors (VIFs) were used to assess multicollinearity among the socioeconomic variables. VIF > 10 indicated the presence of multicollinearity [37]. However, no indicators of multicollinearity were identified because all VIFs were < 5. All analyses were performed using Stata (version 18.0, Stata Corp, College Station, Texas, USA), and statistical significance was set to $\alpha = 0.05$. This study was reviewed by the institutional review board (IRB) of Kyung Hee University and determined to be "not-human subjects research" since the data are publicly available and de-identified.

Results

General characteristics of the study population

The total number of students in the sample was 341,265 (Table 1). Among these participants, 48.1% were girls and 48.5% attended middle school. Some socioeconomic variables, such as subjective income level, father's nationality, and mother's education level, showed statistically significant differences by sex. Among health behavior variables, only the frequency of eating fruit did not differ between boys and girls. The prevalence of dental sealant use in the previous year was higher in girls (31.3%) than in boys (21.7%). A total of 80.9% of students answered that they "usually felt stressed", while almost a quarter of students reported feeling sadness or despair lasting over two weeks during the past year. Girls reported that they were more likely to experience stress or sadness. The weighted proportion of adolescents who brushed their teeth after lunch was 32.0%, with girls reporting an almost 15% higher rate of tooth brushing than boys, which was statistically significant (Table 2). A gap of 22.9% was observed between middle and high school students, indicating that older students brush their teeth more often than younger students. The prevalence of tooth brushing decreased during COVID-19, from 38.9% before COVID-19 to 24.5%. The gap between boys and girls was highest among high school students (19.6%), as well as during the pre-COVID-19 period between 2017 and 2019 (19.4%). The gender gap in tooth brushing decreased by as much as 10.4% during the COVID-19 period (2020–2022), primarily due to a remarkable decline in tooth brushing among girls compared to that in boys.

Probit ratio regression analysis of factors associated with toothbrushing after lunch

The probit ratio regression analysis for factors affecting the prevalence of tooth brushing after lunch among adolescents is presented in Table 3. A significant association was noted between girls and toothbrushing after lunch in Model 1 (probit coefficient 0.50 [95% CI 0.47 to 0.52]; $p < 0.001$), which persisted after the inclusion of all other covariates. Several findings about healthy behaviors were noted: (a) students with unhealthy behavioral profiles (consumption of soda and fast food, higher body mass index) were less likely to brush their teeth (soda – 0.10 [-0.13 to -0.07], fast food – 0.06 [-0.08 to -0.05], or obesity – 0.13 [-0.15

Table 2 The weighted percentage of toothbrushing after lunch according to characteristics among the study population of adolescents

