

Poor oral health is associated with asthma, allergic rhinitis, and atopic dermatitis in Korean adolescents

A cross-sectional study

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Abstract

The purpose of this study was to evaluate the association between oral health and asthma/allergic rhinitis/atopic dermatitis in a large representative Korean adolescent population.

A total of 136,027 participants (aged 12–18 years old) were selected from the Korea Youth Risk Behavior Web-based Survey 2014 to 2015. The subjects' history of asthma, allergic rhinitis, and atopic dermatitis was determined by inquiring whether they had been diagnosed by a medical doctor within the previous 12 months or throughout life. Participants were asked if they had experienced the following 6 symptoms regarding oral health in the past 12 months: “chipped or broken tooth,” “toothache when eating or drinking,” “throbbing and sore tooth,” “sore and bleeding gums,” “pain in the tongue or inside the cheeks,” and “unpleasant breath.” The participants were divided into 3 groups according to the number of oral health-related symptoms as follows: good oral health (symptoms=0), moderate oral health (symptoms=1), and poor oral health (symptoms=2–6). Multiple logistic regression analyses calculated the adjusted odds ratios (aORs) with 95% confidence intervals (CIs) for asthma/allergic rhinitis/atopic dermatitis within the past 12 months and throughout life among groups with oral health-related symptom groups.

Older age, female sex, fewer days of physical activity, lower parental economic level, smoking, and frequent alcohol consumption were associated with poor oral health (each $P < .001$). The aORs for asthma/allergic rhinitis/atopic dermatitis were 1.48 (95% CI = 1.34–1.63, $P < .001$), 1.42 (95% CI = 1.36–1.47, $P < .001$), and 1.35 (95% CI = 1.28–1.43, $P < .001$), respectively, in the poor oral health group compared to the good oral health group.

Poor oral health was significantly correlated with the prevalence of asthma/allergic rhinitis/atopic dermatitis within the past 12 months and throughout life in Korean adolescents. Based on our comparative data, oral health-related education may be considered to adolescents with allergic disease for good oral health.

Abbreviations: AR = allergic rhinitis, BMI = body mass index, CI = confidence interval, CPITN = community periodontal index of treatment needs, DMFT = decayed, missing and filled teeth, IL = interleukin, ISAAC = International Study of Asthma and Allergies in Children, KCDC = Korea Centers for Disease Control and Prevention, KYRBWS = Korea Youth Risk Behavior Web-based Survey, NHANES = National Health and Nutrition Examination Survey, OR = odds ratio, TNF = tumor necrosis factor.

Keywords: oral health, asthma, allergic rhinitis, atopic dermatitis, adolescent health, population surveillance

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JHW, MWP contributed equally to this work.

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The datasets generated during and/or analyzed during the present study are publicly available.

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1. Introduction

Allergic diseases are multifactorial disorders caused by genetic, infectious, and environmental factors.^[1,2] Over the past half century, while infectious oral diseases are decreasing, allergic diseases are significantly increasing.^[3] The “hygiene hypothesis” proposes^[4] that exposure to oral bacteria, including pathogens associated with periodontitis, gingivitis, and dental caries, might play a protective role in the development of allergic disease.

However, controversial studies have reported either supportive^[5–8] or unsupportive^[9–12] data regarding the beneficial effects of periodontal disease on allergic disease. A cross-sectional study in New York reported an inverse association between subject-reported allergy and periodontal disease severity (odds ratio [OR]=0.77; 95% confidence interval (CI)=0.58–1.00).^[5] A population-based study in Germany showed that periodontal disease is inversely and significantly associated with self-reported house dust mite allergy (OR=0.39; 95% CI=0.2–0.9) and hay fever (OR=0.53; 95% CI=0.3–0.9).^[6] A significant inverse association between allergic rhinitis (AR) and periodontal status has been demonstrated in the Korean general population (OR=0.79; 95% CI=0.66–0.95).^[7] Moreover, the presence of dental caries is negatively correlated with AR (OR=0.56; 95% CI=0.43–0.75), asthma (OR=0.55; 95% CI=0.33–0.90), and atopic dermatitis (OR=0.74; 95% CI=0.56–0.98) in Korean children.^[8]

In contrast, some studies have reported a positive association between asthma and periodontal disease,^[9,10] and other studies have reported a null association.^[11,12] In a British study, asthmatic children (n=100) aged 4 to 16 years were found to have more plaque ($P<.05$) and gingivitis ($P<.01$) than nonasthmatic children (n=149).^[9] Asthmatic subjects (n=80) aged 11 to 25 years have higher mean dental plaque and gingivitis levels than nonasthmatic subjects (n=80) in India ($P<.001$).^[10] Another study analyzed data from the third National Health and Nutrition Examination Survey (NHANES III) of adolescents aged 13 to 17 years (n=1596), and neither asthma nor the cumulative use of antiasthma drugs was found to be significantly associated with gingivitis or periodontitis ($P>.05$).^[11] Similarly, in Belgium, asthmatic children (n=140) aged 3 to 17 years reportedly show no significant correlation between oral health measures and asthma duration, severity, or exposure time to medication ($P>.05$).^[12] However, these studies have not investigated the association between periodontal disease and allergic disease, including AR and atopic dermatitis, and only reported the relationship between periodontal disease and asthma. Moreover, with the exception of the study from NHANES III by Shulman, these were case–control studies with relatively small sample sizes.

