DMFT 연관지표를 이용한 치아별 우식 양상 및 치아우식증 경험군과 고위험군의 위험요인 분석

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Caries prevalence by risk factor and tooth type using DMFT-related indices

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Objectives: One of the main causes of tooth loss in Korea is dental caries, a chronic disease affecting individuals of all ages worldwide. The average decayed, missing, and filled teeth (DMFT) index, a measure of the caries experience of the population, has been stagnating in Korea for a number of years. The purpose of this study was to investigate the pattern of caries prevalence by tooth type, and to identify the characteristics and risk factors of the specific affected caries (SaC) and significant caries (SiC) groups in Korea's 12-year-old children. Data were obtained from the 2018 Children's Oral Health Survey.

Methods: Data from a total of 22,303 subjects were included in the study. We grouped the data according to two DMFT-related indices, the SaC index, which includes all subjects who have experienced a carious lesion, and the SiC index, which includes the top one-third of the population by DMFT. We then analyzed the sociodemographic variables and oral health behaviors seen in these groups.

Results: The average DMFT index for all the 12-year-old children was 1.89, and that of those in the SaC and SiC groups was 3.37 and 4.86, respectively. The teeth that were found to be most likely to develop caries were the mandibular and maxillary first molars, and the tooth associated with the highest mean DMFT index was the mandibular first premolar. Among the variables analyzed, perceived oral health status was the most influential variable in the SaC and SiC groups, followed by gender, and then the presence or absence of calculus. Household income was not a statistically significant variable.

Conclusions: The results of this study revealed the characteristics common to 12-year-old children who are vulnerable to caries. This will provide valuable information when planning dental disease management projects.

Key Words: Dental care for children, Dental caries, Dental health surveys, DMF index, Risk factors, World Health Organization

Introduction

One of the main causes of tooth loss in Korea is dental caries, a chronic disease affecting people of all ages worldwide[1]. In 1981, the World Health Organization (WHO) set a goal of making the average caries experience index (DMF index) below 3 for 12-year-olds worldwide by 2000[2]. Subsequently, the overall DMF index has steadily declined, and in 2000, 68% of countries

achieved their goals[3,4]. In Korea, the DMF index for 12-year-old children was 3.30 in 2000, 1.84 in 2012, 1.90 in 2015, and then again decreased to 1.84 in 2018, showing a fairly stagnant trend[5,6]. While 12-year-old children in the world's major industrialized countries saw their DMFT index drop to less than 1.0, in-depth analysis is needed on the causes of Korea's DMFT index stagnation[7-9].

The failure of the DMFT to decline in Korea is largely because of a small high-risk group, who have a larger number of caries lesions than the general population. The Significant Caries (SiC) index helps identify this high-risk group because it is the average DMFT score of the top one-third of the population. The WHO has adopted the SiC index as an official indicator and proposed a new goal to lower the SiC index of 12-year-olds below three by 2015[4].

Schmoeckel et al.[7] recently proposed a new indicator called the Specific Affected Caries (SaC) index. The average DMFT of the those in the population who have caries is calculated. Since caries incidence no longer follows a normal distribution, it was reported that the SaC index could be more useful than the SiC index in groups with low caries prevalence. The SaC index considers only those in the population who have experienced caries, making it easier to categorize the population into the caries-experience group and the caries-free group.

The purpose of this study was to investigate the pattern of caries prevalence by tooth type in 12-year-old children in Korea using the 2018 Children's Oral Health Survey data, and to identify the characteristics and risk factors of groups with caries experience and high-risk groups based on the SiC index and the SaC index and use them as a basis for efficient dental management.

Materials and Methods

1. Sample

'Children's Oral Health Survey' data, which was conducted by the Ministry of Health and Welfare in 2018, was collected from the Korea Health Promotion Institution. From the subjects of this survey, 22,371 12-year-olds were included in the survey, of whom 22,303 were used for our final analysis. We excluded 68 people on whom an oral examination had not been performed or who had missing/non-response data about the variables of interest.

