치의학석사 학위논문

Exploring the determinants of secular decreases in dental caries among Korean children
치아우식증 감소 추세의 결정요인 탐구

2013년 8월

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이 논문을 치의학석사학위논문으로 제출함

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이혜주의 석사학위논문을 인준함

2013년 8월

위 원 장 _____ (인)

부 위 원 장 _____ (인)

위 원 _____ (인)

Abstract

Exploring the determinants of secular decreases in dental caries among Korean children

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1. Aim

The aim of this study is to trace the secular trend of dental caries in Korea from 2003 to 2010 and determine the attributing factors for the trend.

2. Methods

The ecological study design was used from 2003, 2006, and 2010 Korean National Oral Health Survey. Study sample was an Korean children aged 6 (598 in 2003, 925 in 2006, and 5,786 in 2010), 8 (599 in 2003, 875 in 2006, and 5,732 in 2010), 10 (600 in 2003, 888 in 2006, and 5,760 in 2010), 12 (597 in 2003, 1,755 in 2006, and 6,253 in 2010), 15 years old (597 in 2003, 1,755 in 2006, and 6,253 in 2010).

Dependent variables were the prevalence of decayed, missing, filled permanent teeth (DMFT) and the prevalence of decayed teeth (DT).

Independent variable was time (2003, 2006, 2010). Covariates included gender, region (urban/rural), sealant rate, and water fluoridation rate. Complex sample frequency analysis was performed to determine the simple frequencies (categorical variables) and mean (for continuous variables). Linear regression analysis was performed to test *p*-values for linear time trends. Also, we used logistic regression to test the time trends of the prevalence of DMFT and DT. The % excess odd explained was calculrated.

3. Conclusions

Over the past 7 years, prevalence of sealant increased substantially (34.4% to 52.9% in 8 years, 30.5% to 50.9% in 10 years, 24.8% to 48.9% in 12 years, and 14.2% to 43.6% in 15 years, respectively) and prevalence of DMFT was decreased (16.6% to 8.1% in 6 years, 43.2% to 27.2% in 8 years, 61.5% to 46.2% in 10 years, 75.9% to 60.5% in 12 years, and 83.3% to 74.6% in 15 years, respectively). The prevalence of DT was also decreased (10.7% to 3.4% in 6 years, 22.2% to 7.6% in 8 years, 34.0% to 11.4% in 10 years, 49.7% to 19.8% in 12 years, and 55.3% to 30.3% in 15 years, respectively). However, the likely causes for these secular trends remain to be determined.

Keywords : dental caries, fissure sealant, water fluoridation, epidemiology

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Contents

Tables

1. Introduction

Report of the caries prevalence in OECD (Organization for Economic Co-operation and Development) countries showed a general trend towards a further decrease for children and adolescents[1]. For most Americans, oral health status has improved between 1988-1994 and 1999-2004[2]. In previous study, over the last 30 years, there has been a significant decrease in caries severity for children 5 - 6 years old and also a significant decrease in caries prevalence and severity for children in Latin America and Caribbean 11 - 13 years old[3]. Among Japanese respondents sampled in a series of cross-sectional studies between 1957 and 2005, the incidence of dental caries in young adults decreased, suggesting a decrease in prevalence of dental caries in future generations[4]. Similarly, over the past few decades, The mean DMFT scores for the 12-year-old Koreans decreased in Korea[5].

What is the factor in reduced caries experience? Available information on the trend of dental caries suggest various potential factors. In previous studies, water fluoridation was followed by a decrease of caries, and interruptions in fluoridation were followed by increasing caries levels[8,9]. In Sweden, levels of mutans streptococci were significantly related to caries experience and increment and outcome of sealant and fluoride programmes was associated with the concentration of mutans streptococci at baseline[10]. Review paper revealed that fluoride-containing products reduces tooth decay via topical mechanisms which include (1) restrain of demineralization at the crystal surfaces inside the tooth, (2) enhancement of remineralization at the crystal surfaces, and (3) control of bacterial enzymes[11].

Previous study has been reported caries reduction trends and effect of caries prevention programs in Korea[12]. Because caries prevention programs may be potential determinant of caries reduction trends, examining trends and effects these potential determinants will help us better understand caries trends in Korea. Also, understanding relationships between public caries prevention program as determinant and caries trend may provide evidences for improved public oral health policy. However, there is no information about determinants of secular decrease in dental caries in national level.

Therefore, the aim of this study is to explore the determinants of secular decrease in dental caries among Korea representative samples.

2. Materials and methods

Sampling

Korea National Oral Health Surveys (KNOHS) for children aged 6, 8, 10, 12, 15 years were conducted in school. The samples were decided by stratified cluster sampling procedure.

2003 survey was made up of 60 districts, after each classroom in all school grades was randomly selected, every fifth student was examined[13]. 2006 survey was the same as that the 2003 survey except for number of districts and distribution ratio of age group. The number of districts changed to 150 and subjects in 12-year-old group were two times compare with different age group[14]. In 2010 survey, elementary, middle, high school were selected by first stage stratification, sample grades (6years, 8years, 10years, 12years, 15years) were selected by second stage stratification[15].

Contacting the subjects

2003-2006 survey were carried out with the cooperation of the head of the department of education in the survey districts. 2010 survey was conducted with public health center in the survey districts. All school principal received cooperation request letter and noticed students. The surveyor contacted the principal by phone for examination.

Study population

After stratified cluster sampling, 2,994(2003), 5,348(2006), 29,630(2010) children aged 6, 8, 10, 12, 15 years were examined. The number of children by age were 598(6yrs), 599(8yrs), 600(10yrs), 597(12yrs), 600(15yrs) in 2003. The number of children by age were 925(6yrs), 875(8yrs), 888(10yrs), 1,755(12yrs) 905(15yrs) in 2006. The number of children by age were 5,786(6yrs), 5,732(8yrs), 5,760(10yrs), 6,253(12yrs) 6,099(15yrs) in 2010.