Previous studies have explained similar inflammatory and immunological responses with respect to possible associations between oral disease and allergic disease.^[3,13] Based on their common IgE-mediated pathophysiological mechanism, asthma/AR/atopic dermatitis might have some shared effects on oral health. The objective of the present study was to investigate the association between oral health and asthma/AR/atopic dermatitis using a nationwide representative adolescent population in Korea.

2. Materials and methods

2.1. Study population and data collection

The Institutional Review Board (IRB) of Hallym University approved this study (HALLYM 2019-09-005). Because this

web-based survey was performed at schools and included a large number of participants, informed consent from their parents was exempted.

This cross-sectional study used data from the Korea Youth Risk Behavior Web-based Survey (KYRBWS). This study included one nation and used statistical methods based on designed sampling and adjusted weighted values. KYRBWS data collected in 2014 to 2015 were analyzed. The data were collected by the Korea Centers for Disease Control and Prevention (KCDC). Korean adolescents in grades 7 to 12 voluntarily and anonymously completed the self-administered questionnaire. The validity and reliability of the KYRBWS have been documented by other studies.^[14,15] The surveys evaluated data from South Korean adolescents using a stratified, two-stage (schools and classes) clustered sampling method based on the data from the Education Ministry. Sampling was weighted by statisticians, who performed the poststratification analyses and considered the nonresponse rates and extreme values. The data were available at the website.^[16]

Among the 140,103 participants, individuals who did not record their age (n=794) and those who did not record their height or weight (n=3282) were excluded. Finally, 136,027 participants (n=69,543 for males; n=66,484 for females) aged 12 to 18 years were included in this study (Fig. 1).

2.2. Oral health-related symptoms

Participants were asked six questions regarding oral health, namely, whether the participants had experienced the following symptoms in the past 12 months: “chipped or broken tooth,” “toothache when eating or drinking,” “throbbing and sore tooth,” “sore and bleeding gums,” “pain in the tongue or inside the cheeks,” and “unpleasant breath.” These symptoms related to oral disease were based on World Health Organization guidelines,^[17] which state that periodontal (gum) disease often presents as bleeding of swollen gums, pain, and bad breath, and that in severe forms of the disease, loosening of teeth and dental caries result in tooth loss and pain. The participants answered the questions “yes” or “no.” The number of symptoms was counted if the answer was “yes.” If the participants had chipped or broken their teeth during exercising or by accident, they were considered participants who answered “no.” The participants were divided into 3 groups according to the number of oral health-related symptoms as follows: good oral health (symptom=0; n=54,894), moderate oral health (symptom=1; n=35,266), and poor oral health ($2 \leq \text{symptoms} \leq 6$; n=45,867; Fig. 1).

2.3. Definition of asthma, AR, and atopic dermatitis

Participants were asked regarding their history of asthma, AR, atopic dermatitis based on the phase three core questionnaire of the International Study of Asthma and Allergies in Children (ISAAC).^[18] Based on two questions, asthma, AR, atopic dermatitis was defined in two parts. In the first question, participants were asked if they were diagnosed with asthma, AR, atopic dermatitis throughout their lifetime for each disease. In the second question, subjects who were diagnosed were also asked whether they had been diagnosed by a medical doctor in the previous 12 months. If the participants answered “yes” for the first question, then those participants were defined as having “asthma throughout life,” “AR throughout life,” or “atopic dermatitis throughout life” for each question regarding diagnosis. If the