2. Study design

The subjects were classified according to the definitions of the SaC and SiC index to explore the characteristics of the caries-experience and high-risk group of 12-year-old children in Korea. The subjects were ranked according to the DMFT index. Those with zero DMFT index were categorized as the caries-free group, those with one or more DMFT index as the SaC group, and those with the DMFT index in the top third of the total as the SiC group.

To find out the stage of the caries experience, we examined the extent of caries in each tooth. The teeth, which are symmetrical from side to side, were grouped into 14 types, from the upper and lower central incisors to the upper and lower second permanent molars. The average DMFT index of the caries-experience group was calculated according to teeth type to see if there were differences between the group.

The SaC and SiC groups were compared with the caries-free group to identify each group's characteristics and risk factors for caries using sociodemographic variables and oral health behaviors. The sociodemographic variables used were sex, presence of sealants on the first permanent molars, presence of dental calculus, presence of gingival bleeding, and household income. Oral health behaviors were perceived oral health status, incidence of dental treatment within the last year, frequency of teeth brushing per day, use of oral hygiene aids, use of fluoride toothpaste, and frequency of snack intake per day.

3. Statistical analysis

The DMFT index's mean and standard deviation were calculated for the SaC and SiC groups. The rates of caries experience of each tooth and the DMFT index of those with caries of that tooth were calculated. The group differences for each variable were analyzed using a chi-square test. Logistic regression was also performed to identify the variables that are significant predictors of caries in the SaC and SiC groups ($P<0.05$). All statistical analyses were performed using SPSS 22.0 (SPSS Inc., Chicago, IL, USA).

Results

1. Distribution of SaC and SiC groups

Of the 22,303 people surveyed, 12,507 (56.1%) were categorized into the SaC group, and 9,796 (43.9%) were classified into the caries-free group. Among the 22,303 children, 7,006

Table 1. Mean DMFT index in each group

	Total	Sac	Sic
n	22,303	12,507	7,006
Mean DMFT index (±SD)	1.89 (±2.44)	3.37 (±2.37)	4.86 (±2.18)

(31.4%) were categorized into the SiC group. The average DMFT index for all 12-year-old children was 1.89, that of those in the SaC group was 3.37, and that of those in the SiC group was 4.86

(Table 1).

2. Caries prevalence and mean DMFT index for each tooth type

Of the children who had one or more caries lesions, 79.8% had caries in a first mandibular molar. 64.8% had caries in a first maxillary molar These teeth types showed a higher prevalence rate than other teeth. The prevalence rate in the second mandibular molar was 29.0%, and that in the second maxillary molar was 10.9%, whereas the remaining teeth types had a prevalence rate of less than 10%. Among them, the maxillary canine, the mandibular lateral incisor, and the mandibular canine had a very low caries experience rate of less than 1%. The average DMFT index of children with caries in a mandibular first premolar was highest (9.88), followed by the mandibular second premolar and the maxillary canine (Table 2).

3. Characteristics comparison between the caries free and SaC group

The differences in the variables between the caries-free

Table 2. Each tooth's caries frequency and mean DMFT index in the SaC group

	Tooth	n (%)	Mean DMFT index±SD
Maxillary (upper)	Central incisor	376 (3.0%)	5.16±3.440
	Lateral incisor	383 (3.1%)	6.08±3.634
	Canine	34 (0.3%)	8.15±4.377
	First premolar	773 (6.2%)	7.85±3.786
	Second premolar	749 (6.0%)	7.93±3.891
	First molar	8,109 (64.8%)	4.19±2.464
	Second molar	1,359 (10.9%)	6.76±3.346
Mandibular (lower)	Central incisor	160 (1.3%)	3.05±2.189
	Lateral incisor	9 (0.1%)	2.89±3.408
	Canine	2 (0.0%)	5.50±0.707
	First premolar	268 (2.1%)	9.88±4.373
	Second premolar	601 (4.8%)	8.47±3.974
	First molar	9,982 (79.8%)	3.80±2.412
	Second molar	3,630 (29.0%)	5.15±3.009