Data collection

Twenty survey teams composed of dentist, assistant, interview expert and official staff in the 2003 survey; in 2006, eight teams composed of public health dentist and interview expert; in 2010, 21 survey teams was composed of a dentist, assist and official staff.

The experience of caries in the permanent dentition (DMFT index) was calculated from the clinical examination according to the WHO criteria[16]. Calibration exercise for the examiners were carried out before the survey. The chief investigator and examiners examined the same subjects. Any problem during calibration was discussed.
The population, infant death rate, and gross domestic product (GDP) per capita, number of dental hospital and clinic were collected from National Statistical Office[17]. Population drinking fluoridated water and number of fluoridated water plant were found in Guide for Oral

Health Program[18].

Frequency of food consumption

Analysis for dietary pattern used the data from Korea National Health and Nutrition Examination Survey (KNHANES) 1998-2010. Information on the frequency of daily food consumption was collected on the following question, "How often did you eat these food? (snacks, soft drinks, fruits). Criteria of answer were ≥2-3 times/week. Complex sample frequency analysis was performed to determine the simple frequencies of food groups.

Statistical analysis

A database was constructed using SPSS 19.0®(SPSS,Inc.,Chicago,IL). Dependent variables were DMFT, DT prevalence. Independent variable was time (2003, 2006, 2010) Covariates were gender, region (urban/rural), sealant, water fluoridation. Among the covariates, confounders were gender and region, mediators were sealant and water fluoridation. Region variable divided two groups, urban (metropolitan, city area) and rural (rural area) in subjects. Sealant variable indicates prevalence of sealant and water fluoridation variable denotes status drinking fluoridated water (yes/no) in national level[19].

Complex sample frequency analysis was performed to determine the simple frequencies and mean of dependent variables, independent variables, covariates. However, in 2003, because weight variable was

not included in available raw data, frequency analysis was performed. Linear regression analysis was performed to test *p*-values for linear time trends. Also, we used logistic regression analysis to test the time trends of the prevalence of caries and active caries. The model adjusting for confounders (sex, region variable) was base model in this analysis. The role of mediators was evaluated with the percentage (%) excess odd explained, which can be calculated as [(OR(Adjusted for sociodemographic factors) - OR(Adjusted for sociodemographic factors + mediators)) / OR(Adjusted for sociodemographic factors) - 1)] in this study[20]. This % excess odd explained represents the degree to which a mediator explains the relationship between time and caries trends.

3. Results

Table 1 shows that over the past 7 years, prevalence of sealant increased substantially from 24.8% to 18.7% in 6 years of age. Prevalence of caries experience and active caries were decreased 8.5%, 7.3%, respectively in 6 year of age.

Prevalence of sealant increased substantially from 34.4% to 52.9% in 8 years of age in 2003-2010. Prevalence of caries experience and active caries were decreased 16.0%, 14.6%, respectively in 8 year of age.

Table 3 suggested that over the past 7 years, prevalence of sealant increased substantially from 30.5% to 50.9% in 10 years of age. Prevalence of caries experience and active caries were decreased 15.3%, 22.6%, respectively in 10 year of age.

In our data, over the past 7 years, prevalence of sealant increased substantially from 24.8% to 48.9% in 12 years of age. Prevalence of caries experience and active caries were decreased 15.4%, 29.9%, respectively in 12 year of age.

Over the past 7 years, there was also marked increase of sealant prevalence in 15 years of age(from 14.2% to 43.6%). Prevalence of caries experience and active caries were decreased 8.7%, 25.0%, respectively in 15 year of age.

Table 6 revealed series of OR for caries prevalence based on time after adjusting for mediators and DMFT at age 6. The base model

was the model adjusted for confounders (gender, region). Analysis results revealed that 2006 and 2010 had significantly lower OR than 2003 in base model (OR=0.77; 95% CI 0.57-1.02 for 2006 and OR=0.47; 95% CI 0.37-0.59 for 2010). OR for DMFT with adjustment of sealant and OR for DMFT with adjustment of water fluoridation were not founded significant difference compare with base model.

Table 7 demonstrates series of OR for caries prevalence based on time after adjusting for mediators and DMFT at age 8. The base model was the model controlling for confounders (gender, region). Analysis results revealed that 2006 and 2010 had significantly lower OR than 2003 in base model (OR=0.58; 95% CI 0.46-0.72 for 2006 and OR=0.50; 95% CI 0.42-0.60 for 2010). The magnitude of OR for DMFT by time increase with adjustment of sealant in 2010 (OR=0.54; 95% CI 0.45-0.64). The % excess odd explained of 2010 was higher for sealant than water fluoridation model (sealant adjusted model=8.00%, water fluoridation adjusted model=0%).

Our data suggested series of OR for caries prevalence based on time after adjusting for mediators and DMFT at age 10. The base model was the model adjusted for confounders (gender, region). Analysis results revealed that 2006 and 2010 had significantly lower OR than 2003 in base model (0.50; 95% CI 0.41-0.62 for 2006 and OR=0.54; 95% CI 0.45-0.64 for 2010). The magnitude of OR for DMFT by time increase with adjustment of sealant in 2010 (OR=0.60; 95% CI 0.50-0.71). The % excess odd explained of 2010 was higher for sealant than water fluoridation model (13.04%).