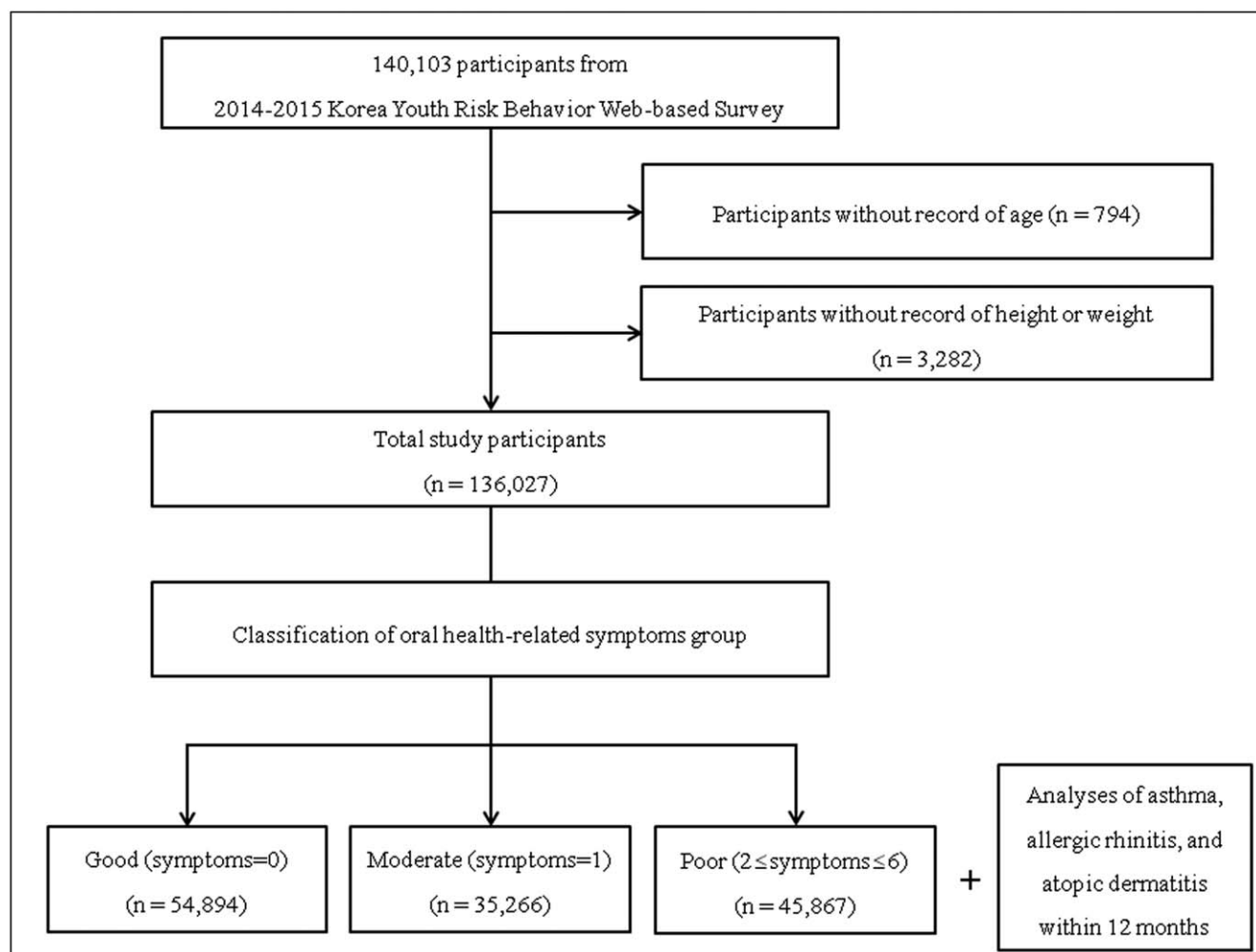


Figure 1. A schematic illustration of the participant selection. Among a total of 140,103 participants, the participants without record of age ($n = 794$) and height or weight records ($n = 3282$) were excluded. The data for the 136,027 participants from whom complete data were obtained.

participants answered “yes” for the second question, then those participants were defined as having “asthma within the past 12 months,” “AR within the past 12 months,” or “atopic dermatitis within the past 12 months,” for each question regarding diagnosis.

2.4. Covariates

The days of physical activity were defined as the number of days in the previous week during which the participants exercised for more than 60 min at a level sufficient to increase the heart rate or respiration. Obesity was classified into 4 groups according to the Centers for Disease Control and Prevention Guidelines and 2007 Korean national growth charts regarding body mass index (BMI, kg/m^2) for children and adolescents^[19,20]: obese \geq 95th percentile; overweight \geq 85th percentile and $<$ 95th percentile; healthy weight \geq 5th percentile and $<$ 85th percentile; and underweight $<$ 5th percentile. Regions of residence were divided into 3 groups according to the administrative district: large city, small city, and rural area. The economic levels were classified into 5 levels from highest to lowest. The education levels of each parent were divided into 4 groups: graduated at the college level or higher; completed high school; completed junior high school or under; and unknown or no parent. The participants were

asked to report the number of days they smoked in the previous month and were divided into 3 groups: nonsmoker, 1 to 19 days per month, and 20 to 30 days per month. The participants were also asked to report the number of days they consumed alcohol and were divided into 3 groups: non-alcohol consumers, consumers 1 to 5 days per month, and consumers 6 to 30 days per month.

