Scientific Research Report

Changes in Antibiotic Prescription After Tooth Extraction: A Population-Based Study from 2002 to 2018

Yoon Young Choi [a], *Kyeong Hee Lee* [b*]

[a] *Artificial Intelligence Big Data Medical Center, Yonsei University Wonju College of Medicine, Wonju, Korea*
[b] *Department of Dental Hygiene, College of Bioecological Health, Shinhan University, Uijeongbu, Korea*

ARTICLE INFO

Article history:
Available online 24 March 2021

Key words:
Antibacterial agents
Antibiotic resistance
Broad-spectrum antibiotics
Prescriptions
Tooth extraction

ABSTRACT

Objective: Microbial resistance due to antibiotic misuse is a worldwide problem. This study aimed to examine the trends in antibiotic prescription after tooth extraction in Korea.

Methods: From the database of National Health Insurance Sharing Service, patients who underwent tooth extraction from 2002 to 2018 were selected as subjects, and 10% of them were selected via stratified sampling based on sex and age. Overall, 15,838,529 cases were observed for annual antibiotic prescription and broad-spectrum antibiotic prescription patterns. Additionally, standardized annual antibiotic use was calculated using a defined daily dose.

Results: Prescriptions were issued in 13,429,770 (84.8%) of the tooth extraction cases, of which 12,179,185 (90.7%) included antibiotics. Logistic regression analysis revealed that the likelihood of prescribing antibiotics after tooth extraction decreased in 2003 compared to 2002 (odds ratio, 0.95) but increased from 2004 to 2018. In the case of the broad-spectrum antibiotic prescription rate, there was no clear trend between 2002 and 2012 (odds ratio, 0.89-1.07); however, over the last 5 years, the likelihood of broad-spectrum antibiotic prescription has steadily increased. The value of antibiotics based on the defined daily dose of 1000 patients per day was calculated to be 4.39 in 2002, exhibiting a steady increase later and reaching 6.97 in 2018, whereas that of broad-spectrum antibiotics was 1.68 in 2002 and has since been on the rise; the highest was 3.82 in 2018.

Conclusions: Antibiotic use after tooth extraction increased over the last 17 years; additionally, the rate of prescribing broad-spectrum antibiotics has increased over the last 5 years.

Introduction

Antibiotic resistance is recognised globally as an important and serious issue that makes the treatment of infectious diseases difficult, reduces the quality of health care, and threatens the safety of humanity.[1,2] Antibiotic resistance mainly occurs because of antibiotic misuse and is considered a major problem, especially in dentistry.[3-5] The antibiotic prescription rate in dentistry is higher than that in other medical specialties, accounting for 10% of all antibiotic prescriptions.[6-8]

Although dentists often prescribe antibiotics to treat oral-maxillofacial infections, they are more commonly prescribed for preventing local and systemic infections that may occur after invasive treatment.[9] Tooth extraction is the most common surgical dental procedure, and most of the antibiotics used in dentistry are prescribed after tooth extraction.[9] It is known that impacted lower third molar removal is the most invasive procedure and can cause complications such as swelling, trismus, bleeding, and postoperative infection.[10] Nevertheless, many researchers have claimed that even after surgical removal of lower third molar, it is not necessary to prescribe antibiotics if there is no preoperative infection.[11-15] In a randomised clinical trial,[14] only anti-inflammatory drugs such as celecoxib and ibuprofen were administered without antibiotics after surgical removal of impacted third molars, and all 98 patients reported good postoperative healing

* *Corresponding author*. Department of Dental Hygiene, College of Bioecological Health, Shinhan University, 95 Hoam-ro, Uijeongbu 11644, Republic of Korea.
E-mail address: khlee@shinhan.ac.kr (K.H. Lee).

https://doi.org/10.1016/j.identj.2021.01.010

without complications such as infections or abscesses during the follow-up period. Posechl et al[11] observed patients (528 cases) for 4 weeks after lower third molar removal and found that there was no significant difference in infectious symptoms between the group that received antibiotics and the group that did not. Similarly, in another randomized clinical trial,[13] after lower third molar removal, placebo (60 patients) and antibiotic-administered (58 patients) groups exhibited no significant difference in the frequency of infection symptoms. Another retrospective study[15] reported that among 1615 cases of lower third molar extraction, 44% used antibiotics; moreover, the overall infection rate was only 2.05%, and there was no significant difference in infection rates between groups that had antibiotics administered and those that did not. Thus, many experts claim that antibiotic prescription after tooth extraction is not essential; however, in Korea, antibiotics are frequently prescribed to all patients after impacted and exposed tooth extraction.[16]

Broad-spectrum antibiotics, in particular, are more likely to cause antibiotic resistance because the range of bacteria is wide. Hence, they should be used only if a serious infection is expected,[11] but researchers are concerned over the excessive use of broad-spectrum antibiotics prescribed by dentists.[17-19] In a study,[19] antibiotics prescribed by dentists in the Czech Republic from 2006 to 2012 were analysed, and it was observed that although the use of narrow-spectrum antibiotics decreased, the use of broad-spectrum antibiotics such as penicillin combined with beta-lactamase inhibitor and lincosamides increased. In Australia, the use of amoxicillin plus clavulanic acid increased by 197% over 12 years (2001-2012).[20] Another study[17] reported that dental clinicians did not follow the guidelines for the use of narrow-spectrum antibiotics as the first option in treating oral-maxillofacial infection.