Results of our study showed that series of OR for caries prevalence based on time after adjusting for mediators and DMFT at age 12. The base model was the model adjusted for confounders (gender,

region). Analysis results revealed that 2006 and 2010 had significantly lower OR than 2003 in base model (0.50; 95% CI 0.40-0.62 for 2006 and OR=0.50; 95% CI 0.41-0.61 for 2010). The magnitude of OR for DMFT by time increase with adjustment of sealant in 2010 (OR=0.54; 95% CI 0.45-0.66). The % excess odd explained of 2010 was higher for sealant than water fluoridation model (sealant adjusted model=8.00%, water fluoridation adjusted model=0%).

Table 10 shows series of OR for caries prevalence based on time after adjusting for mediators and DMFT at age 15. The base model was the model adjusted for confounders (gender, region). Analysis results revealed that 2006 and 2010 had significantly lower OR than 2003 in base model (OR=0.68; 95% CI 0.52-0.88 for 2006 and OR=0.62; 95% CI 0.49-0.79 for 2010). OR for DMFT with adjustment of sealant and OR for DMFT with adjustment of water fluoridation were not founded significant difference compare with base model.

Results of our data showed series of OR for caries prevalence based on time after adjusting for mediators and DT at age 6. The base model was the model adjusted for confounders (gender, region). Analysis results revealed that 2006 and 2010 had significantly lower OR than 2003 in base model (OR=0.35; 95% CI 0.23-0.53 for 2006 and OR=0.31; 95% CI 0.23-0.42 for 2010). OR for DT with adjustment of sealant and OR for DT with adjustment of water fluoridation were not founded significant difference compare with base model.

Table 12 demonstrates series of OR for caries prevalence based on time after adjusting for mediators and DT at age 8. The base model was the model controlling for confounders (gender, region). Analysis results revealed that 2006 and 2010 had significantly lower OR than 2003 in base model (OR=0.42; 95% CI 0.31-0.56 for 2006 and OR=0.30; 95% CI 0.24-0.38 for 2010). The magnitude of OR for DT by time

increase with adjustment of sealant in 2010 (OR=5.71; 95% CI 0.28-0.43). The % excess odd explained of 2010 was higher for sealant than water fluoridation model (sealant adjusted model=5.71%, water fluoridation adjusted model=0%).

Our data suggested series of OR for caries prevalence based on time after adjusting for mediators and DT at age 10. The base model was the model adjusted for confounders (gender, region). Analysis results revealed that 2006 and 2010 had significantly lower OR than 2003 in base model (OR=0.32; 95% CI 0.25-0.41 for 2006 and OR=0.27; 95% CI 0.23-0.33 for 2010).

Results of our study revealed that series of OR for caries prevalence based on time after adjusting for mediators and DT at age 12. The base model was the model adjusted for confounders (gender, region). Analysis results revealed that 2006 and 2010 had significantly lower OR than 2003 in base model (OR=0.30; 95% CI 0.25-0.37 for 2006 and OR=0.27; 95% CI 0.23-0.32 for 2010).

Table 15 shows series of OR for caries prevalence based on time after adjusting for mediators and DT at age 15. The base model was the model adjusted for confounders (gender, region). Analysis results revealed that 2006 and 2010 had significantly lower OR than 2003 in base model (OR=0.34; 95% CI 0.28-0.43 for 2006 and OR=0.36; 95% CI 0.31-0.43 for 2010). The magnitude of OR for DT by time increase with adjustment of sealant in 2010 (OR=0.42; 95% CI 0.36-0.50). The % excess odd explained of 2010 was higher for sealant than water fluoridation model (sealant adjusted model=9.38%, water fluoridation adjusted model=0%).

4. Discussion

Throughout life, adverse exposures gradually accumulate by way of ill oral health episodes, environmental factors or individual behaviours which increase the risk of dental caries and tooth loss. Through the resultant chain of risk or advantage, certain experiences or exposures in early life increase the likelihood of future events which, in turn, lead to greater or lower risk of adult oral disease (Fig. 1). Adult oral health is predicted by not only childhood socioeconomic advantage or disadvantage, but also by oral health in childhood[21].

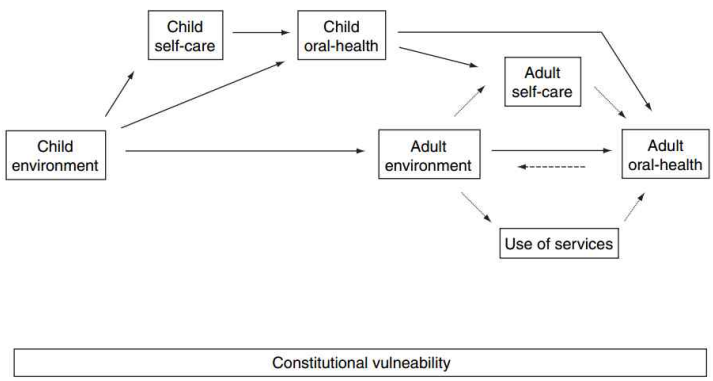

Fig 1. Chains of oral health risk through the life course[21]

In our data, sealant as mediator is less effective in secular decrease of caries. Water fluoridation could not showed effect as mediator. However, because caries etiology is complex and affected by various factors[22], time trends of dental caries could be not clearly explained by changes in sealant prevalence, water fluoridation. Therefore, regarding potential determinants in caries trends may provide clue

about secular reduction of caries prevalence.

Caries prevention program has been applied in Korea. In 1990s, public fissure sealant program began, water fluoridation program also applied in 1981[18]. In addition, the National Assembly of Korea passed the Oral Health Act in 2000 and it could be opportunity to start active public prevention program.