Table 3. Characteristics comparison between the caries free and SaC groups

		Group		P-value
		Caries free n (%)	SaC n (%)	
Gender	Boys	5,565 (56.8)	5,961 (47.7)	0.000*
	Girls	4,231 (43.2)	6,546 (52.3)	
Dental calculus	No	8,984 (91.7)	11,696 (93.5)	0.000*
	Yes	812 (8.3)	811 (6.5)	
Gingival bleeding	No	8,724 (89.1)	11,056 (88.4)	0.064
	Yes	1,072 (10.9)	1,451 (11.6)	
Perceived oral health status	Healthy	4,883 (49.8)	4,571 (36.5)	0.000*
	Fair	4,225 (43.1)	6,217 (49.7)	
	Poor	688 (7.0)	1,719 (13.7)	
Experience of dental treatment (1 year)	Yes	6,293 (64.2)	9,357 (74.8)	0.000*
	No	3,503 (35.8)	3,150 (25.2)	
Frequency of tooth brushing	≤2	5,170 (52.8)	6,560 (52.5)	0.319
	≥3	4,626 (47.2)	5,947 (47.5)	
Use of oral hygiene aids	No	5,824 (59.5)	7,050 (56.4)	0.000*
	Yes	3,972 (40.5)	5,457 (43.6)	
Use of fluoride toothpaste	No	5,794 (59.1)	7,418 (59.3)	0.408
	Yes	4,002 (40.9)	5,089 (40.7)	
Frequency of snack intake	<2	3,179 (32.5)	3,845 (30.7)	0.003*
	≥2	6,617 (67.5)	8,662 (69.3)	
Household income	Above average	4,195 (42.8)	5,334 (42.6)	0.352
	Average	4,782 (48.8)	6,059 (48.4)	
	Below average	819 (8.4)	1,114 (8.9)	
Sealants	<2	5,063 (51.7)	6,842 (54.7)	0.000*
	≥2	4,733 (48.3)	5,665 (45.3)	

P-value from Chi-square test/*P<0.05.

Table 4. Characteristics comparison between the caries free and SiC groups

		Group		P-value
		Caries free n (%)	SiC n (%)	
Gender	Boys	5,565 (56.8)	3,167 (45.2)	0.000*
	Girls	4,231 (43.2)	3,839 (54.8)	
Dental calculus	No	8,984 (91.7)	6,542 (93.4)	0.000*
	Yes	812 (8.3)	464 (6.6)	
Gingival bleeding	No	8,724 (89.1)	6,196 (88.4)	0.110
	Yes	1,072 (10.9)	810 (11.6)	
Perceived oral health status	Healthy	4,883 (49.8)	2,291 (32.7)	0.000*
	Fair	4,225 (43.1)	3,614 (51.6)	
	Poor	688 (7.0)	1,101 (15.7)	
Experience of dental treatment (1 year)	Yes	6,293 (64.2)	5,441 (77.7)	0.000*
	No	3,503 (35.8)	1,565 (22.3)	
Frequency of tooth brushing	≤2	5,170 (52.8)	3,638 (51.9)	0.142
	≥3	4,626 (47.2)	3,368 (48.1)	
Use of oral hygiene aids	No	5,824 (59.5)	3,889 (55.5)	0.000*
	Yes	3,972 (40.5)	3,117 (44.5)	
Use of fluoride toothpaste	No	5,794 (59.1)	4,227 (60.3)	0.063
	Yes	4,002 (40.9)	2,779 (39.7)	
Frequency of snack intake	<2	3,179 (32.5)	2,110 (30.1)	0.001
	≥2	6,617 (67.5)	4,896 (69.9)	
Household income	Above average	4,195 (42.8)	2,915 (41.6)	0.052
	Average	4,782 (48.8)	3,437 (49.1)	
	Below average	819 (8.4)	654 (9.3)	
Sealants	<2	5,063 (51.7)	3,827 (54.6)	0.000*
	≥2	4,733 (48.3)	3,179 (45.4)	