There have been consistent academic and institutional efforts to reduce antibiotic use globally. As a result, overall antibiotic use in Canada decreased from 1996 to 2013.[18] However, during the same period, antibiotic prescriptions for dental clinic outpatients increased, with the proportion of antibiotic prescriptions in dentistry among total antibiotic prescriptions increasing from 6.7% to 11.3%.[18] In recent years, antibiotic use in Korea has decreased,[21] but the trends in the prescription of antibiotics in dentistry has not been studied. In an effort to prevent antibiotic resistance, the study of the use of all antibiotics as well as broad-spectrum antibiotics in dentistry, and changes in trends is essential. This study aimed to evaluate the changes in the number of antibiotic prescriptions after tooth extraction from 2002 to 2018 using a database representing the Korean population.

Methods

Data sources and ethical consideration

National Health Insurance Corporation (NHIC) of Korea established the National Health Insurance Data Sharing Service (NHISS) database to share medical and health-related data with the public. Additionally, the NHISS database includes information on medical services such as diagnosis, treatment, and prescription history, as well as demographic data such as age, sex, and insurance fee quintile. Because enrolment in national health insurance in mandatory by law in

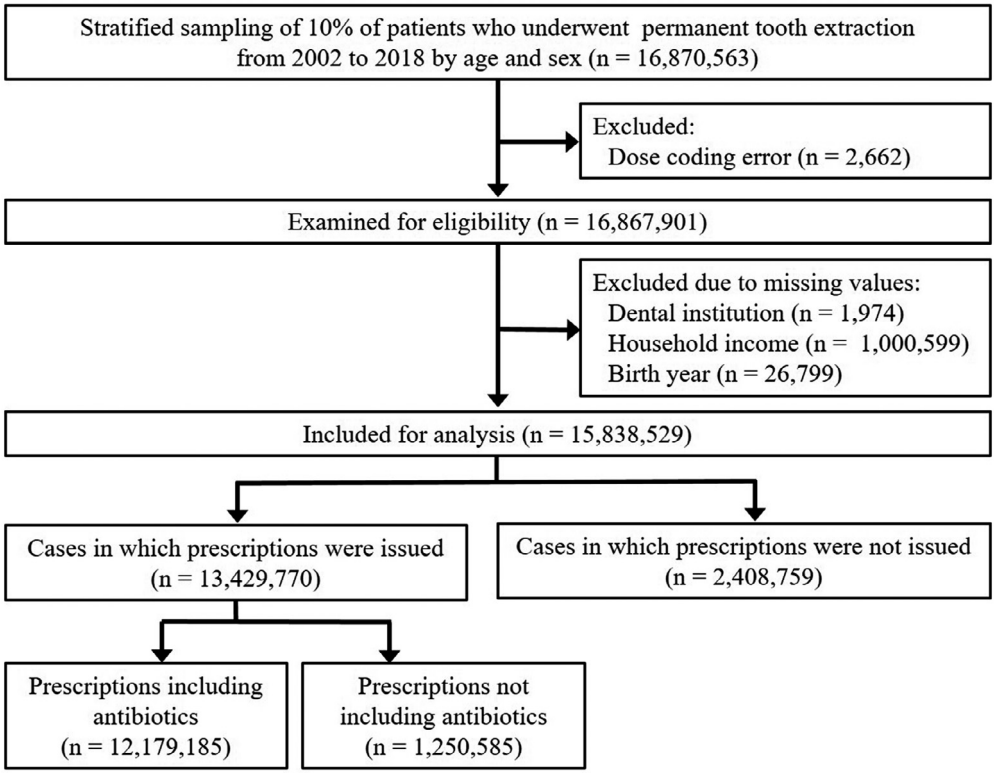

Fig. 1 – Flow of cases included in this study of antibiotic prescribing after tooth extraction.

Korea and it contains data of more than 99% of Koreans, the database was appropriate for this population-based study.

The study was approved by the institutional review board (IRB) of Shinhan University (SHIRB-201908-HR-097-02) and conducted according to the World Medical Association Declaration of Helsinki. The process of obtaining consent was exempted by the institutional review board because this study was conducted using only anonymous secondary data.

Study population

In this study, patients in the NHISS database who visited dentists from 2002 to 2018 and had a tooth extraction were selected as the subjects, and based on sex and age, 10% were selected after stratified sampling. NHISS data are claims data that has the possibility for coding errors; therefore, cases with a daily dose more than 10 times the defined daily dose (DDD)[22] were considered to have coding errors and were excluded from this study. Additionally, the cases with missing data were excluded from the study. Hence, 15,838,529 cases of tooth extraction were analysed (Figure 1).