	N	*n*	Total		Boys (A)		Girls (B)		B-A
Total	341,265	113,506	32.0	***	24.7		39.8		15.1
Socioeconomic factors									
School									
Middle	177,489	40,277	20.2	***	15.1	***	25.5	***	10.4
High	163,776	73,229	43.1		33.7		53.3		19.6
Area									
City	149,313	41,849	26.7	***	20.2	***	33.7	***	13.5
Province	191,952	71,657	35.9		28.0		44.3		16.3
Subjective income level									
Average	303,677	101,425	32.1	***	24.4	***	40.1	***	15.7
Above average	37,585	12,081	30.7		26.7		36.9		10.1
Father's education									
High school	69,604	26,599	37.1	***	28.0	***	45.7	***	17.7
College and more	151,946	50,322	31.8		24.6		38.8		14.2
Father's nationality									
non-Korean	1,275	338	26.0	***	23.9		28.5	***	4.6
Korean	272,686	91,537	32.3		24.6		39.9		15.3
Mother's education									
High school	80,841	30,951	37.3	***	28.4	***	44.9	***	16.6
College and more	146,473	47,817	31.2		24.2		38.0		13.9
Mother's nationality									
non-Korean	5,966	1,790	27.2	***	22.1	**	32.0	***	10.0
Korean	270,214	90,660	32.3		24.6		39.8		15.2
Health-related behaviors									
Having breakfast									
~5 times per week	122,154	37,817	29.8	***	22.4	***	37.1	***	14.7
6 + times per week	219,105	75,688	33.2		25.9		41.4		15.5
Eating fruit									
~6 times per week	275,111	90,778	31.7	***	24.4	***	39.6	**	15.1
once + a day	66,128	22,725	33.0		25.9		40.7		14.8
Having soda & sweet drink									
~once a day	322,669	108,157	32.2	***	24.8	***	40.0	***	15.2
Twice + a day	18,596	5,349	27.9		23.0		35.4		12.4
Eating fast-food									
~2 times per week	260,030	88,375	32.6	***	24.9	**	40.6	***	15.7
3 + times per week	81,235	25,131	30.0		24.2		37.1		12.8
Doing physical activity									
~4 days per week	289,796	98,441	32.7	***	24.8		40.1	***	15.3
5 + days per week	51,469	15,065	27.5		24.4		36.5		12.0
Drinking alcohol last month									
No	295,227	95,699	31.1	***	23.4	***	39.0	***	15.6
1 + days	46,038	17,807	37.4		31.6		45.7		14.1
Smoking last month									
No	322,963	107,366	31.9		24.2	***	39.9	***	15.7
1 + days	18,362	6,140	32.5		31.0		36.6		5.6
Obesity									
No	292,781	98,965	32.5	***	25.1	***	39.9	*	14.8
Yes	48,484	14,541	28.8		22.7		38.9		16.1
Washing hands with soap before lunch at school last week									
Not usually	170,913	55,485	31.6	***	22.0	***	40.1		18.1
Usually	170,352	58,021	32.4		27.1		39.4		12.3
Having sealant last year									

Table 2 (continued)

	N	*n*	Total		Boys (A)		Girls (B)		B-A
No	247,635	80,747	31.4	***	24.5	***	39.6	*	15.1
Yes	93,630	32,759	33.5		25.5		40.2		14.7
Mental health conditions									
Feeling stress usually									
No	66,055	20,451	29.6	***	24.8		39.1	*	14.3
Yes	275,210	93,055	32.5		24.7		39.9		15.2
Feeling sad or despair over two weeks last year									
No	249,929	81,113	31.3	***	24.2	***	40.1	**	15.9
Yes	91,336	32,393	33.9		26.6		39.2		12.7
COVID-19 period									
No (2017 ~ 2019)	179,619	71,704	38.9	***	29.5	***	49.0	***	19.4
Yes (2020 ~ 2022)	161,646	41,802	24.5		19.4		29.8		10.4

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

to -0.11]); whereas (b) students engaged in other hygienic behaviors (washing hands) were more likely to brush their teeth (0.20 [0.18 to 0.21]). Sadness was not strongly correlated with tooth brushing in Model 1. However, as in Model 2, a significant gender interaction with sadness, boys experiencing sadness were more likely to brush their teeth, whereas girls were less likely to engage in brushing (interaction terms: -0.11 [-0.13 to -0.08]) (Fig. 1). In general, the students who reported feeling sad were more likely to brush their teeth after lunch in this model (0.07 [0.05 to 0.10]).

Discussion

Gender differences in health have been attributed to factors ranging from biological, socioeconomic, and cultural to medical service use [38]. Gender differences in tooth brushing could be attributed to disparities in knowledge, health literacy, risk avoidance, and socialization. Health behaviors are affected by health literacy [39]. Health literacy is the degree to which an individual obtains, manages, understands, and applies information to make health-related decisions. Female students exhibited higher levels of knowledge or attitudes related to oral health than male students [40, 41], but the relationship between health literacy, age, and gender has not been consistent in each study [42]. A recent systematic review and meta-analysis examining the association between oral health literacy and outcomes, such as oral health behavior, perception, knowledge, and dental treatment, reported no such relationship, including concerning the frequency of tooth brushing [43]. This finding may be attributed to individuals being educated about the benefits of toothbrushing from an early age. Gender differences in tooth brushing behaviors may also stem from variations in risk avoidance [44]. If tooth brushing is not perceived as a health-risk behavior, females may be more inclined to avoid the risk of deteriorating oral health. Additionally, healthy behaviors are shaped by socialization. Fitzgerald's qualitative study on Canadian adolescents suggested that they viewed oral health behaviors from either a medical or a cosmetic perspective. Those who thought of oral health behaviors from a medical perspective tended to spend less time brushing, while those who viewed it from a cosmetic standpoint often supplemented brushing with gargling solutions. If male students place less emphasis on the cosmetic aspect of tooth brushing, they may devote less time to the behavior. Moreover, boys were less likely to perceive practicing oral healthcare maintenance as a "masculine" behavior [45]. Among females, both adolescents and adults [46] visit dentists more frequently and take greater care of their oral health [47]. Females were more likely to engage in healthy behaviors when they considered that brushing significantly impacted their health and appearance [40, 48]. Improving oral health, therefore, requires consideration of cultural and gender-based differences. Finally, gender gaps exist in various health behaviors. For instance, males are more likely to smoke than females [49, 50], and fast food and soda consumption are positively associated with adolescent masculinity [51]. In our study, smoking and soda intake (both negatively correlated with tooth brushing) were higher among boys, whereas sadness was higher in girls (negatively correlated with tooth brushing). Nevertheless, these behaviors cannot explain the gender gap in tooth brushing.