Community Water Fluoridation (CWF) began in as a pilot program in 1981 in Jinhae and in 1982 in Chungjoo. This CWF was expanded until ealry 2000s. The number of fluoridated water plant was 37, population drinking fluoridated water was 4,428,288 in 2001. However, this preventive program was stopped and declined since the opponents of CWF has increased somewhat and their efforts to discontinue the CWF were effective. Then, the number of fluoridated water plant was 25, population drinking fluoridated water was 2,968,123 in 2010. Our data showed that population drinking fluoridated water and number of fluoridated water plant were founded reduction trends (Table 16).
However, previous studies examining effects of water fluoridation founded that there is a demonstrable justification and necessity for drinking fluoridated water[23),24),25)]. It is essential to maintain the benefit of fluoride to those already receiving it and encourage the use of appropriate and effective strategies and products by those who are not. A study on strategy of the CWF emphasized improvement of consciousness about the CWF[26),27),28)].

The another potential determinant is fluoride toothpaste. In Korea, the

use of fluoride toothpaste increased since 1990s. The ratio using fluoride toothpaste was 39.0% among Seoul citizens in 1994 and was 97.4% among Ulsan citizens in 2000[29),30)]. In 2004, use rate of fluoride toothpaste among college students was 99.3%[31)]. With very few exceptions, most commercial toothpaste sold in Korea currently include fluoride.

Table 16 showed general features of Korea 1998-2010[17)]. Total population of Korea, life expectancy, gross domestic product (GDP) per capita, number of dental hospital and clinic were increased substantially. On the other hand, infant death rate as major economic indicator decreased steadily. Improvement of health care level and living standard with economic development could be potential mediator for caries decline trends.

Dietary factor is most important determinants for understanding changes in caries. Previous studies revealed that sugar consumption remains the major caries risk factors, Although the disease during the last 20 years become manifest in smaller and smaller percentages of children[32)]. Blinkhorn reviewed that in many developing countries the prevalence of caries in young children is high and is increasing in those populations who are adopting a cariogenic diet[33)].
According to data from Korea National Health and Nutrition Examination Surveys (KNHANES), over the past 10 years, frequency of fruits consumption increased substantially (from 69.5% to 49.5%). However, beginning in 2000, frequency of snacks and soft drink decreased (19.7%, 11.9%, respectively) (Table 16). In 2007, government restrict bending machine in school, this policy would influenced consumption of soft drinks in child and adolescence. These

changes in dietary pattern may be another mediator explaining secular reduction of caries prevalence.

This study has several limitations. First, we analyze only two potential mediators (sealant, water fluoridation) in this KNOHS data. Because each survey data has different variable, which has limited ability to merge overlapping variables. Second, in our data, sealant variable indicate prevalence of sealant. This variable also contains subjects sealed in dental hospitals and clinics. In this reason, analysis of sealant as mediator might has resulted in the lack of effect of public sealant program in explaining time trends of caries. Third, we used the KNHANES data for exploring trends of food consumption because KNOHS dietary data was unavailable (2003; 6-15 years are except from dietary questionnaire, 2006-2010; difference of dietary questions). Although KNHANES data is available, it cannot affect the finding on substantial reduction in caries from study data.

With regarding to these potential determinants, we need an improved approach to public caries prevention program for maintaining the secular decrease trends of dental caries.

5. Conclusions

Over the past 7 years, prevalence of sealant increased substantially from 24.8% to 48.9% in 12 years of age. Prevalence of caries experience was decreased from 75.9% to 60.5% in 12 year of age. Also, prevalence of active caries was decreased from 49.7% to 19.8% in 12 year of age. These clear decreases were found among all age and gender group. But the likely causes for these secular trends remain to be determined.

Table 1. Basic characteristics in Korea 2003-2010 (6yrs)

Variables	Total			P for trend†	Boy			P for trend†	Girl			P for trend†
	2003* (n=598)	2006 (n=925)	2010 (n=5,786)		2003 * (n=299)	2006 (n=470)	2010 (n=2,957)		2003* (n=299)	2006 (n=455)	2010 (n=2,829)	
Prevalence of caries experience, % (95% CI)	16.6	13.1 (11.0-15.5)	8.1 (7.3-8.9)	**<0.001**	13.4	10.2 (7.7-13.3)	6.4 (5.4-7.4)	**<0.001**	19.7	16.2 (13.0-20.1)	10.0 (8.8-11.2)	**<0.001**
Prevalence of active caries, % (95% CI)	10.7	4.1 (2.9-5.6)	3.4 (2.9-3.9)	**<0.001**	9.7	2.9 (1.7-4.9)	2.3 (1.8-3.0)	**<0.001**	11.7	5.3 (3.5-8.0)	4.5 (3.7-5.4)	**<0.001**
Region: Urban, % (95% CI)	84.9	86.9 (86.1-87.6)	86.0 (85.7-86.4)	0.053	84.9	86.7 (85.6-87.8)	85.9 (85.3-86.4)	0.207	84.9	87.0 (85.9-88.1)	86.3 (85.7-86.8)	0.142
Region: Rural, % (95% CI)	15.1	13.1 (12.4-13.9)	14.0 (13.6-14.3)		15.1	13.3 (12.2-14.4)	14.1 (13.6-14.7)		15.1	13.0 (11.9-14.1)	13.7 (13.2-14.3)	
Prevalence of sealant, % (95% CI)	24.8	24.2 (21.5-27.2)	18.7 (17.6-19.8)	**<0.001**	23.1	22.4 (18.7-26.6)	17.5 (16.0-19.2)	**0.010**	25.4	26.2 (22.3-30.6)	19.9 (18.3-21.6)	**0.004**
Population of water fluoridation, n	80	49	492		40	25	253		40	24	239	
Water fluoridation, % (95% CI)	13.4	4.8 (3.6-6.3)	8.3 (7.5-9.1)	0.050	13.4	4.8 (3.3-7.1)	8.3 (7.3-9.5)	0.191	13.4	4.8 (3.2-7.1)	8.2 (7.2-9.4)	0.142