Variables

Age, sex, and household income were selected as demographic variables of interest. Dental institution types were classified into dental hospital and dental clinic, and dental institution regions were divided into urban and rural areas. Types of tooth extraction were classified as per NHIC's treatment codes: U4412 (incisor extraction), U4413 (molar extraction), U4414 (complicated extraction; cases where simple extraction is not possible because of root hypertrophy, root

Table 1 – Rate of prescribing antibiotics after tooth extraction.

Characteristics	Division	Antibiotic prescription		*P*
		Yes	No	
Total		12,179,185 (90.7)	1,250,585 (9.3)	
Age, y, mean ± SD		48.0 ± 17.5	46.2 ± 17.6	<.001
Sex	Male	6,648,169 (90.9)	667,487 (9.1)	<.001
	Female	5,531,016 (90.5)	583,098 (9.5)	
Household income	Low	1,991,054 (90.9)	200,436 (9.2)	<.001
	Medium-low	1,824,190 (91.1)	178,598 (8.9)	
	Medium	2,229,167 (91.0)	221,034 (9.0)	
	Medium-high	2,740,572 (90.6)	284,823 (9.4)	
	High	3,394,202 (90.3)	365,694 (9.7)	
Region of dental institution	Urban	10,958,279 (90.8)	1,105,809 (9.2)	<.001
	Rural	1,220,906 (89.4)	144,776 (10.6)	
Type of dental institution	Dental hospital	1,093,947 (90.9)	109,915 (9.1)	<.001
	Dental clinic	11,085,238 (90.7)	1,140,670 (9.3)	
Type of tooth extraction	Incisor extraction	1,306,972 (90.6)	135,424 (9.4)	<.001
	Molar extraction	7,874,755 (90.6)	813,803 (9.4)	
	Complicated extraction*	1,331,141 (91.1)	130,686 (8.9)	
	Simply impacted tooth	477,308 (90.2)	51,664 (9.8)	
	Complexly impacted tooth†	488,028 (91.4)	45,745 (8.6)	
	Completely impacted tooth‡	700,981 (90.5)	73,263 (9.5)	
Year of prescription	2002	494,959 (78.2)	137,983 (21.8)	<.001
	2003	505,683 (77.3)	148,671 (22.7)	
	2004	537,793 (79.1)	141,862 (20.9)	
	2005	567,629 (81.4)	129,736 (18.6)	
	2006	593,520 (82.9)	122,354 (17.1)	
	2007	637,350 (84.2)	119,489 (15.8)	
	2008	687,545 (87.2)	101,253 (12.8)	
	2009	726,017 (91.7)	66,114 (8.4)	
	2010	752,665 (94.2)	46,112 (5.8)	
	2011	766,548 (94.9)	40,929 (5.1)	
	2012	772,486 (96.6)	27,579 (3.5)	
	2013	799,565 (97.1)	23,919 (2.9)	
	2014	825,016 (96.9)	26,135 (3.1)	
	2015	855,217 (96.9)	27,315 (3.1)	
	2016	877,167 (96.8)	28,850 (3.2)	
	2017	880,059 (96.7)	29,864 (3.3)	
	2018	899,966 (96.5)	32,420 (3.5)	

SD = standard deviation.

P values were calculated using independent *t*-test for age, and χ^2 test was used for all other variables.

Data are presented as *n* (%), unless otherwise indicated.

* Cases in which simple extraction was not possible because of root hypertrophy, root dilacerations, or osseointegration.

† Cases involving tooth splitting.

‡ Simultaneous tooth splitting and ostectomy of impacted tooth with ≥2/3 of crown impacted into alveolar bone.

dilacerations, or osseointegration), U4415 (simply impacted tooth), U4416 (complexly impacted tooth; cases involving tooth splitting), and U4417 (completely impacted tooth; simultaneous tooth splitting and osteotomy of an impacted tooth with ≥2/3 of crown impacted in alveolar bone). If 2 or more extractions were performed on the same day, the more invasive procedure was chosen.

Antibiotics were categorised based on the Anatomical Therapeutic Chemical (ATC) classification system:[22] penicillin with beta-lactamase inhibitors, metronidazole, second- to fourth-generation cephalosporins, macrolides, quinolones, and lincomycin derivatives were categorised as broad-spectrum antibiotics; penicillin, first-generation cephalosporins, tetracyclines, and others were categorised as narrow-spectrum antibiotics.[23,24] Cases in which more than 2 types of antibiotics were prescribed at the same time were classified as cases with broad-spectrum antibiotic prescription.