During the COVID-19 pandemic, tooth brushing after lunch declined among both girls and boys, though the decrease was more pronounced among girls, narrowing the gender gap. One possible explanation for this decline is the mandatory use of face masks in Korean schools. Wearing masks may have reduced the perceived need for toothbrushing for cosmetic reasons, such as maintaining the appearance of

Table 3 The probit ratio coefficient and 95% confidence interval (CI) estimates for toothbrushing after lunch from probit regression model among the study population of adolescents

	Unadjusted			Model 1†			Model 2‡		
	Coef.	SE (95% CI)		Coef.	SE (95% CI)		Coef.	SE (95% CI)	
Socioeconomic factors									
Sex	0.42	0.01	***	0.50	0.01	***	0.53	0.02	***
(girls)		(0.40 ~ 0.45)			(0.47 ~ 0.52)			(0.49 ~ 0.56)	
School	0.66	0.01	***	0.78	0.01	***	0.66	0.02	***
(high)		(0.64 ~ 0.69)			(0.75 ~ 0.80)			(0.62 ~ 0.70)	
Area	0.26	0.01	***	0.30	0.01	***	0.30	0.01	***
(province)		(0.23 ~ 0.29)			(0.28 ~ 0.33)			(0.28 ~ 0.33)	
Subjective income level	-0.04	0.01	***	0.09	0.01	***	0.09	0.01	***
(above average)		(-0.06~-0.02)			(0.07 ~ 0.11)			(0.07 ~ 0.11)	
Father's education	-0.14	0.01	***	-0.04	0.01	***	-0.04	0.01	***
(college and more)		(-0.16~-0.13)			(-0.06~-0.02)			(-0.06~-0.02)	
Father's nationality	0.18	0.04	***	0.09	0.06		0.09	0.06	
(Korean)		(0.10 ~ 0.27)			(-0.04 ~ 0.21)			(-0.04 ~ 0.21)	
Mother's education	-0.17	0.01	***	-0.02	0.01	**	-0.03	0.01	**
(college and more)		(-0.18~-0.15)			(-0.04~-0.01)			(-0.04~-0.01)	
Mother's nationality	0.15	0.02	***	-0.02	0.03		-0.02	0.03	
(Korean)		(0.11 ~ 0.19)			(-0.08 ~ 0.04)			(-0.08 ~ 0.03)	
Health-related behaviors									
Having breakfast	0.09	0.01	***	0.10	0.01	***	0.10	0.01	***
(6 + times per week)		(0.08 ~ 0.11)			(0.09 ~ 0.12)			(0.09 ~ 0.12)	
Eating fruit	0.04	0.01	***	0.06	0.01	***	0.06	0.01	***
(once + a day)		(0.02 ~ 0.05)			(0.05 ~ 0.08)			(0.04 ~ 0.07)	
Having soda & sweet drink	-0.13	0.01	***	-0.10	0.01	***	-0.10	0.01	***
(Twice + a day)		(-0.15~-0.10)			(-0.13~-0.07)			(-0.13~-0.07)	
Eating fast-food	-0.07	0.01	***	-0.06	0.01	***	-0.06	0.01	***
(3 + times per week)		(-0.09~-0.06)			(-0.08~-0.05)			(-0.08~-0.05)	
Doing physical activity	0.15	0.01	***	0.02	0.01	*	0.02	0.01	
(5 + days per week)		(-0.17 ~ 0.13)			(0.00 ~ 0.04)			(0.00 ~ 0.03)	
Drinking alcohol last month	0.17	0.01	***	0.02	0.01	*	0.03	0.01	**
(yes)		(0.15 ~ 0.19)			(0.00 ~ 0.04)			(0.01 ~ 0.05)	
Smoking last month	0.02	0.01		-0.11	0.02	***	-0.09	0.02	***
(1 + day)		(-0.01 ~ 0.04)			(-0.14~-0.07)			(-0.13~-0.06)	
Obesity	-0.11	0.01	***	-0.13	0.01	***	-0.13	0.01	***
(yes)		(-0.12~-0.09)			(-0.15~-0.11)			(-0.15~-0.11)	
Washing hands before lunch	0.02	0.01	**	0.20	0.01	***	0.20	0.01	***
(usually)		(0.01 ~ 0.04)			(0.18 ~ 0.21)			(0.19 ~ 0.22)	
Having sealant lats year	0.06	0.01	***	0.03	0.01	***	0.03	0.01	***
(yes)		(0.05 ~ 0.07)			(0.02 ~ 0.04)			(0.02 ~ 0.04)	
Mental health conditions									
Feeling stress usually	0.08	0.01	***	-0.03	0.01	**	-0.03	0.01	***
(yes)		(0.07 ~ 0.09)			(-0.04~-0.01)			(-0.05~-0.01)	
Feeling sad or despair	0.07	0.01	***	0.01	0.01		0.07	0.01	***
(yes)		(0.06 ~ 0.08)			(0.00 ~ 0.03)			(0.05 ~ 0.10)	
COVID-19 period	-0.41	0.01	***	-0.46	0.01	***	-0.42	0.02	***
(yes)		(-0.43~-0.38)			(-0.49~-0.44)			(-0.46~-0.38)	
Girls*High school							0.13	0.02	***
								(0.08 ~ 0.17)	
Girls*Sadness							-0.11	0.01	***
								(-0.13~-0.08)	
Girls*COVID-19 period							-0.20	0.02	***