P-value from Chi-square test/*P<0.05.

and SaC groups were compared (Table 3). Female children were more prevalent in the SaC group than male children. Children who had dental calculus were more likely to be in the caries-free group. Subjects whose perceived oral health was 'less healthy' than 'healthy' were more likely to be in the SaC group than in the caries-free group. Children who had received dental care within the last year were more likely to be present in the SaC group than children who had not received it. Children who used oral hygiene aids were significantly more likely to be present in the SaC group than those who did not. Children with an average daily snack intake of 'more than two' were significantly more likely to be in the SaC group than those with average snack intake of 'fewer than two.' Children with two or more sealants on the first molars were significantly more likely to be present in the caries-free group than children with fewer than two sealants on the first molars.

4. Characteristics comparison between the caries-free and SiC groups

The differences in characteristics between the caries-free and SiC groups were compared (Table 4). Female children were more prevalent in the SiC group than male children. Children

who had dental calculus were more likely to be in the caries-free group. Subjects whose perceived oral health was 'less healthy' than 'healthy' were more likely to be in the SiC group than in the caries-free group. Children who had received dental care within the last year were more likely to be present in the SiC group than children who had not received it. Children who used oral hygiene aids were significantly more likely to be present in the SiC group than those who did not. Children with an average daily snack intake of 'more than two' were significantly more likely to be in the SiC group than those with average snack intake of 'fewer than two.' Children with two or more sealants on the first molars were significantly more likely to be present in the caries-free group than children with fewer than two sealants on the first molars.

5. Analysis of variables affecting inclusion in the SaC and SiC groups (Table 5)

The children who perceived their oral health to be 'fair' and 'poor' had a 1.463 and 2.361 times, respectively, higher risk of being included in the SaC group than those who perceived it to be 'healthy.' The children who perceived their oral health to be 'fair' and 'poor' had a 1.625 and 2.915 times, respectively,

Table 5. Results of logistic regression analysis of factors affecting the SaC and SiC group in 12-year-old children

		SaC group		SiC group	
		OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Gender	Boys	1.00		1.00	
	Girls	1.349 (1.261, 1.445)	0.000*	1.457 (1.344, 1.578)	0.000*
Dental calculus	Yes	1.00		1.00	
	No	1.257 (1.095, 1.444)	0.001	1.214 (1.031, 1.430)	0.020
Gingival bleeding	Yes	1.00		1.00	
	No	0.994 (0.891, 1.109)	0.918	0.981 (0.863, 1.115)	0.768
Perceived oral health status	Healthy	1.00		1.00	
	Fair	1.463 (1.362, 1.571)	0.000*	1.625 (1.492, 1.769)	0.000*
	Poor	2.361 (2.083, 2.676)	0.000*	2.915 (2.535, 3.353)	0.000*
Experience of dental treatment (1 year)	No	1.00		1.00	
	Yes	1.353 (0.682, 2.683)	0.387	1.369 (0.589, 3.180)	0.466
Frequency of tooth brushing	≥3	1.00		1.00	
	≤2	0.942 (0.880, 1.009)	0.089	0.921 (0.850, 0.998)	0.046
Use of oral hygiene aids	Yes	1.00		1.00	
	No	0.908 (0.848, 0.972)	0.005	0.906 (0.837, 0.982)	0.016
Use of fluoride toothpaste	Yes	1.00		1.00	
	No	0.996 (0.930, 1.066)	0.909	1.043 (0.963, 1.131)	0.299
Frequency of snack intake	<2	1.00		1.00	
	≥2	1.076 (1.001, 1.156)	0.046	1.111 (1.020, 1.209)	0.015
Household income	Above average	1.00		1.00	
	Average	0.932 (0.869, 1.001)	0.053	0.952 (0.876, 1.035)	0.253
	Below average	1.049 (0.917, 1.199)	0.484	1.090 (0.933, 1.272)	0.277
Sealants	≥2	1.00		1.00	
	<2	1.101 (1.030, 1.178)	0.005	1.105 (1.021, 1.196)	0.013