Data analyses

Because the dosage, duration, and form vary for each medicine, DDD was used to standardise the use of antibiotics. The DDD is defined as the assumed average maintenance dose per day for a drug used for its main indication in adults; the World Health Organization (WHO) provides relevant information about DDD. In this study, yearly antibiotic usage was calculated as follows.

$$\text{Yearly antibiotic usage (DDD/1000 patients/d)} = \frac{\text{Sum of antibiotics prescribed for a year} \times 1000 \text{ patients}}{\text{DDD} \times 365 \text{ days} \times \text{total number of patients in the year}}$$

Table 2 – Rate of prescribing broad-spectrum antibiotics after tooth extraction.

Characteristics	Division	Antibiotics		P
		Broad-spectrum	Narrow-spectrum	
Total		5,825,369 (47.8)	6,353,816 (52.2)	
Age, y, mean ± SD		47.9 ± 17.7	48.2 ± 17.4	<.001
Sex	Male	3,180,755 (47.8)	3,467,414 (52.2)	.300
	Female	2,644,614 (47.8)	2,886,402 (52.2)	
Household income	Low	953,681 (47.9)	1,037,373 (52.1)	<.001
	Medium-low	875,849 (48.0)	948,341 (52.0)	
	Medium	1,070,830 (48.0)	1,158,337 (52.0)	
	Medium-high	1,308,230 (47.7)	1,432,342 (52.3)	
	High	1,616,779 (47.6)	1,777,423 (52.4)	
Region of dental institution	Urban	5,247,129 (47.9)	5,711,150 (52.1)	<.001
	Rural	578,240 (47.4)	642,666 (52.6)	
Type of dental institution	Dental hospital	737,698 (67.4)	356,249 (32.6)	<.001
	Dental clinic	5,087,671 (45.9)	5,997,567 (54.1)	
Type of tooth extraction	Incisor extraction	596,790 (45.7)	710,182 (54.3)	<.001
	Molar extraction	3,618,708 (46.0)	4,256,047 (54.1)	
	Complicated extraction*	662,869 (49.8)	668,272 (50.2)	
	Simply impacted tooth	239,054 (50.1)	238,254 (49.9)	
	Complexly impacted tooth†	274,579 (56.3)	213,449 (43.7)	
	Completely impacted tooth‡	433,369 (61.8)	267,612 (38.2)	
Year of prescription	2002	218,259 (44.1)	276,700 (55.9)	<.001
	2003	227,016 (44.9)	278,667 (55.1)	
	2004	246,383 (45.8)	291,410 (54.2)	
	2005	258,083 (45.5)	309,546 (54.5)	
	2006	275,895 (46.5)	317,625 (53.5)	
	2007	277,030 (43.5)	360,320 (56.5)	
	2008	290,085 (42.2)	397,460 (57.8)	
	2009	317,499 (43.7)	408,518 (56.3)	
	2010	325,604 (43.3)	427,061 (56.7)	
	2011	326,968 (42.7)	439,580 (57.4)	
	2012	326,141 (42.2)	446,345 (57.8)	
	2013	352,980 (44.2)	446,585 (55.9)	
	2014	402,496 (48.8)	422,520 (51.2)	
	2015	445,793 (52.1)	409,424 (47.9)	
	2016	483,574 (55.1)	393,593 (44.9)	
	2017	507,709 (57.7)	372,350 (42.3)	
	2018	543,854 (60.4)	356,112 (39.6)	

SD = standard deviation.

P values were calculated using the independent *t*-test for age, and χ^2 test was used for all other variables.

Data are presented as *n* (%), unless otherwise indicated.

* Cases in which simple extraction was not possible because of root hypertrophy, root dilacerations, or osseointegration.

† Cases involving tooth splitting.

‡ Simultaneous tooth splitting and ostectomy of impacted tooth with ≥2/3 of crown impacted into alveolar bone.

Table 3 – Rate of prescribing antibiotics according to the type of tooth extraction.