By complex sample frequency analysis

*by frequency analysis

† P-value from linear regression analysis

Bold denotes the statistical significance at $p<0.05$

Table 2. Basic characteristics in Korea 2003-2010 (8yrs)

Variables	Total			P for trend†	Boy			P for trend†	Girl		
	2003* (n=599)	2006 (n=875)	2010 (n=5,732)		2003* (n=300)	2006 (n=438)	2010 (n=2,941)		2003* (n=299)	2006 (n=437)	2010 (n=2,791)
Prevalence of caries experience, % (95% CI)	43.2	30.3 (27.3-33.5)	27.2 (26.0-28.5)	**<0.001**	36.0	27.1 (23.0-31.5)	23.5 (21.9-25.2)	**<0.001**	50.5	33.9 (29.4-38.6)	31.2 (29.3-33.1)
Prevalence of active caries, % (95% CI)	22.2	10.8 (8.8-13.1)	7.6 (6.9-8.4)	**<0.001**	20.3	9.6 (7.1-12.8)	7.1 (6.2-8.2)	**<0.001**	24.1	12.0 (9.2-15.6)	8.1 (7.0-9.3)
Region Urban, % (95% CI)	85.0	87.0 (86.3-87.6)	86.7 (86.4-87.0)	0.446	85.0	86.6 (85.7-87.5)	86.6 (86.1-87.1)	0.576	84.9	87.4 (86.3-88.4)	86.8 (86.3-87.3)
Region Rural, % (95% CI)	15.0	13.0 (12.4-13.7)	13.3 (13.0-13.6)		15.0	13.4 (12.5-14.3)	13.4 (12.9-13.9)		15.1	12.6 (11.6-13.7)	13.2 (12.7-13.7)
Prevalence of sealant, % (95% CI)	34.4	39.4 (36.2-42.8)	52.9 (51.5-54.3)	**<0.001**	37.3	39.8 (35.3-44.5)	53.4 (51.4-55.3)	**<0.001**	31.4	39.1 (34.5-43.8)	52.4 (50.4-54.4)
Population of water fluoridation, n	80	48	482		40	24	248		40	24	234
Water fluoridation, % (95% CI)	13.4	5.0(3.8-6.6)	8.5(7.8-9.3)	**0.012**	13.3	5.0(3.4-7.4)	8.5(7.5-9.7)	0.090	13.4	5.0(3.4-7.4)	8.5(7.4-9.6)

By complex sample frequency analysis

*by frequency analysis

† P-value from linear regression analysis

Bold denotes the statistical significance at $p<0.05$

Table 3. Basic characteristics in Korea 2003-2010 (10yrs)

Variables	Total			P for trend†	Boy			P for trend†	Girl			P for trend†
	2003* (n=600)	2006 (n=888)	2010 (n=5,760)		2003* (n=300)	2006 (n=445)	2010 (n=2,968)		2003* (n=300)	2006 (n=443)	2010 (n=2,792)	
Prevalence of caries experience, % (95% CI)	61.5	44.4 (41.1-47.7)	46.2 (44.8-47.6)	**<0.001**	58.0	40.1 (35.5-44.8)	42.9 (40.9-44.8)	**0.004**	65.0	49.2 (44.5-54.0)	49.8 (47.8-51.9)	**0.002**
Prevalence of active caries, % (95% CI)	34.0	14.2 (12.0-16.8)	11.4 (10.6-12.3)	**<0.001**	34.0	14.0 (11.1-17.7)	10.8 (9.6-12.0)	**<0.001**	34.0	14.5 (11.4-18.2)	12.1 (10.9-13.4)	**<0.001**
Region Urban, % (95% CI)	85.0	86.9 (86.3-87.5)	87.7 (87.3-88.0)	0.568	85.0	86.8 (85.9-87.7)	87.5 (87.0-87.9)	0.801	85.0	87.0 (86.1-87.9)	87.9 (87.4-88.4)	0.588
Region Rural, % (95% CI)	15.0	13.1 (12.5-13.7)	12.3 (12.0-12.7)		15.0	13.2 (12.3-14.1)	12.5 (12.1-13.0)		15.0	13.0 (12.1-13.9)	12.1 (11.6-12.6)	
Prevalence of sealant, % (95% CI)	30.5	41.6 (38.4-45.0)	50.9 (49.5-52.3)	**<0.001**	28.0	44.1 (39.5-48.7)	51.2 (49.2-53.2)	**<0.001**	33.0	38.9 (34.3-43.6)	50.5 (48.5-52.6)	**<0.001**
Population of water fluoridation, n	80	48	483		40	24	253		40	24	230	
Water fluoridation, % (95% CI)	13.3	5.0 (3.8-6.5)	8.6 (7.9-9.5)	**0.027**	13.3	5.0 (3.3-7.3)	8.5 (7.4-9.7)	0.159	13.3	5.0 (3.3-7.3)	8.8 (7.7-10.0)	0.085

By complex sample frequency analysis

*by frequency analysis

† P-value from linear regression analysis

Bold denotes the statistical significance at $p<0.05$

Table 4. Basic characteristics in Korea 2003-2010 (12yrs)