Table 3 (continued)

	Unadjusted		Model 1†		Model 2‡		
	Coef.	SE (95% CI)	Coef.	SE (95% CI)	Coef.	SE (95% CI)	
COVID-19 period*High school					0.12	0.03 (-0.25∼-0.15) (0.06∼0.17)	***
P value, goodness of fit				0.00		0.83	

Coef.: Coefficient, Se Standard Error, Sig Significance

†Model 1: fully adjusted with explanatory variables; ‡Model 2: Model 1 plus interaction terms

*$P<0.05$, **$P<0.01$, ***$P<0.001$

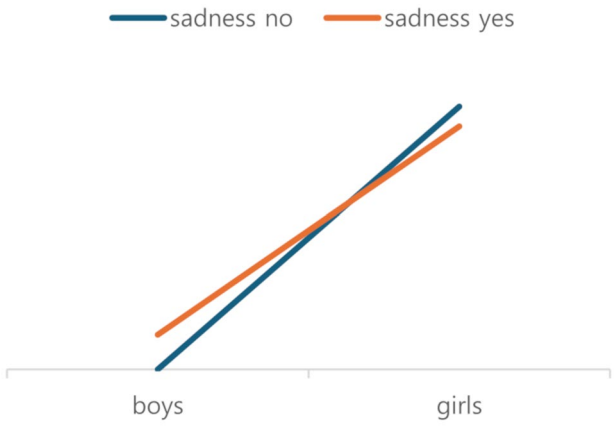

Fig. 1 The probit ratio coefficient changes by sex and sadness interaction

clean teeth and fresh breath. If girls were more motivated than boys to brush their teeth for cosmetic purposes, this could explain the larger drop in tooth brushing among girls during the period of mandatory mask-wearing. Studies have reported on the changes in oral health behavior during COVID-19 [52]. Wearing a mask, which was strongly recommended during this period, changed self-perceptions of bad breath [53, 54] but also reduced oral health-related behavior, including dental visits and tooth brushing [55]. It also has been reported that wearing a mask reduces worries about appearance, particularly among women, for example need to apply daily make-up [56]. Mask wearing may have moderated the association between substance use (binge drinking, marihuana use) and mental health [57].