Year	Incisor extraction	Molar extraction	Complicated extraction*	Simply impacted tooth	Complexly impacted tooth†	Completely impacted tooth‡
2002	45,445 (76.5)	327,858 (77.8)	58,367 (79.1)	22,960 (80.1)	16,959 (80.4)	23,370 (81.7)
2003	45,451 (75.7)	332,322 (76.7)	58,808 (78.3)	23,627 (79.0)	18,643 (80.0)	26,832 (81.5)
2004	49,070 (77.2)	347,716 (78.5)	63,038 (80.4)	26,015 (81.1)	21,167 (82.0)	30,787 (83.1)
2005	52,513 (79.4)	364,628 (80.9)	67,049 (82.3)	26,879 (83.2)	22,590 (84.4)	33,970 (85.6)
2006	54,402 (80.9)	383,606 (82.4)	68,869 (83.3)	27,428 (84.8)	23,377 (86.0)	35,838 (87.4)
2007	64,597 (81.9)	414,518 (83.8)	70,985 (85.1)	26,883 (85.9)	23,590 (87.1)	36,777 (88.8)
2008	75,882 (85.6)	449,520 (87.0)	72,832 (87.5)	27,330 (88.3)	25,749 (89.0)	36,232 (90.0)
2009	79,963 (90.3)	475,795 (91.6)	74,736 (92.2)	28,970 (92.5)	28,886 (93.1)	37,667 (93.0)
2010	84,531 (93.5)	495,928 (94.2)	74,521 (94.8)	28,519 (94.4)	30,088 (95.0)	39,078 (94.0)
2011	85,367 (94.3)	502,212 (95.1)	76,973 (95.5)	29,018 (94.5)	31,669 (95.1)	41,309 (93.6)
2012	87,612 (96.6)	503,493 (96.9)	78,293 (97.0)	29,165 (95.4)	31,531 (95.2)	42,392 (93.5)
2013	92,108 (97.4)	518,729 (97.4)	82,516 (97.7)	29,309 (96.1)	31,984 (95.7)	44,919 (93.4)
2014	93,236 (97.4)	531,065 (97.4)	87,343 (97.3)	30,071 (95.7)	34,624 (94.7)	48,677 (93.4)
2015	98,314 (97.3)	547,008 (97.3)	93,381 (97.3)	29,877 (95.9)	35,603 (95.9)	51,034 (92.9)
2016	99,715 (97.4)	557,398 (97.3)	98,941 (97.2)	30,092 (95.7)	36,446 (95.5)	54,575 (92.0)
2017	98,872 (97.3)	559,230 (97.2)	99,514 (97.2)	30,019 (95.6)	36,625 (95.1)	55,799 (92.4)
2018	99,894 (97.2)	563,729 (97.0)	104,975 (97.0)	31,146 (95.4)	38,497 (94.5)	61,725 (92.4)
P	<.001	<.001	<.001	<.001	<.001	<.001

P values were calculated using χ^2 test.
Data are presented as *n* (%).

* Cases in which simple extraction was not possible because of root hypertrophy, root dilacerations, or osseointegration.
† Cases involving tooth splitting.
‡ Simultaneous tooth splitting and ostectomy of impacted tooth with ≥2/3 of crown impacted into alveolar bone.

χ^2 test was used to compare the rate of prescribing antibiotics and broad-spectrum antibiotics, and subgroup analysis was conducted for each type of tooth extraction. Using independent *t*-tests, the mean age was compared among groups. Two logistic regression models, 1 with antibiotic prescription and the other with broad-spectrum antibiotic prescription, were developed as response variables. Both models had the same explanatory variables, including age, sex, household income, region and type of dental institution, type of tooth extraction, and

Table 4 – Rate of prescribing broad-spectrum antibiotics according to type of tooth extraction.

Year	Incisor extraction	Molar extraction	Complicated extraction*	Simply impacted tooth	Complexly impacted tooth†	Completely impacted tooth‡
2002	19,137 (42.1)	140,818 (43.0)	26,436 (45.3)	10,419 (45.4)	8442 (49.8)	13,007 (55.7)
2003	19,202 (42.3)	144,600 (43.5)	26,577 (45.2)	11,072 (46.9)	9715 (52.1)	15,850 (59.1)
2004	20,813 (42.4)	154,826 (44.5)	29,016 (46.0)	12,429 (47.8)	11,187 (52.9)	18,112 (58.8)
2005	22,326 (42.5)	159,817 (43.8)	31,182 (46.5)	12,839 (47.8)	12,161 (53.8)	19,758 (58.2)
2006	23,256 (42.8)	171,604 (44.7)	32,830 (47.7)	13,645 (49.8)	12,834 (54.9)	21,726 (60.6)
2007	26,056 (40.3)	172,334 (41.6)	31,865 (44.9)	12,488 (46.5)	12,448 (52.8)	21,839 (59.4)
2008	31,049 (40.9)	181,366 (40.4)	31,127 (42.7)	12,158 (44.5)	13,753 (53.4)	20,632 (56.9)
2009	33,720 (42.2)	198,823 (41.8)	33,353 (44.6)	13,649 (47.1)	15,867 (54.9)	22,087 (58.6)
2010	34,757 (41.1)	205,150 (41.4)	33,551 (45.0)	13,436 (47.1)	16,135 (53.6)	22,575 (57.8)
2011	34,693 (40.6)	204,745 (40.8)	34,516 (44.8)	13,130 (45.3)	16,404 (51.8)	23,480 (56.8)
2012	36,025 (41.1)	203,527 (40.4)	34,965 (44.7)	12,801 (43.9)	15,419 (48.9)	23,404 (55.2)
2013	39,266 (42.6)	219,735 (42.4)	38,551 (46.7)	13,632 (46.5)	16,301 (51.0)	25,495 (56.8)
2014	43,664 (46.8)	249,725 (47.0)	44,482 (50.9)	15,364 (51.1)	19,152 (55.3)	30,109 (61.9)
2015	49,132 (50.0)	274,822 (50.2)	51,286 (54.9)	16,080 (53.8)	21,089 (59.2)	33,384 (65.4)
2016	52,089 (52.2)	296,485 (53.2)	57,287 (57.9)	17,635 (58.6)	22,855 (62.7)	37,223 (68.2)
2017	54,209 (54.8)	311,268 (55.7)	60,101 (60.4)	18,437 (61.4)	24,284 (66.3)	39,410 (70.6)
2018	57,396 (57.5)	329,063 (58.4)	65,744 (62.6)	19,840 (63.7)	26,533 (68.9)	45,278 (73.4)
P	<.001	<.001	<.001	<.001	<.001	<.001

P values were calculated using χ^2 test.
Data are presented as *n* (%).