Participants were asked regarding dental health-related behaviors as follows: if the participants had received a sealant in the past 12 months or not and if the participants had received scaling in the past 12 months or not. The participants were asked how many times they brushed their teeth per day. The number of times teeth were brushed was classified into four groups according to the distribution of participants as follows: ≤ 1 times a day, 2 times a day, 3 times a day, and ≥ 4 times a day. We used the number of toothbrushing episodes as a covariate.

2.5. Statistical analysis

The general characteristics were compared according to the oral health-related symptom groups. The Rao-Scott Chi-square test with sampling weights was used to compare categorical variables, and linear regression analysis with sampling weights was used to compare continuous variables.

To calculate the ORs with 95% CIs for asthma, AR, atopic dermatitis within the past 12 months among oral health-related symptom groups, a crude model (simple model), model 1 (adjusted for age, sex, economic level, region of residence, father's education level, mother's education level, days of smoking, days of alcohol consumption, days of physical activity, and obesity), model 2 (adjusted for model 1 with asthma, AR, atopic dermatitis [excluded when used as a dependent variable]), and model 3 (adjusted for model 2 with history of sealants, scaling, and number of toothbrushing episodes) were analyzed using multiple logistic regression with sampling weights.

Two-tailed analyses were conducted, and significance was defined as P -values $<.05$. The statistical analyses were performed using SAS version 9.4 (SAS Institute, Inc, Cary, NC). Sampling weights were used to conduct a complex sampling design of the national survey using a survey procedure (PROC SURVEY).

3. Results

According to the distribution of participants, older age, female sex, fewer days of physical activity, lower economic level and lower education level of the father and mother, smoking, and frequent alcohol consumption were associated with poor oral health (each $P < .001$; Table 1). Less frequent toothbrushing and no history of sealants and scaling within the past 12 months were associated with the poor oral health group (each $P < .001$). A higher prevalence of asthma, AR, atopic dermatitis both throughout life and within the past 12 months was associated with a poor oral health group compared to a good oral health group (each $P < .001$).

The OR for asthma within the past 12 months in model 3 was higher in the poor oral health group than in the good oral health group (OR = 1.48, 95% CI = 1.34–1.63, $P < .001$; Table 2). The ORs for asthma in model 3 were higher in participants who answered “yes” than in participants who answered “no” for each of the 6 symptoms (each $P < .05$).

The OR for AR within the past 12 months in model 3 was higher in the poor oral health group than in the good oral health group (OR = 1.42, 95% CI = 1.36–1.47, $P < .001$; Table 3). The ORs for AR in model 3 were higher in participants who answered “yes” than in participants who answered “no” for each of the 6 symptoms (each $P < .001$) except the “chipped or broken tooth” symptom ($P > .05$).

The OR for atopic dermatitis within the past 12 months in model 3 was higher in the poor oral health group than in the good oral health group (OR = 1.35, 95% CI = 1.28–1.43, $P < .001$; Table 4). The ORs for AR in model 3 were higher in participants who answered “yes” than in participants who answered “no” for each of the 6 symptoms (each $P < .001$) except the “chipped or broken tooth” symptom ($P > .05$).

The above results were consistent with the ORs for asthma, AR, atopic dermatitis throughout life according to oral health-related symptoms (see Supplemental Table S1 [<http://links.lww.com/MD/E637>], Table S2 [<http://links.lww.com/MD/E638>], and Table S3 [<http://links.lww.com/MD/E639>]).

4. Discussion

The present study showed that the ORs for asthma, AR, atopic dermatitis within the past 12 months and throughout life were significantly higher in subjects with poor oral health having 2 to 6

symptoms than in those with good oral health having no symptoms. These results may not be explained by the “hygiene hypothesis,” which contends that fewer opportunities for infections and microbial exposures result in more allergic disease.

Recent evidence has shown that poor periodontal condition is a potential risk factor for systemic inflammatory diseases, including allergic disease.^[21–25] Several studies have indicated an association between chronic periodontitis and systemic diseases such as cardiovascular disease,^[26,27] diabetes,^[28] and respiratory disease.^[29] These associations are described as being related to inflammatory and immunological responses common to chronic periodontitis and systemic diseases, eliciting an increase in circulating inflammatory cytokines, such as C-reactive protein, interleukin (IL)-6, and tumor necrosis factor (TNF)-alpha. A recent study reported that the rate of tooth loss, oral fillings, and dental caries in children with AR was greater than in those without AR (OR = 1.21, 95% CI = 1.05–1.35).^[24] Similarly, asthmatic children presented significantly higher dental caries and dental erosive lesions than their matching controls ($P < .001$).^[25] The present study also demonstrated a positive correlation between poor oral health and asthma, AR, atopic dermatitis in Korean adolescents.