Variables	Total				Boy				Girl		
	2003* (n=597)	2006 (n=1,755)	2010 (n=6,253)	P for trend†	2003* (n=300)	2006 (n=888)	2010 (n=3,309)	P for trend†	2003* (n=297)	2006 (n=867)	2010 (n=2,944)
Prevalence of caries experience, % (95% CI)	75.9	61.1 (58.7-63.4)	60.5 (59.2-61.8)	**<0.001**	70.0	56.9 (53.6-60.2)	55.8 (54.0-57.6)	**0.013**	81.8	65.8 (62.5-68.9)	65.8 (63.9-67.6)
Prevalence of active caries, % (95% CI)	49.7	23.7 (21.7-25.7)	19.8 (18.8-20.9)	**<0.001**	45.7	21.1 (18.5-23.9)	17.5 (16.1-18.9)	**<0.001**	53.9	26.6 (23.7-29.7)	22.5 (21.0-24.2)
Region: Urban, % (95% CI)	84.9	86.2 (85.7-86.7)	89.2 (88.8-89.5)	0.891	85.0	86.9 (86.3-87.5)	88.6 (88.1-89.1)	0.698	85.8	85.4 (84.6-86.3)	89.8 (89.3-90.3)
Region: Rural, % (95% CI)	15.1	13.8 (13.3-14.3)	10.8 (10.5-11.2)		15.0	13.1 (12.5-13.7)	11.4 (10.9-11.9)		15.2	14.6 (13.7-15.4)	10.2 (9.7-10.7)
Prevalence of sealant, % (95% CI)	24.8	34.0 (31.8-36.3)	48.9 (47.6-50.2)	**<0.001**	22.7	33.1 (30.0-36.3)	49.4 (47.6-51.2)	**<0.001**	26.9	35.0 (31.8-38.4)	48.4 (46.4-50.3)
Population of water fluoridation, n	70	96	393		35	48	199		35	48	194
Water fluoridation, % (95% CI)	11.7	5.0 (4.1-6.1)	7.0 (6.3-7.7)	**<0.001**	11.7	4.9(3.7-6.5)	6.8(5.9-7.9)	**0.005**	11.8	5.0(3.8-6.6)	7.1(6.2-8.2)

By complex sample frequency analysis

*by frequency analysis

† P-value from linear regression analysis

Bold denotes the statistical significance at $p<0.05$

Table 5. Basic characteristics in Korea 2003-2010 (15yrs)

Variables	Total				Boy				Girl			
	2003* (n=597)	2006 (n=1,755)	2010 (n=6,253)	P for trend†	2003* (n=300)	2006 (n=888)	2010 (n=3,309)	P for trend†	2003* (n=297)	2006 (n=867)	2010 (n=2,944)	P for trend†
Prevalence of caries experience, % (95% CI)	83.3	77.5 (74.7-80.1)	74.6 (73.3-75.9)	**<0.001**	78.3	75.2 (70.9-79.0)	69.2 (67.4-70.9)	**<0.001**	88.3	80.1 (76.2-83.5)	80.7 (78.9-82.4)	**0.040**
Prevalence of active caries, % (95% CI)	55.3	29.4 (26.5-32.4)	30.3 (28.9-31.8)	**<0.001**	54.3	27.2 (23.2-31.6)	29.8 (28.1-31.6)	**<0.001**	56.3	31.8 (27.6-36.2)	31.0 (28.7-33.3)	**<0.001**
Region Urban, % (95% CI)	85.0	90.8 (90.4-91.3)	88.8 (87.9-89.6)	0.643	89.9 (89.6-90.2)	90.7 (90.1-91.3)	90.0 (89.4-90.5)	0.709	85.0	90.9 (90.2-91.6)	87.5 (85.7-89.0)	0.757
Region Rural, % (95% CI)	15.0	9.2 (8.7-9.6)	11.2 (10.4-12.1)		10.1 (9.8-10.4)	9.3 (8.7-9.9)	10.0 (9.5-10.6)		15.0	9.1 (8.4-9.8)	12.5 (11.0-14.3)	
Prevalence of sealant, % (95% CI)	14.2	27.1 (24.3-30.1)	43.6 (42.2-45.1)	**<0.001**	16.0	26.9 (22.9-31.2)	43.3 (41.4-45.2)	**<0.001**	12.3	27.3 (23.4-31.7)	44.0 (41.8-46.3)	**<0.001**
Population of water fluoridation, n	70	45	434		35	24	265		35	21	169	
Water fluoridation, % (95% CI)	11.7	4.7 (3.5-6.2)	8.0 (7.2-8.8)	**0.003**	11.7	5.1 (3.4-7.4)	8.1 (7.1-9.2)	0.086	11.7	4.2 (2.8-6.4)	7.9 (6.7-9.2)	**0.014**

By complex sample frequency analysis

*by frequency analysis

† P-value from linear regression analysis

Bold denotes the statistical significance at $p<0.05$

Table 6. Roles of mediators in the relationship between time and dental caries: adjusted odds ratio (95% confidence intervals) of DMFT by time and percentage excess odd explained (6yrs)

	2003	2006		2010	
		OR (95% CI)*	% excess odd explained	OR (95% CI) *	% excess odd explained
Base model (B)	1.00 (reference)	0.77 (0.57−1.02)	−	0.47 (0.37−0.59)	−
B + sealant	1.00 (reference)	0.76(0.57−1.02)	−4.35	0.48(0.38−0.60)	1.89
B + water fluoridation	1.00 (reference)	0.77(0.58−1.03)	0.00	0.47(0.37−0.59)	0.00
B + sealant & water fluoridation	1.00 (reference)	0.77 (0.58−1.03)	0.00	0.48 (0.38−0.61)	1.89

*By logistic regression analysis

Base model was adjusted for gender, region

Table 7. Roles of mediators in the relationship between time and dental caries: adjusted odds ratio (95% confidence intervals) of DMFT by time and percentage excess odd explained (8yrs)

	2003	2006		2010	
		OR (95% CI)*	% excess odd explained	OR (95% CI) *	% excess odd explained
Base model (B)	1.00 (reference)	0.58 (0.46-0.72)	-	0.50 (0.42-0.60)	-
B + sealant	1.00 (reference)	0.58(0.47-0.73)	0.00	0.54(0.45-0.64)	8.00
B + water fluoridation	1.00 (reference)	0.57(0.46-0.71)	-2.38	0.50(0.42-0.60)	0.00
B + sealant & water fluoridation	1.00 (reference)	0.58 (0.47-0.72)	0.00	0.54 (0.45-0.64)	8.00