* Cases in which simple extraction was not possible because of root hypertrophy, root dilacerations, or osseointegration.
† Cases involving tooth splitting.
‡ Simultaneous tooth splitting and ostectomy of impacted tooth with ≥2/3 of crown impacted into alveolar bone.

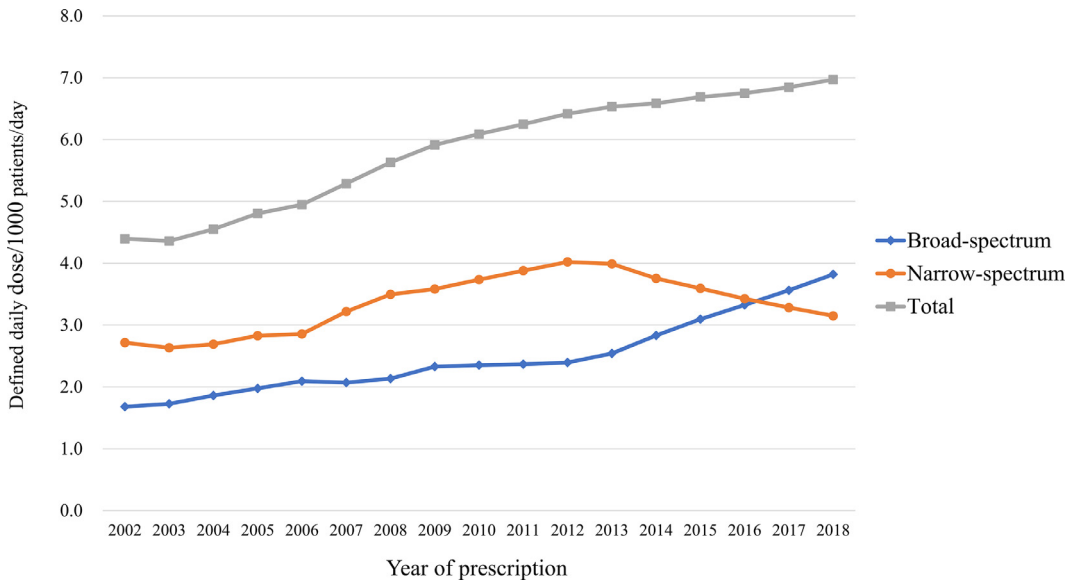

Fig. 2 – Broad- and narrow-spectrum antibiotic prescription from 2002 to 2018.

prescription year. All statistical analyses were performed using SAS Software (version 9.2, SAS Institute), and *P* value <.05 was considered statistically significant.

Results

Of the 15,838,529 cases of tooth extraction during 2002-2018, 13,429,770 (84.8%) cases included a prescription. Among them, antibiotics were included in 12,179,185 (90.7%) prescriptions (Figure 1). The group with antibiotic prescription had a higher mean age (48.0 vs 46.2 years, $P < .001$), and the rate of antibiotic prescription was 78.2% in 2002 and 96.5% in 2018 (Table 1).

Among all antibiotics prescribed after tooth extraction, broad-spectrum antibiotics were prescribed in 47.8% of cases (Table 2). The mean age of the patients who were prescribed broad-spectrum and narrow-spectrum antibiotics was 47.9 and 48.2 years, respectively ($P < .001$). The rate of prescribing broad-spectrum antibiotics after tooth extraction was 44.1% in 2002 and 60.4% in 2018 ($P < .001$), and it was significantly higher in dental hospitals than in dental clinics (67.4% and 45.9%, respectively, $P < .001$). Broad-spectrum antibiotics were prescribed for 45.7% of all incisor extraction cases and 61.8% of completely impacted tooth extraction cases ($P < .001$). Following stratification by the type of tooth extraction, the rate of antibiotic and broad-spectrum antibiotic prescriptions increased in 2018 compared to 2002 in all types of extractions (Tables 3 and 4). To control the confounding effect of age, the subjects were divided into 3 groups according to their birth years (1963-1967, 1968-1972, and 1973-1977), and the rate of prescribing antibiotics was calculated for each year (Appendix Table S1, available online). Even in the subgroup analysis, the rate of prescribing antibiotics clearly increased over time and that of prescribing broad-spectrum antibiotics increased after 2013 (Appendix Table S2, available online).