The biological plausibility of the association between poor oral health and allergic diseases has not been established but is thought to be in line with increased inflammatory cytokines. Oral pathogens themselves or inflammation in periodontal tissues activate host immune cells to release proinflammatory cytokines, such as IL-1 β , IL-6, and TNF- α , and may contribute to the systemic inflammation.^[3,21] In addition, emerging evidence indicates that a skewed inflammatory environment can overcome the regulatory response of the allergen-specific T regulatory cells and redirect toward a pathogenic and proinflammatory phenotype.^[30] CD4+CD25+ Treg cells have been found in both gingivitis and periodontitis lesions,^[31] and there is speculation that Treg cells are involved in immune responses to oral pathogens and allergic disease.

In addition, some studies have suggested that poor oral health is a result of allergic disease or a side effect of antiallergic medications. The children with allergic disease become mouth breathers, which causes the oral palate to develop abnormally and to grow the teeth crookedly and in malocclusion. The prevalence of malocclusion was significantly higher in children with asthma (OR = 2.47, 95% CI = 1.14–5.37) and impaired nasal breathing (OR = 6.24, 95% CI = 2.08–18.73).^[32] Malocclusion causes temporomandibular joint problems, unilateral chewing, and restricted use of toothbrushes. The repetition of such symptoms results in deteriorating oral hygiene and increases in dental caries, gingivitis, and periodontal diseases.^[33] Oral breathing in AR children leads to dry mouth; moreover, drug therapies for allergic disease, including antihistamines, decongestants, corticosteroids, and leukotriene modifiers, may decrease the salivary flow rate, and this condition can increase the incidence of missing and filled teeth.^[24,34] The community periodontal index of treatment needs (CPITN) score was significantly related to AR ($P < .001$), and the decayed, missing and filled teeth (DMFT) index was significantly higher in asthma patients (8.23 ± 0.60) than in the control group (7.18 ± 0.12) in a recent Korean population-based study ($P = 0.028$).^[35] Higher salivary mutans streptococci, a group of cariogenic bacteria, were observed in children with AR compared to controls ($P < .05$).^[36] In addition, children with AR are more prone to sinus infection, which causes tooth discomfort.

Table 1
General characteristics of participants.