*By logistic regression analysis

Base model was adjusted for gender, region

Table 8. Roles of mediators in the relationship between time and dental caries: adjusted odds ratio (95% confidence intervals) of DMFT by time and percentage excess odd explained (10yrs)

	2003	2006		2010	
		OR (95% CI)*	% excess odd explained	OR (95% CI) *	% excess odd explained
Base model (B)	1.00 (reference)	0.50 (0.41-0.62)	-	0.54 (0.45-0.64)	-
B + sealant	1.00 (reference)	0.53(0.43-0.65)	6.00	0.60(0.50-0.71)	13.04
B + water fluoridation	1.00 (reference)	0.50(0.41-0.62)	0.00	0.54(0.45-0.64)	0.00
B + sealant & water fluoridation	1.00 (reference)	0.53 (0.42-0.65)	6.00	0.60 (0.50-0.71)	13.04

*By logistic regression analysis

Base model was adjusted for gender, region

Table 9. Roles of mediators in the relationship between time and dental caries: adjusted odds ratio (95% confidence intervals) of DMFT by time and percentage excess odd explained (12yrs)

	2003	2006		2010	
		OR (95% CI)*	% excess odd explained	OR (95% CI) *	% excess odd explained
Base model (B)	1.00 (reference)	0.50 (0.40-0.62)	-	0.50 (0.41-0.61)	-
B + sealant	1.00 (reference)	0.51(0.41-0.63)	2.00	0.54(0.45-0.66)	8.00
B + water fluoridation	1.00 (reference)	0.50(0.40-0.61)	0.00	0.50(0.41-0.61)	0.00
B + sealant & water fluoridation	1.00 (reference)	0.51 (0.41-0.63)	2.00	0.54 (0.44-0.66)	8.00

*By logistic regression analysis

Base model was adjusted for gender, region

Table 10. Roles of mediators in the relationship between time and dental caries: adjusted odds ratio (95% confidence intervals) of DMFT by time and percentage excess odd explained (15yrs)

	2003	2006		2010	
		OR (95% CI)*	% excess odd explained	OR (95% CI) *	% excess odd explained
Base model (B)	1.00 (reference)	0.68 (0.52-0.88)	-	0.62 (0.49-0.79)	-
B + sealant	1.00 (reference)	0.68(0.52-0.89)	0.00	0.63(0.50-0.79)	2.63
B + water fluoridation	1.00 (reference)	0.67(0.52-0.88)	-3.13	0.62(0.49-0.77)	0.00
B + sealant & water fluoridation	1.00 (reference)	0.68 (0.52-0.89)	0.00	0.63 (0.50-0.79)	2.63

*By logistic regression analysis

Base model was adjusted for gender, region

Table 11. Roles of mediators in the relationship between time and dental caries: adjusted odds ratio (95% confidence intervals) of DT by time and percentage excess odd explained (6yrs)

	2003	2006		2010	
		OR (95% CI)*	% excess odd explained	OR (95% CI) *	% excess odd explained
Base model (B)	1.00 (reference)	0.35 (0.23-0.53)	-	0.31 (0.23-0.42)	-
B + sealant	1.00 (reference)	0.35(0.23-0.53)	0.00	0.30(0.23-0.41)	-1.45
B + water fluoridation	1.00 (reference)	0.36(0.23-0.55)	1.54	0.32(0.24-0.43)	1.45
B + sealant & water fluoridation	1.00 (reference)	0.36 (0.23-0.54)	1.54	0.31 (0.23-0.42)	0.00

*By logistic regression analysis

Base model was adjusted for gender, region

Table 12. Roles of mediators in the relationship between time and dental caries: adjusted odds ratio (95% confidence intervals) of DT by time and percentage excess odd explained (8yrs)

	2003	2006		2010	
		OR (95% CI)*	% excess odd explained	OR (95% CI) *	% excess odd explained
Base model (B)	1.00 (reference)	0.42 (0.31−0.56)	−	0.30 (0.24−0.38)	−
B + sealant	1.00 (reference)	0.43(0.32−0.58)	1.72	0.34(0.28−0.43)	5.71
B + water fluoridation	1.00 (reference)	0.41(0.31−0.55)	−1.72	0.30(0.24−0.37)	0.00
B + sealant & water fluoridation	1.00 (reference)	0.42 (0.31−0.57)	0.00	0.34 (0.27−0.42)	5.71

*By logistic regression analysis

Base model was adjusted for gender, region

Table 13. Roles of mediators in the relationship between time and dental caries: adjusted odds ratio (95% confidence intervals) of DT by time and percentage excess odd explained (10yrs)

	2003	2006		2010	
		OR (95% CI)*	% excess odd explained	OR (95% CI) *	% excess odd explained
Base model (B)	1.00 (reference)	0.32 (0.25-0.41)	-	0.27 (0.23-0.33)	-
B + sealant	1.00 (reference)	0.34(0.26-0.44)	2.94	0.31(0.26-0.38)	5.48
B + water fluoridation	1.00 (reference)	0.32(0.25-0.41)	0.00	0.28(0.23-0.33)	1.37
B + sealant & water fluoridation	1.00 (reference)	0.34 (0.26-0.44)	2.94	0.31 (0.26-0.38)	5.48

*By logistic regression analysis

Base model was adjusted for gender, region

Table 14. Roles of mediators in the relationship between time and dental caries: adjusted odds ratio (95% confidence intervals) of DT by time and percentage excess odd explained (12yrs)