The value of DDD/1000 patients/d for antibiotics was calculated to be 4.39 in 2002, with a steady increase until 2018 when the value was 6.97 (Figure 2 and Appendix Table S3, available online). The DDD/1000 patients/d for narrow-spectrum antibiotics was 2.71 in 2002, the highest at 4.02 in 2012, and declined to 3.15 in 2018. The DDD/1000 patients/d for broad-spectrum antibiotics was 1.68 in 2002; it further increased and was found to be the highest at 3.82 in 2018.

Logistic regression analysis revealed that the chances of prescribing antibiotics after tooth extraction decreased in 2003 compared to 2002 (odds ratio [OR], 0.95), but from 2004 to 2018, all ORs were greater than 1, showing that the antibiotic prescription rate increased ($P < .001$) (Table 5). Regarding the broad-spectrum antibiotic prescription rate, from 2003 to 2013, there was no clear increasing or decreasing trend (OR, 0.89-1.07); however, the OR consistently increased from 2014 to 2018 (OR, 1.16, 1.33, 1.50, 1.66, and 1.86, respectively; $P < .001$).

Discussion

Our findings showed that the rate of prescribing antibiotics consistently increased from 2002 to 2018; additionally, the rate of prescribing broad-spectrum antibiotics increased in the last 5 years, consistent with previous findings.[17-20] Korea is an aging society, and therefore, the average age of the population will increase over time; this was a characteristic of the subjects in this study as well (Appendix Table S4, available online). Different tooth extraction methods are used depending on the patient's age (Appendix Table S5, available online); moreover, age is a risk factor for postoperative infection.[15,25] Hence, the possibility that age may affect the trends

Table 5 – Logistic regression for antibiotic prescription and broad-spectrum antibiotic prescription.

Characteristics	Division	Antibiotic prescription			Broad-spectrum antibiotic prescription		
		OR	CI	*P*	OR	CI	*P*
Age		1.00	1.00-1.00	.604	1.00	1.00-1.00	<.001
Sex	Male	Ref.			Ref.		
	Female	0.98	0.97-0.98	<.001	0.99	0.99-0.99	<.001
Household income	Low	1.00			1		
	Medium–low	1.00	0.99-1.01	.817	1.00	0.99-1.00	.262
	Medium	1.01	1.00-1.01	.087	1.00	0.99-1.00	.143
	Medium–high	1.01	1.01-1.02	<.001	0.99	0.98-0.99	<.001
	High	1.00	0.99-1.00	.573	0.97	0.97-0.98	<.001
Region of dental institution	Urban	Ref.			Ref.		
	Rural	0.88	0.88-0.89	<.001	1.06	1.05-1.06	<.001
Type of dental institution	Dental hospital	Ref.			Ref.		
	Dental clinic	1.12	1.11-1.13	<.001	0.44	0.44-0.44	<.001
Type of tooth extraction	Incisor extraction	Ref.			Ref.		
	Molar extraction	1.08	1.07-1.09	<.001	1.04	1.04-1.04	<.001
	Complicated extraction*	1.16	1.15-1.17	<.001	1.20	1.19-1.20	<.001
	Simply impacted tooth	1.12	1.11-1.13	<.001	1.23	1.22-1.24	<.001
	Complexly impacted tooth†	1.14	1.12-1.15	<.001	1.43	1.42-1.44	<.001
	Completely impacted tooth‡	1.01	1.00-1.02	.055	1.70	1.69-1.71	<.001
Year of prescription	2002	Ref.			Ref.		
	2003	0.95	0.94-0.96	<.001	1.02	1.01-1.02	<.001
	2004	1.06	1.05-1.07	<.001	1.05	1.04-1.06	<.001
	2005	1.22	1.21-1.23	<.001	1.03	1.02-1.04	<.001
	2006	1.36	1.34-1.37	<.001	1.07	1.06-1.08	<.001
	2007	1.49	1.48-1.51	<.001	0.94	0.94-0.95	<.001
	2008	1.90	1.89-1.92	<.001	0.90	0.89-0.90	<.001
	2009	3.08	3.05-3.11	<.001	0.95	0.95-0.96	<.001
	2010	4.58	4.53-4.63	<.001	0.93	0.93-0.94	<.001
	2011	5.25	5.19-5.32	<.001	0.91	0.9-0.910	<.001
	2012	7.86	7.75-7.96	<.001	0.89	0.88-0.90	<.001
	2013	9.38	9.25-9.51	<.001	0.96	0.96-0.97	<.001
	2014	8.86	8.73-8.98	<.001	1.16	1.15-1.17	<.001
	2015	8.78	8.66-8.90	<.001	1.33	1.32-1.34	<.001
	2016	8.52	8.41-8.64	<.001	1.50	1.49-1.51	<.001
	2017	8.26	8.15-8.37	<.001	1.66	1.65-1.67	<.001
	2018	7.78	7.68-7.88	<.001	1.86	1.85-1.87	<.001

CI = confidence interval; OR = odds ratio.
P values were calculated by logistic regression analysis.