Characteristics	Oral health-related symptoms				P
	Total	Good (symptoms = 0)	Moderate (symptoms = 1)	Poor (2 ≤ symptoms ≤ 6)	
Number (n, %)	136,027 (100.0)	54,894 (39.1)	35,266 (25.3)	45,867 (32.7)	
Mean age (yr, mean, SE)	15.0 (0.02)	14.9 (0.02)	15.0 (0.02)	15.2 (0.02)	<.001*
Physical activity (d, mean, SE)	1.9 (0.01)	2.0 (0.01)	1.9 (0.02)	1.9 (0.02)	<.001*
Sex (n, %)					<.001†
Males	69,543 (52.1)	30,930 (57.3)	18,024 (52.1)	20,589 (45.9)	
Females	66,484 (47.9)	23,964 (42.7)	17,242 (47.9)	25,278 (54.1)	
Obesity (n, %)					.092
Underweight	8373 (6.3)	3427 (6.4)	2217 (6.4)	2729 (6.1)	
Normal weight	106,813 (78.6)	43,166 (78.7)	27,532 (78.1)	36,115 (78.8)	
Overweight	15,594 (11.3)	6192 (11.2)	4063 (11.4)	5339 (11.4)	
Obese	5247 (3.8)	2109 (3.8)	1454 (4.0)	1684 (3.7)	
Region (n, %)					
Large city	60,389 (43.7)	24,597 (44.1)	15,543 (43.2)	20,249 (43.6)	.332
Small city	64,529 (50.0)	25,797 (49.7)	16,848 (50.4)	21,884 (50.0)	
Rural area	11,109 (6.3)	4500 (6.2)	2875 (6.4)	3734 (6.4)	
Economic level (n, %)					<.001†
The highest	11,235 (8.3)	5691 (10.4)	2560 (7.4)	2984 (6.6)	
Middle high	35,881 (26.7)	15,548 (28.6)	9353 (26.7)	10,980 (24.4)	
Middle	65,469 (47.9)	26,523 (48.1)	17,336 (48.8)	21,610 (46.9)	
Middle low	18,942 (13.9)	5813 (10.6)	4970 (14.1)	8159 (17.6)	
The lowest	4500 (3.3)	1319 (2.4)	1047 (3.0)	2134 (4.7)	
Education level, father (n, %)					<.001†
Unknown	27,772 (19.3)	12,141 (20.8)	7013 (18.9)	8618 (17.9)	
Junior high school or under	3613 (2.5)	1172 (2.0)	891 (2.4)	1550 (3.2)	
High school	39,566 (28.6)	15,312 (27.4)	10,478 (29.3)	13,776 (29.4)	
College or over	65,076 (49.6)	26,269 (49.7)	16,884 (49.5)	21,923 (49.5)	
Education level, mother (n, %)					<.001†
Unknown	26,671 (18.5)	11,786 (20.2)	6743 (18.1)	8142 (16.8)	
Junior high school or under	3123 (2.2)	1010 (1.8)	798 (2.2)	1315 (2.7)	
High school	49,976 (36.7)	19,280 (35.1)	13,098 (37.2)	17,598 (38.4)	
College or over	56,257 (42.5)	22,818 (42.9)	14,627 (42.5)	18,812 (42.1)	
Smoking (n, %)					<.001†
None	125,338 (91.8)	51,092 (92.7)	32,689 (92.3)	41,557 (90.3)	
1–19 d/mo	4336 (3.3)	1552 (2.9)	1037 (3.0)	1747 (3.9)	
20–30 d/mo	6353 (4.9)	2250 (4.3)	1540 (4.7)	2563 (5.8)	
Alcohol (n, %)					<.001†
None	114,428 (83.6)	47,582 (86.2)	29,721 (83.7)	37,125 (80.4)	
1–5 d/mo	17,020 (12.9)	5681 (10.7)	4437 (13.1)	6902 (15.4)	
6–30 d/mo	4579 (3.5)	1631 (3.1)	1108 (3.2)	1840 (4.2)	
Toothbrushing (n, %)					<.001†
≤ 1 times a d	9195 (6.7)	2724 (4.9)	2367 (6.5)	4104 (8.8)	
2 times a d	57,238 (42.7)	22,009 (40.5)	15,353 (44.3)	19,876 (44.0)	
3 times a d	52,677 (38.3)	22,749 (41.1)	13,484 (37.7)	16,444 (35.5)	
≥ 4 times a d	16,917 (12.3)	7412 (13.4)	4062 (11.5)	5443 (11.7)	
Sealant (n, %)					<.001†
Within 12 mo	99,113 (73.0)	42,963 (78.4)	25,830 (73.4)	30,320 (66.3)	
None	36,914 (27.0)	11,931 (21.6)	9436 (26.6)	15,547 (33.7)	
Scaling (n, %)					<.001†
Within 12 mo	105,496 (77.1)	44,587 (80.7)	27,424 (77.3)	33,485 (72.5)	
None	30,531 (22.9)	10,307 (19.3)	7842 (22.7)	12,382 (27.5)	
Asthma (n, %)					<.001†
Throughout life	12,108 (8.9)	4274 (7.8)	3086 (8.8)	4748 (10.3)	<.001†
Within 12 mo	3057 (2.2)	992 (1.8)	732 (2.1)	1333 (2.9)	<.001†
Allergic rhinitis (n, %)					<.001†
Throughout life	44,117 (33.1)	15,579 (29.1)	11,597 (33.5)	16,941 (37.6)	<.001†
Within 12 mo	23,714 (17.8)	7928 (14.8)	6103 (17.6)	9683 (21.5)	<.001†
Atopic dermatitis (n, %)					<.001†
Throughout life	32,693 (24.2)	11,297 (20.7)	8658 (24.8)	12,738 (27.9)	<.001†
Within 12 mo	9221 (6.8)	3037 (5.5)	2334 (6.7)	3850 (8.4)	<.001†

SE=standard error.

* Linear regression was analyzed with sampling weights, significance at $P < .05$.† Rao-Scott Chi-square test was analyzed with sampling weights, significance at $P < .05$.