	2003	2006		2010	
		OR (95% CI)*	% excess odd explained	OR (95% CI) *	% excess odd explained
Base model (B)	1.00 (reference)	0.30 (0.25-0.37)	-	0.27 (0.23-0.32)	-
B + sealant	1.00 (reference)	0.31(0.26-0.38)	1.43	0.31(0.26-0.37)	5.48
B + water fluoridation	1.00 (reference)	0.29(0.24-0.36)	-1.43	0.26(0.22-0.31)	-1.37
B + sealant & water fluoridation	1.00 (reference)	0.31 (0.25-0.37)	1.43	0.30 (0.25-0.36)	4.11

*By logistic regression analysis

Base model was adjusted for gender, region

Table 15. Roles of mediators in the relationship between time and dental caries: adjusted odds ratio (95% confidence intervals) of DT by time and percentage excess odd explained (15yrs)

	2003	2006		2010	
		OR (95% CI)*	% excess odd explained	OR (95% CI) *	% excess odd explained
Base model (B)	1.00 (reference)	0.34 (0.28-0.43)	-	0.36 (0.31-0.43)	-
B + sealant	1.00 (reference)	0.36(0.29-0.45)	3.03	0.42(0.36-0.50)	9.38
B + water fluoridation	1.00 (reference)	0.34(0.27-0.42)	0.00	0.36(0.31-0.43)	0.00
B + sealant & water fluoridation	1.00 (reference)	0.36 (0.29-0.45)	3.03	0.42 (0.35-0.50)	9.38

*By logistic regression analysis

Base model was adjusted for gender, region

Table 16. General features of Korea 1998-2010

		1998	2000	2001	2003	2005	2006	2007	2008	2009
Population*		46,991,171	47,732,558	48,021,543	48,386,823	48,782,274	48,991,779	49,268,928	49,540,367	49,773,145
Life expectancy*		74.8	76.0	76.5	77.4	78.6	79.2	79.6	80.1	80.5
Infant death probability*		–	6.6	–	–	5.3	–	–	–	–
GDP (gross domestic product per capita (USD))*		7,739	11,349	10,655	13,448	17,547 4	19,662	21,592	19,018	16,966
No. of dental hospital & clinic*		9,775	10,652	10,855	11,659	12,672	13,138	13,492	13,918	14,425
No. of fluoridated water plant†		18	18	37	33	26	25	25	27	27
Population drinking fluoridated water†		2,985,972	3,261,000	4,428,388	3,839,713	2,776,598	2,771,842	2,287,591	2,967,150	3,086,509
Frequency of food consumption§	Snacks (≥2-3 times/week)	–	–	76.3 (70.2-81.5)	–	75.0 (69.5-79.8)	–	64.8 (54.9-73.6)	59.2 (52.2-65.9)	58.5 (51.8-65.0)
	Soft drinks (≥2-3 times/week)	–	–	46.8 (40.3-53.3)	–	43.8 (37.8-50.0)	–	36.1 (27.1-46.2)	33.6 (27.2-40.7)	33.4 (27.3-40.0)
	Fruits (≥2-3 times/week)	49.5 (43.9-55.1)	–	59.9 (53.5-65.9)	–	71.5 (65.6-76.8)	–	85.4 (77.9-90.7)	78.4 (72.0-83.7)	75.4 (69.3-80.6)

*Obtained from National Statistical Office

†Obtained from Guide for Oral Health Program

§Obtained from Korean National Health and Nutrition Examination Survey

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국문초록

치아우식증 감소 추세의 결정요인 탐구

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이 혜 주

본 연구의 목적은 2000년대 한국의 아동 및 청소년에서 치아우식증의 추세변화를 조사하고 이러한 추세변화에 기여한 요인을 평가하는 것이다.

연구자료는 구강보건법에 근거하여 2003, 2006, 2010년에 시행한 국민구강건강실태조사 자료를 이용하였다. 연구대상은 6세(2003년 598명, 2006년 925명, 2010년 5,786명), 8세(2003년 599명, 2006년 875명, 2010년 5,732명), 10세(2003년 600명, 2006년 888명, 2010년 5,760명), 12세(2003년 597명, 2006년 1,755명, 2010년 6,253명), 15세(2003년 600명, 2006년 905명, 2010년 6,099명) 아동 및 청소년이었다. 결과변수는 영구치 치아우식증, 혼동변수는 성별과 지역, 설명변수는 치면열구전색과 수돗물불소농도사업이었다. 영구치 치아우식상태는 세계보건기구에서 권장하는 조사기준에 의거하여 검사하였으며, 치면열구전색유무, DMFT (decayed, filled, and missing teeth) prevalence, DT (decayed) prevalence를 산출하였다.

자료분석은 DMFT, DT, 치면열구전색, 수돗물불소농도조정사업 수혜지역의 분포와 평균을 알아보기 위해 복합표본 빈도분석을 시행하였고, 선형회귀분석을 사용하여 선형추세에 대한 유의확률을 계산하였다. 또한 시간에 따른 치아우식경험률의 추세를 확인하기 위해 로지스틱 회귀분석을 시행하였다. 추세변화에 미치는 mediator의 영향력을 평가하기 위해 % excess odd explained를 산출하였다.

2003년 이후 지난 7년 간, 12세 남자아동의 치면열구전색 보급률은 22.7%에서 49.4%로 현저히 증가하였으며, 여자아동의 경우에도 26.9%에서 48.4%로 증가하였다. 12세 아동의 치아우식증 유병률은 75.9%에서 60.5%로 감소하였으며, 이러한 감소경향은 모든 연령그룹에서 확인할 수 있었다. 이러한 장기적인 치아우식증 감소추세에 대한 좀 더 명확한 요인을 파악하는 후속연구가 필요할 것이다.

주요어 : 치아우식증, 치면열구전색, 수돗물불소농도조정사업, 역학
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