Social interactions were restricted during COVID-19 as well. As a result, social connections and mental health were adversely affected [58]. In 2021, depressive illness was estimated to have the second greatest influence on years lived with disability by the Global Burden of Disease (GBD). Depressive illness had a greater impact on women aged 15 to 19 and women aged 60 to 64, compared to men. The gender gap in depressive illness existed [59], but decreased during COVID-19 by 1.4 times, still more affected by female students compared to male students in Korea. Toothbrushing showed similar patterns [34]. Female students had a greater tendency to brush than male students [60], but it was negatively impacted when they were depressed in this study. Mental health affects brushing as well, and this appears differently according to gender. Gender impacts health through exposure, related behaviors, access to care, and health-care systems [61]. Further study is necessary to search for the relationship between COVID-19, mental health, and gender.

High school students were more likely to practice brushing after lunch than middle school students. Even in Model 2, which included interaction terms, girls in high school were more likely to practice tooth brushing after lunch than those in middle school. High school students were more likely to brush their teeth than middle school students, even during the COVID-19 period, when the rate of all students decreased. This is consistent with the results of a study conducted in 72 countries that showed that female [62] and elderly [63] students were more likely to brush their teeth after lunch [64]. In addition, students living in small- and medium-sized cities in the province were more likely to practice brushing after lunch than those living in large cities. This may be due to an overall increase in tooth brushing practice in provincial areas over the past decade, as well as fewer challenges in brushing after school, given the lower population density and fewer restrictions related to mask-wearing.

Conclusions

During the COVID-19 pandemic, the rate of tooth brushing in adolescents in South Korea decreased among both sexes. However, the tooth brushing rate reduced more precipitously in girls than in boys, resulting in a narrowing of the gender gap. The gender gap cannot be explained by corresponding differences in hygiene practices (e.g., handwashing), health behaviors (smoking), parental education, family socioeconomic circumstances, depressive symptoms, or stress. A possible reason for the decline in the gender gap in tooth brushing may be the policy of mandatory

mask-wearing in Korean schools during the pandemic. If girls are more motivated than boys to brush their teeth for cosmetic reasons (a clean appearance of teeth and fresh breath), this might account for the larger decrease in tooth brushing among girls during the mandatory mask-wearing policy. Wearing masks affected health more broadly than controlling the spread of infection. Further studies are warranted to consider these unintended consequences of COVID-19 control policies on oral health.

Abbreviations

KYRBS	Korea Youth Risk Behavior Web-based Survey
PSUs	Primary Sampling Units
VIF	Variance Inflation Factors
IRB	Institutional Review Board
GBD	Global Burden of Disease
KDCA	Korea Disease Control and Prevention Agency

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Author contributions
IK: Writing– review & editing, Methodology, Data curation, Conceptualization. JR: Writing– original draft, Project administration, Funding acquisition, Methodology, Formal analysis, Data curation, Conceptualization. All authors reviewed the manuscript.

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Data availability
The data that supports the findings of this study are available from the Korean Disease Control and Prevention Agency (KDCA), but restrictions apply to the availability of data, which was used with permission for the current study and therefore not publicly available. Data is, however, available on reasonable request and with permission of KDCA.

Declarations

Ethics approval and consent to participate
This study used the dataset obtained from the KYRBS 2017 to 2022. All KYRBS were conducted with participants' informed consent by the Korea Disease Control and Prevention Agency (KDCA). This analytical study was approved again by the institutional review board (IRB) of Kyung Hee University (IRB No. KHSIRB-21-337(EA)) as exemption of the review because this retrospective analysis included the dataset of national surveillance and did not contain personally identifiable information. All methods were carried out following the KYRBS analytic guidelines and regulations.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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