Table 2**Odds ratios for asthma within 12 months according to oral symptoms.**

Oral symptoms	ORs for asthma within 12 months							
	Crude	P	Model 1 [†]	P	Model 2 [‡]	P	Model 3 [§]	P
Chipped or broken tooth								
Yes	1.29 (1.12–1.47)	<.001*	1.27 (1.11–1.46)	.001*	1.27 (1.11–1.46)	.001*	1.24 (1.08–1.43)	.002*
No	1		1		1		1	
Toothache when eating/drinking								
Yes	1.39 (1.28–1.50)	<.001*	1.43 (1.32–1.54)	<.001*	1.29 (1.19–1.40)	<.001*	1.28 (1.18–1.38)	<.001*
No	1		1		1		1	
Throbbing and sore tooth								
Yes	1.42 (1.31–1.55)	<.001*	1.53 (1.40–1.67)	<.001*	1.40 (1.28–1.54)	<.001*	1.38 (1.26–1.51)	<.001*
No	1		1		1		1	
Sore and bleeding gums								
Yes	1.51 (1.38–1.65)	<.001*	1.59 (1.45–1.73)	<.001*	1.46 (1.33–1.60)	<.001*	1.44 (1.32–1.58)	<.001*
No	1		1		1		1	
Pain in tongue or inside cheeks								
Yes	1.72 (1.55–1.91)	<.001*	1.79 (1.61–1.98)	<.001*	1.58 (1.43–1.76)	<.001*	1.56 (1.40–1.73)	<.001*
No	1		1		1		1	
Unpleasant breath								
Yes	1.35 (1.23–1.47)	<.001*	1.33 (1.22–1.46)	<.001*	1.22 (1.11–1.34)	<.001*	1.22 (1.11–1.34)	<.001*
No	1		1		1		1	
One of above symptoms exist								
Exist	1.42 (1.30–1.54)	<.001*	1.49 (1.37–1.63)	<.001*	1.33 (1.22–1.45)	<.001*	1.31 (1.20–1.44)	<.001*
None	1		1		1		1	
Oral health-related symptoms								
Poor (2 ≤ symptoms ≤ 6)	1.61 (1.47–1.77)	<.001*	1.73 (1.57–1.91)	<.001*	1.50 (1.37–1.65)	<.001*	1.48 (1.34–1.63)	<.001*
Moderate (symptoms = 1)	1.16 (1.05–1.29)	.005*	1.21 (1.09–1.34)	.001*	1.12 (1.00–1.24)	.044*	1.11 (1.00–1.24)	.053
Good (symptoms = 0)	1		1		1		1	

* Logistic regression with sampling weights, significance at $P < .05$.[†] Model 1 was adjusted for age, sex, economic level, region of residence, education level of father, education level of mother, obesity, smoking, alcohol intake, and physical activity.[‡] Model 2 was adjusted for model 1 with allergic rhinitis and atopic dermatitis history.[§] Model 3 was adjusted for model 2 with sealant, scaling, and the number of toothbrushing.**Table 3****Odds ratios for allergic rhinitis within 12 months according to oral symptoms.**

Oral symptoms	ORs for allergic rhinitis within 12 months							
	Crude	P	Model 1 [†]	P	Model 2 [‡]	P	Model 3 [§]	P
Chipped or broken tooth								
Yes	1.09 (1.03–1.15)	.005*	1.12 (1.05–1.19)	<.001*	1.10 (1.04–1.17)	.002*	1.06 (0.99–1.12)	.076
No	1		1		1		1	
Toothache when eating/drinking								
Yes	1.36 (1.31–1.40)	<.001*	1.33 (1.29–1.38)	<.001*	1.29 (1.25–1.33)	<.001*	1.25 (1.21–1.30)	<.001*
No	1		1		1		1	
Throbbing and sore tooth								
Yes	1.34 (1.30–1.39)	<.001*	1.32 (1.27–1.37)	<.001*	1.27 (1.22–1.32)	<.001*	1.22 (1.18–1.27)	<.001*
No	1		1		1		1	
Sore and bleeding gums								
Yes	1.32 (1.27–1.37)	<.001*	1.30 (1.26–1.35)	<.001*	1.25 (1.21–1.30)	<.001*	1.22 (1.18–1.27)	<.001*
No	1		1		1		1	
Pain in tongue or inside cheeks								
Yes	1.50 (1.44–1.57)	<.001*	1.45 (1.38–1.51)	<.001*	1.37 (1.31–1.43)	<.001*	1.33 (1.27–1.39)	<.001*
No	1		1		1		1	
Unpleasant breath								
Yes	1.26 (1.22–1.31)	<.001*	1.28 (1.23–1.32)	<.001*	1.24 (1.19–1.28)	<.001*	1.22 (1.17–1.26)	<.001*
No	1		1		1		1	
One of above symptoms exist								
Exist	1.42 (1.37–1.46)	<.001*	1.40 (1.36–1.45)	<.001*	1.34 (1.30–1.39)	<.001*	1.30 (1.26–1.35)	<.001*
None	1		1		1		1	
Oral symptom group								
Poor (2 ≤ symptoms ≤ 6)	1.57 (1.51–1.63)	<.001*	1.56 (1.50–1.62)	<.001*	1.47 (1.42–1.53)	<.001*	1.42 (1.36–1.47)	<.001*
Moderate (symptoms = 1)	1.23 (1.18–1.28)	<.001*	1.22 (1.17–1.27)	<.001*	1.19 (1.14–1.24)	<.001*	1.17 (1.12–1.22)	<.001*
Good (symptoms = 0)	1		1		1		1	

* Logistic regression with sampling weights, significance at $P < .05$.[†] Model 1 was adjusted for age, sex, economic level, region of residence, education level of father, education level of mother, obesity, smoking, alcohol intake, and physical activity.[‡] Model 2 was adjusted for model 1 with asthma and atopic dermatitis history.[§] Model 3 was adjusted for model 2 with sealant, scaling, and the number of toothbrushing.