* Cases in which simple extraction was not possible because of root hypertrophy, root dilacerations, or osseointegration.
† Cases involving tooth splitting.
‡ Simultaneous tooth splitting and ostectomy of impacted tooth with ≥2/3 of crown impacted into alveolar bone.

in antibiotic prescription cannot be ruled out. However, in the subgroup analysis as per subjects' birth years, it was found that the number of antibiotic prescriptions increased regardless of age (Appendix Tables S1 and S2, available online).

Additionally, the type of tooth extraction procedure is a powerful confounding factor in antibiotic prescriptions; hence, stratification analysis was performed. The rate of prescribing antibiotics increased after 2002 for all types of tooth extraction (Table 3). Even for relatively less invasive procedures, such as incisor extraction, the antibiotic prescription rate increased from 76.5% in 2002 to 97.2% in 2018. This is considerably higher than the antibiotic prescription rates reported in previous studies,[26,27] suggesting that a considerable amount of unnecessary prescriptions were provided. The rate of prescribing antibiotics following the removal of a completely impacted tooth (81.7%) was higher than that after incisor removal (76.5%) in 2002, whereas the rate of antibiotic prescription in incisor extraction was higher than that after completely impacted tooth removal in 2018 (97.2% vs 92.4%). This may be because only antibiotics prescribed on the same day of the tooth extraction were included, but prophylactic antibiotics prescribed before the extraction were not included in this study. Additional studies on the use of prophylactic antibiotics are necessary.

In the analysis of broad-spectrum antibiotics prescribed for each type of extraction procedure, it was observed that the more invasive the procedure was, the greater was the rate of broad-spectrum antibiotic prescription (Table 4). Besides, in all kinds of tooth extraction, the broad-spectrum antibiotic prescription rate did not exhibit a clear increase or decrease from 2002 to 2013; however, after 2014, the rate increased. In logistic regression analysis, a similar trend was observed (Table 5). However, the change in the DDD/1000 patients/d value of broad-spectrum antibiotics was different from the change in the prescription rate and exhibited a pattern that steadily increased from 2002 to 2018. Hence, although the change in the broad-spectrum antibiotic prescription rate from 2002 to 2013 was small, usage was

increased; therefore, further studies should investigate the prescription rate and standardised dose using DDD.

These findings suggest that prescription for several antibiotics after tooth extraction were unwarranted. Dentists may prescribe unnecessary antibiotics because they do not want their patients to develop complications; however, this in turn can place them in undesirable situations. A study reported that the use of antibiotics is increasing because of the demand by patients who fear pain after tooth extraction, and patients who received antibiotics experienced reduced discomfort.[28] However, antibiotic misuse is occurring, and the possibility of contributing to the problem should always be considered. Additionally, the lack of proper guidelines for antibiotic prescriptions in dentistry can be a cause of overuse. In the last few years, when overuse of antibiotics was recognized, it can be assumed that unnecessary antibiotic prescriptions became habitual, and as a result, antibiotic use increased.

These data indicate that antibiotic abuse after tooth extraction is a growing problem. Antibiotic abuse leads to antibiotic resistance, which further leads to increased use of broad-spectrum antibiotics in a vicious cycle. The risk of postoperative infection is extremely low for healthy patients without systemic diseases who do not show clear signs of infection before tooth extraction.[14,15] In addition, the risk of complications does not significantly vary depending on whether antibiotics were prescribed.[11,13-15] It should be remembered that the risk of antibiotic resistance outweighs the benefit of antibiotic use, and ways to reduce antibiotic misuse and overuse in dentistry should be considered.

As this study used the NHISS database, the results must be carefully interpreted because of the inherent limitations of claims data, such as coding errors. Prescription records issued on the day of tooth extraction were used, and the cases could not be excluded in which antibiotics were prescribed because of another procedure or symptoms and not because of the extraction. Cases of prophylactic antibiotic prescription and additional antibiotic prescription because of postoperative infections were not included. A tooth extraction classification method developed for administrative purposes rather than research purposes had to be used; this made it difficult to accurately identify the type of tooth extraction and reason for extraction. Some potential confounders were not considered in this study, such as systemic diseases and the types of drugs already received. Additionally, there is a possibility that the number of patients with systemic diseases increased over time as the patients aged, and this increase affected the results of this study. Despite these limitations, it is meaningful to study changes in antibiotic use using long-term population-based longitudinal data.

Conclusions

The rate of prescribing antibiotics after tooth extraction in 2018 increased significantly compared to that in 2002; additionally, the value of DDD/1000 patients/d for antibiotics was increased over the last 17 years. The DDD/1000 patients/d of broad-spectrum antibiotics in 2018 increased by more than 2 times compared to 2002. Our findings warn against the increasing use of antibiotics in dentistry. Further studies are needed on the causes of increased antibiotic prescriptions. In addition, there is a need for studies on antibiotic prescriptions after dental procedures other than tooth extraction and ways to reduce antibiotic prescription in dentistry.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

None disclosed.

Acknowledgements

This study was conducted using data from National Health Insurance Sharing Service (NHIS-2020-1-117).

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.identj.2021.01.010.

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