P-value from logistic regression/*P<0.05.

higher risk of being included in the SiC group than those who perceived it to be 'healthy.' Girls had a 1.349 and 1.457 times higher risk of being included in the SaC and SiC groups, respectively, than boys. Children without dental calculus were 1.257 and 1.214 times more likely to be in the SaC and SiC group, respectively, than children with calculus. Children with fewer than two first molars with sealants were 1.101 and 1.105 times more likely to be included in the SaC and the SiC groups. The children who had more than two snack intakes per day were 1.076 and 1.111 times more likely to be in the SaC and SiC groups, respectively. Children who did not use oral hygiene aids were 0.908 and 0.906 times more likely to be in the SaC and SiC groups, respectively. Children whose daily average frequency of teeth brushing was not more than twice were 0.921 times more likely to be in the SiC.

Discussion

The purpose of this study was to analyze the prevalence of caries by teeth type in 12-year-old children in Korea and to identify the characteristics and risk factors of the caries-experience group and the high-risk group. Because it was carried out by a fully trained investigator and included subjects representing the whole country, the Children's Oral Health Survey data were thought to be generalizable[6].

In this study, the caries prevalence rate was found to be highest in the maxillary and mandibular first molars (Table 2). This is consistent with a previous study[10], which studied the prevalence of molar caries. This is believed to be because the first molar is the first tooth to appear. In the case of premolars, even though the second premolar erupts after the first premolar, it had a caries prevalence rate more than twice that of the mandibular first premolar. This is considered to be because of the high caries prevalence in the adjacent first molar[11]. Although the rate of caries prevalence in the mandibular premolars is low in itself, since their average DMFT index is high, overall efforts to prevent caries should be actively carried out even for the premolars (Table 2).

Among Korea's 12-year-old children, perceived oral health status was the most influential variable in the SaC and SiC groups (Table 5, $P<0.001$, $P<0.001$). The worse the perception of one's own oral health, the more likely one is to be in the caries-experience and high-risk groups.

In a previous study by Kim et al.[12], which identified the relationship between a child's awareness of their own oral health status and the likelihood of being in the high-risk group for caries, the risk ratio was found to be 2.67 times. In a study by Jung et al.[13], it was found to be 2.60 times. Although the subjects under review were 12-year-old children, they were fully aware of the objective information about their oral health in terms of the number of caries lesions they had. Therefore, the perceived and objective oral health statuses are judged to be relevant. Thus, improving the oral health awareness of the patients through regular oral examination and education can help to manage the high-risk group for dental caries more efficiently.

The study showed that sex was the next most significant influential variable, with a higher risk of girls being in the SaC and SiC groups than boys. This finding supports that of existing studies that report differences in caries prevalence between girls and boys because girls' first molars appear earlier than boys[10,13,14]. Shortly after their appearance, the tooth enamel is not fully mineralized. Therefore, it can easily be demineralized and needs cautious care[10,15].

Those without dental calculus have a higher risk of being included in the SaC and SiC groups. This result is consistent with the protective effect of dental calculus on the proximal side of premolars, reported by Keyes and Rams[16]. This indicates that the outer surface of teeth covered with mineralized calculus is relatively less vulnerable to decay. A study by Patanaporn and Navia[17] on a large group with calculus deposition also reported that they had less caries, but concluded that calculus deposition was not a causative factor for the low caries prevalence because of the differences in the areas of calculus deposition and caries. Therefore, further research is needed on this.

Children whose average number of snack intake per day was two or more were more likely to be included in the SaC and SiC groups. An increased frequency of snack intake does not allow time for normal recovery from the low pH, thus breaking the balance of tooth mineralization and demineralization[18]. According to Akarslan et al.[19], the DMFT index increased due to the increased frequency of snack intake, lack of regular dietary habits, and accumulation of dental plaque. Therefore, it is necessary to establish regular eating habits along with restrictions on snacking for the management of dental caries.