Table 4**Odds ratios for atopic dermatitis within 12 months according to oral symptoms.**

Oral symptoms	ORs for atopic dermatitis within 12 months							
	Crude	P	Model 1 [†]	P	Model 2 [‡]	P	Model 3 [§]	P
Chipped or broken tooth								
Yes	1.11 (1.02–1.21)	.021*	1.07 (0.98–1.17)	.124	1.06 (0.97–1.16)	.196	1.04 (0.96–1.14)	.337
No	1		1		1		1	
Toothache when eating/drinking								
Yes	1.34 (1.28–1.40)	<.001*	1.29 (1.23–1.35)	<.001*	1.22 (1.16–1.28)	<.001*	1.21 (1.15–1.27)	<.001*
No	1		1		1		1	
Throbbing and sore tooth								
Yes	1.40 (1.33–1.48)	<.001*	1.33 (1.26–1.40)	<.001*	1.26 (1.20–1.33)	<.001*	1.25 (1.18–1.32)	<.001*
No	1		1		1		1	
Sore and bleeding gums								
Yes	1.35 (1.28–1.43)	<.001*	1.30 (1.23–1.37)	<.001*	1.23 (1.16–1.30)	<.001*	1.22 (1.15–1.29)	<.001*
No	1		1		1		1	
Pain in tongue or inside cheeks								
Yes	1.38 (1.30–1.48)	<.001*	1.32 (1.23–1.41)	<.001*	1.21 (1.13–1.29)	<.001*	1.20 (1.12–1.28)	<.001*
No	1		1		1		1	
Unpleasant breath								
Yes	1.24 (1.17–1.31)	<.001*	1.22 (1.16–1.29)	<.001*	1.16 (1.10–1.23)	<.001*	1.16 (1.09–1.22)	<.001*
No	1		1		1		1	
One of above symptoms exist								
Exist	1.42 (1.35–1.49)	<.001*	1.36 (1.29–1.43)	<.001*	1.27 (1.21–1.34)	<.001*	1.26 (1.20–1.32)	<.001*
None	1		1		1		1	
Oral symptom group								
Poor (2 ≤ symptoms ≤ 6)	1.57 (1.48–1.65)	<.001*	1.48 (1.40–1.57)	<.001*	1.36 (1.29–1.44)	<.001*	1.35 (1.28–1.43)	<.001*
Moderate (symptoms = 1)	1.23 (1.16–1.31)	<.001*	1.20 (1.13–1.28)	<.001*	1.15 (1.08–1.23)	<.001*	1.15 (1.08–1.22)	<.001*
Good (symptoms = 0)	1		1		1		1	

* Logistic regression with sampling weights, significance at $P < .05$.

[†] Model 1 was adjusted for age, sex, economic level, region of residence, education level of father, education level of mother, obesity, smoking, alcohol intake, and physical activity.

[‡] Model 2 was adjusted for model 1 with asthma and allergic rhinitis history.

[§] Model 3 was adjusted for model 2 with sealant, scaling, and the number of toothbrushing.

The strengths of the present study include a large representative sample of adolescents and adjustment for numerous potential covariates, including age, sex, economic level, region of residence, parents' educational level, obesity, smoking, alcohol intake, physical activity, history of other allergic disease, and dental health-related behaviors.

However, our study was limited in its cross-sectional design, making the directionality of the association unclear. The causality of this association may be bidirectional. Longitudinal studies need to be conducted as the only way to clarify these doubts. In addition, information on oral health was collected by a questionnaire for symptoms instead of examination. However, self-reporting methods may be considered cost-effective in a large-scale population-based study.^[37] Additionally, a previous study showed a correlation between subjective oral health status perception and the CPITN score/DMFT index.^[35] Periodontal diseases, such as gingivitis and periodontitis, can result in bleeding, erythematous, and inflamed gingival tissue due to the loss of attachment and alveolar bone,^[38] and therefore, we examined these associated symptoms in this study.

In conclusion, poor oral health was significantly correlated with the prevalence of asthma, AR, atopic dermatitis within the past 12 months and throughout life in Korean adolescents. These relationships persisted even after adjusting for several covariates, including dental health-related behaviors. Based on our comparative data, oral health-related education may be considered to adolescents with allergic disease for good oral health.

Author contributions

All authors read and approved the final manuscript.

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