When children had fewer than two sealants, their risk of being included in the SaC and SiC groups was 1.105 and 1.101 times higher, respectively. This result is in line with a study by Berger et al.[20] that reported that children with at least one tooth with sealant had significantly fewer initial stage dental caries fissures. Prior research conducted in Korea by Kim et al.[12] and Jung et al.[13] and an AI-based algorithm developed in 2015 for predicting DMFT indices[22] showed that the most influential variable was the number of teeth with sealants. Conversely, our study using 2018 data showed that this variable was less influ-

ential than others studied. The reason for the large difference in the influence of this variable is thought to be the application of dental sealant insurance. Since 2009, the government has included dental sealants as a benefit item covered under health insurance. Due to the increased accessibility for most children to dental sealants, the influence of this variable has decreased.

There was a high risk that children who brush more than three times a day would be included in the SiC group. Levine et al.[23] also reported that the frequency of brushing teeth and dental caries prevalence are not significantly correlated and have only an inverse proportion. This can indicate that children in the high-risk group are aware of their oral health and make efforts to improve it. It should be noted that it is more important to perform oral hygiene habits like brushing teeth correctly than merely increasing the frequency of brushing teeth. Therefore, children using oral hygiene aids had a greater risk of belonging to the SaC and SiC groups and were thought to be a result of the efforts of both groups to improve oral health.

Household income was not a statistically significant variable. According to a study by Kim et al.[24], income and caries prevalence on permanent teeth are inversely related. This study did not show a significant correlation because of the subjectivity of the data used in the study. Because it was not an objective item and was just an economic condition based on a subjective survey, significant conclusions could not be drawn about it.

The first limitation of the study is that being a cross-sectional study, limited information could be provided about the time-and-after relationship between the risk factors of being included in the SaC and SiC groups and the prevalence of dental caries. Second, in this study, although household income was examined as a variable, unlike in previously performed studies, the lack of objectivity in the data resulted in statistically insignificant findings. A retrospective study is needed to examine this topic further.

However, as we studied subjects with caries experience and high-risk groups for caries using epidemiological approaches for population groups, the findings can be generalized for the whole of Korea.

Conclusions

This study used data from the Children's Oral Health Status Survey conducted in 2018 to identify the pattern of dental caries based on tooth type and characteristics of caries experience in the high-risk group of Korean children aged 12 years. The ratio of caries experience and average DMFT for each tooth were calculated and classified based on the caries experience into high-risk groups based on the SiC and SaC indices. Each group was compared and analyzed with caries-free groups according to the sociodemographic variables and oral health behavior.

According to the study, the caries experience was the highest in the upper and lower first molars, and the lower first premolar had the highest average DMFT index. Factors related to the risk of inclusion in the SaC group included perceived oral health status, sex, presence of dental calculus, sealants, frequency of snack intake, and use of oral hygiene aids. The factors related to the high-risk group were similar, in addition to the average frequency of brushing per day. Perceived oral health status was the most influential variable, which showed a 2.361- and 2.915-fold higher risk of inclusion in the SaC and SiC groups, respectively. We think that further research using objective data is needed to determine the influence of household income.

Therefore, the current study identified the characteristics associated with the risk of dental caries in Korea, and demonstrated the aspects of caries occurring in the first molars. Therefore, oral health-related education, oral environment management through regular hospital visits, and controlling the intake of caries-inducing foods should be implemented in a planned manner, to improve the individual awareness: the application of sealants to the first molar should be actively encouraged. The results of the study, which revealed the characteristics of teeth and groups that were more susceptible to dental caries, can be used to guide policy for oral health projects in Korea. The "Health For All"[25] goal set by the World Health Organization has been met in Korea. However, Korea has yet to achieve the goal of lowering the average DMFT for 12-year-olds below 1 by 2020, also set by the WHO[26]. Therefore, effective prevention projects should be planned for this purpose.

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